

2016

**7th Conference
Proceedings**

Digital Inclusion: Transforming Education Through Technology

May 23rd – 25th
MIT, Cambridge,
Massachusetts, USA



OFFICE OF DIGITAL LEARNING
LINIC 2016 CONFERENCE





Foreword

This book includes the proceedings of the Learning International Networks Consortium (LINC)'s seventh meeting held at Massachusetts Institute of Technology from May 23-25, 2016. The meeting provided an opportunity for individuals and organizations to talk about and share best practices on current digital learning topics. The 2016 conference theme was Digital Inclusion: Transforming Education through Technology, with particular emphasis on the following topics: Quality Education at Scale, Bridging the Education Divide, Understanding Learning Engineering, Developing Tools for the Digital Learning Experience, and Recognizing the Role of Digital Learning for Students of All Ages.

The meeting started with a day of workshops facilitated by experts from the MIT community, who shared their experiences with the development of MOOCs online active learning video lessons, teaching cell biology concepts using MIT's Kinesthetic DNA, RNA and Protein Models; and the use of social tools to support online learning. The main program featured seven plenary speakers and seven panel presentations with 26 participants who shared their work and expertise in the LINC 2016's topic areas. The speakers from MIT included Dr. Sanjay Sarma, Dr. Richard Larson, Dr. Vijay Kumar, Dr. Eric Klopfer, Mr. Philipp Schmidt, Dr. Cynthia Barnhart, Mr. Israel Ruiz, Dr. Denny Freeman, Dr. Hazel Sive, Dr. David Darmofal, Dr. Christine Ortiz, Dr. Catherine Drennan, Dr. Krishna Rajagopal, Dr. Mitch Resnick, Ms. Georgia Van de Zande, Ms. Cecelia d'Oliveira, Ms. Anna Leonard, Ms. Rachel Reed, Mr. John Peurifoy; and from a variety of experts in education: Dr. Arthur Levine, Dr. Roxana Morduchowicz, Dr. Cristobal Cobo, Dr. Stephen Anzalone, Ms. Maysa Jalbout, Mr. Nafez Dakkak, Ms. Hila Azadzoy, Mr. Ramji Raghavan, Dr. Asha Kanwar, Dr. Anant Agarwal, Dr. Zaleha Abdullah, Dr. Naveed Malik, Mrs. Hanan Al-Arfaj, Dr. Cliff Missen, Dr. Bakary Diallo and Mr. Cody Coleman. Video recordings of the presentations can be seen on YouTube on the MIT Office of Digital Learning channel.

Thirty-six papers submitted by 92 authors were accepted for presentation. Those authors came from 16 different countries: Argentina, China, Colombia, Costa Rica, Ghana, India, Israel, Malaysia, Nigeria, Pakistan, Russian Federation, Spain, United Kingdom, United States and Uruguay. We would like to thank the members of the Program Committee from MIT, Harvard, and Tata Institute of Social Sciences (TISS), who helped review the papers, offered advice, and made final recommendations about the program.

Special thanks go to the Office of Digital Learning, in particular to Anine Ward, Rita Sahu and Steve Nelson, who worked hard to make the conference a tremendous success.

Claudia Urrea, PhD
Office of Digital Learning
MIT





May 23, 2016

Dear Participants of MIT LINC 2016:

On behalf of the MIT Learning International Networks Consortium (MIT LINC), I am pleased to welcome you to this seventh international meeting on “Digital Inclusion: Transforming Education through Technology”. We are excited to hold this conference on the MIT campus and to extend our hospitality to professionals from over 30 countries.

You bring astonishing capability to this conference, and we are excited to learn from your experiences, plans, and strategies. Your involvement with the ever-expanding dimensions of technology-enabled learning is invaluable and will help shape important research and outreach policies.

We are grateful to the many MIT volunteers and to the universities, companies, and foundations that have made this conference possible. In true MIT essence, the bar is set high, and we are grateful that your professional, academic, and entrepreneurial exchanges at the conference will move LINC forward to achieve a greater understanding of our role in digital learning.

Sincerely,

Sanjay Sarma, Vice President for Open Learning





May 23, 2016

Dear LINC Participant,

Welcome to MIT LINC 2016, our seventh international LINC Conference! Whether you have travelled from Argentina, Thailand, Pakistan, India or one of the many other locations, we very much value your presence at LINC 2016. You, the participants of LINC 2016, represent over 30 countries, presenting over 35 papers, together with 20 plenary speakers.

LINC, *Learning International Networks Consortium*, is an MIT-based all-volunteer effort started 15 years ago. By participating in LINC, you have joined our LINC family, representing concerned professionals from many countries – each wanting to leverage technology to improve educational opportunities for under-served communities in their respective regions.

The theme of LINC 2016 is *“Digital Inclusion: Transforming Education through Technology”*. Worldwide, education is experiencing a world of change, made possible by the Internet, computers and the willingness of many to post their educational content online for free – as part of Open Educational Resources (OER). Add to this the many established MOOC’s, Massive Open Online Courses, and the ingredients for transformation are there. Trained and committed educators on the ground are also necessary, of course, to complete the new learning systems. All of this and more will be presented, discussed and debated over the next few days.

LINC 2016 would not be possible without the dedicated efforts of our volunteers and the financial support of our sponsors. As I pass the baton of LINC Director to Professor Sanjay Sarma, I want to thank him and all others who have made previous LINC conferences possible and who are making this one a huge success! Going forward, LINC is in good hands with Sanjay and his Team!

Please let us know how we can serve you better in your time here. Feel free to stop any one of the LINC volunteers to inquire about any issue or to make suggestions. And we will be soliciting your formal feedback in a short online evaluation questionnaire. We hope you choose to complete it after your stay with us. **Again, welcome to LINC 2016!**

Sincerely,

Richard C. Larson

Professor, Founder and Director Emeritus of LINC, MIT



Sponsors

We would like to extend our gratitude to the sponsors of this year's LINC Conference for all their support of this endeavor.

MIT Alumnus, Mr. Glenn P. Strehle, 1958 & 1960 SM



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Is Education Making our Students Less Emotionally Intelligent? Holistic Education and Developing Emotional Intelligence using MOOCs

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Abstract

Pursuing Holistic Education is a growing trend among institutions of higher learning. This implies that academic institutions need to inculcate soft skills as well as the traditional academic skills. However, there seems to be little agreement on what works when it comes to inculcating and measuring the development of soft skills. This paper reports on a course to develop a holistic educational experience through the introduction of emotional intelligence to engineering students. The preliminary results indicate that students attended the course exhibited growth in majority of emotional intelligence traits when compared to a control group.

1. Introduction

Educational institutions are aspiring to develop graduates who are not only academically sound, but those who are ready for surviving and thriving in the 21st century, which is a key century that is riddled with grand challenges for the humanity as a whole. In the era of globalisation and integrated communities, holistic development of individuals is a prerequisite for nations' competitiveness and security. Tony Wagner [1] identified in "The Global Achievement Gap" 7 survival skills for the 21st century that are not being taught in schools. These skills are

1. Critical thinking
2. Collaboration across networks
3. Agility and adaptability
4. Initiative and entrepreneurialism
5. Effective oral and written communication
6. Accessing and analysing information
7. Curiosity and imagination

To address these gaps, universities are increasingly identifying lists of graduates' attributes and are investing in developing these attributes. However, developing curricular and extra curricular activities to inculcate and measure these attributes can represent a real challenge. Unlike academic skills that can be developed through lectures, tutorials and other exercise and measured through exams, developing interpersonal and intrapersonal traits necessary for holistic development takes longer timeframe and often there is on universal methods to measure them.

This paper reports the preliminary findings of a programme that is aimed at the development of holistic education curricula through integrating emotional intelligence into a project based learning course taught at the Foundation in Engineering Programme at Taylor's University (Malaysia).

2. Holistic Education

Taylor's University has its Purpose to "educate the youth of the world to take their productive places as leaders in the global community." The university pursues its purpose while observing its guiding core values, also known as the RECIPE, are

1. Respect and care
2. Excellence
3. Communication openness
4. Integrity
5. Passion
6. Enjoyable environment

Besides subject specific knowledge, the graduates' attributes often cover interpersonal and intrapersonal skills that are seen to mark the holistic education. Taylor's Graduate Capabilities (TGC) include

1. Discipline Specific Knowledge
2. Lifelong Learning
3. Thinking and Problem Solving
4. Communication Skills
5. Interpersonal Skills
6. Intrapersonal Skills
7. Citizenship and Global Perspective
8. Digital Literacy

To fulfill the Purpose of the university, develop the graduate capabilities and adhere to the university core values, holistic education seems to be a natural method and aspiration. In aiming at developing students' emotional wellbeing, developing life skills as well as to improve academic ability and performance, holistic education attempts to provide a broader vision of education and human development. Miller [2] identified three key elements to assist in this process: balance, inclusion, and connection.

One attempt to drive the holistic education agenda is through developing emotional intelligence in the students. Besides holistic development, emotional intelligence is increasingly accepted as a viable business choice for employers. Cherniss [3] established a business case for emotional intelligence as a contributor towards the bottom line. In this study, 19 cases of how emotional intelligence was used in governmental and business entities to deliver real value with direct contributions towards the profitability and performance.

Taking a cross section of the human brain along its plane of symmetry, the brain has three main regions, the old brain directly on top of the spinal chord, which is dedicated to survival instincts, the middle brain where emotions are processed and the new brain where rational high level thinking happens. We perceive the world around us through the variety of sensory signals that are relayed to our brains. Signals flow in and out of the brain through its lower part, the old and middle brain, which means that any signal that goes through the brain will be emotionally “flavoured” before reaching the new brain for rational processing. This is the reason why we sometimes emotionally overreact to events and stimuli. Being aware of this emotional overdrive and being able to manage the impact of emotions on ourselves as well as others around us is called Emotional Intelligence. Emotional intelligence framework developed by Goleman [4] shown below in Fig. 1 has four main domains, self awareness, self management, social awareness and relationship management.

The cornerstone of emotional intelligence is self-awareness. Emotionally intelligent individuals are aware of their internal state, capabilities and limitations and they are able to use language to describe how they feel in clear and precise words. These individuals can manage themselves better and can develop better relationships. According to Daniel Goleman [4], self-awareness encompasses emotional awareness, accurate self-assessment and self-confidence.

Self management is a very important component of emotional intelligence. Individuals who are self-aware learn that all emotions are ok. It is ok to be angry, sad or happy. However, not all actions are ok. It is not acceptable, for example, to insult others or physically harm them while we are angry or disappointed.

To survive in the environment in which our ancestors lived, our brains evolved to quickly respond to negative stimuli and threats. If a caveman is walking in the jungle, it makes sense for him to run if he feels danger approaching rather than stopping and analysing the consequences. This fast action that served us well in the past has become a liability that we need to mitigate in today’s world. There is a need to train our brains to be able to identify and quickly respond to opportunities, not only threats. This fits clearly in the realm of self-management.

Just like self awareness, social awareness refers to presence of the mind and other character traits that enable individuals to be aware of their surroundings and how they are impacted by and impact other people’s feelings and emotions. To nurture social awareness, Daniel Goleman [4] proposed the development of empathy, organisational awareness and service orientation.

While self-awareness is the cornerstone of the emotional intelligence, relationship management is its ultimate objective. As mentioned earlier, happiness is measured by the quality of relationships that we cultivate with those around us. The pillars of the character of an individual who is capable of nurturing and managing great relationships with others include developing others, inspirational leadership, influence, being change catalyst, conflict management and teamwork and collaboration.

The four emotional intelligence dimensions are mapped in Table 1 to the survival skills identified by Tony Wagner [1], Taylor’s Graduate Capabilities (TGC) as well as Taylor’s Core Values.

3. Emotional Intelligence Course

A three credit hours course was developed and delivered over 18 week semester to the students of the Foundation in Engineering programme at Taylor’s University (Malaysia). The Foundation programme is equivalent to year 12 and students who complete it successfully are eligible to start their bachelor engineering degree programme. The course was developed based on Daniel Goleman’s emotional intelligence framework [4] and offered as a Massive Open Online Course (MOOC) both to students on campus as well as students online. Besides the emotional intelligence component, the course also has a robotic project that the cohort of students on campus needed to work on. The platform used to deliver the MOOC is openlearning.com which has many social media like features to enable student’s collaboration and learning [5]. Table 2 shows the course activities that are established to develop different emotional intelligence traits.

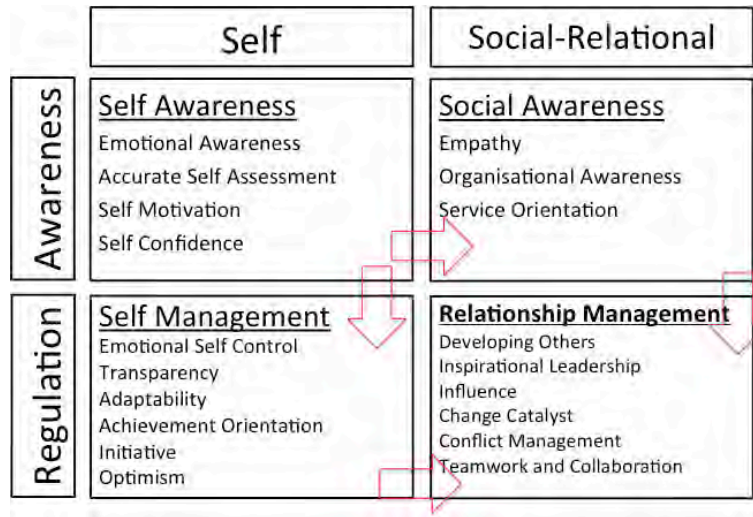


Figure 1. Daniel Goleman’s Emotional Intelligence framework [4].

All the course lectures and activities were video recorded and made available online on the MOOC platform to enable both on campus and online students to refer to them. The main course activities are outlined and briefly described below. The course website is available for free at

<https://www.openlearning.com/courses/Success>

3.1 Brain Rewiring

Although the human brain seems to be hard-wired to respond to negative stimuli as a survival necessity [6], research shows that the brain is a plastic organ and repeated deep practice of a certain thought pattern can literally generate new neuron connections, rewiring the brain. To impact this wiring process positively, Brain Rewiring required the students to report 5 things that they are grateful for on a daily basis [7]. This is done online on the MOOC platform and is meant to develop self motivation, optimism and adaptability.

3.2 My Emotions Today

Students were also required to report how they felt mentally, emotionally, relationally, spiritually, vocationally and physically on a daily basis. Developing the vocabulary to describe feelings is expected to foster emotional awareness and emotional self-control.

Table 1. Mapping of Emotional Intelligence to the 21st century survival skills, Taylor’s Graduate Capabilities and Core Values

Emotional Intelligence Trait	EI Dimension	Survival Skill	TGC	Core Values
Emotional Awareness	Self Awareness	Critical thinking Accessing and analysing information	Critical Thinking Intrapersonal Skills	Passion
Accurate Self Assessment				
Self Motivation				
Self Confidence				
Emotional Self Control	Self Management	Initiative and entrepreneurialism	Discipline Specific Knowledge	Excellence
Transparency				
Adaptability		Agility and adaptability	Lifelong Learning	Integrity
Achievement Orientation				
Initiative				
Optimism				
Empathy	Social Awareness	Curiosity and imagination	Citizenship & Global Perspectives Digital Literacy	Enjoyable Environment
Organisational Awareness				
Service Orientation				
Developing Others	Relationship Management	Effective oral and written communication	Communication Skills	Respect and Care
Inspirational Leadership				
Influence				
Change Catalyst		Collaboration across networks	Interpersonal Skills	Openness in Communication
Conflict Management				
Teamwork & Collaboration				

3.3 Meditation

Students were introduced to the meditation practice and three group meditation sessions were performed in class. The objective of the meditation is to enable emotional awareness, focus and mindfulness.

Table 2. Emotional Intelligence course activities.

Dimension	Emotional Intelligence Trait	Course Activity
Self Awareness	Emotional Awareness	My Emotions Today, Meditation
	Accurate Self Assessment	Personal SWOT Analysis
	Self Motivation	Brain Rewiring
	Self Confidence	Vision and Mission
Self Management	Emotional Self Control	My Emotions Today
	Transparency	Lecture
	Adaptability	Brain Rewiring, Opportunity Note
	Achievement Orientation	SMART Goals
	Initiative	Vision and Mission
	Optimism	Brain Rewiring
Social Awareness	Empathy	Mirroring, Empathetic Listening
	Organisational Awareness	Project, Organisation Chart
	Service Orientation	Guest Lecture
Relationship Management	Developing Others	Mission Partnership
	Inspirational Leadership	Vision and Mission
	Influence	Lecture
	Change Catalyst	Lecture
	Conflict Management	Lecture
	Teamwork and Collaboration	Project, Lecture: Tuckman's Model

3.4 Vision, Mission, SWOT and SMART Goals

To promote accurate self assessment, confidence, initiative and achievement orientation, workshops to craft vision, mission, SWOT (Strengths, Weaknesses, Opportunities and Threats) and SMART (Specific, Measurable, Attainable, Realistic and Timely) goals for the students were conducted.

3.5 Mirroring and Empathetic Listening

Empathy is the ability to put one's self in another individual's position. To develop this skill mirroring exercises as well empathetic, nonjudgmental listening sessions were conducted between the students and moderated by the lecturer. The mirroring exercise simply required the students to physically mirror the movements and emotions of a course mate while the empathetic listening entailed listening to a course mate and repeating what the course mate said that she (he) felt without adding own interpretation.

3.6 Mission Partnership

Students were paired were the records the missions of each other. Each student kept his/her partner's mission. Students were asked to send each other weekly encouraging messages. This is to instill the trait of developing others.

3.7 Karma Points and Badges

To encourage collaborative learning and foster students collaboration, Karma Points and Course Badges were awarded to the students. When a course participant "likes" a course

submission or comment by another participant, the originator of the comment automatically receives 1 Karma Point. Six badges, corresponding to the six Taylor's core values, were designed. A badge is issued by the lecturer to a student when that student exhibits behaviour consistent with the respective core value.

4. Method

4.1. Participants

To assess the effectiveness of the course in supporting the development of different traits associated with emotional intelligence, two groups of students were selected, test group and control group. The test group has 75 students (70% male) between the ages of 18 and 21 years, registered for the foundation in engineering programme. This group took the emotional intelligence MOOC together with students from all over the world. The control group (a cohort of students who did not take the emotional intelligence MOOC) is selected with students of very similar profile taking the foundation in science programme offered by the school of biosciences. The control group has 75 students (12 % male) between the ages of 18 and 20 years. While both groups are from the "science" stream, the engineering group has a much larger percentage of male members.

4.2. Measures

To measure the emotional intelligence for both the test group and the control group, before and after the semester, a 30-item questionnaire developed by Ong and Yeo [8] was used. The questionnaire is designed based on Goleman's emotional intelligence framework and items are responded to on a 5-point Likert scale. The questionnaire's items are listed below.

1. I am aware that anger can cause me to make mistakes. (EA)
2. I am aware of how I feel most of the time. (EA)
3. I am confident with what I do. (SC)
4. I am decisive when a situation calls for a quick decision. (SC)
5. I know what I am good at doing. (ASA)
6. I know what I am not good at doing. (ASA)
7. I believe in learning from past experiences, regardless good or bad. (ASA)
8. I have learned to control my negative feelings. (ESC)
9. I can think clearly even when I am under stress. (ESC)
10. I can easily adapt to changes. (A)
11. I admit my mistakes if I am wrong. (T)
12. I support ethical decisions even if they are not popular decisions. (T)
13. I make the effort to see my lecturer/professor if I need further assistance in my study. (I)
14. I am positive in pursuing my goals even if I experience difficulties. (O)
15. I set goals for me to achieve in my course of study. (AO)

16. I am a good listener. (E)
17. I care about people's thoughts and feelings. (E)
18. I try to look at other people's perspectives, not just my own. (E)
19. I believe that customers are always right. (SO)
20. I believe that increasing customers' loyalty is important in any business. (SO)
21. I am able to sense when there is tension in a group activity/meeting. (OA)
22. I am aware of how things are normally done in my class. (OA)
23. I like teaching my knowledge/skill to the juniors/younger people. (DO)
24. I believe that changes are necessary for progress. (CC)
25. I am excited when there are new changes in the college/university. (CC)
26. I am a good team player. (TC)
27. I believe in working in a team rather than working alone. (TC)
28. I will step forward to lead, regardless of my position. (IL)
29. I believe that conflicts should be addressed through open discussions. (CM)
30. I have the skill to persuade people. (IF)

5. Results and Discussion

The mean values of the responses to questionnaire items related to different emotional intelligence traits are calculated. On average, students from test group exhibit an improvement in emotional intelligence after attending the course. The control group exhibited no gain over the same period.

The test group shows a 3.86% improvement on the overall means exhibiting an improvement for 16 out of 18 of the emotional intelligence traits. The top 3 improvements are in Emotional Self-Control (+17.1%), Organisational Awareness (+9%), Influence (+8.9%). The control group emotional intelligence overall mean shows a decline of 1.15%. 7 out of 18 traits show some improvement. With the top 3 improvements in Emotional Self-Control (+6.2%), Organisational Awareness (+5%), Emotional Awareness (+2.2%). These results are shown graphically in Figures 2 and 3.

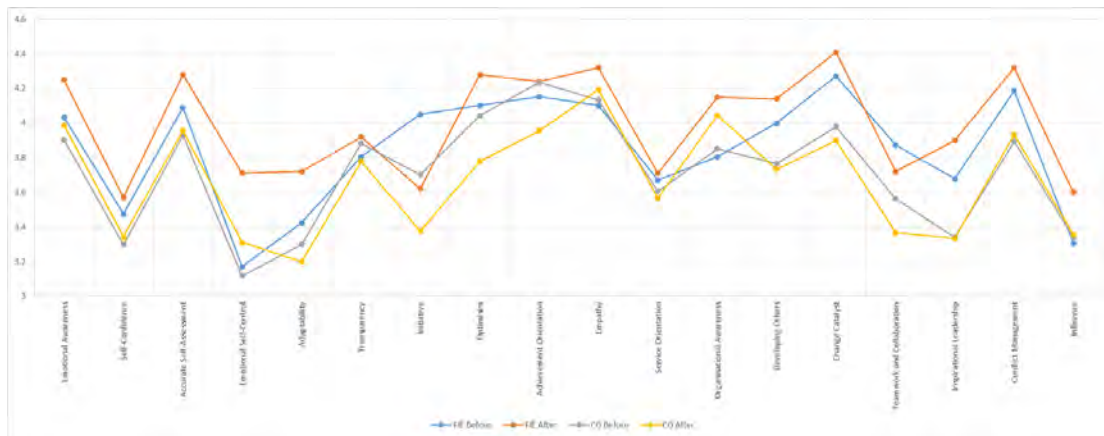


Figure 2. Emotional Intelligence traits of the test and control groups, before and after taking the course

The initial results seem to suggest that the course has helped improve the emotional intelligence of the participants. Since both the male-dominated group (the group that took the emotional intelligence MOOC) and the female-dominated control group had very similar emotional intelligence score at the beginning of the semester (before the course), gender seems to bestow no emotional intelligence advantage.

Although further testing need to be performed to establish that the adequacy of the course and whether the gender disparity between the test group and the control group played any role in the emotional intelligence growth, the results reported here can have significant implications as the university moves into developing holistic education strategies. One area that needs testing is the retention of the acquired skills if the students are quizzed 6 months to 1 year later.

6. Conclusions

An emotional intelligence course was developed and delivered to foundation in engineering students. The initial results suggest that the course helped the students achieve growth in most of the emotional intelligence traits when compared to a control group. This indicates that emotional intelligence can be used as a way to develop holistic education at the university level. It also indicates the adequacy of MOOCs as a suitable platform to build emotional intelligence.

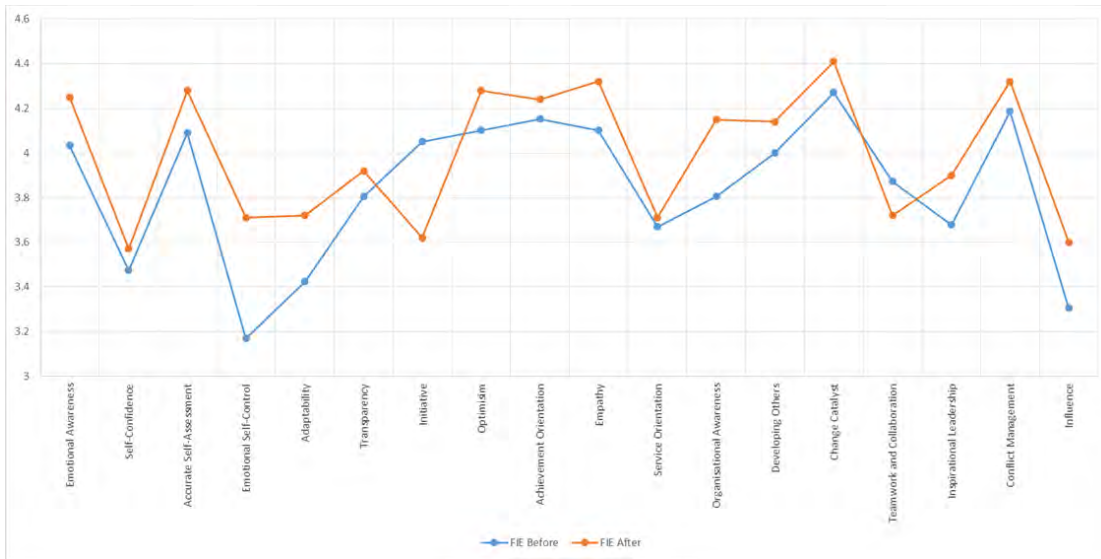


Figure 3. Comparison of the test group Emotional Intelligence before and after taking the course

References

- [1] T. Wagner (2010). The global achievement gap: Why even our best schools don't teach the new survival skills our children need--and what we can do about it. Basic Books.
- [2] J. Miller (1998). Making connections through holistic learning. *Educational Leadership*, 56(4), 46-48.
- [3] C. Cherniss (1999) The Business Case for Emotional Intelligence. http://www.eiconsortium.org/pdf/business_case_for_ei.pdf
- [4] Goleman, D. (2006). *Emotional intelligence: Why it can matter more than IQ*. Random House Digital, Inc.
- [5] M. Al-Atabi and J. DeBoer (2014). Teaching entrepreneurship using Massive Open Online Course (MOOC). Technovation.
- [6] T.A. Ito, J.T. Larsen, N.K. Smith, and J.T. Cacioppo (1998). Negative information weighs more heavily on the brain: the negativity bias in evaluative categorizations. *J. Pers. Soc. Psychol.* 75 (4), 887.
- [7] T. Ben-Shahar (2010). *Even Happier: A Gratitude Journal for Daily Joy and Lasting Fulfillment*. McGraw-Hill
- [8] P.F. Ong and R.K. Yeo (2007). Influence of emotional intelligence on learning styles: an exploratory study on management undergraduates in Malaysia and Saudi Arabia in Enhancing Higher Education, Theory and Scholarship, Proceedings of the 30th HERDSA Annual Conference [CD-ROM], Adelaide, 8-11 July.

From the Classroom to a Massive Audience: A Successful Experience Introducing Programming with Java

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Abstract

MOOCs represent a great opportunity to spread knowledge that has been traditionally restricted to small groups of students to potentially any learner from anywhere in the world. Thus, the expertise gained over years of practice by teachers on certain topics is now made available to a wider audience. This expertise, captured in the form of good practices and common misconceptions, is very valuable to create quality MOOCs that are rich in contents and exercises. This paper describes the design and development of the MOOC “Introduction to Programming with Java Part 1: Starting to Code with Java”, which is focused on teaching programming using Java as the driving language. This MOOC is offered on the edX platform, and has turned out to be a successful experience with more than 130,000 enrollees so far in its two runs (the second still ongoing). It was designed and developed to be highly interactive, making extensive use of exercises created with edX built-in tools, but also with other external tools, such as Blockly, Codeboard, and Greenfoot; numerous ad hoc animations and simulations are also included as part of the courseware. This MOOC has received good critiques from learners, achieving a score of 4.5 stars out of 5 (70 reviews) in the course reviewer CourseTalk, which puts this course in the top 10% of the courses published in edX, and in the top 10 of the courses published by European universities in edX, according to this review tool (as of March 2016).

1. Introduction

MOOCs are able to connect people with very different backgrounds that sit in front of the computer to acquire new knowledge, either by leisure or necessity. Furthermore, MOOCs somehow contribute to meet the constant need for education that our society and the changing labor market are demanding. This demand grows steadily, particularly for retraining professionals in new skills and technologies [1]. Fields related to Information and Communication Technologies (ICTs) are among the most popular ones in MOOCs, due to the incorporation of ICTs in many areas of our society, and the fast pace with which technologies evolve today [2].

Within the field of ICTs, MOOCs related to programming, in general, or to specific programming languages, in particular, tend to have a strong demand, as they can represent an opportunity to increase employability. More and more MOOCs on programming are being deployed in major platforms; Java, Python, C, R or HTML5 are among the most popular programming languages. MOOCs on programming face the challenge of meeting expectations at the same time of novice learners, who have no programming background, and of experienced programmers, who wish to learn a new language. Moreover, just teaching the key concepts in videos shall not be enough for learning programming. Learners need to practice, dedicating large amounts of time to code programs of increasing difficulty, as it typically happens in traditional face-to-face programming courses. And, therefore, teachers need to prepare large problem set and realistic projects in the MOOC to reinforce key concepts.

This paper presents the design and development of the MOOC “*Introduction to Programming with Java – Part 1: Starting to Code with Java*”, which is a successful course deployed in the edX platform, and whose aim is to introduce programming from scratch, using Java as the programming language. The next section presents the design of the MOOCs with special focus on the course structure, the videos and the exercises. The following section presents some data about this course, before drawing up the conclusions in the last section.

2. Design of the MOOC

The MOOC “Introduction to Programming with Java – Part 1: Starting to Code with Java” (named “... Starting to Program with Java” in its first run) has five weeks of learning contents. This MOOC is the first of a series of three courses dedicated to teaching the basic principles of programming using Java as the driving language. The MOOC has been deployed in the edX platform and is entirely taught in English language. The initial estimated workload for learners was between 5-7 hours per week, although data from the surveys filled in by learners who completed the course indicate that the real workload was between 10-12 hours per week (especially in the case of novice learners).

This MOOC was released for the first time from April 2015 to June 2015. After a very successful first run, the course was re-run in a self-paced mode from November 2015 to June 2016. Changes between runs were very few and mainly intended to fix some minor errors and typos. Therefore, the design and implementation of the course can be considered practically the same in both runs.

2.1 Course structure

The MOOC Introduction to Programming with Java – Part 1: Starting to Code with Java has five weeks with a similar structure, preceded by an introductory week (week 0) to present the course syllabus and an overview of the course contents, and followed by a final week with a farewell video and a survey.

Each week (using the edX terminology) is divided in subsections. Each subsection has several units, which contain videos, activities, complementary texts and discussion components. Subsections are classified as follows (see Figure 1):

- **Main contents (4 subsections).** The main contents are divided into four quarters (subsections), each presenting related concepts, and practicing them afterwards through exercises. Each of the four subsections contains several units with videos, formative exercises and complementary texts. Each quarter typically includes from 2 to 5 short videos, and multiple exercises arranged in units. Each unit has a discussion component at the bottom, which is intended to foster learners' discussion about the concepts addressed in that unit, and also to detect errors in the videos or exercises that are part of the unit.
- **Laboratory.** Every week includes a set of formative exercises, grouped under a subsection called laboratory. The laboratories of the five weeks are strongly related, following a common storyline and an incremental approach, so that learners can perceive how the contents taught in each week can be applied to a complete development project. The laboratory of the course has been designed to engage learners with programming activities, applying three key design principles used in game-based learning: encouraging learners' personal motivation, failing soon and in a fun way, and applying what was learned to achieve a goal. The methodology used in the design of the laboratory is partially based on the PhyMEL (Physical, Mental and Emotional Learning) methodology [3], evoking physical aspects (e.g., a character moving through a maze following the statements defined by the learner); emotional (e.g., short-term rewards for completing an individual exercise and long-term rewards for completing the overall project); and mental (e.g., understanding and applying concepts and algorithms related to the topics of each week).
- **Recap.** This subsection summarizes (in textual form) the most important concepts that were addressed during the week, so that learners have all these concepts in a single place, and can review them when doing the exercises. This subsection also provides solutions to some of the most complex problems that learners had to do during the week, providing full code and teachers' comments.
- **Exam.** This subsection includes the activities that are part of the summative evaluation. Exams typically include a problem set of automatic correction exercises. In the first run of the course learners had a limited time of two weeks to complete the exam. This limitation does not apply to the second run of the course, which is offered in a self-paced mode.
- **Students' view.** At the end of each week learners could find a special video of about 5-8 minutes recorded with students from the American School of Madrid (16-17 years), who took the course before opening it to the world. These videos included informal discussions in groups of 2 or 3, personal impressions about the course materials, and common misconceptions about some of the concepts explained in the week. These videos were intended to increase learners' motivation and reduce the feeling of loneliness by presenting the thoughts of a group of students taking this course.
- **Want to practice more? (Only in weeks 1 and 2).** Learners could find a set of additional exercises in this special subsection for those who wanted to continue working and exercising all the concepts that were explained in the first two weeks.

- **Peer assessment (only in weeks 3 and 5).** Two of the weeks included a special subsection in which learners had to write a small piece of code, submit it to the platform and assess their peers' code. These activities were part of the summative assessment of the course, but only in the first run. They were removed from the second run of the MOOC, as it was offered in a self-paced mode, and learners' paces are not necessarily synchronized.

The screenshot shows the edX interface for the course "UC3Mx: IT.1.1x Introduction to Programming with Java - Part 1: Starting to Program in Java". The user is logged in as "CarlosAH". The course is viewed from the "Student" perspective. The navigation menu includes Home, Course, Discussion, Progress, Twitter, and Calendar. The left sidebar shows the course structure with "Week 4: Object Encapsulation" selected. The main content area displays "Week 4: Object Encapsulation > 4.3 Inheritance > Casting". A video player is embedded, showing a diagram of "Downcasting" where a "Vehicle" class is converted to a "Car" class. The video player includes controls for play, speed (1.0x), HD, and download options. To the right of the video, there is a text box explaining casting: "an object from a class to a subclass. Now we want to force a general vehicle to become a car. We go from a broad class to one that is more specific, and this has to be done explicitly. In this example, we declare a variable of type vehicle, but store a car in it. So we may explicitly downcast this variable to store the car, which is in variable v, in a car variable. So you have to be very careful when casting up and down. Again, we declare a variable v and we store a car in it. We can do that since a car is a vehicle. However, you cannot downcast v to a".

Figure 1 Screenshot of the Java MOOC in edX. The left frame shows the structure of the course (sections or weeks) and the detail for Week 4 (subsection).

2.2 Videos

Videos are central elements for introducing the main concepts of the course. 64 videos were created from scratch with the main concepts, and were distributed throughout the five weeks of the MOOC. Five additional videos with the students' view and the presentation and farewell videos were also recorded. All videos are between three and nine minutes depending on the particular contents addressed. Most of the videos are in the range of 5-7 minutes, which is a common best practice in MOOCs [4]. All the videos were recorded in English, but include transcripts in four languages (English, Spanish, Portuguese and Mandarin) to improve user experience. Videos are offered in high and low resolutions and can be downloaded by learners (see Figure 1).

Videos try to include real-life anecdotes as a way of engagement (e.g., decision making in a program is exemplified through teacher's decision to leave home with or without an umbrella depending on whether it rains or not). Objects from the physical world are used to accompany the explanations in videos (e.g., the aforementioned umbrella, or Russian dolls to explain the concept of recursion) (see Figure 2). The teacher always tries to use a pleasant tone with occasional jokes to help the learner to remember concepts. In the platform, videos are preceded by a short textual summary and a question for reflection.

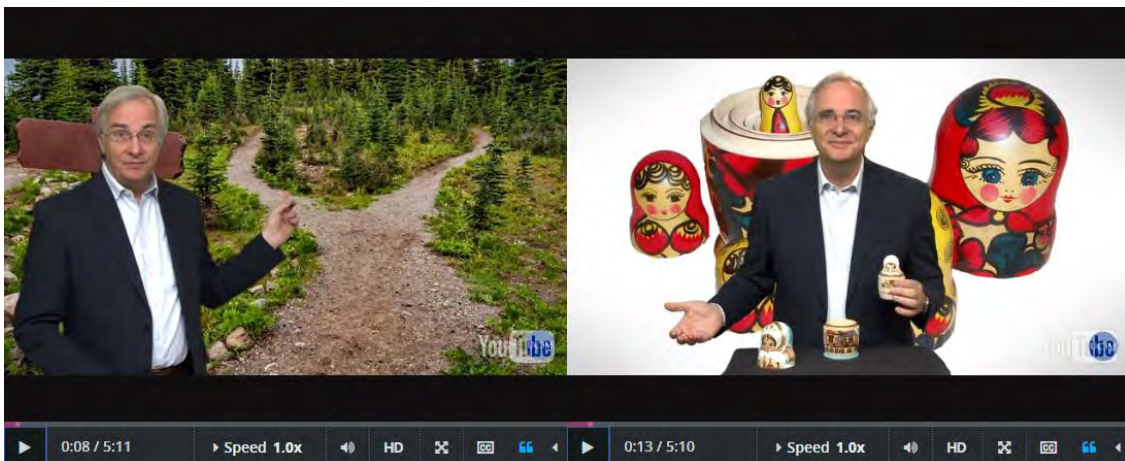


Figure 2 Example videos: on the left, explanation of making decisions to introduce `if/else` statements; on the right, explanation of recursion to introduce recursive methods.

2.3 Activities

The MOOC has been designed to promote learners' interaction with course materials and teaching programming incrementally through numerous activities [5]. Each week includes a wide set of formative activities of different duration and difficulty. These activities are normally located after videos to reinforce the concepts explained on them.

Activities were designed using both edX built-in tools (multiple choice problems, checkbox problems, dropdown problems, numerical input problems, drag and drop problems, and peer assessment activities) and external tools. External tools include: Blockly [6], Codeboard [7], Greenfoot [8], and numerous animations and simulations developed by the course team and supporting staff. All of them deserve a further explanation as they represent a specific innovation in this course.

Blockly is a web tool by Google, which allows creating simple games through visual representations. With Blockly the learner just assembles blocks of pseudocode, dragging and dropping from a central panel to a panel in the right side (see Figure 3). This way a novice learner does not need to know the syntax of the language to practice basic programming concepts. Blockly was particularized in this course to generate a sequence of mazes of increasing difficulties as part of the laboratories of Weeks 1 and 2. Blockly was also customized to show the resulting code to the learner in the Java language, as Blockly originally shows the resulting code only in JavaScript and other languages, but not in Java. Blockly exercises were integrated in edX as an IFrame component.

Codeboard is a web-based development environment by ETH Zurich that was integrated in this MOOC to facilitate learners the compilation and running of simple Java programs. Codeboard was integrated in the course through the IMS Learning Interoperability Standard (LTI), which is supported by both edX and Codeboard (see Figure 4). Numerous exercises were created in Codeboard and integrated in different subsections of Weeks 1 to 5 as part of the main contents and as part of the laboratory of the week. The teaching staff created projects in Codeboard that later learners could modify, compile and run dynamically and directly from the browser, without installing any software in their computers. Codeboard has a maximum runtime per code execution to avoid typical problems in novice programmers, such as infinite loops. If the learner makes a mistake while modifying the code he just needs to reload the browser to go back to the starting code. Learners can create a Codeboard account to save the projects, although this is not a mandatory requirement to work with the development environment. These reasons make Codeboard a powerful solution for Java coding in a MOOC, as edX does not include any tool for programming in Java, as it does with other languages such as Python.

Greenfoot is a standalone development environment, specifically designed for teaching object-oriented programming with Java, creating visual applications and games with very few lines of code. Greenfoot could not be seamlessly integrated in edX for this MOOC. Instead learners had to download and install it. Teachers created small exercises in Greenfoot so that learners could download, modify, compile and run them. Videos of Greenfoot screencast for supporting and guiding learners were also recorded (see Figure 5). Learners use Greenfoot in Weeks 4 and 5 of the MOOC and develop a racing game as a transversal project to practice key concepts of object-oriented programming, such as classes, objects, inheritance, polymorphism, or abstract classes, among others.

The MOOC also integrates several external animations and simulations. These animations and simulations were developed in HTML5 and JavaScript and were integrated as an IFrame in different subsections of the course to support a better understanding of key concepts. These animations and simulations include for instance: calculators with different levels of complexity to operate with integers, Booleans, and both; a car with remote control to understand the concepts of sequence of instructions and repetitions; an interactive converter from decimal to binary (including support to negative numbers through the two's complement representations). Additional simulations were developed with codes presented in videos so that learners could run them step by step (simulating the role of a debugger) and see the values taken by each variable in each step (see Figure 6). All these animations and simulations run directly from learners' browser to avoid scalability problems.

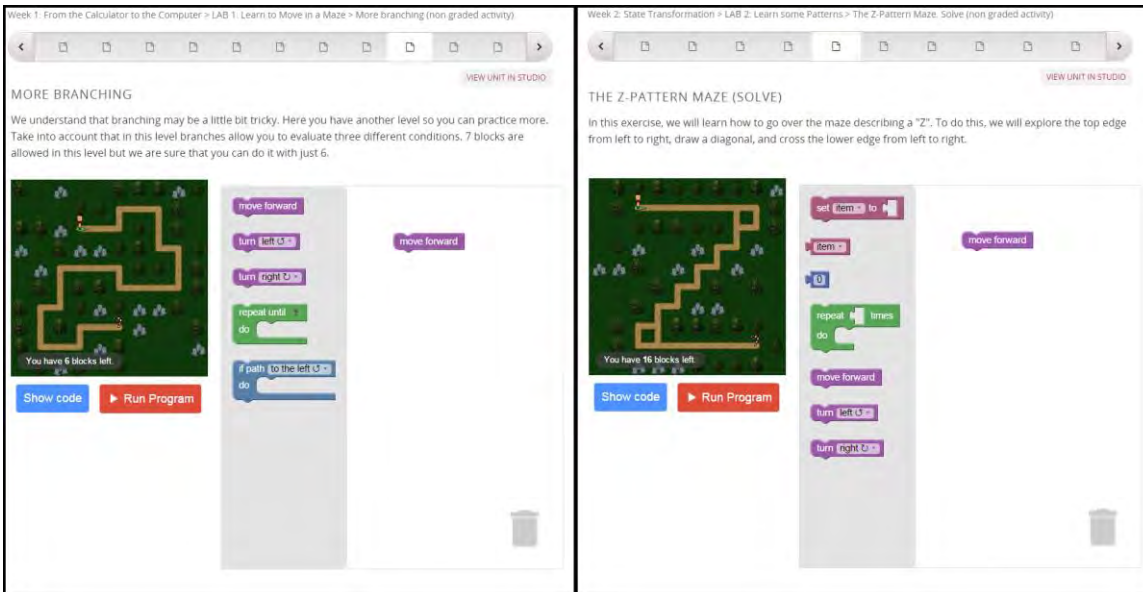


Figure 3 Example of Blockly exercises integrated in edX as part of laboratories of Week 1 and Week 2. Learners have to find the way out of the maze in the left panel using the blocks provided in the central panel and assembling them in the right panel. Once the blocks are assembled learners click the “Run Program” button to make the character move in the maze and the “Show code” button to get the resulting code in Java.

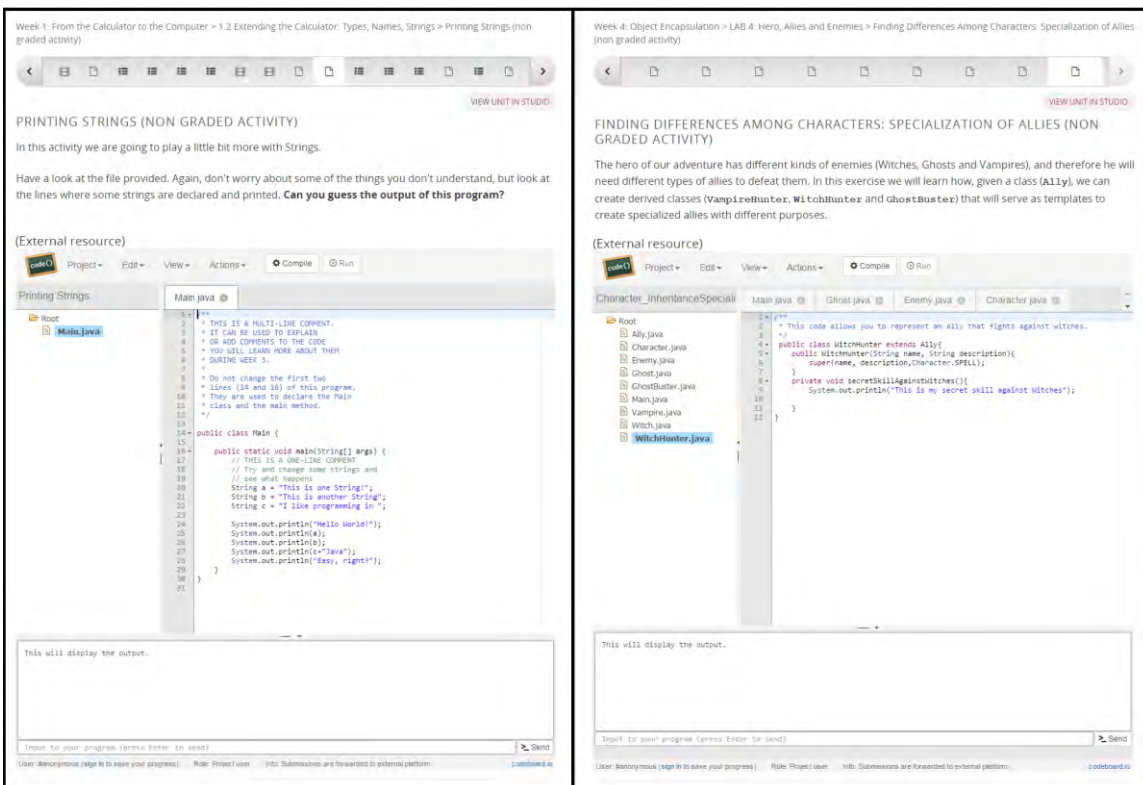


Figure 4 Example of Codeboard exercises integrated in edX as part of Week 1 and Week 4. Learners could modify, compile and run the Java code provided directly from the browser to solve the exercise. It is also possible to have several classes in the same project as in the example in the right side.

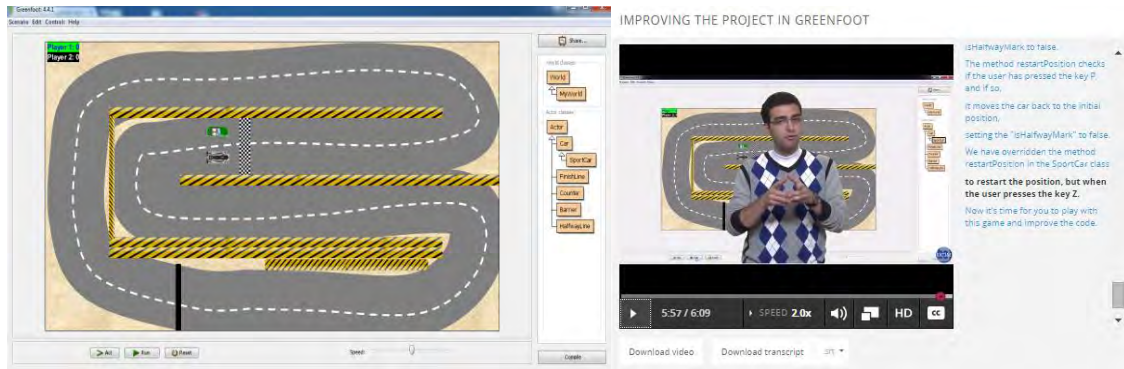


Figure 5 Example of Greenfoot exercise. On the left there is a basic racing game that learners have to code using the structure of classes provided on the right panel. On the right there is a video with the explanation of the activity and the base code provided.

```
int n = ;
int x = ;
for (int y = 0; x >= n; y++)
{
    x = x-n;
}
```

Start

```
int n = 3;
int x = 12;
for (int y = 0; x >= n; y++)
{
    x = x-n;
}
```

$x = 9 - 3;$
 6 is assigned to x

Back
Next
Restart

n	x	y
3		
	12	1
	6	

Figure 6 Example of simulation designed to understand how for loops work. On the left side the user sets the values for variables n and x. On the right side the user runs the code step by step and sees the values of the variables in each step.

3. Some high-level data

The Java MOOC has been running twice so far, from April to June 2015 (first run), and from November 2015 to June 2016 (second run as a self-paced course). In the first run there were more than 70,000 learners during the delivery dates, reaching a total enrollment of more than 93,000 learners overall. In the second run, the course has, as of March 2016, more than 65,000 enrollees. Top countries in the number of enrollees for the two runs of this course are: United States (with about 21-24% of enrollees), India (with 17-19% of enrollees), and Spain and United Kingdom (with over 3% of enrollees each).

The course has received positive critiques from learners. As of March 2016, the course reviewer CourseTalk [9] assigns 4.5 stars (out of 5) to this MOOC, based on 70 reviews. According to these data, CourseTalk places this course in position 56 of the 852 courses that are currently on edX. Nevertheless, it is important to note that there are quite a number of courses that do not have any review yet, and that courses with few reviews (even only with one review) but with five stars are above this course in the CourseTalk list.

4. Conclusion

This paper has presented the design of the MOOC “Introduction to Programming with Java – Part 1: Starting to Code with Java”, describing the general structure of the course, the videos, and the interactive activities, the latter representing the main innovation of the course. This MOOC follows a bottom-up, imperative-first approach to teach programming, starting from basic statements and imperative programming to high-level design, based on the object-oriented paradigm. Future plans include the development of a top-down, object-first approach, and the use of A/B testing to determine the most effective approach of the two, as there is no general consensus in the community yet about which approach is best. In addition, there are two upcoming modules (parts) to complete the entire syllabus of “Introduction to Programming in Java”. The second one will be released in April 2016 and addresses the writing of good programs (correct, efficient, and maintainable ones). The third part is expected in early 2017 and will cover algorithms and data structures.

Some of the experience gained in the production of this MOOC will be transferred within the MOOC-Maker project [10] to our partners in Latin America.

Acknowledgements

This work has been co-funded by the Erasmus+ Programme of the European Union, projects MOOC-Maker (561533-EPP-1-2015-1-ES-EPPKA2-CBHE-JP), and SHEILA (562080-EPP-1-2015-BE-EPPKA3-PI-FORWARD), by the Madrid Regional Government, through the eMadrid Excellence Network (S2013/ICE-2715), and by the Spanish Ministry of Economy and Competitiveness, project RESET (TIN2014-53199-C3-1-R) and fellowship FPDI-2013-17411.

References

- [1] G. Christensen, A. Steinmetz, B. Alcorn, A. Bennett, Amy, D. Woods, E. J. Emanuel, “The MOOC Phenomenon: Who Takes Massive Open Online Courses and Why?”, 2013. Available at SSRN: <http://ssrn.com/abstract=2350964> or <http://dx.doi.org/10.2139/ssrn.2350964>
- [2] A. D. Ho I. Chuang, J. Reich, C. A. Coleman, J. Whitehill, C.G. Northcutt, J.J. Williams, J.D. Hansen, G. Lopez, R. Petersen, “HarvardX and MITx: Two Years of Open Online Courses Fall 2012-Summer 2014”, 2015. Available at SSRN: <http://ssrn.com/abstract=2586847> or <http://dx.doi.org/10.2139/ssrn.2586847>
- [3] C. Fernández-Panadero, C. Delgado Kloos, “PhyMEL. A Framework to Integrate Physical, Mental and Emotional Learning in Meaningful Experiences and Multidimensional Reports”, *Proceedings of the 3rd European Immersive Education Summit*, 203-209, London, UK, 2013.
- [4] P. Guo, “Optimal Video Length for Student Engagement”, edX, 2013. Retrieved in March 2016 from: <https://www.edx.org/blog/optimal-video-length-student-engagement>
- [5] C. Alario-Hoyos, C. Delgado Kloos, I. Estévez-Ayres, C. Fernández-Panadero, J. Blasco, S. Pastrana, G. Suárez-Tangil, J. Villena-Román, “Interactive activities: the

key to learning programming with MOOCs”, *Proceedings of the Fourth European MOOCs Stakeholders Summit, EMOOCs 2016*, 319-328, Graz, Austria, 2016.

[6] Blockly. <https://developers.google.com/blockly>, retrieved March 2016

[7] Codeboard. <https://codeboard.io>, retrieved March 2016

[8] Greenfoot. <http://www.greenfoot.org>, retrieved March 2016

[9] CourseTalk. <https://www.coursetalk.com>, retrieved March 2016

[10] MOOC-Maker. <http://www.mooc-maker.org>, retrieved March 2016

Digital Innovation, School Readiness and Intervention Approaches: a case of Connected Learning Initiative (CLIX) in Indian high schools

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Abstract

The expansion and sophistication in the field of design and development of technological affordances in school education offers numerous possibilities for improving education delivery and quality. In recent years, governmental policy and programs in India have acknowledged the need to integrate technology at secondary education level given its potential to transform classrooms. Yet, the key challenges have been about organically integrating technology within the school curriculum while simultaneously empowering the teachers to use these affordances as effective pedagogical tools. Adoption and diffusion of innovative educational practices at scale has suffered due to lack of adequate infrastructure on the one hand as well as lack of educational resources that can foster deep, authentic and connected learning in regional Indian languages on the other. This paper presents the relevance of digital innovation at the high school level, keeping in mind the status and challenges of secondary education in India, particularly in government schools serving the disadvantaged groups in rural and semi-urban areas. The idea of 'readiness' of schools is then examined at two levels: first, the 'technological readiness' comprising of infrastructure provisions and second, the 'stakeholder readiness' comprising of aspirations and openness of stakeholders to receive a digital innovation in school.

Based on primary data collected through school level surveys and interviews with education officials, principals, teachers and students in three Indian states, the paper analyses the school 'readiness' in terms of challenges and opportunities for rolling out a large scale digital innovation program in Indian high schools. Using the case of Connected Learning Initiative (CLIX) which is a unique, collaborative program of Tata Institute of Social Sciences, Massachusetts Institute of Technology and Tata Trusts, the paper discusses the key intervention approaches that can address the school readiness. The approaches include working at scale, mobilising existing resources working with government for sustainability and building local ecosystems that can enable creation of digital pathways of learning in schools.

1. Introduction

The rapidly evolving landscape of digital learning has the potential to change how education is transacted and how learners engage and participate in the pedagogical processes. In several developing countries, technology is used as one of the tools to address challenges of education provision, access, equity, efficiency and quality. The 2030 Agenda for Sustainable Development adopted by the United Nations in September 2015 acknowledged that there is great scope in accelerating the human progress by eliminating digital gaps, which is only possible by educating the society on the spread of information and communications technology. In the Indian context, the existing inequities in educational opportunities are further exacerbated by a digital divide and there is a need to facilitate connectedness at all levels between the learners, teachers and the larger ecosystem. Technology enabled "connected learning" has the potential to address geographical and social disparities by working at scale and thereby addressing the goals of equity and social inclusion.

Empirical evidence on the impact of such programs has been mixed (OECD, 2015). Literature on the impact of technology on improving education, specifically in the Indian context, is sparse. Banerjee et al. (2005) found that computer assisted instruction improved student performance in mathematics score among fourth-grade students in Vadodara, India. Linden (2008) showed that out-of-school programs are more effective in improving schooling outcomes than in-school programs. Some of the evaluation studies conducted in developing countries show positive effects on student test scores (Banerjee et al., 2007; He, Linden and MacLeod, 2008; Linden, 2008; Barrera-Osorio and Linden, 2009). Hattie and Yates (2013) did a meta-analysis of 81 research studies on computer assisted learning and found that learning gains are neither bigger nor smaller than any well intentioned teaching activity. On the other hand, Leuven et al., 2007; Carrillo, Onofa and Ponce, 2010), Goolsbee and Guryan (2006), Angrist and Lavy (2002), Rouse and Krueger (2004). Cristia, Czerwonko and Garofalo (2010) found limited or no evidence of positive impact of technology on improvement of student performance. Research shows that for programs to be sustainable they should be integrated within the school curriculum (Underwood et al 2000).

In recent years, governmental policy and programs in India have acknowledged the need to integrate technology at secondary education level given its potential to transform classrooms. Yet, the key challenges have been about organically integrating technology within the school curriculum while simultaneously empowering the teachers to use these affordances as effective pedagogical tools. Adoption and diffusion of innovative educational practices at scale has suffered due to lack of adequate infrastructure on the one hand as well as lack of educational

resources that can foster deep, authentic and connected learning in regional Indian languages on the other.

2. Secondary education status in India and need for digital innovations

There has been an unprecedented increase in demand for secondary education in India during the past decade. The challenge of improving access, equity and quality of secondary education has been addressed through the *Rashtriya Madhyamik Shiksha Abhiyan* of the Ministry of Human Resources Development, Government of India. As per the latest figures available (U-DISE 2014-15), 38 million adolescents receive secondary education (grades IX and X) from 233517 secondary schools while 23 million are doing their senior/higher secondary education (grades XI and XII) from 109318 senior secondary schools in India. There are inequalities in enrollment at secondary and senior secondary level in terms of gender and socio-economic backgrounds. Transition rate from upper primary to secondary education is 92.67 percent and it decreases significantly to 58.34 percent from secondary stage to senior secondary level (Registrar General, Census of India, 2011).

A major area of concern is the quality of learning and poor performance in standardised assessments. The first ever National Assessment Survey (NAS) to understand whether students have attained expected “specified and valued learning standards after ten years of schooling, irrespective of their diverse social, cultural and economic backgrounds” was conducted in 2015, by the National Council for Education Research and Training (NCERT) on a sample basis. The analysis shows that rural children, children studying in government schools and government - aided private schools and those from socially marginal groups like Scheduled Tribes (ST) and Scheduled Castes (SC) did well below national average. Around 85% of the students got less than half of the answers correct in English and Math while only 22% students got more than 50% of answers right in Science subject. Overall, the quality of learning in language, Mathematics, Science and Social Studies leaves a lot for improvement (NCERT, 2015).

Recognizing the possibilities of education technology in improving the quality of education as early as in mid-1980s, the National Policy of Education (1986, modified in 1992) stressed the need to employ education technology in education. The Centrally Sponsored Schemes (CSS) initiated as a result of this policy – Education Technology and Computer Literacy and Studies in Schools (CLASS) on pilot basis finally led to the more comprehensive Information and Communication Technology@schools (ICT@schools) program in 2004, which was revised in 2010 and integrated within RMSA in 2015. The ICT@school mainly targets secondary students, to provide them with opportunities to build their ICT skills and capacities and enable them to learn through computer aided learning. The scheme was envisaged to be a major catalyst to bridge the digital divide amongst students of various socio-economic and other geographical barriers (Government of India: National Policy on ICT in school education, 2012). This scheme initially implemented through the Public, Private Partnership (PPP) approach of BOOT (Build, Own, Operate and Transfer) model. An early evaluation of two large scale ICT@school program by IT for Change (Kasinathan and Vishwanath, 2010), shows that “the integrated model” followed in Kerala state’s ICT@Schools program, which emphasised developing systemic in-house capabilities anchored around the role of school teachers, showed considerable success. On the other hand, the evaluation commented that the alternative model of ‘outsourcing’ or ‘BOOT’ in the state of Karnataka did not demonstrate any improvement. The program funds

were mainly used to pay the private vendors to run the program instead of building in-house capacities. The study cautioned that outsourcing of such programs should fully take into account the distinction between non-core processes such as procurement, installation and maintenance of hardware, and core activities with direct pedagogical implications like content and software, teacher training and learning processes. Another evaluation carried out by the Central Institute of Education Technology in collaboration with a group of state specific evaluators in 2015 shows that the core activities related to content, software, pedagogy, teacher training and learning processes were not given much attention under ICT@ school program in most places. The use of ICT infrastructure was limited to basic office level administrative tasks. In addition, the education resources provided lacking in imagination and depth. In sum, although the program of ICT@Schools scheme has been an important starting point in terms of getting the technological readiness in schools, it has remained at that level without leveraging the infrastructure provision to build systemic capacities through enhanced student learning practices and teacher professional development.

3. School readiness

Studies on impact of large scale interventions on ICT in schools at the international level point to the presence of a number of factors that contribute to the success of interventions. These include school related factors such as school technology and support (Grimes & Warschauer, 2008; Penuel, 2006; Dexter, Anderson, and Ronnkvist (2002), professional development of teachers, teacher motivation and readiness (Inan and Lowther, 2010), school leadership, correspondence of technology with pedagogical aims of education (Eickelmann, 2011). Studies have also shown the importance of stakeholder support and administrative encouragement for successful technology integration in schools (Inan & Lowther, 2010; ISTE, 2007; Murphy et al., 2007; Nachmias, Mioduser, Cohen, Tubin, & Forkosh-Baruch, 2004; Rutledge et al., 2007).

The idea of ‘school readiness’ in literature is framed from the point of view of the learner’s readiness for the schooling or the learning process. While this is an important dimension of any intervention, we argue that it is also important to focus on the readiness of the school system to receive the intervention. The impact of the intervention and its sustainability, we suggest, will depend on how prepared is the school system to adopt digital innovation in classrooms. The idea of schools’ readiness is relevant to prepare the ground for intervention itself and also to ensure pathways for its sustainability. In this paper, we propose a conceptualisation of school readiness which comprises of two components [a] *technological readiness* in terms of availability and access to infrastructure [b] *stakeholder readiness* which includes the receptivity, openness and motivation of the stakeholders to engage with the innovation. These two components provide us a useful conceptual tool to identify the key ingredients or requirements of a field oriented innovation. We argue that both technological readiness as well as stakeholder readiness are required to make a digital innovation successful and sustainable. While many innovative programs aim to build readiness of both components (technology and stakeholders), these are not available ready-made as a starting point. The achievement of such readiness becomes a process goal in itself and informs the intervention approaches adopted as part of the innovation.

In this paper, we discuss the two components that make up school readiness for adopting a digital innovation by using a case study of the Connected Learning Initiative (CLIX), a unique, collaborative program of Tata Institute of Social Sciences, Massachusetts Institute of Technology

and Tata Trusts. CLix is an effort to improve the professional and academic prospects of high schools students from under-served communities in India. It incorporates thoughtful pedagogical design and leverages contemporary technology, including online capabilities, to provide quality educational content and experiences at scale. Data gathered from field surveys and key informant interviews over a period of one year is used to describe the technological readiness in two states (Rajasthan and Mizoram) and stakeholder readiness in four states (Rajasthan, Mizoram, Chhattisgarh and Telangana) that are taken up for intervention in India. Since innovation is an incremental process, there is value in presenting our findings and approach based on field work in progress.

3.1 Technology readiness of schools selected for CLix

The technological readiness of schools for CLix intervention is ensured through the selection process wherein the sub-sample of the schools have the maximum likelihood of being technology-ready due to their coverage under the ICT@School scheme. During the pilot phase, four states of India representing different regions have been selected (Rajasthan in the North-West, Mizoram in North-East, Telangana in South and Chhattisgarh in Central India). The technological readiness parameters used for selecting the schools included: (a) electricity and internet connectivity and (b) ICT@school related provisions. Data collected through field mapping surveys show that the status of technological readiness poses at least two challenges. First, is the lack of adequate infrastructure itself, in terms of availability and functionality and second, is the challenge posed by the patchy and uneven readiness of technological infrastructure to the design and development of appropriate curricular offerings that will work in a range of infrastructure settings.

Data also shows that Jaipur (where state capital is located) is better in terms of many parameters compared to Sirohi. Mizoram does not have access to some technological aids such as web camera, a dish or a LAN setting. In Rajasthan, 96% of the CLix schools in Jaipur and 94% of the CLix schools in Sirohi have internet connection. However, in Mizoram, only 43% or 13 schools out of 30 CLix schools have access to internet. In Rajasthan, CLix schools, 22% use wired broadband for internet services while 67% schools use 2G/3G dongles for connection. On the other hand, in Mizoram, almost all schools use wired broadband for internet connectivity.

Internet speed is also important to facilitate better functioning of CLix curricular offerings. In more than half of the schools in Rajasthan (around 57%) have internet connection with a speed of less than 256 kilobyte per second (kbps). On the other hand, all schools with internet facility in Aizawl have a speed of 512 kbps. More than half of the schools in Rajasthan reported irregular connectivity with internet.

3.2 Stakeholder readiness: Preparation for “CLix Habitat”

Literature indicates the critical role played by the stakeholders themselves, in terms of their positions, expectations, openness, concerns and motivations towards the intervention. Within CLix, the stakeholders are intended to serve as active learners and contributors to the innovation itself. To create the “CLix habitat”, some of the readiness activities undertaken at school level are (a) school computer labs must be open before/after school hours for maximizing use of resources, (b) timetable of the school hours will be adjusted in such a way that every

student would get a fair amount of time to engage in CLIX curricular offerings, (c) a special introductory curricular offering called Invitation to CLIX (i2c) which is meant to orient teachers and students to work on computers, (d) to activate science lab with the help of students and teachers to utilize the lab space more often and regular. Continuous feedback and guidance from experts and CLIX curriculum resource persons would help to make Science lab more meaningful than before, (e) interaction of high school students with local engineering/Science/B.Ed Colleges to mobilize resources and to create a bi-directional learning experiences for all (f) CLIX-curriculum teams are continuously interacting with students on various module piloting, so that students authentic experiences will be the part of CLIX curricular offerings. A bottom up approach is being used to prepare modules, where learners will play a major role in it, (g) build up local resource support and including teacher education institutions such as IASEs in the intervention for continuity and sustainability of program, (h) integration with other program on ICT and building on synergies in input and output.

There is also a significant space created for establishing new epistemic communities for academic discussion and associated discourses. The CLIX preparation of teachers is at two levels. One level is to make state resource group for mathematics, science and communicative English which will work closely with the CLIX-Teacher Professional Development team. The teacher professional development, is a core component under CLIX to prepare school teachers to roll out various curricular modules developed by CLIX. Another level of teacher preparation is at school level, where teachers will be an active participant of module offerings and module testing. The school principal is another important stakeholder of the intervention. CLIX orients them on scope of this initiative at district level, understands their everyday experiences about school management and their feedback helps CLIX to make readiness plan more robust.

CLIX is working closely with government schools although the CLIX approach itself is quite new to the government school system. Thus, the biggest requirement is to help them understand the whole idea about CLIX as a digital innovative intervention, quite unlike the earlier programs of the government. Formal agreements have been entered into with the state governments which allows for leveraging existing resources. For instance, in Rajasthan state, the education department has signed MOU with internet providers to setup broadband connections in all schools. This level of motivation and engagement from state official across four different states gives rise to new kinds of challenges: (a) officers are more ambitious in terms of output and visibility of the intervention, (b) they are comparing and assessing level of input in terms of quantity of outputs, (c) due to their own budgetary constraints, they are unable to commit to provide/upgrade technological infrastructure as per the requirements of the CLIX curricular offerings. Work on stakeholder readiness has been a critical pillar of the early preparation because it creates the foundation on which a robust intervention would rest. This process also allows for the concerns and tensions amongst the stakeholders to surface, which need to be resolved through the intervention process.

4. Intervention approaches

CLIX has partnered with organisations in four states, that are invested locally, to optimally utilize the experience and resources that the local implementation partners have. These partnerships are unique in each of these states. In addition to the common framework and approach to the implementation, the state partnership and local implementation partnership leverage on their

specific strengths to build state level interventions. For instance, in Telangana state, it is the government, State Council of Educational Research and Training (SCERT), which has taken the ownership of implementing the program. Its openness to technology, educational reforms, leadership and organisation structures makes intervention approach different in Telangana. In Mizoram, with department of school education, it is the Mizoram University that is the local implementation partner offering the possibility of recognizing the communities of practice and network of support systems. In the Chhattisgarh state, with the department of school education, there is a multi-agency partnership with an NGO, UNICEF and Tata Institute of Social Sciences, while in Rajasthan, the partnership is between the department of school education and an NGO, Centre for Education Research and Practice (CERP) which has closely worked with state education department on teacher professional development. The various kinds of collaborating institutions allow for building on state specific requirements and resources.

4.1 Course offering

CLix builds digital and new media skills among student and teachers and provides authentic learning experience for English, Mathematics and Science with hands-on learning, enabled through technology. It leverages technology for continuous professional development of teachers. The CLix proof of concept includes a significant implementation component to establish the relevance and viability of the project and to demonstrate the intervention's ability to contribute to teaching-learning process, both inside/outside the education system, and at scale. A field action research approach is followed to develop the working model by which the curricular components would be accessed by the learners and teachers, and incorporated into the teaching learning process. Development, research and implementation goes hand in hand. The offerings are open access as well as focused on specific geographies (Rajasthan, Chhattisgarh, Mizoram, Telangana) where there are identified learner groups (teachers and students) who will use these resources in curriculum and pedagogy.

It is important that the course offerings developed in CLix are amenable to refinement and modification. Such changes emerge from the field realities and experiences during the process of implementation. Our processes will enable teachers to engage and innovate by presenting local examples, alongside the content of the modules or courses developed by our curriculum teams. Thus, each of the curricular offerings or modules would be reviewed and redesigned after the first round of large scale roll out, based on the feedback from the implementation process. In Maths and Science subjects modules will be based on the state curriculum and in English subject modules will support teachers and students to acquire general proficiency in communicative English. The teacher professional development (TPD) would precede, run concurrently with and succeed each modular offering and course. The TPD is designed in the form of courses that are offered through MOOCs and in which teacher educators will be involved as instructors and mentors. These courses will be certified by Tata Institute of Social Sciences within the existing programs and through additional certificate and diploma modes.

4.2 Open access

Open access of curricular offerings is critical and integral to the implementation of the CLix initiative. Once registered, teachers and students would be able to access the courses and modules on their own via the CLix platform. We envision that once rolled out, the platform will

draw learners by establishing a reputation for credible and emotionally satisfying learning. Processes for certification of learning through these open modalities are being evolved. The platform will enable the field implementation teams as well as the research and monitoring teams to understand the learners, their motivations and their experience throughout the course offering.

4.3 CLIX learning lab

CLIX offerings are blended in nature, it includes hand-on activities, project work, games, simulations, discussion with peers and teachers, etc. It is important that students and teachers have access to the required tools and space to engage with them. CLIX is proposing setting up of a learning lab to all the intervention states. This is a space which has the necessary technological infrastructure, network connectivity, science lab materials, low cost and recycle material and equipments, a collection of books on science, mathematics and English, and various tools for hands-on learning. This is envisaged as a maker's place for exploration and self-learning. Access to the learning lab before and after school hours and during holidays is crucial. This will provide opportunities as well as resources for students and teachers to create and become engaged as a community of practice.

4.4 Sustainability - Nurturing a local ecosystem

An ecosystem approach, with sustainability and integration of technology are at the core of the CLIX approach. Through this, we envision communities building processes and sharing knowledge with each other. Sustainability will rely on developing such an ecosystem that can promote scholarship and involve continuous collaborations in an open ecosystem of partnerships around the core values of the initiative. Ecosystem is to be nurtured both at local level and across the states. It is the local ecosystem of a particular geography that will ensure the sustenance of new pedagogical practices. Local ecosystem involves communities of learners comprising teachers from school systems who are participating in the initiative as well as those who may sign up independently to study courses that are offered. Members of the educational community (including student teachers, teacher educators, curriculum developers, researchers and academic experts), students from local science and engineering colleges who have capability to use, develop and integrate education technology into their work and support teachers and students will participate. Constructive and symbiotic engagements with a range of partners from academia, government and non-government and the private sector is the central to this initiative.

4.5 Working at scale

Usually interventions are first trialed or piloted at a very small scale, which is very resource intensive but then challenges are faced when these interventions are scaled up. This usually happens because of not factoring many components while designing the program on a small scale. In CLIX, scale is an input to design, which means scale is part of the design, implementation and framework of the program.

4.6 Mobilizing existing resources

A digital innovation of this scale requires different kinds of resources for its implementation. Our primary approach has been to mobilize and build on the existing resources. Teacher professional development delivery is planned with the existing state structures. Government has accommodated our training within their yearly training schedule. These teacher training programs are also supported by state. Teacher groups are formed as communities of practice within the official structure of the state.

5. Way forward

Connectedness is an idea which is central to learning. The first and foremost objective is to create a vibrant environment in the schools, where technology is the method to connect learners and teachers. It is expected that the government supports this, recognizes the values of a digital innovation as compared with conventional pedagogy. Large scale implementation requires skills in information technology as well as technology enabled communication among the communities selected for the intervention, such as students, school teachers and teachers educators. This teaching learning process can be sustained through continuous knowledge building, maintaining and sustaining relationships, as well as critical reflection and analysis in order to evaluate the CLix efficacy whether through formal or informal evaluative methods. Although content and pedagogies are not independent concepts but it is important to recognize that they influence one another. A more complete and effective integration of curriculum, technology and devices can evolve with professional practice and establishing the network among teachers educators, teachers and learners.

‘Technology’ in schools is synonymous with computer. A transformation in this imagination requires a lot of advocacy with the government for continuous support. Research and monitoring tools can help estimate or describe what impact did the innovation have, how did the innovation take place and how can it be sustained as well as scaled up. It is important to separate enabling components and core components of intervention from the beginning and this can be exemplified through the tangible activities that a teacher or field staff would do when working within setting of classroom and a school. This indicates that we need to understand and work on at least two categorical challenges: first, exploring how to choose alternatives to conventional pedagogy with a clear rationale based on pedagogical principles, perspectives, research and assessment; and second, establishing the extent to which alternative pedagogical design can strengthen the school curriculum and widen horizons beyond. Developing readiness of the school (both technology and stakeholders) is an important starting point but as our preparatory fieldwork indicates, there is a definite need to go beyond what is obvious and what is available. A digital innovative program of the scale and complexity such as CLix requires a continuous praxis that will close the gap between what is doable and what is done in Indian high schools.

References

- [1] Angrist, J., & Lavy, V. (2002). New Evidence on Classroom Computers and Pupil Learning. *Economic Journal* The Economic Journal, 112(482), pp. 735-765.
- [2] Banerjee, A. V., Cole, S., Duflo, E., & Linden, L. (2007). Remedying Education: Evidence from Two Randomized Experiments in India. *The Quarterly Journal of Economics*, 122(3), pp. 1235-1264.
- [3] Carrillo, P., Onofa, M., & Ponce, J. (2011) . Information Technology and Student Achievement: Evidence from a Randomized Experiment in Ecuador, IDB Working Paper Series, No. IDB-WP-223.

- [4] Dexter, S. L., Anderson, R. E., & Ronnkvist, A. M. (2002). Quality technology support: what is it? Who has it? And what difference does it make? *Journal of Educational Computing Research*, 26(3), pp. 265–285.
- [5] Goolsbee, A., & Guryan, J. (2006). The Impact of Internet Subsidies in Public Schools. *Review of Economics and Statistics*, 88(2), pp. 336-347.
- [6] Grimes, D., & Warschauer, M. (2008). Learning with laptops: a multi-method case study. *Journal of Educational Computing Research*, 38(3), pp.305–332.
- [7] Hattie, J.A.C. & Yates, G.C.R (2014). *Visible learning and the science of how we learn*. London: Routledge.
- [8] He, F., L. Linden & M. MacLeod. (2008). “How to teach English in India: Testing the relative productivity of instruction methods within the Pratham English Language Education Program.” Manuscript no publicado. Columbia University.
- [9] Inan, F. A., & Lowther, D. L. (2010). Laptops in the K-12 classrooms: Exploring factors impacting instructional use. *Computers & Education*, 55(3), pp.937-944.
- [10] International Society for Technology in Education (ISTE). (2007). National educational technology standards for students: technology foundation standards for all students. Retrieved May 15, 2009, from http://cnets.iste.org/students/s_stands.html.
- [11] Julian P. Cristia & Alejo Czerwonko & Pablo Garofalo, (2010). Does ICT Increase Years of Education?: Evidence from Peru, IDB Publications (Working Papers) 25758, Inter-American Development Bank.
- [12] Kasinathan, G. & Vishwanath, K. (2010). ICTs programmes in schools in Yadgir district, Research report. Retrieved Nov 11, 2012 from <http://www.itforchange.net/>.
- [13] Linden, L. (2008). “Computer or Substitute? The Effect of Technology on Student Achievement in India.” Working Paper. Columbia University Department of Economics.
- [14] Murphy, D., King, F., & Brown, S. (2007). Laptop Initiative Impact. *Comp. in the Sch. WCIS Computers in the Schools*, 24(1), pp. 57-73.
- [15] Nachmias, R., Mioduser, D., Cohen, A., Tubin, D., & Forkosh-Baruch, A. (2004). Factors Involved in the Implementation of Pedagogical Innovations Using Technology. *Education and Information Technologies*, 9(3), pp.291-308.
- [16] National Council for Education, Research and Training (2015). What students know and can do: A Summary of National Achievement Survey, Class X, 2015. Retrieved March 1, 2016, from <http://www.ncert.nic.in/departments/nie/esd/pdf/NASSummary.pdf>
- [17] OECD (2015). *Students, Computers and Learning: Making the Connection*, PISA, OECD Publishing. <http://dx.doi.org/10.1787/9789264239555-en>
- [18] Planning Commission. (2011). *Faster, sustainable and more inclusive growth: An approach to the 12th five year plan* (No. id: 4452).
- [19] Penuel, W. R. (2006). Implementation and Effects Of One-to-One Computing Initiatives. *Journal of Research on Technology in Education*, 38(3), pp.329-348.
- [20] Registrar General, India (2011). "Census of India 2011: provisional population totals-India data sheet." Office of the Registrar General Census Commissioner, India. Indian Census Bureau.
- [21] Rouse, C. E., & Krueger, A. B. (2004). Putting computerized instruction to the test: A randomized evaluation of a “scientifically based” reading program. *Economics of Education Review*, 23(4), pp.323-338.
- [22] Rutledge, D., Duran, J., & Carroll-Miranda, J. (2007). Three years of the New Mexico laptop learning initiative (NMLLI): stumbling toward innovation. *AACE Journal*, 15(4), pp. 339–366.
- [23] Underwood, C., Welsh, M., Gauvain, M., & Duffy, S. (2000). Learning at the Edges: Challenges to the Sustainability of Service - Learning in Higher Education. *Language and Learning Across the Disciplines*, 4 (3), pp. 7–26.

Digitizing Education in the World's Largest Democracy

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Abstract

Continuous though slow educational changes in Pathshala (traditional learning in classroom) happened throughout the course of Indian history that have played a major role in laying the foundation of modern 'Digitalshala'. However, due to several cultural, social and economic reasons, digital education could not become the popular choice. Moreover, failure of the Indian Government so far to deliver on their promises to achieve quality education for all has cast doubts on the very nature and effective implementation of current and upcoming policies. Challenges with respect to the familiarity and adoption of different digital media create hurdles for the advent of digital education in India. Incomplete electrification in rural areas is a major roadblock. These factors have been analysed in this paper. Cost saving, increased accessibility and quality education could be the major merits of digital learning to make it mainstream. Moreover, it has been illustrated that embracing digital education is demanded by India's uneven distribution of infrastructure and inability of the Government's investments to benefit the downtrodden. Also, some light has been thrown on the initiatives and steps taken by the Indian Government and other organizations in this direction. In addition, some institutions that impart education by digital means and are self-reliant on energy and infrastructure have inspired other schools/institutions to replicate their pedagogy and their success stories have been shared in this paper. Last but not the least, the merits of educating by digital means, in Indian educational scenario, have been highlighted. Also, few suggestions to make propagation of digital education easier and more effective have been given.

1. Introduction

Transformation from century-old industrial age model to quality education for all in digital age will be the paradigm of evolution. John Maynard Keynes was one of the most influential economists of the 20th century. The most important lesson that we can learn from him is to let go of inherited ideas. If we cling to the panaceas of earlier times, we can't sustain the civilization we have inherited. This is the Keynesian insight which should be embraced [1].

According to the World Economic Forum's Report, India scored 4.31 points out of 7 (55th position among 140 economies) on Global Competitiveness Index [2]. Being the largest democracy in the world, India must reap its talent of 1.31 billion population. Talent-driven economy with information and communication technologies in the forefront is identified as the priority area for structural reforms this year by the World Economic Forum.

Inclusive growth is the need of the hour. Strengthening technological readiness and higher education could be game changing factors for a country such as India with a low internet penetration of approximately 19% [3]. The uneven degree of adoption of modern information and communication technologies will further widen the chasm of “information rich” and “information poor”.

The Planning Commission of India addressed these issues by constituting a committee on Vision 2020 for India in the beginning of this millennium under the chairmanship of Dr. S.P. Gupta. Education is one of the main thrust areas of this report. Greater coverage and better quality education at all levels ranging from literacy to advanced science and technology is the essential prerequisite for:

- Raising agricultural productivity and quality of industrial production,
- Spurring growth of India’s budding Information Technology and Biotechnology sectors,
- Stimulating growth of manufactured and service exports,
- Improving health and nutrition and
- Quality of governance

The report calls for concerted efforts to abolish illiteracy, and to widen the access to higher education and vocational training through both traditional and non-traditional delivery systems [4]. Recent twelfth five-year plan from the Planning Commission of India has also upheld faster, inclusive and more sustainable growth in the field of education achievable by boosting the innovation systems along with strong backing from large organizations and venture funds.

2. Evolution of Indian Education System

The development of education is a continuum, which gathers its past history into a living stream, flowing through the present into the future. It is essential to see the historical background of educational development to understand the present and visualize the future. The development of the education system in India can be broadly divided into three stages:

2.1. Education in Ancient Period

About the 2nd millennium B.C., the Aryans entered the land and the society was divided into classes based on 'Chaturvarna' (four varnas) system. Later, the classes hardened into castes. This was a typical hierarchical society which even influenced education. The right to advanced education was limited to higher castes. Education was not denied to women in principle but normally girls were instructed at home. Indian society at the end of the 18th century was stratified, hierarchical and lopsided. The bulk of the population was underprivileged and poor. The scheduled castes, untouchables, and scheduled tribes turned into the lowliest, the poorest and the most exploited groups. The socio-economic background of the society is itself reflected in the educational policy.

2.2. Education under British Rule

The decay of indigenous Indian Education started with advent of the British. The colonial interests of the British shaped the then educational policies of India and led to the spread of English language and culture in the colonies. This period saw a rapid expansion of

educational institutions. A direct link between English education and rise of the Indian nationalism was seen. The education system, which the British had worked out to consolidate their rule, within four decades, produced results contrary to their expectations. Thus, expansion of higher education led to strengthening the national movement and providing the human resources for the development of capitalism in Independent India. This clearly reflects the powerful impact of equipping population mass with education in Indian social landscape.

2.3.Education since Independence

Post-independence, several steps were taken by Indian government to achieve reorientation of the education system to acquire economic independence, the increase of general prosperity, the attainment of effective democracy, removal of the distinctions of caste and economic status. Vocational education, common school system of public education which would provide equality of access to children from all social strata, development of modern languages as medium of instruction, adult literacy, provision of quality primary and secondary education to all were key emphasis areas of Indian government. Indian education system is characterized by low levels of development and persistence of disparities. The fruits of education have not reached the downtrodden. As per the document, "Challenge of Education: A Policy Perspective", released by the Indian Govt.[5], at the time of independence, there were only 700 colleges and 20 universities with an enrollment of 4 lakhs, in 1985 it has risen to 5,246 colleges and 140 universities with an enrollment of 33.60 lakhs. According to the document, we are still far from fulfillment of the goal of a common elementary education, which was envisaged in the Constitution to be achieved by the year 1960. One of the principal reasons for erosion of the gains from educational expansion is low retention and high drop-out rate in classes I-VIII which continues to be above 75%.

Table 1.Sex-Wise enrollment (in lakhs) of Scheduled Castes and Scheduled Tribes since 1971

Particulars	Years		
	1970-71	1980-81	1983-84
Scheduled Castes	79	132	158
Male	56	88	103
Female	23	44	55
Scheduled Tribes	31	54	68
Male	22	37	45
Female	9	17	23
Grand Total	110	186	226

Source: Ministry of Education, Trends of Educational Development of SCs and STs in India, Ministry of Education, Education and Allied Statistics 1980-81. Ministry of Education, Selected Educational Statistics, 1983-84.

Table 2. Expenditure on education in Five-year plans

	Current Price (in mn INR)	At constant (1970-71) Prices (in mn INR)	Percentage to Total Plan Outlay
First Five Year Plan	153	304	7.86
Second Five Year Plan	273	526	5.83
Third Five Year Plan	589	966	6.87
Fourth Five Year Plan	786	764	5.17
Fifth Five Year Plan	912	585	3.27
Sixth Five Year Plan	2835	1047	2.59
Seventh Five Year Plan	6383	1894	3.55

Above table includes 'actual' expenditure for the first 2 years, 'revised' expenditure for 1983-84, and outlay for 1984-85. Outlay (Draft). Source: Indian Journal of Public Administration, July- September 1986, P.729.

According to the document, there were more illiterates in 1981 (437 million) than there were at the time of Independence (300 million). In terms of literacy, India is still amongst the most backward countries with literates in 1981 accounting for only 36.2% of the population. The document rightly mentions that the most important reason for the slow progress has been an acute paucity of resources. The percentage of total plan out lay for education in the first plan was 7.86% and it was reduced to 3.55% in the Seventh Five-Year Plan (as shown in above table). The above analysis shows that even after 40 years of Independence, India is lagging behind in the field of education.

3. Scope and Hurdles in the path of Digital Education Development in India

India's literacy has improved to a significant extent from 12% at the time of independence to 74% as per 2011 census. But, it still has got a lot to catch up with respect to the World's average of 84% [6]. Data figures and enrollment ratios available seem to be a fallacy when one delves deeper into the reality. Unravelling the dark side of Indian education presents to us the twin problems of access and affordability that keeps education out of the reach of substantial child population. 'The Right of Children to Free and Compulsory Education Act' or Right to Education Act (RTE) was introduced by the Parliament of India in 2009 to mandate free education to all children from 6 to 14 years of age. On the first anniversary of the Act, 8.1 Million children in the age group of 6-14 years remained out of school and the report stated that there is requirement of 5,08,000 teachers across the nation [7]. Children are perceived as extra earning hands for the household income by their ignorant and poor parents and hence, discouraged from schooling and learning. We are talking of those households where there is dearth of essential needs – food, shelter and clothing. Thus, this leaves no ground for convincing the parents who are struggling for the survival of their families.

As per a survey conducted by an NGO Pratham of school children across 500 districts in 2014, a fifth of 10 year olds were unable to read sentences and a half of 7 year olds to read letters. Level and quality of education imparted also need to be measured as India has been churning out dropouts at an increasing rate in some states exceeding 50% before Tenth grade. In 2014, engagement in economic activities had been the most common reason for

dropping out for males, whereas for the females the dominant reason was engagement in domestic activities [8]. It was also noticed that in urban areas the second major reason for leaving education is marriage (17.1%) for females. Financial constraints is another prevalent ground for all the population categories for leaving study before completing desired level of education.

Table 3. Per 1000 distribution of dropping out/discontinuance (for persons aged 5- 29 years) by reasons for dropping out/discontinuance (Source – NSSO)

Major reasons	rural		urban		rural + urban	
	male	female	male	female	male	female
not interested in education	251	162	208	143	238	156
financial constraints	236	154	237	149	236	152
engaged in domestic activities	59	329	24	231	48	297
engaged in economic activities	299	39	336	69	310	49
school is far off	6	42	2	18	5	34
unable to cope up with studies	55	51	53	36	54	46
completed desired level/class	45	43	83	113	57	65
marriage	-	124	-	171	-	139
other reasons*	48	57	58	70	51	62
all	1000	1000	1000	1000	1000	1000

***Include:** timings of educational institution not suitable, language/medium of instruction used unfamiliar, inadequate number of teachers, quality of teachers not satisfactory, unfriendly atmosphere at school.

Significant proportion of the population lacks even the will to get educated as they are unaware of the benefits of education and are compelled to work from an early age because of their socio-economic circumstances. In 2014, the major reason for never enrolment came out as not interested in education (33% male and 27% females) in rural areas [8]. Also, in urban areas, it was seen that 33% males and 30% females never enrolled because of financial constraints. The aforementioned adversities, lack of will and ignorance of the deprived add to the challenge of imparting education to them by the unfamiliar digital media.

Policies and plans aimed to spread distance education in rural and semi-urban areas have been introduced from time to time. But, unfamiliarity of the targeted audience with usage of digital media has rendered these efforts ineffectual. 100% computer literacy is still a high-hanging fruit and ailing web interface backbone impedes global information flows in India when world itself has become a global village. According to a 2015 survey, about a fifth of respondents who lived in urban areas and three quarters of rural residents said they didn't know about the internet and therefore did not use it [9]. This is illustrated further in Table 4, which presents the results of survey conducted by NSSO in 2014 [8]. In this survey, ability to operate a computer and to use internet was studied in different age groups. It can be observed from the table below that overall proportions of people having basic acquaintance with computer and internet in both urban and rural areas are low.

Table 4. Proportion (per 1000) of persons (age 14 years and above and can operate computer) by types of ability to use a computer (Source – NSSO)

Sector	Able to use computer word processing/typing			Able to use internet for searching desired information			Able to use internet for sending e-mails		
	male	female	persons	male	female	persons	male	female	persons
Rural	104	52	78	100	45	73	89	39	65
Urban	334	225	281	331	207	271	311	193	254
Rural + urban	177	106	142	173	95	135	160	87	124

Mobile learning is a subset of distance learning. According to a report [10], India has one of the fastest-growing numbers of internet users in the world. However, as evident from a report [11], there is a wide disparity between 219 million urban internet users and 87 million rural internet users at the end of December, 2015 in terms of internet accessibility. Also, India's peak Internet connection speed was the lowest in the Asia Pacific region at 21.2 Mbps [12]. There were 0.4% 4G connections out of total mobile connections, 15.7% 3G connections and 83.9% 2G connections in 2015. The average 4G speed was 9.19mbps, average 3G speed was 1.89 mbps and average 2G speed was 0.075 mbps in 2015 [13]. In addition, data costs have been rapidly increasing over the years. There is a 150% price hike in Airtel's 2G plans over a period of six years. Slow data connection speeds and expensive data plans is detrimental to the educational growth through mobile devices.

Inadequate electricity distribution has also proved to be a hindrance in growth of education. Only 6000 out of 18500 villages have been electrified. Only 6% of the rural households and 29% of urban households were observed to possess the computer according to a study [8].

Also, the budgetary allocation to education sector by the Government seems to be inadequate for meeting the required standards and needs of education. The military expenditure for 2014-15 as per the central budget was increased by 12 percent from the previous year to INR 2290 billion. While the expenditure on education was 3.3 percent of the GDP in 2013-14 (compared to 9 percent of the GDP for military expenditure), the budgetary allocation rose by 12.3 percent to INR 837.71 billion in the 2014 budget. With 1.4 million children between the ages of 6 and 11 still out of school in India (according to the UNESCO Education for All Global Monitoring Report), the increase in expenditure is definitely inevitable [14].

4. Merits of Digital Education – World is Everyone's Oyster

The Information and Communication Technologies Revolution is a ray of hope in the present waning Indian education system. Digital education has enabled every child to have access to the same content and different instructional styles and languages everywhere unlike in the brick and mortar model where world class education with a well-defined curriculum is not possible for many children. The content could also be played many times in video tutorials and thus, results in better grasp on the concepts. Some of the major benefits of digital learning are that it can be accessible in remote areas that have an internet connection. I-slate revolution has transformed the lives of children in Mohamed Husainpally Village school in Andhra Pradesh. I-slate is a cheap, solar-powered tablet designed specifically for classrooms

with no electricity and few teachers in developing countries through joint development by the I-slate Consortium [15].

Distance from school is one of the important factors affecting access to education and attendance. According to a survey [8], there was no significant difference between rural and urban India in terms of physical access to primary schooling within less than 1 km distance from sample households, but for upper primary and secondary schools the gaps between rural and urban areas are quite prominent. More than 12% of rural households in India did not have any secondary schools within 5 kilometers whereas in urban areas such cases are insignificant (less than 1%). Digital learning is a blessing indeed for areas that do not have schools/learning institutions in close proximities.

Table 5. Per 1000 distribution of households by distance from school having primary, upper primary and secondary level classes

Level of education	Distance (d)			
	$d < 1km$	$1km \leq d < 2kms$	$2kms \leq d < 5kms$	$5kms \leq d$
Rural				
Primary	941	49	9	1
Upper primary	665	190	121	24
Secondary	367	236	275	122
Urban				
Primary	925	65	8	1
Upper primary	829	131	37	2
Secondary	727	187	80	7

Digital education does have a capacity to create enormous impact in the field of healthcare and medical education as envisaged by the dawn of telemedicine and the Internet of Things. The World Health Organisation (WHO) has recommended 1:1000 as the desired doctor-to-population ratio. Indian Healthcare has been witnessing an unmatched supply and demand with only 0.12 doctors per 1000 population count in rural communities against 1.13 doctors per 1000 people in urban communities [16]. Many apps such as Curofy, Sermo, Doximity, etc. have been developed to become the pacemakers at the heart of abysmal medical education. These apps are built on providing a forum specifically for doctors to connect and share their problems, findings and special medical cases. Doctors also gain tremendous opportunities to learn about the prevailing medical research through various journals.

The discourse on education is not complete until it passes the multilinguistic threshold especially in a country like India with diverse set of languages. Learning is affected when the media of instruction is not same as the language of the learner. Digital learning is capable of putting a block on these incoherent elements by providing quality education and offering the flexibility to share the same content with the learners in their respective first languages.

The mismatch between skills required for job markets and outdated curriculum is one of the weak pillars of higher education architecture. The Ministry in India launched several skill development programs through NSDC (National Skill Development Corporation), NSDA (National Skill Development Agency), Directorate of Training and ITI (Industrial Training

Institute) with underutilized outcomes. In a written reply to the House of the People questions, the Union Minister for Skill Development and Entrepreneurship & Parliamentary Affairs, Government of India, shared the following information on the status of achievement for different skill development programs implemented by the ministries in different financial years. In five financial years (FY'2011 to FY'2015), mere 1.53 mn people got employment out of 5.05 mn trained [17].

Table 6.Source - Lok Sabha Questions, *up to February, 2015

Schemes Implemented by various Ministries			
Year	Target (in lakhs)	Persons skilled (in lakhs)	Achievement
2011-12	46.53	45.58	98%
2012-13	72.51	51.88	72%
2013-14	73.42	76.37	104%
2014-15	105.7	51.50*	49%

Year	Persons trained (in lakhs)
2010-11	0.02
2011-12	1.82
2012-13	4.03
2013-14	10.05
2014-15	34.42

Digital learning can bridge the chasm by focusing the curricula on the specific skill set or knowledge area as required by the changing demands of the industry. For instance, Flipkart – India’s largest online marketplace – has revamped its recruitment method by hiring the candidates who have gained skills after completion of Nanodegree programs from Udacity [18], an online learning platform.

People have to incur expenditure in the form of course fee, expenses on conveyance, uniforms, etc. to receive education under the conventional classroom model. A report by Accenture states that digital learning is less costly per beneficiary over time for 83% of cross-sector organizations. ‘Economic Impact of Free and Open Source Software’ is a study conducted in 2009 to signify incremental economic benefits of FOSS (Free and Open Source Software) in different domains [19]. This can make digital education cheaper and viable in Indian context. It states that FOSS is used by 20 kinds of organisations including higher education in the form of operating system on a desktop or server.

Table 7.Forecast cost savings in the year 2010 from replacement of proprietary software with FOSS software (Source – Economic Impact of Free and Open Source Software: A study in India)

Replacement by FOSS	Cost savings
50% of desktop operating system sold in the retail market with FOSS alternative. Saving assumed to be INR 3600 per unit	INR 9,847 mn (\$ 205 mn)
50% of desktop office productivity tools sold in the retail market with FOSS products. Saving assumed to be INR 16500 per unit.	INR 45,152 mn (\$ 940 mn)
50% of desktop software sold in the enterprise market with FOSS products. Saving assumed to be INR 20000 per unit.	INR 46,388 mn (\$ 966 mn)
Total	INR 101,387 mn (\$ 2111 mn)

The cost savings for use of FOSS on servers, as an operating system or as an application was expected to be INR 1,380 million (\$28.75 million) at a very conservative estimate in 2010. To summarize, weak learning outcomes at each stage of current model of education owe to numerous factors and can be combated by digital learning to some extent. However, digitization of education could only achieve full scale when the content, technology platforms and the delivery infrastructure are in resonance.

5. Measures taken by the Indian Government and Non-Governmental Organisations for the Propagation of Digital Education Mission

Numerous attempts have been made by the Indian Government to fortify the technological front of Indian ecosystem. This year's budget (2016-17) is marked by the allocation of funds to launch two schemes: 'National Digital Literacy Mission' and 'Digital Saksharta Abhiyan', in support of digital literacy (knowledge to handle digital devices like computers, tablet PCs, smartphones, and internet usage) in around 60 mn additional rural households. If these efforts become the launch pads for the presence of digital paraphernalia in every Indian rural household, 'Digital Inclusion for all' would not be a far-fetched dream. Digital education would arrive on the heels of digital literacy but, education is untenable when the tools for delivering it are unable to run because of no supply or erratic supply of electricity.

As per the results of Teacher Eligibility Tests (introduced after the Right to Education Act, 2009) conducted in the western Indian state of Maharashtra in 2015 [20], barely 1% of more than 245,800 primary (first grade to fourth grade) teachers who took the test could pass. Teaching profession is considered the last pursuit in India and this outlook has negatively affected the level of teaching quality to the point where it has become an epidemic despite the expenditure of \$94 billion over the last decade on primary education. There are 0.4 million untrained elementary school teachers.

"Digital India" programme, launched on July 1, 2015 and powered under India's Prime Minister's governance is conceptualized on the three vision areas (infrastructure as utility to every citizen, digital empowerment of the citizens and Governance and services on demand) and nine pillars that are expected to bring out ubiquitous technological development in the nation by 2019 and make nation into a knowledge economy. The concept of 'Digital India by 2019' is great but ambitious considering the overview of the present conditions of infrastructure facilities in India.

CSC (Community Service Centers) Special Purpose Vehicles (SPVs) have performed a significant role in capitalizing on the national network of CSCs to meet India's financial inclusion requirement for rural areas. However, a lot of people in rural areas still are unaware of the internet and there is no power supply in many areas to ensure proper functioning of CSCs. Entrepreneurs in rural areas who have opened the CSCs with support from the Govt. are often unable to make worthwhile gains as they don't know how to best utilize this scheme. A school teacher in the state of Maharashtra utilized this scheme well by teaching little children computer skills and is making profits [21]. Govt. should run programs to inform the masses about the effective ways to utilize the schemes.

Broadband Highways is a "Broadband for All" project introduced under Digital India to establish nationally-connected infrastructure would undoubtedly affect the access to the information and communication technologies and bolster the digital education through

National Optical Fiber network (NOFN) in rural areas and Virtual Network operators in urban areas. But, the goals themselves generate skepticism considering the living definition of broadband in India i.e., speed over 0.5 mbps unlike 10-50 mbps in other countries [22]. NKN (National Knowledge Network) is used to connect engineering and medical educations across the nation for dissemination of quality education. 150 medical colleges have been connected so far. It requires extensive infrastructure that all ought to work in tandem for realistic and effective flow of information. Three years after the launch of NOFN scheme, less than 3% of the target has been achieved [22]. Adverse effects to health are prime reasons that have curtailed the installation of towers in many areas. Wide optical fiber cable network in 96% of all districts and 80% of blocks is rendered useless when unaffordable devices, higher cost of internet access, unavailability of content in local languages slash the demand for broadband. Unless there is user-friendly software, all the efforts to empower culturally diverse population of India digitally are in vain. Ailing power supply, infrastructure presence and costs have also questioned the success of these attempts in the present and near future.

6. Benchmarks

In this section, some success stories where digitization of education has been achieved are shared below to illustrate its significance in resource scarce areas to reach the deprived and unmotivated through smart utilization of renewable energy and digital devices.

- **Digital Education in a Box** - It is an advanced education platform by Founder & Director, Edtech, Buddha Burman who has set up 'Digital Education in a Box' (DEIAB) [23] that extends the ability to create digital classroom in the middle of nowhere. It is inspired by the portable communication technology deployed in the event of disaster or other emergency conditions. To create an ecosystem suitable for such a platform, there are many components i.e., Education Server (Solar + Hardware + Software + Long Range Wi-Fi + HD Projector), Tablets (for Autonomous Learning), Teachers (for Supported Learning) and Innovative educational content. An intermittent connection to the cloud enables the syncing of data between the remote hub and the central cloud server, thus enabling track of learning progress and the effectiveness of the system. Target schools have between 65 – 265 students of the age group 12–16 from lower income backgrounds, and suffer from unreliable grid performance and access. It is significantly economical as one teacher teaches many students with the help of HD projector in the classroom.
- **Gund Model of Teaching** [24] - It is named after Sandip Gund, a 27 year-old entrepreneur who has completely revamped the old school and ineffective education model of a small district council school in Pashtepada, in western Indian state of Maharashtra without any financial assistance from the Government. His school is powered by solar panels, projectors and tablets. Textbook lessons are being converted here into PDF files and projected on the touchscreen. The dropout rates have decreased and this school has inspired over 40 other schools in the Thane district of Maharashtra to adopt this pedagogy. This particular digital learning project has been awarded from Maharashtra's State Council of Educational Research and Training.

7. Recommendations

- Efforts should be made to familiarize the subjects (especially in rural areas) with the computers, internet and other devices.
- Indian Government, telecom industries, IT companies should collaborate to create an equipped environment where digital education can flourish.
- To ensure the success of skill development programs launched by the Indian Govt. for increasing employment, incentives should be given to varied industries by the Govt. to promote hiring of people getting skilled through these programs.
- There should be more focus on rolling out zero cost data plans especially for consuming educational resources as internet penetrations more in mobiles in rural areas of India.
- Renewable energy powered devices with ‘Free and Open Source Software’ is a blessing for areas afflicted with uncertain power supply and small pockets to afford the software costs.
- Virtual classroom approach is promising and it should be deployed to get the privilege of interaction with other learners and teachers for resolution of doubts and development of competitive spirit in the remote learner. Tests should be conducted at regular intervals and test score comparison of the learner with other students should be displayed to assess the performance. Virtual classroom indeed could provide a platform for group projects among students to develop their behavioral and communication skills. College credits should be rewarded to the online students similar to those who pursue formal education for employment.
- There are increasingly more course options available online and learners are bound to get confused to make the right choice. Online counselling service would help learners to a great extent in pursuing the right course of study according to their strengths, previous background and interests for securing employment.

8. Bibliography

- [1] J. Gray, 22 July 2012. [Online]. Available: <http://www.bbc.com/news/magazine-18923542>.
- [2] A. D. Battista, R. Crotti, M. D. Hanouz, C. Browne, G. Corrigan, C. Galvan, T. Geiger, T. Gutknecht, G. Marti and X. Sala-i-Martin, "World Economic Forum Report," World Economic Forum, 2016.
- [3] "InternetLiveStats.com," 2014. [Online]. Available: <http://www.internetlivestats.com/internet-users/india/>.
- [4] T. P. C. Committee, "Planning Commission, Government of India," The Planning Commission of India, 2002.
- [5] D. R. Ganesan, "Panel XII: The Challenge Of Education—a Policy Perspective," *The Indian Journal of Political Science*, vol. 47, no. 1, pp. 154-160, 1986.
- [6] P. Satish Bisla, "Digital Education: Scope And Challenges - A Perspective Of A Developing Society," eLearningindustry.com, 24 May 2015. [Online]. Available: <http://elearningindustry.com/digital-education-scope-challenges-developing-society>.
- [7] Wikipedia, "Right of Children to Free and Compulsory Education Act," Wikipedia, 3 March 2016. [Online]. Available: https://en.wikipedia.org/wiki/Right_of_Children_to_Free_and_Compulsory_Education_Act.

- [8] I. National Sample Survey Office, "NSS 71st Round (January-June, 2014) - Key indicators of Social Consumption in India Education," National Sample Survey Office, India, 2015.
- [9] H. Wu, "CNN Money," 9 March 2016. [Online]. Available: <http://money.cnn.com/2016/03/09/technology/india-internet-access/>.
- [10] A. Shah, N. Jain and S. Bajpai, "India@Digital.Bharat," 2015.
- [11] T. I. Express, "Mobile Internet users in India to reach 371 mn by June 2016," The Indian Express, February 2016. [Online]. Available: <http://indianexpress.com/article/technology/tech-news-technology/mobile-internet-users-in-india-to-reach-371-mn-by-june-2016/>.
- [12] D. Belson, "Akamai's State of the Internet - Q4 2015 Report," Akamai, 2015.
- [13] Cisco, "Cisco VNI Mobile Forecast Highlights 2015-2020," Cisco.com, [Online]. Available: http://www.cisco.com/assets/sol/sp/vni/forecast_highlights_mobile/index.html.
- [14] S. Santosh, "Trends in India's Education Budgeting," Centre for Civil Society, 2015.
- [15] P. Sivakumar, "I-slate sparks revolution in Andhra Pradesh village," The Hindu, 15 August 2012. [Online]. Available: <http://www.thehindu.com/todays-paper/tp-national/islate-sparks-revolution-in-andhra-pradesh-village/article3773707.ece>.
- [16] U. A. Kumar, "India has just one doctor for every 1,700 people," The New Indian Express, 22 September 2013. [Online]. Available: <http://www.newindianexpress.com/magazine/India-has-just-one-doctor-for-every-1700-people/2013/09/22/article1792010.ece>.
- [17] S. I. "Skill Development in India– present status and recent developments," Swaniti Initiative, 2015.
- [18] B. Dasgupta, "Flipkart partners with Udacity to hire graduates based on Nanodegree projects," The Economic Times, 28 January 2016. [Online]. Available: http://articles.economictimes.indiatimes.com/2016-01-28/news/70150332_1_flipkart-partners-udacity-graduates.
- [19] R. De', "Economic Impact of Free and Open Source Software - A study in India," Indian Institute of Management, Bangalore, 2009.
- [20] P. Salve, "India's \$94 bn spend on basic education doesn't address teaching crisis," Business Standard, May 2015. [Online]. Available: http://www.business-standard.com/article/specials/india-s-94-bn-spend-on-basic-education-doesn-t-address-teaching-crisis-115050200118_1.html.
- [21] M. Kaul, "Digital inclusion is the need of the hour," The Guardian, [Online]. Available: <http://www.sunday-guardian.com/analysis/digital-inclusion-is-the-need-of-the-hour>.
- [22] R. Khullar, "Mission impossible: Digital India is not doable by 2019," The Indian Express, 7 September 2015. [Online]. Available: <http://indianexpress.com/article/opinion/editorials/mission-impossible/#sthash.2gOzMCTK.dpuf>.
- [23] M. Rohinesh, "Digital 'Jugaad' Puts Education-In-A-Box For Rural Kids," Networked India, 31 August 2015. [Online]. Available: <http://www.networkedindia.com/2015/08/31/digital-jugaad-puts-education-in-a-box-for-rural-kids/>.
- [24] S. Pareek, "A 27-Year-Old Govt School Teacher is Making Headlines with his Unique Model of Education," The Better India, 18 February 2016. [Online]. Available: <http://www.thebetterindia.com/24107/27-year-old-teacher-maharashtra-making-headlines-unique-model-education/>.

Three Instructional Design Techniques for University Faculty Inclusion in Digital Learning

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Abstract

Successful digital learning requires not just technical skills but a particular mindset characterized with readiness and openness for this way of learning. Unfortunately in our country there is still an issue of university faculty resistance to the changes. This barrier can be overcome through the positive learning experience in digital environment. Our study argues that positive learning experience is more likely to be gained while studying at the online course implementing three proposed instructional design techniques. They are creative collaborative projects with a digital artifact production, tiered assessment based on ability and interest and gamified course elements to keep track of progress. The study presents the results on the collaborative technique implementation research within university Professional Development settings and the provisional basis for the other instructional design techniques to be researched.

Introduction

Digital learning is quite often proclaimed to be a panacea for all the problems of traditional education and a “must-have” option for competitive educational institutions. For about five years this idea has been reflected in the policies for the state-funded universities in Russia demanding them to teach a number of blended and online courses for every degree level. Though digital learning introduction does have huge potential for universities, like any policy transferred downwards as a directive it can be considered by the faculty as inconvenient pressure. Among the other reasons of the negative attitude to digital learning there is the low level of computer literacy, lack of financial encouragement and *persistence of thinking* as a characteristic of the traditional mindset [1]. All the reasons above can result in passive sabotage of digital technology use. If the situation is existing for significant time it potentially lowers faculty member’s ranking and professional perspectives as for many of Russian universities teaching online and blended courses is one of the effectiveness indicators. Most of resisting university faculty chooses to make some kind of *quasi* online course in order to get a check mark in the profile. Obviously, the use of such courses lacks most of the quality digital learning benefits and causes permanent dissatisfaction with both faculty and students proving digital learning deficiency to the resisting faculty member. This vicious circle is hard to break.

We believe that positive personal learning experience of the faculty is the possible way out in the described situation. “Positive learning experience” in this context is considered to be a subjective opinion of a university teacher that he or she has become more literate in both digital learning tools and pedagogy behind them with minimum stress and maximum satisfaction. It seems necessary to introduce the new ways of teaching to the faculty through their active learning and learning by doing. The question of how to design the process facilitating to gain positive experience becomes the most important. That makes a required Professional

Development (PD) course on digital learning quite similar to a connectivist MOOC in terms of being process-defined rather than outcomes-defined [2]. At the same time the course participants need to develop a set of skills as well as working knowledge of educational theories. How should we reach both goals making university teachers' inclusion in digital learning smooth and encouraging further development of their online teaching potential?

Literature Review

To develop the instructional design for the required Professional Development courses it was necessary to analyse the main findings on the topic retrieved from the literature accessible to us in order to define the most likely positive experience “building blocks”.

It was agreed that Social Presence defined as “an ability to socially and emotionally project himself/herself in a course or online community” [3] was a key concept in this case. According to Aragon “learners, who have a higher level of social presence, are more satisfied with online learning” [4]. Within this broader concept we intended to focus on building a short-term collaborative community of practice where course participants would play an active role in creating new artefacts rather than just consuming educational materials. Taking into account all the controversies of collaborative learning it was necessary to design the course “with the full understanding and consideration of group dynamics, social interaction, and instructional technology” [5].

One more instructional design principle that seemed to be promising for student satisfaction was a partial individual approach. As we were prepared to deal with participants of different computer literacy levels and creative abilities we had to provide differentiated elements. In this particular case instruction based on the differences in “ability (multiple resources to address multiple levels of academic readiness) is possible when integrating technologically-enhanced activities into the instructional setting” [6]. So we agreed to use tiered assessment for the most time- and effort-consuming projects to provide the options for three different types of project according to computer literacy level and personal preferences.

Gamification as “the use of game design elements in non-game contexts” [7] became the third approach we chose to implement as a part of instructional design. This phenomenon has been rapidly changing in business, education and some other spheres, and judging from both research studies and our personal experience has great potential in managing e-learning satisfaction.

This list of three approaches became the starting point in developing the instructional design techniques for professional development online course on digital learning and teaching.

Study Context and Instructional Design Strategies Implementation

The study is aimed at analysing the data on the online Professional Development course “Cloud technologies for Education and Research” (further referred as “PD course” or “the course”). It was taught at Siberian Federal University, Russia for three terms starting 2014, was offered twice in 2015, and is currently being offered to the faculty for Spring 2016 term. PD course is taught completely online for 9 weeks and uses LMS Moodle as a learning environment according to the university policy. Its target audience is the university faculty and sometimes other staff regardless of position, age and computer literacy level. The number of participants varies from 50 to almost 80 university teachers every term. The PD course includes seven benchmark projects to be submitted. One of them is a group project with peer reviewing by other

groups. Peer reviewing is also a part of two individual projects. In-course interaction is facilitated by thematic forums and one, scheduled for every 10 people, synchronous video webinar. There are no fines or other punishment for late submission but PD course completion is achieved only when all the activities are completed.

Introducing new strategies in the course we had to take into account the following considerations:

1. As for quite a big part of the audience this course is introductory it cannot rely on automated formative assessment and peer evaluation only. There are always participants who need additional help.
2. The number of participants is large so the assignments need to be checked easily and quickly but to be enough educationally challenging.
3. The learning environment should be supportive and friendly taking into account that the faculty is quite often “the worst students”.
4. It should not be too innovative or disruptive as some of the faculty can be conservative or technology resistant in general.
5. The course needs to become a temporary platform for participants to interact with each other and the instructors to further their knowledge and skills on the topic.

Based on the above considerations we decided to start implementing the instructional design techniques gradually. Online collaborative group project assignment is introduced at the third week followed by peer reviewing. For this assignment collaborators within the randomly assigned group are supposed to create a simple digital artefact based on a set of clear criteria. To promote positive learning experience the collaborative group projects are to meet the following requirements:

1. The project topic should be neutral. We used topic “Seasons in the city” for the most of the group assignments.
2. Every team has its own online space for discussing project-related issues and presenting the final version. The LMS forum serves as a platform for these purposes.
3. The contribution of every team member should be evaluated independently against clear assessment criteria. The data for individual contributions is obtained from history tool in LMS and cloud applications.
4. Peer-reviewing by colleagues is monitored to keep it a positive encouragement tool rather than critical feedback.

Standardized / individualized assignment feedback is given every week. Final individual project is tiered offering basic, intermediate and upper intermediate level options. Gamified track keeping with individual numbers instead of names shows cells filled in with the color according to the level of assignment completing: “green” - accepted, “yellow” - corrections needed, “red” - not submitted. Every participant can see his / her individual achievements and compare them with the others without seeing the names.

The course has been the hit in Professional Development for four terms in raw. It is now one of the longest taught PD courses at the university.

Study Method

The study aims to determine if the exceptional popularity of the course with the university faculty has something to do with the implemented instructional design techniques discussed above. The study suggests the quantitative data analysis as the major source of data as well as

observations and non-structured mini-interviews to verify the major source. The data for implemented instructional design technique has been collected, analysed and verified additional mini-interviews. There are two types of quantitative data: LMS Moodle system statistics for Spring 2015 and Fall 2015 terms and the results of the participant survey conducted in 2015 after Spring 2015 course completion (distributed via Google forms).

For the other two techniques the studies are still in progress and we only have the results of non-structured mini-interviews with the course participant and the Head of Professional Development department.

Though the study is still in progress the results already acquired seem to be worth sharing.

Study Results and Implications

The data on “productive” collaboration comes from both LMS statistics, participant survey and forums activity observation. As we already mentioned above, the third week this assignment that divides participants into randomly assigned groups of 3-4 people. The division may be further corrected to make sure that group members do not belong to one school and most likely do know know each other personally.

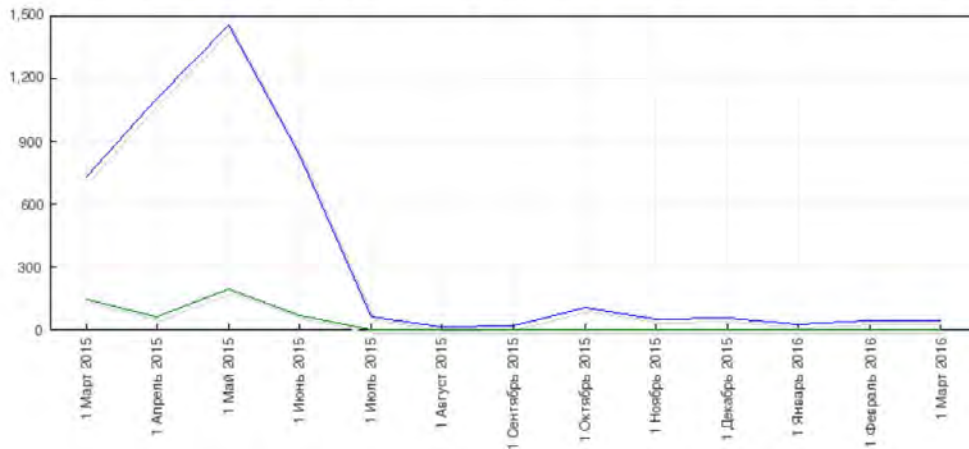


Figure 1. Participant activity for Spring 2015

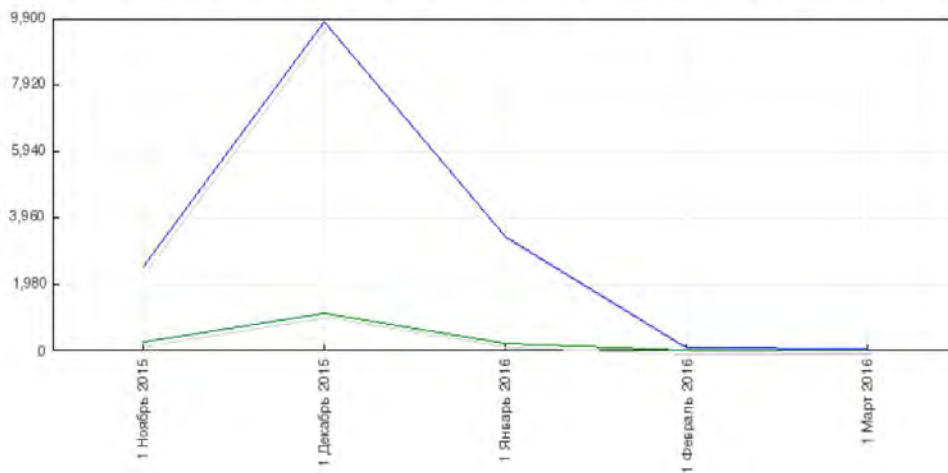
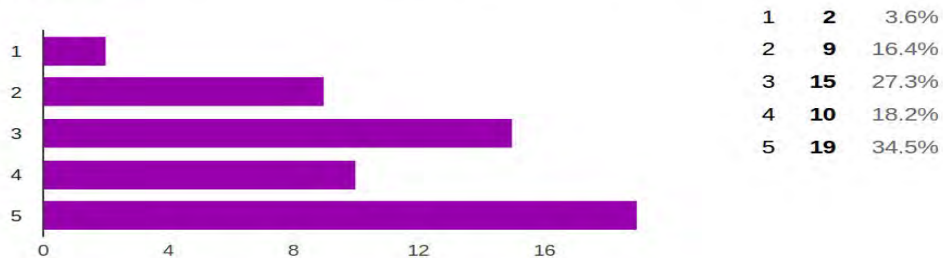


Figure 2. Participant activity for Fall 2015

The figures 1 and 2 present the LMS Moodle statistics screenshots of Spring 2015 and Fall 2015 accordingly. The blue line shows student activities with LMS. On Figure 1 the participation starts to grow rapidly after collaborative assignment is introduced. The same effect is visible on Figure 2 where it is even more obvious as the distribution is more recent in terms of time period.

If we compare this distribution to the very common one when the starting point of a course has high rate of participation and then it slowly decreases we may see a difference. This difference is likely correlated to the fact that the participation peak is collocated the collaborative activity period.

Форум-визитка: знакомство [8. Каково Ваше мнение о заданиях, которые пр слушателями?]



Презентации: групповой проект и отзывы на другие работы [8. Каково Ваше взаимодействие с другими слушателями?]

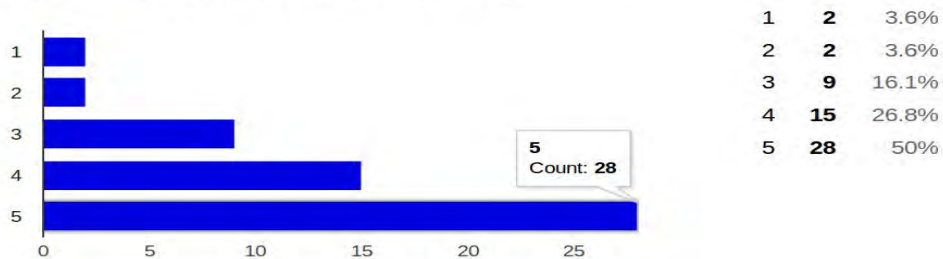


Figure 3. Google Forms Statistics. Forum vs. Collaborative project: evaluation.

Another evidence comes from the participant survey distributed via Google Forms after Spring 2015 PD course completion. The participants were asked to answer 14 questions anonymously. 57 out of 67 recipients responded to the survey. Answering Question 8 the participants had to grade the interactive activities based on how useful they had been during the course. The upper activity on Figure 3 represents the Introductory Forum and the lower one shows assigned group collaborative activity. The scale is from 1 (not useful) to 5 (very useful). It is obvious that the second graph presents a more consolidated positive result with 50% higher rate.

The additional data is provided by the answers to the question about overall course satisfaction - 95% positive responses, and by the question about the gained knowledge and skills implementation and the readiness for further professional development in digital learning, when 63% participants claim that they were already practicing the and 28% of them are about to start.

This data was also verified by several non-structured mini-interviews. During them participants were mostly positive about collaborative activities emphasizing their productive

nature as a big advantage. The interviews showed that even the faculty with low initial computer literacy level mostly shared this point of view.

Quantitative studies on Tiered Assessment and Gamified Track Keeping are still in progress but we have provisionally justified hypotheses on them. The participants of mini-interviews were very positive about the gamification elements and described them as “stimulating”, “encouraging” and even “addictive”, emphasizing not only the importance of regular feedback but also the importance of visualizing the personal progress on the “bigger picture”.

The data for provisional hypothesis on the use of Tiered Assessment as a type of differentiated instruction came from the Head of Professional Development department at the university. She considered that approach to be quite efficient and was insisting on developing this practice to increase the number of faculty members involved in digital learning.

Introduction to the new way of teaching/ learning is a very important and very sensitive stage for both students and faculty. It can be especially challenging for those faculty members who are “digital immigrants” and do not have internal motivation for inclusion in digital learning process.

The study suggests that collaborative projects encouraging positive learning experience through the use of an online course environment is very likely to increase inclusion in digital learning and teaching process and readiness to continue development of digital learning capabilities. It also suggests further research on the role of differentiated instruction and assessment as well as the introduction of gamification elements for online professional education.

References

- [1] A.S. Gotlib, “Can Online Education Become an Alternative to the Traditional University?”, *Vestnik of Samara State University, Samara, Russia*, 2015, 1(123), pp. 15-22 [in Russian].
- [2] S. Downes, “The Quality of Massive Open Online Courses”, available at: <http://cdn.efquel.org/wp-content/blogs.dir/7/files/2013/05/week2-The-quality-of-massive-open-online-courses-StephenDownes.pdf>
- [3] L. Rourke, T. Anderson, D.R. Garrison, and W. Archer, “Assessing social presence in screen text-based computer conferencing”, *Journal of Distance Education*, 2001, 14.
- [4] Aragon, S.R., “Creating social presence in online environments”, *New Directions for Adult and Continuing Education*, 2003, 100, pp. 57-68.
- [5] H.J. So, “The content analysis of social presence and collaborative learning behaviors in a computer mediated learning environment”, in Looi C.-K., Jonassen D., and Ikeda M. (Eds.), *The 13th international conference on computers in education*, IOS Press, Amsterdam, 2005, pp. 413-419.
- [6] C. Figg, and K. Jaipal, “Engaging 21st century learners and differentiating instruction with technology”, *Teaching and Learning*, 2009, 5(1), pp. 1-12.
- [7] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, “From Game Design Elements to Gamefulness: Defining “Gamification””. *MindTrek '11*. Tampere, Finland, 2011.

An Investigation into Everyday Language Learning using Mobile Applications

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Abstract

The exponential growth of mobile phone applications has created a diversity of additional affordances and new ways of learning. In particular, mobile language learning applications such as online dictionaries and Google Translate combined with the technical affordances of smartphones and tablets are creating a new relationship between mobile learners and smart devices. In this exploratory study, a mixed method research design is used to understand how youth in Malaysia use their smart devices for learning languages and to uncover the extent of these learning experiences in their daily lives. 141 youths participated in a survey of their language learning experiences using mobile learning applications. Additionally, phenomenological interviews were conducted with 12 youths over a period of 4 months to uncover the lived experiences of their language learning. This paper presents the preliminary findings of the study which suggest learning is serendipitous and purposive. The findings may yield new understanding that may prove useful to Malaysia and other countries as well especially in its implications for formal and informal learning.

1. Introduction

With increasing ownership to portable, smart devices such as smartphones worldwide, youth utilize these devices every day for entertainment, playing games, communication, and social networking. Current improvements in location aware and social software using Web 2.0 technologies (e.g., *Instagram, Foursquare, What's App*) or social networking sites (e.g., *Twitter, Facebook*) have made smartphones more ubiquitous and also suggest more learning and teaching potential. The exponential growth of mobile applications (apps) has afforded many smartphone users with ubiquitous access to learning as seen in the various mobile apps used to learn languages and multiple skills.

In this new and technology-rich landscape, language learning practices are changing, impacted by learners' views of their available times for learning, the locations for their learning and their evolving perspectives of the significance of these fragments of learning experiences [1], [2]. Hence, language learning in everyday environments has become more

self-directed and learner-centered as the mobile devices assist and enhance the processes of resource sharing, creation and collaboration among communities of learners [3], [4], [5]. Thus, there is a compelling need to understand how youth use their smart devices to learn in general and learning languages in particular, and if that learning takes place in the course of everyday routines and in the interconnection of life, education, leisure and work.

The aim of this paper is to investigate how youth in Malaysia use their smartphones to learn different languages, and the extent of their learning of languages in their everyday lives.

2. Research study and research questions

Mobile assisted language learning (MALL) is an increasing area of research with the development of mobile applications specially dedicated to language learning and the growing perception of the importance of acquiring multiple languages in an interconnected world [6], [7], [8]. This study explores how learners use their smartphones for language learning by examining the following research questions:

1. How do learners use their smartphones for language learning in their everyday lives?
2. When and why do learners use their smartphones for language learning in their everyday lives?

3. Literature review: mobile assisted language learning

Mobile technologies are progressively influencing cultural practices and enabling new contexts for learning [1], [7], [9]. The use of such technologies in education has however, been more gradual as educators contend with how understanding and application of these tools and devices in their classrooms could be more effectively used to support different types of learning [6], [2]. While mobile learning (m-learning) has been depicted as having the affordances of immediacy, permanency, interactivity, and accessibility [10], more recent definitions have moved from a predominantly technocentric focus to an increasing emphasis on the mobility of the learner and learner agency [11], [6]. [11, p. 225] define m-learning as ‘the processes of coming to know through conversations across multiple contexts.’ [1, pp. 6] adds to this conception of m-learning by proposing that learning occurs as ‘a process of meaning making through acts of conversation on the basis of a pre-given, objectified cultural world.’ This socio-cultural ecology of m-learning has the core constituents of agency, structures and cultural practices [1]. This paper adopts these definitions of m-learning with an emphasis on the use of smartphones for language learning in everyday environments.

Located within m-learning is an area of increasing interest to educators and researchers: mobile assisted language learning (MALL). [6, pp. 273] define MALL in terms of ‘its use of personal, portable devices that enable new ways of learning, emphasizing continuity or spontaneity of access and interaction across different contexts of use.’ They argue that with different contexts and locations of use and the association of factors such as ‘partial attention, shifting motivation, opportunistic scheduling of study, availability of physical space, real or perceived costs to the user, social conventions of device’, learners will learn in new ways even with ‘old content’ [12, p. 218].

It can be argued that MALL studies are anchored within existing Second Language

Acquisition (SLA) theoretical frameworks. Some features of technology-mediated communication are beneficial for SLA when examined through the lens of sociocultural theory and SLA interactionist theory [13]. Sociocultural theory contends that learning languages is a socially mediated process and people use mediated tools (language being the most important) to alter the world and to set their relationships [14], [15], [16]. The interactionist theory of SLA argues that cognitive and sociocultural factors are important in language learning and suggests that incidental acquisition and L2 (second language) learning occurs through the process of interacting [17]. The SLA interaction processes comprise ‘input, apperception, semantic and syntactic comprehension, intake, integration into the learner’s linguistic system and output’ [18], [19, pp. 120]. Mobile technologies enable human interaction to be readily conveyed, saved, archived, re-examined and edited, thereby encouraging reflection and interaction [13], [19].

In a review of MALL developments, [6] found that research studies comprised mainly content and design-based studies. There were mobile learning applications on vocabulary and grammar lessons [20], the use of text messages to learn Italian outside the classroom [21], [22], and the development of ‘short (from 30 seconds to 10 minutes) learning modules’ to cater to the ‘highly fragmented’ attention of m-learners [23, pp. 1796]. Cross platform approaches involving mobile technologies and interactive television for language learning were developed [4], [24]. [7] reviewed MALL research (2007–2012) in the explicit area of second language acquisition and found that mobile technology could enhance learners’ second language acquisition. However, it was noted that most of the reviewed studies were small in scale, experimental, and of short duration [7]. Thus, there would be reliability and scalability issues of the findings as there was also a shortage of cumulative research with most concepts and theories used only in one or a few studies.

While most of the research studies in MALL have been conducted in structured, teacher or researcher directed environments, there is increasing interest in language learning in informal environments where learners choose the time and place for their learning [25], [26]. Progressively, there is interest in the personalized and cumulative learning that occurs in everyday practices. [27, pp. 772] describes ‘everyday mobile practices’ as the “doings, sayings and relating that constitute informal social practice’ grounded on [28]’s social practice theory. There is emergent research on MALL practices in everyday environments [29], [30] although a more detailed analysis of evidence-based technological experiences and MALL practices and their relationship to formal and incidental learning have been suggested [27], [26]. With the scarcity in the literature of how smartphones are used to learn multiple languages in everyday settings, this study addresses this gap by exploring the everyday MALL practices and lived experiences of student participants in Malaysia to uncover the significance of this learning and its perceived value.

4. Research methodology

The research approach used in this study is Mixed Methods Research (MMR) which combines and integrates qualitative and quantitative research approaches. This study adopts pragmatism as its guiding philosophy founded on the principles developed by classical pragmatists such as James, Peirce, Dewey and later augmented in new directions by neo-pragmatists, Rorty, Putnam and Rescher [31]. Pragmatists search for the correct methodological mixes that can better answer their research questions, rather than any congruence to specific philosophical

assumptions. The research design used here is that of the exploratory design - a two phase mixed methods design. There is firstly, a collection and analysis of quantitative data, after which the qualitative phase is designed such that it follows the results of the initial quantitative stage [32], [33].

The qualitative research is based on the theoretical underpinnings of phenomenology which advocates the study of experience (or the appearance of things) and the nature and meaning of such experiences for one person or a group [34], [35]. As 'human experience has a vertical depth, and methods of data gathering, such as short-answer questionnaires with Likert scales that only gather surface information, are inadequate to capture the richness and fullness of an experience' [36]. The phenomenological interview was specifically chosen to uncover the technological experiences of the participants' language learning using smartphones. In this study, the qualitative phase functions to support and illuminate the findings of the primary, quantitative stage.

4.1. Research methods

Quantitative and qualitative data were both needed to answer the research questions in this study. A survey questionnaire was designed to investigate the youths' use of smartphones to learn various languages, the contexts of their uses and their perceptions of the value and significance of this language learning. There were two approaches used in the collection of the data. Primarily, the survey was conducted in face to face sessions in a private university in Malaysia. The second approach used snowball sampling where participants were asked to inform their friends and friends of friends from other universities and secondary schools to participate in the online survey over a period of 4 weeks. 19.1% of the respondents used the online survey and were from different institutions. Data analysis was conducted using SPSS software and from the analysis of the survey, broad trends were identified which then informed the design of the interview questions.

Semi-structured phenomenological interviews were subsequently conducted and permission for the interviews and recordings was sought from the participants, and transcripts and interpretations were made available to them to comment. This ensures accuracy of data analysis and interpretation to achieve better methodological rigour. To avoid researcher bias, the bracketing of presuppositions was carried out throughout the study and the researcher continually reflected to prevent preconceived biases from *influencing* her understanding of participants' descriptions [34], [35]. Confidentiality of participants' data was adhered to and pseudonyms adopted in the analysis.

The target participants in this study comprise youth from 16-30 years old. Purposive sampling strategies such as Snowball Sampling and Typical Case Sampling were used. Out of the 141 participants, 114 were from the face to face surveys in one tertiary institution and 27 were online responses from different institutions and schools. The semi-structured interviews had 12 participants ranging from 16-19 years old. Table 1 below shows the different age groups of the respondents. 31.2% were males and 68.8% were females. 86.5% were Malaysians and 13.5% were international students studying in Malaysia.

Table 1. Frequency of respondents by age (n = 141)

Age groups	Frequency	Percentage (%)
16 – 20 years	29	20.6
20 – 25 years	106	75.2
25 – 30 years	6	4.3
Total	141	100.0

5. Results and discussion

5.1. New languages, new horizons

There were 17 languages reported by participants that they used their smartphones to learn (Table 2). Participants reported more than one language (n=286) as they were given a choice to report more than one foreign language that they were currently learning. English Language (39.9%) is as the most popular choice as it is likely English is the medium of instruction in private colleges and universities in Malaysia and students have the motivation to improve their English proficiency in order to perform better in their studies. The status of English Language as a lingua franca and a global language means that increasingly learners perceive English as an important language to learn to improve their job opportunities and economic standing in life [37],[38].

Other languages include Chinese (Mandarin) at 16.1%, Bahasa Malaysia (11.2%) and French (8.7%). Participants indicated their interest in learning new languages as it would increase their knowledge, broaden their horizons and enable them to get to know more friends as seen in Sam’s quotation below:

Yes! (smiling) Like smartphones, like iPhones, the apps they have, not sure, I don’t know what that category is called but I’ve come across apps where they have *Learn English, Learn Malay, Learn French, Learn Thai*. I downloaded *Learn Thai* as I’ve friends in Thailand. I want to learn a bit that’s why I downloaded the app.

Sam, L: 97-100

Table 2. Languages learning using smartphones (n=286)

	Frequency	Percentage (%)
1. English	114	39.9
2. Bahasa Malaysia	32	11.2
3. French	25	8.7
4. Spanish	12	4.2
5. Thai	8	2.8
6. Chinese	46	16.1
7. Korean	19	6.6
8. Japanese	14	4.9
9. German	3	1.0
10. Dutch	1	0.3
11. Portuguese	1	0.3
12. Cantonese	1	0.3
13. Hokkien	1	0.3
14. Hakka	1	0.3
15. Arabic	4	1.4

16. Tamil	2	0.7
17. Sanskrit	1	0.3
18. None	1	0.3

In their pockets of time, in between classes or waiting for friends and when they are bored, they would use one of the applications (apps) to learn languages:

No, like when I'm bored, I like to disturb people..Like 'Hi', 'How are you?', 'How're you doing?' Emm..first of all, Korean....Portuguese. Just for fun. And also knowledge.....like in my class, we ..I meet all kinds of people,so I make sure I'm prepared.

Ismail, L: 163, 168-173

Well, in my class, I'm the only Malay... So I like to learn all the cursing words... Chinese, some Korean, Hong Kong also. Actually the curse words..easier to learn... Google Translate.

Ismail, L: 149-156

The main reason for learning new languages (Table 3) is to extend their knowledge and horizons (33.1%). Participants also perceive the economic benefits of extending their classroom learning of languages such as English Language and French into their everyday lives (22.3%). Johan, one of the participants explained his reasons for learning French, English and Chinese:

French must be for me. A lot of French terms in Culinary Arts. I feel happy I know a lot of terms and their meanings. Can improve in test this term...I think what goes on in my mind...it's a little bit hard. Learn Chinese because of friends. Learn French. Learn English because of some difficult words.

Johan, L: 66-70

French is a second language requirement for Johan's Diploma in Culinary Arts and he used his dictionary app to search for the meanings and pronunciations of French words and phrases. He learnt Chinese phrases and words in order to interact with his Chinese friends who use the language in their social interactions. Sam used to learn Japanese but since the course has ended, she used a Japanese language app to practise and communicate in Japanese. She believed that learning different languages would benefit her future and make her more 'marketable.'

I used to take lessons, Japanese lessons outside. I want to improve and no one can communicate with me at home, it's the app...Learn Japanese the easy way. Japanese 101. There is a lot of apps, actually. Ya, got to refresh my own memory.

Sam, L: 141-144

Thus, learning foreign languages is a trendy and fun way to learn anytime, anywhere utilizing the affordances of their smart devices, and yet in unison, for the more savvy among the youth, they see this activity as benefitting their future (Table 3). These young people, hence, will go beyond the basic social etiquette phrases to continue learning the languages at a higher level with the help of the apps.

Table 3. Reasons for learning languages (n = 141)

	Frequency	Percentage (%)
When I travel overseas and need to know some basic phrases and words	63	20.1
To add on to my classroom learning and practice in the particular language	50	22.3
To converse with my friends (in Malaysia and abroad) in the language	32	9.4
To extend my knowledge and proficiency of the language	75	33.1
To show off to others that I am able to speak and write in other languages	14	5.0
To increase my job prospects by learning other languages	33	10.1

5.2. This is my learning: mobile applications

The 141 participants reported one or more mobile applications that they used (n=171). Among the various language learning apps used (Table 4), the most commonly used were the online dictionaries (35.1%), *Google Translate* (33.9%) and other mobile apps (31%).

Table 4. Most used language learning applications (n = 171)

	Frequency	Percentage (%)
Online dictionaries	60	35.1
Google Translate	58	33.9
Mobile apps like Duolingo, memrise, Youtube, Learn English from Google Android, App Store or the Internet	53	31.0

The 12 interview participants reported that they had downloaded online dictionaries into their smartphones for easy availability and use. Different apps are used in a combination to enable learners to maximize their learning, for example, Ismail reported:

I don't have a French dictionary, I just...*Google Translate* and I will always ... log in to *Youtube* and see how do they... how do they pronounce it.. Em..for that, em..I ask my friend like, 'is this correct' 'is this right or wrong'?

Ismail, L; 57-59

Online dictionaries and *Google Translate* may be the first application used to search for meaning of words and phrases. Participants understood that oral proficiency was also important and hence, other apps with oral exercises and pronunciation tips were used in tandem with interaction and practice with other learners. This suggests that learners were interacting with their mobile apps and other learners, and second language learning occurs through this input processing, syntactic and semantic comprehension, and subsequent integration into the learner's linguistic system and output [13], [18].

Table 5. Reasons for using MALL apps (n = 181)

	Frequency	Percentage (%)
I like that it convenient and I can access it anytime	94	45.6
I like that it is free	46	22.3
I like that the learning is presented in an easy manner to learn	25	12.1
I like the pronunciation of the words and the easy repetitions	16	7.8
I like the vocabulary and the exercises	10	4.9
I like that I can move from basic level to advanced levels using these apps	15	7.3

Participants cited more than one reason for using the mobile applications (n=181). They valued the convenience and accessibility of this type of learning (Table 5, 45.6%), enabling them to search for meanings of foreign words and practicing pronunciation and vocabulary items in their pockets of available time every day. Youth also appreciated that the MALL apps they chose were free (22.3%) and presented with short activities and user-friendly features (12.1%). Additionally, learners liked the choice of being able to move from basic to advanced levels in their language learning (7.3%).

In many research studies portability, ‘learning on the go’, and convenience are the benefits cited in language learning using mobile devices [25], [39], [26]. [5, p. 8] suggests that smartphones are ‘ideal for individualized informal learning’ with learner agency foregrounded as learners user can ‘determine which apps to acquire and how to use them.’ In this study, the participants reported they were able to personalize their language learning to ‘achieve learning tasks quickly and easily, spontaneously and habitually, so that time could be used profitably for language acquisition’ [39, p. 877].

5.3. Serendipitous learning, purposive learning

The nature of the learning that is crammed into the capillaries of everyday life, and which is conducted and developed over time and multiple contexts, has yet to be fully explored. [26] define incidental learning that takes place with smartphones as unplanned learning with no previous goals to achieve and with no learning outcomes set. Such learning may occur while carrying out a task or while pursuing another goal. [40] suggest that there appears to be mainly 2 different types of learning engendered by smartphone use: *serendipitous* learning and *purposive* learning. Serendipitous learning is defined as learning incidentally, when participants are playing games or social networking on their smartphones. Purposive learning could be comprised of using smartphones to search for information to do homework or projects, exploring hobbies or communicating with others in communities of practice. This learning has intention, is goal oriented, and habitual with longer periods of time allocated. Thus, purposive and temporal factors differentiate the two different types of learning. Both types of learning are characterized by learners’ personal agency, satisfaction and enjoyment of their learning [9]. The findings of this study suggest that for language learning with smartphones, both *serendipitous* learning and *purposive* learning appears to be evident. Of the 12 participants in the phenomenological interviews, all 12 (100%) reported cases of serendipitous and purposive learning.

Serendipitous learning takes place when participants reported their search for meanings of words or phrases in their target foreign languages in the classroom, their spare time while waiting for friends or when they stumble upon something which they wish to translate into a foreign language or vice-versa. However, such serendipitous or incidental learning may not translate to deep learning [41] as the language learning may comprise of short, unconnected fragments with no cumulative activity [26]. It would appear that participants use surface approaches to learning [41] when they are engaged in serendipitous learning episodes as their engagements with texts and images are usually superficial and exploratory.

Some of the learning practices described by participants have a planned element. They would deliberately put aside their leisure time to learn languages, either to improve their English Language proficiency or to practice pronunciation of a target language that they were currently learning. Several of the participants reported habitual learning of English, particularly at night before sleeping, where they had allocated time to learn using apps or reading e-books in English. Deep approaches to learning appears to be displayed in participants' purposive and intense engagement with language learning. Research findings on mobile learning, especially its empirical impact on learning outcomes are yet to be conclusive [25], [26], [27]. As such, the conclusion of learning languages either incidentally or purposively in everyday settings can be only a tentative claim and of which needs to be further investigated with larger sample sizes and in different socio-cultural settings, given the small sample size of this study. Hence, the findings cannot be generalizable. As an exploratory, pilot study, these findings suggest deeper and broader investigations into how learning languages using smart device should be conducted either in the classroom or outside.

The implication, thus, for universities and secondary schools could be to investigate further if these informal language learning practices could be utilized as an extension of classroom learning. Many schools in Asia ban the use of smartphones in the traditional classrooms. If smartphones were to be allowed, teachers could plan for the purposeful use of smartphones in their teaching using the relevant apps for language learning. Online dictionary and language learning applications could be further exploited to extend such learning practices outside the classroom or as 'seamless learning' [42] that is, as a bridge between formal and informal learning contexts. Another implication for educators is to examine further the extent of the deep language learning that occurs in everyday practices. If there were purposive intent in some of these learning practices, there could be further studies to investigate the extent of the deep learning and whether such learning could be measurable.

6. Conclusion

This is an exploratory study using a mixed method design and a small, purposive sample. Findings, therefore may not be generalizable. The findings suggest that language learning in everyday lives can be either serendipitous or purposive. The purposive dimension of the informal learning suggests that educators and teachers could influence this learning through the design of homework and projects which could lead to more purposive informal learning. Traditional classrooms could incorporate some of the informal learning habits such 'learning on the go' practices into their teaching and learning. Additionally, the new knowledge that the participants mostly prefer using *Google Translate* and online dictionaries for language learning suggest that mobile apps designers should take into account the simple functionality of these apps and intentionality of the users into their future designs.

7. References

- [1] N. Pachler, J. Cook, and B. Bachmair, "Appropriation of mobile cultural resources for learning," *Int. J. Mob. Blended Learn.*, vol. 2, no. 1, 2010, pp. 1–21.
- [2] C. Crook, "The 'Digital Native' in Context: Tensions associated with Importing Web 2.0 Practices into the School Setting," *Oxford Rev. Educ.*, vol. 38, no. 1, 2012, pp. 63–80.
- [3] G. Clough, A. C. Jones, P. McAndrew, and E. Scanlon, "Informal learning with PDAs and Smartphones," *Journal of Computer Assisted Learning*, vol. 24, no. 5, Sep. 2008, pp. 359–371.
- [4] S. Pemberton, L. and Fallahkhair, "Design Issues for Dual Device Learning: Interactive Television and Mobile phone," in *Proceedings of MLEARN*, 2005.
- [5] R. Godwin-Jones, "Emerging Technologies: Mobile Apps for Language Learning," *Lang. Learn. Technol.*, vol. 15, no. 2, 2011, pp. 2–11.
- [6] A. Kukulska-Hulme and L. Shield, "An Overview of Mobile Assisted Language Learning: From Content Delivery to Supported Collaboration and Interaction," *ReCALL*, vol. 20, no. 3, 2008, pp. 271–289.
- [7] O. Viberg and Å. Grönlund, "Mobile Assisted Language Learning: A Literature Review," in *Proceedings of the 11th International Conference on Mobile and Contextual Learning*, pp. 2012, 1–8.
- [8] B. McNally, M. L. Guha, L. Norooz, E. Rhodes, and L. Findlater, "Incorporating Peephole Interactions into Children's Second Language Learning Activities on Mobile Devices," in *Proceedings of the 2014 Conference on Interaction design and children*, 2014, pp. 115–124.
- [9] N.-N. Chan, "Learning with Smartphones: A Hermeneutic Phenomenological Study of Young People's Everyday Mobile Practices.," University of Durham, 2014.
- [10] H. Ogata and Y. Yano, "Knowledge Awareness for Computer-assisted Language Learning using Handhelds," *Int. J. Learn. Technol.*, vol. 5, no. 1, 2005, pp. 435–449.
- [11] M. Sharples, J. Taylor, and G. Vavoula, "A Theory of Learning for the Mobile Age," *Learning*, vol. 85, no. 3, 2007, pp. 221–247.
- [12] V. Demouy and A. Kukulska-Hulme, "On the Spot: Using Mobile Devices for Listening and Speaking Practice on a French Language Programme," *J. Open Distance Learn.*, vol. 25, no. 3, 2010, pp. 217–232.
- [13] M. Warschauer, "Computer-mediated Collaborative Learning: Theory and Practice," *Mod. Lang. J.*, vol. 81, no. 4, 1997, pp. 470–481.
- [14] R. Ellis, *SLA Research and Language Teaching*. Oxford, UK: Oxford University Press, 1997.
- [15] J. P. Lantolf, "Introducing Sociocultural Theory," in *Sociocultural Theory & Second Language Learning*, Hong Kong: Oxford University Press, 2000, pp. 1–26.
- [16] S. L. Lantolf, J. & Thorne, "Sociocultural Theory and Second Language Learning," in *Theories in Second Language Acquisition*, B. van P. & J. Williams, Ed. Mahwah, NJ: Lawrence Erlbaum, 2007.
- [17] D. Larsen-Freeman and M. H. Long, *An Introduction to Second Language Acquisition Research*. New York: Longman, 1991.
- [18] C. Chapelle, "Multimedia CALL: Lessons to be learned from Research on Instructed SLA.," *Lang. Learn. Technol.*, vol. 2, no. 1, 1998, pp. 21–39.
- [19] H. Lin, "Establishing an Empirical Link between Computer-mediated Communication (CMC) and SLA: A Meta-Analysis of the Research," *Lang. Learn. Technol.*, vol. 18, no. 3, 2014, pp. 120–147.
- [20] C. Thornton, P. & C. Houser, "Using Mobile Phones in English Education in Japan," *J. Comput. Assist. Learn.*, vol. 21, no. 3, 2005, pp. 217–228.

- [21] C. Levy and M. Kennedy, "Learning Italian via Mobile SMS," in *Mobile Learning: A Handbook for Educators and Trainers*, A. Kukulska-Hulme and J. Traxler, Ed. London: Taylor & Francis, 2005, pp. 76–83.
- [22] G. E. Kennedy, T. S. Judd, A. Churchward, K. Gray, and K. L. Krause, "First Year Students' Experiences with Technology: Are they really Digital Natives?" *Australas. J. Educ. Technol.*, vol. 24, no. 1, 2008, pp. 108–122.
- [23] M. Trifanova and A. Ronchetti, "Where is Mobile Learning Going?" in *Proceedings of the E-learn Conference*, 2003, pp. 1795–1801.
- [24] S. Fallahkhair, L. Pemberton, L. and R. Griffiths, "Development of a Cross-Platform Ubiquitous Language Learning Service via Mobile Phone and Interactive Television," *J. Comput. Assist. Learn.*, vol. 23, no. 4, 2007, pp. 312–325.
- [25] A. Kukulska-Hulme, "Language Learning Defined by Time and Place: A Framework for Next Generation Designs," in *Left to my Own Devices: Learner Autonomy and Mobile Assisted Language Learning, Innovation and Leadership In English Language Teaching*, J. E. Diaz-Vera, Ed. Bingley, UK: Emerald Group Publishing Limited, 2012, pp. 1–13.
- [26] A. Jones, M. Gaved, A. Kukulska-Hulme, E. Scanlon, C. Pearson, P. Lamerias, I. Dunwell, and J. Jones, "Creating Coherent Incidental Learning Journeys on Smartphones Using Feedback and Progress Indicators," *Int. J. Mob. Blended Learn.*, vol. 6, no. 4, 2014, pp. 75–92.
- [27] G. Merchant, "Mobile Practices in Everyday Life: Popular Digital Technologies and Schooling Revisited," *Br. J. Educ. Technol.*, vol. 43, no. 5, 2012, pp. 770–782.
- [28] T. R. Schatzki, *The Site of the Social: a Philosophical Account of the Constitution of Social Life and Change*. University Park, PA: Pennsylvania State University Press, 2002.
- [29] Y. Song and R. Fox, "Uses of the PDA for Undergraduate Students' Incidental Vocabulary Learning of English.," *ReCALL*, vol. 20, no. 3, 2008, pp. 290–314.
- [30] J. Underwood, R. Luckin and N. Winters, "Managing Resource Ecologies for Mobile, Personal and Collaborative Self-directed Language Learning," in *EUROCALL Conference September 2010*, 2010, pp. 8–11.
- [31] R.B. Johnson and A.J. Onwuegbuzie, "Mixed Methods Research: A Research Paradigm Whose Time Has Come," *Educ. Res.*, vol. 33, no. 7, Oct. 2004, pp. 14–26.
- [32] J. W. Creswell & V. Plano Clark, *Designing and Conducting Mixed Methods Research*. Thousand Oaks, CA: Sage, 2007.
- [33] O. Gelo, D. Braakmann, and G. Benetka, "Quantitative and Qualitative Research: Beyond the Debate.," *Integr. Psychol. Behav. Sci.*, vol. 42, no. 3, Sep. 2008, pp. 266–90.
- [34] E. Husserl, *Logical Investigations. Vol I & II (trans J.N. Findlay)*. New York: Humanities Press. (Original work published 1900).
- [35] A. Giorgi, "A Phenomenological Perspective on Certain Qualitative Research Methods.," *J. Phenomenol. Psychol.*, vol. 25, no. 2, 1994, pp. 190–220.
- [36] D.E. Polkinghorne, "No Title," *J. Couns. Psychol.*, vol. 52, no. 2, 2005, pp. 137–145.
- [37] D. Crystal, *English as a Global Language*, 2nd ed. Cambridge, UK: Cambridge University Press, 2003.
- [38] M. Dewey, "English as a Lingua Franca and Globalization: An Interconnected Perspective," *Int. J. Appl. Linguist.*, vol. 17, no. 3, 2007, pp. 332–353.
- [39] C. Steel, "Fitting Learning into Life: Language Students' Perspectives on Benefits of using Mobile Apps," in *Proceedings of ASCILITE 2012 25-28 November*, 2012, no. Clil, pp. 875–880.
- [40] N.-N. Chan, C. Walker, and A. Gleaves, "An Exploration of Students' Lived Experiences of Using Smartphones in Diverse Learning Contexts using a Hermeneutic Phenomenological Approach," *Comput. Educ.*, vol. 82, 2015, pp. 96–106.
- [41] F. Marton and R. Säljö, "Approaches to Learning," in *The Experience of Learning: Implications for Teaching and Studying in Higher Education. 3rd (Internet) edition*, F. Marton,

- D. Hounsell, and N. Entwistle, Eds. Edinburgh: University of Edinburgh, Centre for Teaching, Learning and Assessment, 2005, pp. 39–58.
- [42] C.K. Looi, B. Zhang, W. Chen, P. Seow, G. Chia, C. Norris and E. Soloway, “1:1 Mobile Inquiry Learning Experience for Primary Science Students: a Study of Learning Effectiveness,” *J. Comput. Assist. Learn.*, vol. 27, no. 3, Jun. 2011, pp. 269–287.

The ISTEAM Program - Case Study: "Steaming" forward to a Multidisciplinary Approach, Innovation, Entrepreneurship, and a Start-up Culture

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Abstract

This article describes a unique curriculum and educational domain that encourages multi-disciplinary learning coupled with innovation. ORT Israel has developed a new model for Project Based Learning (PBL) enriched by the use of Information and Communications Technology (ICT). This model is entitled ISTEAM – Innovation, Science, Technology, Engineering, Art, and Mathematics. The novelty of this program is adding the I (Innovation) to the STEAM; this is the element that has earned Israel its nickname of "start-up nation". The ISTEAM curriculum emphasizes the development of emotional involvement and the encouragement of motivation among students. In addition to the skills of project management and construction of knowledge through independent learning, students experience active collaborative work. They structure ongoing exploration processes, whereby they deal with current challenges in science, engineering, technology, arts, and combinations thereof. The pilot program is currently embedded in 6 schools with over 600 Jewish and Arab students in Grades 9 through 11. Initiated in September 2015, the program is to last for over half a year and the first evaluation process is to be conducted during the spring term of 2016.

Background - beyond the era of disciplines....ISTEAM

Our era offers a rich and complex world of accessible information. It offers tools and complex communication systems that cut across space and time. The essence of the multi-knowledge, multi-channel, multi-options of this reality and the widespread use of digital technology affect all aspects of human life. This also poses challenges and raises critical questions about the existing learning culture and the relevance of the education system for our students' future lives and careers. It urges a shifting from a discipline-centered paradigm controlled by partial and 'absolute' knowledge to one that imparts the ability to cope with complex and constantly changing knowledge.

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In recent decades, the need for a transition from a closed, discipline-based curriculum to the development of dynamic curricula and learning environments has become ever more apparent. This new integrated approach involves developing learning processes that explore complementary domains of knowledge and encouraging creativity and its expression in a wide array of contexts. At the heart of this new approach lies the concept that epistemological knowledge of a discipline does not enable an individual to represent the transformations, changes and creative outcomes that occur in a meaningful learning process, and that exclusive reliance on one discipline is now seen as artificial and restrictive.

In 2014, Israel launched a new [national curriculum](#) [11] with an emphasis on meaningful learning. Since the core of this new program focuses on adapting the education system to the 21st century – it enabled ORT Israel Network [13] to develop a unique curriculum - ISTEAM, based on multi-disciplinary learning processes.

The ISTEAM (Innovation, Science, Technology, Engineering, Art, and Mathematics) curriculum is an example of an innovative educational approach that combines the perspectives of different disciplines to inform a major project which reflects the developmental needs of individual learners and of the society to which they belong. Moreover, this curriculum aims to bridge the gap between the knowledge acquired in school and the real-world knowledge outside the education system. The current need for flexibility requires graduates to have the skills and an arsenal of tools appropriate to the dynamic lifestyle of our complex and diverse world.

The innovative pedagogy for ISTEAM embraces the use of 21st century skills as defined by PISA [14], with a wide variety of teaching techniques that provide a thorough understanding of useful performances and behaviors in both the real and virtual worlds. It also models function, management and leadership opportunities and challenges. As innovation is defined as a deliberate educational activity that displays new ideas in a given context in order to significantly improve the ability to learn through interaction and interactivity, it is important to add constructivist processes anchored in the knowledge-based learning project, which deals with authentic real-life problems (Mioduser et al, 2004, [12])

The roadmap for implementing these ideas is via Project Based Learning (PBL) techniques. Through the use of Information and Communications Technologies (ICT) and collaborative learning we can improve the readiness of our young people in terms of the social and work skills they will need in their future real-world careers. In the ISTEAM approach, ICT serves as a platform for collaborative communication and production applications. For example, in many cases the students use infographics to present their products and collaborative tools to engage in group challenges. An example of using infographics is Wordle, the word cloud generator.

Two key facets make this program unique. The first one is upscaling: this is not a local episode in a particular class, but is being applied in a wide array of classes in various schools all over Israel. Secondly, it functions in a specific framework: not within a particular existing discipline, but as a special discipline of its own. These two facets have earned the program the [ETF](#) Good Practice Award in the area of youth entrepreneurship training (ETF, 2016, [8]).

Following the rationale of embracing a multidisciplinary approach, below are the principles of the ISTEAM curriculum, as defined by its Steering Committee:

- blurring of boundaries between disciplines in which the student is enrolled, as well as strengthening disciplinary and interdisciplinary teaching and learning.
- restructuring of school and timetable so that the ISTEAM model, PBL and ICT become key factors in the school's pedagogical and social activities.
- establishing school learning processes that combine meaningful PBL with an emphasis on innovation and entrepreneurship.
- incorporating the principles of alternative assessment including project portfolios, presentations and face-to-face interviews.
- implementing educational work processes based on ICT, encouraging collaboration and content generation processes using a variety of digital tools.
- deepening linguistic literacy as part of the ISTEAM emphasis on cross-disciplinary vocabulary.

The ISTEAM model clearly supports the principle of instilling linguistic literacy, as well as enhancing other literacies. The term “literacy” has changed in recent decades. Its definitions may vary according to the domain to which it is applied, such as financial literacy or reading literacy. The scientific literacy definition according to PISA 2015 relates to three components: scientific explanation of phenomena, evaluation and design of scientific inquiry, and scientific interpretation of data and evidence (Duschl, Bismack, [6]). When referring to the merging of several areas, PISA has determined that literacy incorporates an awareness and appreciation of the contexts in which texts are constructed, mathematics is used, and science operates, and an ability to apply the knowledge, understanding and skills specific to the appropriate domain to a wide range of contexts in the world outside the classroom (PISA [14]). This definition of literacy goes beyond the narrower conceptions of content knowledge to offer a holistic view of the subject matter. This might strengthen the "knowledge about" the discipline which is so difficult to achieve (Chores, 2009 [5]).

The ISTEAM learning approach allows an overview of the various areas of science and engineering with different depths of knowledge in the field. Learning in this manner develops a broad perspective of science and engineering disciplines, of product design processes, and of the systemic approach. This mode of teaching and learning allows students to develop the professional language of the 21st century, connecting the fields of science, engineering and design. A 6:30 minute [video](#) gives an idea of the wide scope of the program in Israel.

ISTEAM in action

Activating this innovative program requires a special preparatory phase at school. The following aspects have to be considered:

- It is necessary to develop a school model based on in-depth learning of at least one of the areas included in the multi-disciplinary curriculum. This is in order to give the students hands-on experience in skills such as teamwork, research and development,

problem analysis, presentation of ideas to the public, and dealing with issues that involve different areas.

- This new approach to education focuses on the interface between several disciplines pertinent to system engineering. Hence, complex logistics pertaining to the organizational structure of the school must be taken into consideration.
- It is important to emphasize the development of motivating tools and factors that stimulate competition between groups, and positive emotional involvement in particular.
- There must be focus on the process the students are experiencing. Project success means significant team work among students and not just the product itself.
- The change agents – the teachers – must be focused on, especially in the pilot program. In order to get a sense of the method they are asked to implement, the teachers are asked beforehand to experiment and submit a product in the same manner that their students will experience. Thus teacher training must be a prerequisite preliminary stage for running the program in schools.
- Concepts in mother tongue connected to reference vocabulary through a cross-disciplinary context must be taught.

The essence of the ISTEAM perception is the customized curriculum presented to the students. This should fit each team respectively for the project they are undertaking. The backbone of the study program consists of ten stages:

1 - *Exposure*: Students are exposed to the ISTEAM model during a single week, centered around school activity that suspends regular school life. Content, skills and tools that define the innovative learning environment are introduced to the students. Content includes: multidisciplinary thinking, free thinking, curriculum rationale, the components of ISTEAM and expected products. In addition, students are also introduced to assessment methods, data recording tools and reflective feedback. During that week, the first attempts at forming groups are made and the issues of roles, processes and feedback within the group are clarified.

2 - *Initial Thinking*: Group formation is encouraged on the basis of ideas, and not just on the basis of friendships. This involves analyzing personal aspects such as what I am good at, what I know, what interests me, what I love to do, what I can do well, etc. This can be achieved through role-play games. Groups thus formed then engage in brainstorming through a general discussion, relating to problem formulation and scheduling. Students are introduced to ICT tools, thinking tools such as concept maps and logical reasoning, and other necessary skills such as documentation processes and computerized database data. Computerized work environments such as Wiki are presented to enable students to practice collaborative team work. This includes building norms of cooperation, and thinking about coping in the event of disagreement.

3 – *Definition of the problem/need*: Each team formulates the main idea using the web for informatics purposes. One option is the joint construction building of a Wiki site that supports collaborative work. Another option is preparing a visual product which must be recorded such as a presentation, a drawing, or a video.

An example of a product at this stage is shown in in the Figure 1, taken from a video clip presenting the concept of an "erasable table":



Figure 1: Defining the problem

4 – *Presenting ideas and receiving feedback*: At this stage teams present their ideas to their classmates in order to receive constructive feedback. Effective self-reflection is also a skill that has to be taught.

An example of the initial presentation of the "no-sweat shirt" is given in Figure 2:



Figure 2: Presenting the concept and getting feedback

Steps 5 through 8 are executed spirally a number of times until they have been fully refined:

5 – *Studying*: At this stage students deepen their knowledge of the subject matter, prepare for an interview with an expert and learn some advanced tools relevant for their project.

6 – *Gathering information*: Students search for additional information and tools that were offered to them in the program. The information may be specific content, statistical data, measurements, observations, interviews and more.

7 – *Interim evaluation*: The purpose of this stage is to determine whether the project is proceeding in the right direction or is in need of correction. Feedback from group members or the facilitator may enrich the project by finding connections between disciplines, construction or correction of a concept map, and checking planning versus performance.

8 - *Writing a Wiki entry*: This section is used to reflect the individual learning process of the students in teams. Students write a Wiki entry derived from their personal experience of the project process and link it to the entries of the other members of their team.

9 - *Preparing the final product*: This stage is dedicated to producing the project's output, including updating of the final presentation. In order to demonstrate the appeal of this program not just to those who have an analytic thinking, but to "everyone", examples of products that could fit the Art element of ISTEAM might include an animation, a sculpture, a story, an interview, a community service, an excursion etc.

10 - *Presenting the project*: This should be done in the framework of a Peak Day. This is a day dedicated to presenting projects to an audience. It is important to remember that this step is part of students' learning process. The projects do not necessarily come to an end at this stage, but may continue on as a final school project, an entry in various project competitions, and even end up as real products.

Project assessment is based on three dimensions, each of which is divided into certain criteria. Each dimension is allocated one of three levels: Required level not yet attained, Adequate level, and High level

The array of dimensions is as follows:

- **Initiation (20 points)**: This is assessed through the 'doing' part and aims to send a message that is not only the final result that is important, but also the process itself. Its three assessment criteria are: initiation, innovation and complexity.
- **Product (30 points)**: This is assessed towards the end of the project and consists of six criteria: rationale, innovation, complexity in ISTEAM terms, quality of workmanship, creativity and applicability.
- **Presentation (20 points)**: This is assessed at the final stage and consists of 10 criteria: language and vocabulary, refinement of message, adaptation to audience (creating interest and adjusting the level to suit the audience), mastery of knowledge displayed, answering questions from the audience (if presented in the plenum), critical thinking, usage of measures that contribute to display, group work while displaying output, timely presentation of the product and finally, organizing before the presentation.

In addition, we built two more indicators based on the same three levels as described above (Required level not yet attained, Adequate level, and High level):

- **Team work (20 points)**: This has four criteria: performing, initiative and leadership, support and social interactions. These criteria apply to the single student in the group, whereas the above-mentioned criteria apply to the team.
- **Marketing, external relations and public relations (10 points)**: This also has four criteria: contact with foreign officials, using research tools such as survey / interviews / observations, support of external factors and advertising the initiative.

However, what about students who cannot not fit into a group project for various reasons?

Students who did not join any of the team projects, or were not satisfactorily involved, are required to write and submit a written paper on a topic such as: Israel - The Start-Up Nation. One of the components of the score for this paper is an oral and visual presentation.

ISTEAM in practice

In the pilot program, preparations were made for principals, teachers, and students:

Principals: The program was presented to 6 school principals who wished to participate and requested to be included. Mostly, their choice stemmed from their motivation to generate a change in the school's spirit, and the confidence in their ability to lead the teachers in this mission. The schools are from different parts of Israel, 5 Jewish schools and one Arab school, in which the language of instruction is Arabic and not Hebrew.

Teachers: 50 leading teachers of various disciplines were chosen from these schools. In each school, one teacher was put in charge of running the program. The leading teachers were selected mainly for their curiosity, their drive for change, and their broad view of educational processes. They participated in an extensive 60-hour training course delivered in two stages: (a) 30 hours based on professional content of ISTEAM integrative learning, the power of ICT and PBL skills. This approach was based on the on the work of Bradshaw (Bradshaw et al. 2012 [3]) (which encourages response to teachers' reflective practices, matching the teaching and learning demands of the 21st century. (b) 30 hours focusing on educational management aspects such as the role of the leading coordinator, process moderation, and dealing with success and failure. These capabilities are important to the success of the program, alongside a high level of uncertainty for certain knowledge areas and the challenges chosen by the students.

The training course objectives were: (1) Designing and engineering educational initiatives through PBL using a STEAM multidisciplinary approach, alongside application of 21st century thinking skills – I – Innovation. (2) Encouraging team work, documentation processes, critical and creative thinking, and intelligent and effective use of online environments. (3) Learning to plan PBL initiatives based on the ISTEAM approach in collaborative teams. (4) Promoting mother tongue literacy, as well as other literacies, as part of the writing and oral expression processes in the ISTEAM program.

Students: Over 600 students in 25 classes are participating in the pilot program, which is operating in a variety of formats: seven classes are 9th grade, one class is 11th grade, and the remaining 17 classes are 10th grade. The schools also differ in how the program is run: in two schools, three classes of engineering sciences with excellent students were selected, and in all the other schools the students study in heterogeneous classes. This array gives a variety of designs which will enable wise planning of the project for the following year. The choice to focus on middle school age (9th grade) is based on Jeong (Jeong, 2015, [10]), but we chose to expand the pilot to high school students as well.

Prior to entering the program, the students were informed about its objectives and its special educational activities during the week in which the program was introduced in various attractive ways. The activities provided details about the objectives, a description

of the learning process and how it is assessed. In order to increase motivation, a special emphasis was placed on its advantages and benefits for the students. A significant step is the initial formation of the study teams, including aspects of composition and selection of the team, team roles, and rules of debate and decision. The goal of this phase is to create heterogeneous groups, to be composed of students with knowledge expertise in a variety of disciplines. We recommended that the selection into groups be conducted jointly by teachers and students so that it would not rely only on social preferences. Prevention of rejection or regard for students dislikes were taken into consideration. This also enabled use of an optimum diversity of ISTEAM fields, as excellent students who might choose engineering, science and math, could cooperate with peers who might choose to study humanities such as art (Jeong, 2015, [10]). In order to help teachers, team-building activities and recognition of the various interests of students emphasizing the advantage of heterogeneous groups were conducted.

Evaluation

Evaluation of the pilot phase is being conducted by the Henrietta Szold Institute, Israel's national institute for research in behavioral sciences (Henrietta Szold Institute, [15]). Assessment is both qualitative and quantitative across several dimensions:

Principals: Since the principal is the "engine" driving the ISTEAM "train", interviews were held to gain insights into the keys to success, and the risks one should be aware of in order to prevent failures. Sample questions: Has the ISTEAM program changed your management insights? If so - how? What steps have you taken in order to promote the project among your staff?

Leading teachers: Since the teachers are the change agents, it is important to listen to them. An open discussion session was held at the end of the training course in order to generate recommendations for the next course. A number of insights emerged, such as their degree of satisfaction with the ISTEAM curriculum, and missed opportunities that should be taken into consideration. One teacher commented: "At first I did not connect to the idea, and now I don't understand why the entire education system doesn't work this way"

Students: At the heart of this program lie our students. It is important to understand what they have gained, what went wrong, what needs improvement. To obtain answers to these questions, the students will be monitored twice, by two means described below: The first round of assessments is conducted in the middle of the program, and second round, towards the end of the process. The assessments are conducted online, based on the belief of Cleary, Callan, and Zimmerman (2012, [4]), that assessment tools examining regulatory thought and action as they occur in real time during a particular task have the potential to provide useful information. Our multiple monitoring fits their recommendation that a multidimensional assessment approach that includes various types of self-reports and teacher ratings may prove to be a most valuable approach towards understanding human regulation.

The first means of assessment is an online questionnaire each student has to complete. The questionnaire revolves around five key issues: personal relevance of topics covered in

ISTEAM, the uncertain, temporary state of technological knowledge, a critical voice providing a legitimate expression of critical opinion, shared control of the learner involved in determining the planning, management and evaluation of learning and in fact the responsibility for learning and collaborative learning, student negotiation discussions with other learners to explore new ideas, and finally, attitudes toward the ISTEAM program. The first five scales were recommended by Fraser and Tobin (1991) and Tobin and Fraser (1998) in the study of Aldridge, Fraser, and Taylor (Aldridge, Fraser, and Taylor, 2000, [1]). The attitude scale was built following the work of Han, Sun Young and Carpenter (2014) [9]. Items on this scale address basic personal resources such as connection and belonging, efficacy and autonomy which might increase in PBL methods of work (Assor, Kaplan, 2001 [2]).

The second means of assessment is an online questionnaire in which each teacher assesses 15 students: 5 weak, 5 average and 5 good students. The distinction is made by the teachers themselves. Both of these questionnaires are based on a 5-point Likert scale.

Both questionnaires have been validated according to the recommendations of Ebrahimi (Ebrahimi, 2013, [7]). Triangulation will be performed by combining the data from both the qualitative and quantitative methods.

Alongside the many advantages of the ISTEAM program, its expansion into the entire education system requires careful consideration. This should take place alongside continuing development of updated teaching materials and teacher training processes that will enhance the promotion and implementation of the multidisciplinary approach in the future. As the addition of the Arts to the STEM did in the past, we hope that the addition of Innovation to the STEAM approach will take matters one step further.

Nobel Laureate, Professor Dan Shechtman, a member of the ISTEAM program steering committee, has succinctly expressed our aims as follows: “Hi-tech, creativity and entrepreneurship go hand in hand. The idea is to teach every child in Israel entrepreneurship like you teach mathematics, physics, chemistry, and English.” (ETF, [8])

Acknowledgements:

This work was enabled through the support of a few highly valued members of the ORT Israel network: Mr. Gadi Herman, Dr. Eli Eisenberg, Mr. Ran Soffer, Mr. Yoel Rothchild, Dr. Tziona Levi, Mr. Shai Stern, Mr. Doron Drucker and Mrs. Michaela Ziv.

References

[1] Aldridge, J.M., Fraser, B.J., Taylor, P.C. "Constructivist learning environments in a cross-national study in Taiwan and Australia", *Int. J. Sci. Educ.*, 2000, vol. 22, no. 1, 37- 55

[2] Assor, A. & Kaplan, H. (2001). "Mapping the domain of autonomy support: Five important ways to enhance or undermine students' experience of autonomy in learning".

In Efklides, A., Sorrentino, R., & Kuhl, J. (Eds.) *Trends and Prospects in Motivation Research*. Holland: Kluwer

[3] Bradshaw, P., Twining, P., and Walsh, C. S., 2012. "The vital program: transforming ICT professional development". American journal of distance education, 26(2), 74-85.

[4] Cleary, T., Callan, G., and Zimmerman, B. (2012). Assessing Self-Regulation as a Cyclical, Context-Specific Phenomenon: Overview and Analysis of SRL Microanalytic Protocols. Education Research International Hindawi Publishing Corporation Volume 2012 (2012) Article ID 428639, 19 pages

[5] Choresh, C., Mevarech, Z. R., and Frank, M., "Developing argumentation ability as a way to promote technological literacy", International Journal of Educational Research, v48 n4 p225-234 2009

[6] Duschl, R., Bismack. A. "Reconceptualizing STEM Education. The Central Role of Practices". Edited by Richard A. Taylor & Francis Group, New York, 2016

[7] Ebrahimi, N, "Constructivist Translation Classroom Environment Survey (CTLES): Development, Validation and Application" Translation & Interpreting Vol 5, No 2 (2013) <http://www.trans-int.org/index.php/transint/article/view/214/138>

[8] ETF - European Training Foundation:

http://www.etf.europa.eu/web.nsf/pages/ETF_Enterpreneurship_Training_Awards___EN

[9] Han, S.Y., Carpenter, D., "Construct Validation of Student Attitude toward Science, Technology, Engineering, and Mathematics Project-Based Learning. The Case of Korean Middle Grade Students", Middle Grades Research Journal, Volume 9(3), 2014, pp. 27–41

[10] Jeong, S.), Kim, H., "The Effect of a Climate Change Monitoring Program on Students' Knowledge and Perceptions of STEAM Education in Korea", Eurasia Journal of Mathematics, Science & Technology Education, 2015, 11(6), 1321-1338

[11] Ministry of Education, Israel (2015). The National Program– Adapting the Education System to the 21st Century- vision and rationale.

http://cms.education.gov.il/EducationCMS/Units/MadaTech/englishsifria/AdaptingtheEducationSystemtothe21Century/Vision_and_rationale.htm

[12] Mioduser, D., Nachmias, R., Forkosh-Baruch, A., Tubin, D. (2004). "Sustainability, Scalability and Transferability of ICT-based Pedagogical Innovations in Israeli Schools". Education, Communication & Information, Vol. 4, No. 1, March 2004. <http://muse.tau.ac.il/publications/87.pdf>

[13] ORT Israel Network. <http://en.ort.org.il/>

[14] PISA - Measuring Student Knowledge and Skills. The PISA 2000 Assessment of Reading, Mathematical and Scientific Literacy

<http://www.oecd.org/edu/school/programmeforinternationalstudentassessmentpisa/33692793.pdf>

[15] Henrietta Szold Institute, the National Institute for Research in the Behavioral Sciences. <http://www.szold.org.il/?CategoryID=156&ArticleID=686&sng=1>

A Global Network for Deep Learning: the Case of Uruguay

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Abstract

The aim of this paper is to describe an innovative large-scale action research in the field of education. This paper illustrates a unique sample of a global network of schools working together as a "living lab" to test, implement and improve innovative pedagogical practices in seven different countries (clusters). This experience can be regarded as a disruptive experiment from the methodological (i.e. network of schools), pedagogical (i.e. learning by creating) and accountability perspective (i.e. novel ways of assessing learning outcomes). This global network allocates special relevance to the cultural and contextual specificities of each member. This paper focuses on the Uruguayan case, the only non-developed partner country, which is working in incorporating up to 2,800 schools in this global network by the end of 2019. After providing a background and key figures of the current education system in Uruguay, the authors describe the outcomes of this experience so far (2013- 2016) and highlight some of the expected achievements and instruments to assess the second phase of this experience (2016-2019), with special emphasis in the design of new metrics and the adoption of new assessment tools. After stating the conclusions, the paper points out the limitations and further questions to be explored along the implementation of this global experiment in education.

2. Introduction

2.1 NPDL and Uruguayan educational reality.

New Pedagogies for Deep Learning Global Partnership (NPDL) is a large-scale action research, which offers a remarkable opportunity of national and international cross collaboration. This partnership is conceived as "living lab" to test and improve different ways to implement innovative pedagogies.

Hereby "living lab" is understood as a formal and/or informal coalition of various organizations engaged with open innovation. The co-creation and exchange of its members is integrated with research and systematic innovation processes [1]. Real-life scenario inputs are also considered to co-design, explore, experience and evaluate different forms of innovation: a) Co-creation:

adoption of technology to integrate a diversity of views, constraints and knowledge sharing that sustains the ideation of new scenarios, concepts and related artefacts. b) Exploration: engage all stakeholders, especially user communities. c) Experimentation: users can adopt and evaluate innovation in their context. d) Evaluation: assess new ideas through various dimensions making observations on the potentiality of a larger adoption as a result of its confrontation with different users and contexts [2].

NPDL is a multi national initiative which includes seven countries or clusters (Australia, Canada, Finland, Netherlands, New Zealand, United States, Uruguay) which joined the movement creating a network of over 500 schools worldwide. In Uruguay, this initiative is implemented in partnership by two institutions: the National Administration of Public Education (ANEP), and Plan Ceibal (the Uruguayan implementation of One Laptop per Child). NPDL is known in Uruguay as the Red Global de Aprendizajes (redglobal.edu.uy)

Uruguayan education system is going through a crisis, mainly affecting middle school education. This crisis is quantified by critical indicators such as dropout and repetition rates. The official reports indicate that only 70% of the children who start middle school are able to complete this cycle, and only 40% of the students who start high school, are able to graduate (Observatorio de la Educación, ANEP, 2014). In turn, repetition is still used as a pedagogical strategy and it shows high rates, especially in 1st year middle school, where up to 30% of the children repeated 1st year in 2013.

In what refers to the structure, the Uruguayan education system is in general a very traditional one, highly centralized and vertical. Teachers at all levels are subject to an external accountability system of supervision and have little opportunities of working in collaboration. There is also a problem of quality in the initial training and lack of teachers in some content areas, which affects mainly Secondary schools.[3][4]

The indicators of performance in academic evaluations also show poor results in the area of Maths (see e.g. the latest PISA evaluation, which shows that the performance of Uruguayan students has decreased, OCDE Report 2016). The results are socially stratified, students from low income families systematically show lower levels of performance, thus creating a growing social gap and increasing inequities. In a more subjective and qualitative domain, Uruguayan middle school education is struggling with students boredom and lack of interest in school, and teachers stress and suffering in isolation. This situation, although not new, seems to be hard to reconcile with highly positive characteristics of Uruguay as an egalitarian country, with a strong-middle-class, a stable democracy, modern and advanced legislation, low levels of corruption, and the ideal of social development based on capacity building and education [5] .

This situation of education in Uruguay can be explained in a broader crisis affecting middle schools in many regions of the world. It is thus clear the need for debating, sharing and searching together. The integration of Uruguay to the NPDL movement is rooted in that exact intention of searching for ways of exploring with others alternatives and innovative ways of facing this reality. There is no previous experience in Uruguay of participating in a global intervention of this scale, not to mention to embrace such an ambitious international educational agenda.

The general goal of NPDL in Uruguay can be summarized as the implementation of a pedagogical approach called "deep learning" where “students will gain the competencies and dispositions that will prepare them to be creative, connected, and collaborative lifelong problem solvers and to be healthy, holistic human beings who not only contribute to, but also create the common good in today’s knowledge-based, creative, interdependent world.” [6]

The specific goals of this initiative in Uruguay are:

- Offering teachers new ways of presenting and working with contents. In particular, the teachers in the schools that are part of NPDL are invited to work in multidisciplinary projects oriented to solving real life problems connected to students interests.
- Experimenting on new ways of evaluating both content and cross curricular competences (also known as the “6 Cs”: communication, creativity, critical thinking, collaboration, citizenship, character).
- Creation of school networks for collaboration and exchange, on the basis of common interests and concerns, based on a non-judgemental and cooperative spirit.

In order to achieve the previous goals, this global network aims at fostering capacity building as well as assessing deep learning initiatives, trying new models of pedagogies, exploring new ways of assessing knowledge as well as adopting and improving a set of collaborative tools and novel teaching and learning methodologies.

Some of the key features and concepts that describe this action-research intervention are:

Deep learning: A pedagogic approach which is framed in problem based learning experiences, generating a set of conditions that allow to better connect trans-disciplinary knowledge applied on specific problems or challenges where students are invited to improve and exchange the knowledge and skills they have. [7]

Global approach: This partnership integrates a large group of schools from different countries interested in participating in this initiative. Each country has the possibility of adapting and contextualising the project according to the local characteristics, interests, needs and idiosyncrasies. This becomes a challenge of ‘cultural translation’ in terms of applying this intervention in countries with very different educational systems and backgrounds.

Networked based structure: The schools that participate are not structured under a specific hierarchy, but in an intertwined network of collaboration that enables the possibility of a more horizontal collaboration between schools (e.g. open exchanges from school-to-school, peer based collaboration between participant students, creation of communities of practice, peer based assessment, among others). These exchanges allow for flexible and dynamic ways of sharing and building knowledge. Additionally, with the use of digital technologies this collaboration and knowledge exchange can be done with participants from distant locations.[8]

The global network in Uruguay is implemented through two main components: capacity building, and new measures. Each of them has its specific agenda and is organized considering the phases of what is called the Collaborative Inquiry Cycle (a methodological approach that has four stages: Evaluation, Design, Intervention and Self reflection or analysis).

Capacity building: The main goal is building collective knowledge and expertise focus on the new pedagogies for Deep learning in three key areas required to conduct NPDL approach: leadership and change management, collaborative-project based learning, and new measures. In 2015 the project implemented the first series of workshops and virtual courses. Between February and March 2016 a new edition of workshops and courses started, with the participation of local and invited facilitators.

New measures: This is a key area of the project. Teachers participating in the project will be invited to implement new measures at the school level, the evaluation applied to every student, and self evaluation [9][10]. The underlying assumption for the implementation of an agenda of new measures proposed by NPDL is that by using innovative tools for assessing the cross-curricular competences teachers will be able to: a) learn the relevance of competences as opposed to purely content instruction; b) understand the importance of using detailed, objective and tested tools to evaluate students' progress; c) adopt the idea of progression as opposed to a standard based evaluation.

Table 1. This table illustres the organization of activies and assessments involving principals, teachers and students along the year.

Once a month Cluster meetings are held in order to achieve two main purposes: inform about the cluster status on the Global agenda, and exchange information on each country's own projects. Although annual proposals are based on common goals, each Cluster has developed interest for specific areas. Australia and Uruguay, for example, are working on the adaptation of new measures tools for making them accessible for students as understandable feedback. Canada and Australia, in turn, have been developing rubrics for assessing activities and combining results with the process assessment.



The case of Villa Cardal School (Florida, Uruguay)

- **School principal:** At the beginning of the year, principals attend the launching workshop. By the end of April, principals have prepared the school’s rubric that contains an evaluation of the situation and conditions for change and submit the rubric to the central team.
- **Teachers:** Educators participate at workshops and enroll in virtual courses since the beginning of the school year. The first module of the course focusses on evaluation, guiding teachers through the progression application and submission process. Teachers are expected to submit progressions data (evaluation of two of the six competences) during April and May. The second module of the course starts engaging teachers in the design of deep learning activities.
- **Students:** At the beginning of the school year (March), students answer a nationally administered questionnaire about their activities and interests. Teacher can access their students’ answers. Students engage in a collaborative project activity where two schools work together using videoconference. The project demands problem solving through peer learning (6th grade primary school students with 1st grade secondary school students in different schools). The implementation phase consists of working on geometry problems by tessellation. During the implementation phase teachers submit the exemplars using a design protocol. Teachers exchange planning designs using free online tools. In December the evaluation is done using the progressions rating to assess the process and a rubric to assess the activity. The moderation process takes place at the end of the year, so that the activity enters a general repository for other teachers to access it.

Figure 1. Villa Cardal School Year Calendar

3. Action Research - what are the goals, target, social innovation interventions.

This paper describes a large-scale action research regarded as a “living lab” to test, implement and improve innovative pedagogical practices in seven different countries.

A purposeful sampling [10] is used here to describe a relevant information-rich experience. In order to do that the 200 participant schools from Uruguay are included in this analysis. Rather than providing information that can be generalized, the idea is to point out the lessons learned so far and highlight the key factors that need to be considered during the coming years of the intervention. The outcomes of this experience are organized in two stages. The first one (2013-2016) is a compilation of qualitative and quantitative outcomes which illustrate the early adoption of this intervention. While the second stage (2016- 2019) still undergoing, will require to identify, develop and implement new metrics and novel assessment instruments [11].

4. A two stages action research results - (and how they will be measured/ registered): New Assessment - Collaboration.

4.1. Stage one: a summary of innovation drivers to be highlighted from the implementation (2013- 2015) so far are:

Some of the elements that make this Uruguayan initiative particular are:

Scale: As known by previous studies in many cases innovation in education is conducted through pilot experiences, which might be difficult to scale up at a national level. In other cases this interventions are implemented in an ideal context or highly controlled educational environment (e.g. Small schools or a well off institution) [12] [13]. However in this case the context is different, during the first year of field-work implementation (2015), the project included 100 schools. In 2016 the project doubled the number of schools to 200, and the goal is to expand progressively to include the 100% of the public schools (2800) in the next four years.

Multiple innovation fluxes: Although the project was designed by a group of experts in pedagogy, the implementation of the project requires the development of phases of innovation. This innovative process needs to be adapted and adopted from the foreign context and translated into national and local practices. In this case the experience integrates a complex but dynamic set of communities. In other words, in Uruguay different strategies for change can be found, *top-down innovations* which come from the government (ANEP, Plan Ceibal, Ministry of education, etc.) to the schools; as well as *bottom-up innovations* which move from schools and local communities who are part of this network, and *open innovation*, which implies innovation among different schools regardless if they are in the country or part of this global network.

An ‘invisible’ role of technology: Plan Ceibal was created in 2007 as a digital inclusion program to provide technology to all students in Uruguay. Likewise, information technologies are adopted by the NPDL to leverage the power of digital tools in a innovative but also flexible way. The project includes six key cross curricular competences (the mentioned “6Cs”) considered as the main capacities to be promoted by the students and teachers. The development of these competences are closely intertwined with the use of technologies. However, the integration of technology is considered a tacit capacity (the training on digital tools is not considered a priority) but the school-to-school as well as country-to-country exchanges of those involved in NPDL play a key role during the whole experience. Technologies are chosen by students (not by teachers) only when they add value to their learning experience. Students are allowed to adopt what they consider relevant such as programming, robotic, video-conferencing, social networks, among others. See the following samples: 1) *Robotic*: where kids work together on coding and robotic projects facilitating team building, problem-solving but also self-esteem, creating an environment of mutual trust. 2) *DeepChallenge.org*: where creative groups from around the world work in partnership to explore solutions to common challenges. As these experiences illustrate, although technology is not per se a goal within this intervention, the strategic and savvy use of technology is considered as a key enabler which facilitate collaboration and knowledge building. 14]

Teachers as Students: The NPDL aims to generate a whole ecosystem of change by integrating a holistic systemic approach of the project, by implementing long term processes and enabling intra – inter connections between participant institutions. The NPDL cluster assembles top down policies along with bottom up feedback, which works as a two ways negotiation stream between educational priorities on the political agenda and feedback from different institutional levels.

In what follows, the authors offer a summary of some of the evidences and work-in-progress made by the communities of teachers involved in NPDL Uruguay.

- A book with a collection of ten academic papers written by participant teachers who describe their experience in this first two years participating in NPDL. The title of the book is “Thinking outside the box”. The aim of the volume is to give voice to teachers that are innovating at their school or classroom level, and to offer an opportunity of professional development through the process of academic writing, external review process, feedback and rewriting on the part of the teachers. The first edition of this book was December 2015; the plan is to publish a selection of papers every year.

- A national scale survey that explores students interests and beliefs. With the goal of exploring students’ interests, the NPDL team prepared a survey that will be administered online to students in NPDL schools. However, the authorities of Secondary School decided to extend it to all schools in the country. During March and April 2016, when students return to school after summer holidays, they will complete a survey with questions about their thoughts, interests, and opinions about school, subject areas, free time activities, among others. This type of data collection about students’ interests has not been done before in Uruguay. The fact that this survey will take place is important not only because of the information that will provide to the system, but also because of its symbolic value of giving a voice to students. The results of the survey will be available by May 2016.

- Uruguay suggested the regular proposal of “Deep Challenges” where any group of students and teachers in the world could participate, as a way of motivating NPDL communities to think about global problems, get organized in groups, propose creative solutions and discuss with others. A problem is presented by one of the seven countries of the NPDL network through the global hub and it remains open for a period of four weeks. The topics or “challenges” are rooted in real life problems; they typically have both a global and local dimension, so that participants are able to imagine solutions that go beyond their immediate context and are encouraged to exchange ideas globally. The NPDL Project endorsed this initiative as a part of its annual plan. In 2015, four deep challenges were launched (deepchallenge.org): 1. “The device of the future (How a no-carbon footprint device would look like?)” (created by Uruguay, launched in July 2015); 2. “How can we eat better to live better?” (created by USA, launched in August 2015); 3. “The world needs sustainable sources of energy. How can we harness the power of the sun to improve our lives?” (created by Australia, launched in October 2015); 4. “How can we communicate transcending language?” (co-created by The Netherlands and Uruguay, launched in November 2015). A total of 121 proposals were submitted in 2015, including the participation of countries such as Argentina, Peru or Colombia.

- Training for school principals and teachers on Leadership and Change Management. Four workshops including more than 300 teachers each year and one annual virtual course with more than 1500 teachers enrolled were offered to teachers in Uruguay in order to develop the key skills embraced by this intervention. School leaders and teachers were guided through new topics such as leadership and change management. These areas of training are rarely included in the training of school principals and supervisors. As a consequence, the principals build their authority in seniority and experience, but have no training in strategies for conducting change, identifying opportunities and leading teams. The training also includes pedagogical strategies to foster deep learning practices among students.

4.2. Stage two: A summary of expected outcomes and factors to be assessed during the second phase of the intervention (2016- 2019):

The global network of learning was not conceived to improve students' scores in any particular discipline but to expand, diversify, and bring more relevance to the educational agenda. The nature of these goals can hardly be measured by a summative assessment or by a particular standardized test. Given the ambitious objectives, the scale of the intervention, as well as its disruptive approach, it will be challenging to pre-establish how to create the needed accountability, as well as registering in a systematic and reliable way those middle and long-term outcomes that this experience is intended to generate.

The implementation of the NPDL in Uruguay invites schools to work with a plan of action that establishes goals in terms of: a) participation in training events, both face to face and distance courses; b) preparation of "deep learning activities" (DLA), following a specific protocol and using the technological tools provided to be shared with other teachers. Once the teachers propose DLA, they go through a process of exemplar moderation, in which teachers from other schools comment, give feedback and ask questions to the creators of the DLA. c) administration of the rubrics for self evaluation of the school (with the school principal as the leader of the process), students progress on the competences and teachers self-evaluation.

By the end of 2016, the schools participating in the project will have worked on all (a, b and c) components of the project, that is, a number of teachers in each school will have completed the course, created, proposed and uploaded DLAs, participated in the moderation process of other teachers' DLA, and worked with the new measures proposed by the NPDL team.

Specific attention will be given to collaborative work, which in this experience is understood as the collective conduction of the different tasks and activities proposed by the NPDL team, in particular, preparation of DLA and administration of new measures of student progressions.

The activities presented above are prepared by teachers using a learning management system that will allow the conducting team to gather specific data of teacher participation.

5. Conclusions and final observations.

This paper analyzes an ambitious mid-term action research in the field of education. One of the most remarkable features identified in this analysis is the implementation of a collective

innovative pedagogical approach grounded on a global network of collaboration and a multi stakeholder partnership where collective creation of knowledge plays a key role.

In the case of Uruguay, digital technologies are regarded as key enablers for the social construction of knowledge, although the use of the technologies as such are not described as one of the goals of the experience, the idea is to use them as tools to offer more flexible ways of knowledge building. That is why it is considered as the “invisible” (tacit) role of technology.

Although the rhetoric of innovation and education is widely spread in today’s literature (i.e. 21st century skills, schools 2.0, digital tutors, flipped classroom, etc.), the time frame that these changes require to be embraced in the culture of the organizations are not always considered. Therefore, the fact that in Uruguay NPDL has been design as a mid term intervention (2013-2019) is seeing as an opportunity that may foster a culture of change within the education sector.

Some of the challenges that this initiative includes are:

1) *lack of a single and unified metric* - different from the score in traditional standardized tests - which can be used to assess and trace the learning path and the development of skills that are the goal of NPDL in the students involved in the project,

2) related to the previous one, the real accountability of this experience can be difficult to illustrate under a specific assessment or standardised test. This will require to *identify alternative learning outcomes and novel ways of recognizing learning and innovation.*

These pieces of evidence will necessary be connected to the use of technology, the integration of collaboration from a global perspective, and project based type of teaching;

3) considering that this project aims to *tackle some of the most change-resistant rationales and practices embedded into traditional education systems* it is considered possible that some communities might try to neglect or avoid these "disruptive" practices and keep their traditional way of teaching the traditional curriculum.

4) constancy and consistency. Although participation is voluntary for all schools and teachers, constant participation is considered one of the main challenges for the project. Only one third on the total amount of teachers enrolled fully completed the courses and even less completed all assignments. *There is a clear need to pursue new ways to strengthen and foster capacity building.*

As stated above, the NPDL project in Uruguay presents both challenges and opportunities. Some of them are probably specific to the Uruguayan case, but most could be seen as more general. These may apply to other countries that aim at introducing new ways of dealing with the problems of traditional models of education. NPDL aims at creating the need for a student-based model, where curricular content is organized considering students’ interests and real life outside schools. Also, new associations between students and teachers are fostered, where both are considered as learners and teachers guide students that are genuinely involved in projects. Finally, one of the defining properties of NPDL is providing a set of tools and a specific agenda

for implementing new measures. These would allow to better understand the conditions for change at the school level, as well as the progression that students experience in the development of cross-curricular competences. The main challenges relate to the fact that new and different approaches that question the very foundations of the system are typically resisted by part of the education community, teachers, principals and even parents. Whether Uruguay will be able to successfully implement the NPDL project, and expand it to all schools in the country in the next three-year period, remains to be seen and we believe is worth analyzing closely. It will require great capacity for negotiation and persuasion as well as the capability of showing positive results and reassure teachers in their new role. In this sense, the Uruguayan case could be considered as a living lab for experimentation on change in education.

Bibliography

- [1] Pallot, M., Trousse, B., Senach, B., Scapin, D. (2010) *Living Lab Research Landscape: From User Centred Design and User Experience towards User Cocreation*. 1st EU Summer School "Living Labs". Paris.
- [2] Schuurman, D. Marez, L.D., & Ballon, P. (2016) *The impact of Living Lab Methodology on Open Innovation Contributions and Outcomes*. *Technology Innovation Management Review*, 1(6): 7-16
- [3] Faltan docentes de varias materias. (2014, March 8). El País. Retrieved March 7, 2016, from <http://www.elpais.com.uy/informacion/faltan-docentes-varias-materias.html>
- [4] Falta asignar más 10.000 horas de docentes en liceos. (2015, March 16). El País. Retrieved March 7, 2016, from <http://www.elpais.com.uy/informacion/falta-asignar-horas-docentes-liceos.html>
- [5] Western European Cities Top Quality of Living Ranking - Mercer. (2016, February 23). Retrieved March 7, 2016, from <http://www.mercer.com/newsroom/western-european-cities-top-quality-of-living-ranking-mercero.html>
- [6] Fullan, M. (2014). *Big City School Reforms Lessons from New York, Toronto and London*. Toronto, Ontario Principals Council: NY, Teachers College Press
- [7] Fullan, M., Langworthy, M. (2013) *Towards a New End: New Pedagogies for Deep Learning*. Obtenido de <http://www.newpedagogies.org/>
- [8] Fullan, M., & Langworthy, M. (2014). *A Rich Steam: How new Pedagogies find deep learning*. London: Pearson.
- [9] Hess, K. (2008). *Developing and Using Learning Progressions as a Schema for Measuring Progress*. Obtenido de www.nciea.org/publications/CCSSO2_KH08.pdf
- [10] Davidson, E. J. (2013). Actionable Evaluation Basics: Getting succinct answers to the most important questions. Real Evaluation. <http://www.amazon.com/gp/aw/d/1480102695/>
- [11] Lawrence, A. P., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2013). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Administration and Policy in Mental Health and Mental Health Services Research*. Retrieved March 7, 2016, from

https://www.researchgate.net/publication/258315317_Purposeful_Sampling_for_Qualitative_Data_Collection_and_Analysis_in_Mixed_Method_Implementation_Research.

[12] Towne, & Shavelson (2002) *Scientific Research in Education*. Washington DC: National Academy Press.

[13] Baumert J, Lüdtke O, Trautwein U, Brunner M: *Large-scale student assessment studies measure the results of processes of knowledge acquisition: evidence in support of the distinction between intelligence and student achievement*. *Educational Research Review* 2009, 4: 165–176.
doi:10.1016/j.edurev.2009.04.002 10.1016/j.edurev.2009.04.002

[14] Fullan, M. (2013). *Stratosphere: Integrating Technology, Pedagogy, and Change Knowledge*. Toronto: Pearson.

What role do “power learners” play in online learning communities?

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Abstract

This study focusses on the role of highly active participants in online learning communities on Facebook. These people, often known as “power users” in the literature on social computing, are a common feature of a wide range of online learning groups, and are responsible not only for creating most of the content but also for getting discussion going and providing a basis for other’s participation. We test whether similar dynamics hold true in the context of online learning.

Based on a transactional dataset of almost 10,000 interactions with an online community of 32 postgraduate students who were following the same online course, we find evidence that power users also exist in the context of online learning. However, whilst they do create a lot of content, we find that they are not fundamental to keeping the group together, and in fact are less adept at creating content which generates responses than other “normal” users. This suggests that online learning communities may have different dynamics to other types of electronic community: it also suggests that design efforts should not be focused solely on attracting a small core of “power learners”. Rather, diverse types of users are needed for online learning communities to survive and prosper.

1. Introduction

In recent years, social media platforms such as Facebook have become an integral part of the educational experience. A wide variety of schools and colleges have experimented with making use of these platforms to directly complement learning activities; many groups of students also set up ad-hoc groups on social media platforms of their choosing as a complement to their course [1]. The potential of social media platforms for supporting learning is clear [2]; and the fact that these platforms also form part of students’ lives outside of the classroom means that there are far fewer barriers to adoption and uptake than there are with bespoke educational tools [3].

The usefulness of social media for learning means there is a wealth of literature studying its adoption and uptake [2], [4]. However, while work has emphasised the importance of social media platforms, individual differences in experience are large: some classrooms boast vibrant online discussions running parallel to the offline learning activity, whilst other communities attract little participation. In other words, the richness of interaction varies in online communities. Yet we know little about the factors driving this variation.

In this study, we place a focus on the concept of *power users*, a term taken from the field of social computing which describes individuals who make a disproportionately large contribution to online activities. Power users have been observed in a wide variety of online contexts such as Wikipedia editing groups [5], usenet discussion forums [6] and citizen science communities [7]. In addition to creating significant portions of the content, they have also been found to be crucial for getting things started [8], to take on key leadership roles [9], [10], and hence to stimulate the participation of others. This has driven some to argue that retaining these power users should be a key focus when designing online activity [11].

It seems likely that power users might play a similarly important role in online learning communities which complement classroom activity. However, online educational groups also have a crucial difference to platforms such as Wikipedia: they complement existing offline activities, and hence provide an alternative community for people to interact (rather than the only community). Whether online or off, learning is an interaction between individuals, involving the sharing of information, negotiating of roles, and the establishing of communication norms and practices [12]. While power roles in these interactions have been negotiated for decades, the online environment offers unique opportunities for student participation and an emergence of new roles and practices. As yet, to our knowledge, no study has yet addressed whether power users are indeed as important in these new learning communities as they are in other areas.

We propose two fundamental questions related to the role of these users in learning communities, whom we dub “power learners”. 1) Are power learners naturally committed to the learning community, or do they decide to become more involved progressively? Power users typically show high levels of activity from the beginning of their participation [13]; though studies have also suggested that power users can also learn as they develop [14]. Does the same hold true for online education? 2) Are power learners crucial for starting and maintaining online education communities? In other contexts, such as Wikipedia editing, active early involvement of a small mass of committed participants is crucial for starting collective activities [8]. Is this also the case when it comes to online education?

2. Methodology

Although a growing body of literature argues that this is the Big Data era, where privacy is concerned it is also increasingly important to recognize the value of ‘small’ sampling [15], [16] which can be done with the active consent of participants, as this allows a much richer view of what happens in an individual group. Therefore, our data describe interactions of 32 masters and PhD level students in a Facebook group specifically set up to promote interaction amongst a real life masters cohort during their year-long interdisciplinary study programme at a large UK university. Our dataset records the time of all interactions with the group, and whether the interaction consisted of a novel posting to the group or a comment on a previous posting. All

members signed an informed consent form prior to data collection. One member of the group, we should note, did not consent to data collection: hence their data was not collected.

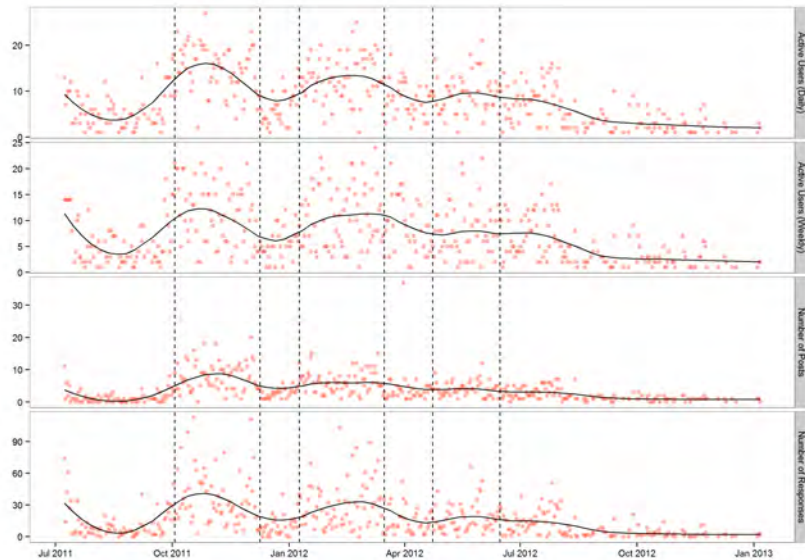


Figure 1 – Activity in the Facebook group over time

General levels of activity in the group are displayed in figure 1. The group was a highly active one: in total almost 10,000 contributions were made during the window of observation, with an average of around 4 novel posts per day and 18 responses to those posts. Remarks within the Facebook group were typically brief, fitting in with the general format of social media: an average of 470 words appeared every day. Contribution levels were typically higher during term time, and levels generally declined from the start of the course in October, though the group was still attracting a non-trivial amount of traffic even six months after the course finished (it finished in approximately September 2012). The number of daily and weekly active users remained high until the course ended as well.

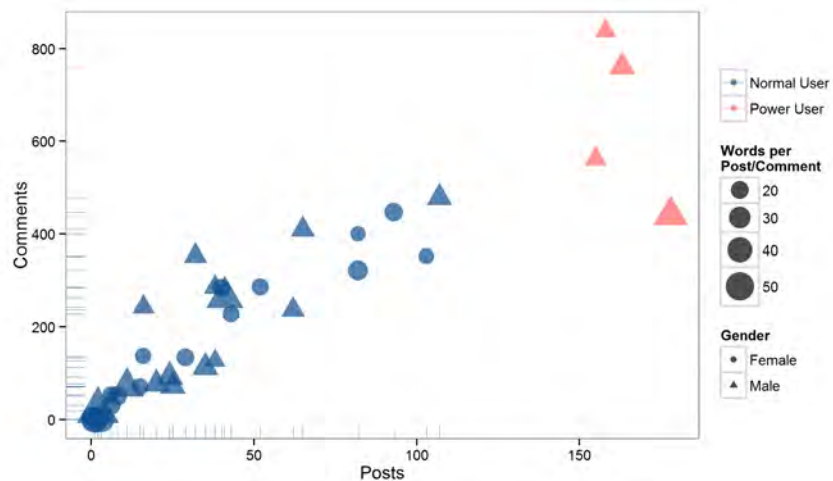


Figure 2 - Distribution of posts and comments per user

How are comment activities distributed amongst individuals? This is explored in figure 2, which shows the number of posts and comments per user. Most members made a high level of contribution (the median user made 285 separate posts or comments to the group). But there is clear evidence of “power learners”, if we consider these people to be outliers in terms of the number of contributions they make. Two members are clear outliers in terms of number of comments made (each posting around 800 comments), whilst these two and two others are clear outliers in terms of number of posts made (each making over 150 posts). These four users are the ones we will consider to be power learners and they are marked in red in the image.

3. Results

We will begin with our first question: what explains the emergence of power learners? As we highlight above, previous literature has identified two competing perspectives on this question: first, that they are naturally predisposed to take on this high activity role; and second, that they are much like normal users when they begin to interact with the online groups, but gradually take on the mantle of power learner as time goes by.

One way of assessing this is to look at whether power learner activity is different during the early days of interaction with a community. Figure 3, plots the cumulative number of contributions made by each user to the Facebook group, with power users highlighted in red. For the two most active users, the decisive moment came between 75 and 100 days after their initial posting: up until this time, they were still the most active members, but they were by no means outliers in terms of contributions made. For the third and fourth most active users, the separation takes place even later. On this basis, it does not appear that people were “natural” power learners when they arrived.

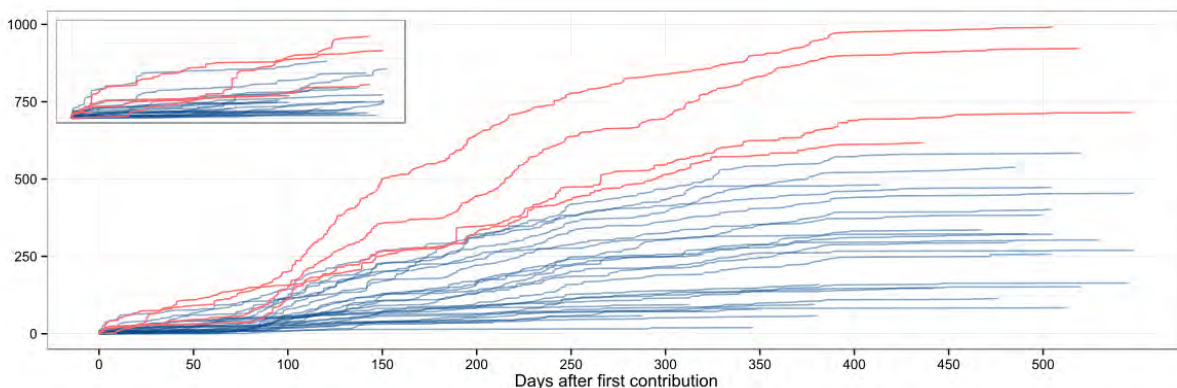


Figure 3 – Cumulative contributions by user type. Power learners are highlighted in red. Inset shows the first 50 days of activity

However, if we look more closely at interactions occurring during the earliest part of the group, a slightly different picture emerges. The boxplots in figure 4 show the amount of contributions made by users in the first day, week and month of their participation on the site. This plot highlights that, generally, power learners were noticeably more active than normal users even during their earliest interactions with the site (even on the first day they started using it).

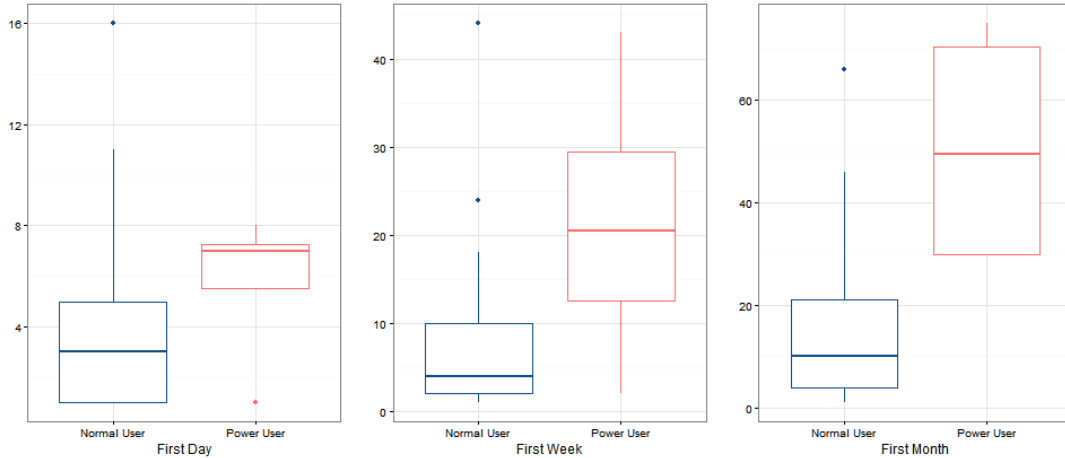


Figure 4 - Number of contributions by normal and power learners during the early parts of the group

This shows evidence, in other words, that the power learners were predisposed to be somewhat more active than other users when they originally arrived in the group (and in terms of predisposition, it is also worth noting that all the power learners were male, even though males and females were split approximately 50-50 within the cohort, see figure 2 above). However the decisive break with other users then emerged later on during the course.

We will now move onto our second question: do power users drive the activity of the group? We will assess this question in two parts. First, we look at the role of power learners in generating content for the Facebook group, both in terms of their own postings and in terms of driving others to comment. Second, we will look at their role in terms of holding the community together.

In terms of absolute volume of activity, we have already highlighted how power learners contributed a significant amount to the Facebook group: indeed, this is central to their definition. However it is worth noting that this level of contribution nevertheless constituted less than half of the overall activity of the group. This is explored in figure 5. The top right panel of figure 5 shows the number of posts per day created by different user types. We can see that the amount created by power learners never exceeds that created by normal users (until right at the end of the observation window when the course itself was long finished). The bottom right panel looks at the rate of responses generated to posts. We can see that, throughout the lifetime of the course, the posts of power learners attracted slightly fewer comments than those of normal users. The left panel shows total posts to the group and response rate: we can see that power learners received no more responses than other users.

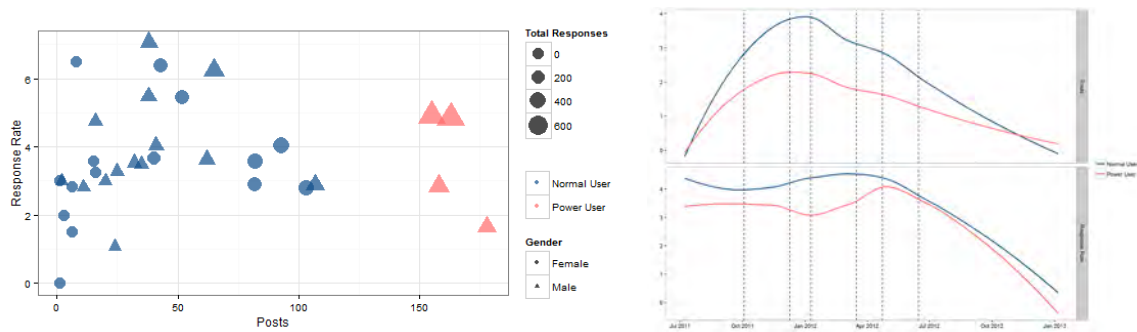


Figure 5 – Posts created and response rates (left panel), local regression line showing the evolution of posts and response rates (right panel)

This finding is reinforced by table 1, which is a logistic regression which seeks to explain why some posts received a comment whereas others did not. It includes three control variables: whether the post contained a question mark (which increased the likelihood of a response by 174%), the number of words in the post (with each word increasing the likelihood of a response by 1%), whether the post contained a link (which decreased the likelihood of a response by 49%). It also includes a variable for whether the user was a power learner or not, which shows that posts created by power learners were in fact 22% less likely to receive a response. All these findings were statistically significant at conventional levels.

	β	$\exp(\beta)$	P
(Intercept)	0.80	2.22	***
#Question Marks	1.01	2.74	***
#Words	0.01	1.01	***
#Links	-0.66	0.51	***
Created by Power User	-0.25	0.78	*
<u>Nagelkerke R-sq.</u>	0.12		
N	1721		

Table 1 – Logistic regression explaining the likelihood of a post receiving a response

The conclusions from this section are quite surprising. Power learners do generate a lot of content, and hence also generate a lot of responses. But they are not especially talented in generating responses: in fact, their activity was less likely to attract a response than that of a normal user.

We will now move on to our second perspective on the importance of power learners. Past work has shown that online learning groups can usefully be considered as “networks” [17], with each node in the network a user and each link being a time when one user responded to another. This helps identify whether the network is fragmented into distinct groups (which perhaps only talk amongst themselves). It also helps identify which users are crucial for holding the network together (perhaps by creating connections between people who otherwise would not communicate).

Figure 6 visualises this online learning community as a network. Each individual panel in the picture is a month of activity in the Facebook group, starting from October when the course started

and ending in June. The left hand set of nine networks shows the full network, with power learners included (again highlighted in red). The right hand set of networks are visualized with the same layout but without the power learners included.

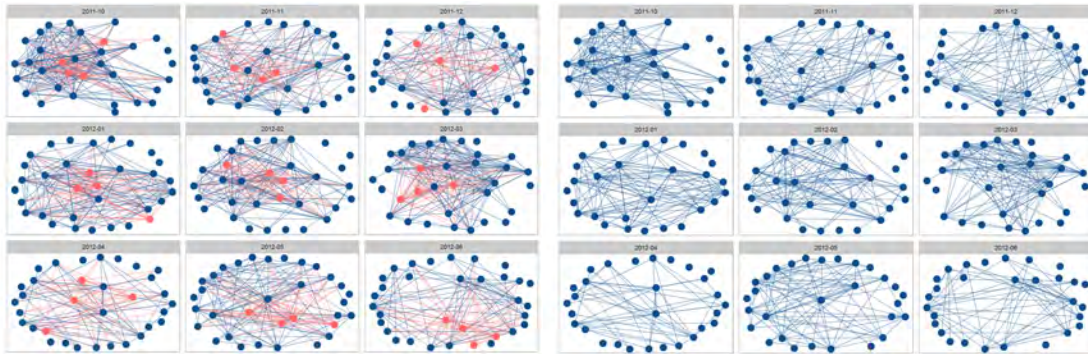


Figure 6 – Community considered as a network with power learners (left panel) and without power learners (right panel)

Two findings are apparent from these images. First, the network itself shows little evidence of being fragmented into groups. Rather, each month there is a core of well-connected users (in the centre of each graphic) and a periphery of less well-connected users. Second, as we would expect given their levels of contribution, the power learners are almost always near the centre of the graph, showing that they are typically quite well connected to all other parts of the network. However, if we remove them, we can also see that the network remains quite tightly connected, with a group of other nodes providing for connections between individuals. Hence power users themselves do not seem to be fundamental in keeping the network together.

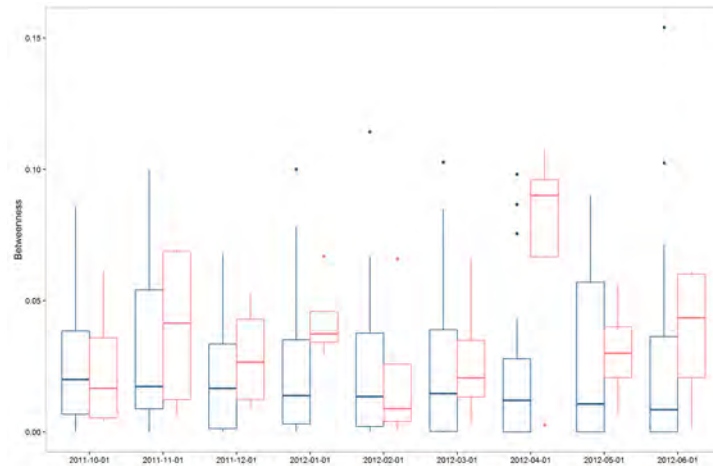


Figure 7 – Betweenness centrality for different user types over time

This finding is reinforced in figure 7, which looks at the “betweenness centrality” [18], [19] of each node in the network for each of the months in figure 6, and plots the distributions of these centralities as boxplots (again, power learners are in red). Betweenness centrality is a concept in network science which measures the extent to which a node is central to a network, on the basis of

how many other pairs of nodes it sits between. It is especially helpful in capturing the extent to which nodes are important in terms of facilitating communication between other pairs of nodes within a network.

We can see that, for many of the months, power learners have values of betweenness centrality which are systematically higher than for normal users. However it is not the case for all months, and only in the last three months do the values become considerably higher. Interestingly therefore, this seems to show that, rather than getting the network started and holding it together at the beginning, these power learners are more active in terms of trying to hold it together towards the end as the group as a whole peters out.

4. Conclusions

This article aimed to investigate the role of power users in online learning communities, whom we have called “power learners”. It has produced three main findings. First, we have shown that these users do seem to be naturally predisposed towards becoming high activity users, as they are more active even from the first day they start interacting with the community. However, it also takes time before they truly distinguish themselves as power learners. Second, we have shown that power learners create a lot of content, but they aren’t above average in terms of their ability to generate responses to that content or generally get discussion going. Indeed, posts by power learners were in fact less likely to receive a response than posts by other users. Third, we have shown that, if we consider the online learning community as a network, power users can be shown to be central to the communication patterns of that network, but not absolutely vital. Furthermore, rather than getting things going, their centrality seems to increase as time goes on, suggesting they are trying to hold the Facebook group together while it starts to die out. All these findings suggest that, while power learners are clearly important in online learning communities, they are not fundamental, and that design efforts do not need to focus solely on attracting them. They also suggest that online communities which complement offline activities may well have very different behavior patterns to communities which only operate online.

It is worth concluding by highlighting the principal limitations of the study. Most obviously, the size of the community is small, and furthermore findings are based on just one community. Hence it is unclear the extent to which these results can be generalized. Furthermore, we know little about the type of communications being made within the group – it could be that power learners are creating more “influential” posts, but we lack detail on the topics of what was being produced. In further research it is recommended to include in-depth qualitative analysis of specific issues such as comments or responses from participants. The authors also do not know the extent to which the activity in the Facebook group correlates with offline results in the educational programme being undertaken: whether being a key part of the learning community was correlated with success, or made no difference at all.

Another limitation is the qualitative diversity of the group studied. This study focused on a limited group of highly educated students (32) who were part of an elite university in the UK. It is recommended to study groups with a higher number of members and a more diverse population. Future research should examine what types of roles and contributions are provided by different type of users present in online learning. Additionally, further work that addressed these gaps could enhance our knowledge of the role of “power learners” in online communities. All that might help

not only to better understand the kind of interactions that best describe online learning communities but also enable the identification of critical factors to facilitate and support better learning experiences for those who learn using the Internet.

The authors wish to acknowledge contributions made by Dr. Rebecca Eynon, the two anonymous reviewers and also would like to thank the students for sharing their social network group data for this study.

6. References

- [1] M. Bulger, J. Bright, and C. Cobo, “Why do MOOC users meet face to face?,” *Information, Commun. Soc.*, 2015.
- [2] G. Grosseck, “Using microblogging for collaborative learning,” *Proc New Technol. Platforms Learn. {...}*, p. 212, 2009.
- [3] M. D. Roblyer, M. McDaniel, M. Webb, J. Herman, and J. V. Witty, “Findings on Facebook in higher education: A comparison of college faculty and student uses and perceptions of social networking sites,” *Internet High. Educ.*, vol. 13, no. 3, pp. 134–140, 2010.
- [4] J. V. Lock, “Laying the groundwork for the development of learning communities within online courses,” *Q. Rev. Distance Educ.*, vol. 3, no. 4, pp. 395–408, 2002.
- [5] K. Panciera, A. Halfaker, and L. Terveen, “Wikipedians are born, not made: a study of power editors on Wikipedia,” *Hum. Factors*, pp. 51–60, 2009.
- [6] S. Whittaker, L. Terveen, W. Hill, L. Cherny, P. Ave, and F. Park, “The dynamics of mass interaction,” *Proc. CSCW 98, ACM Conf. Comput. Coop. Work (Seattle, WA, Novemb. 14-18, 1998)*, pp. 257–264, 1988.
- [7] H. Sauermann and C. Franzoni, “Crowd science user contribution patterns and their implications,” *Proc. Natl. Acad. Sci.*, p. 201408907, 2015.
- [8] R. Priedhorsky, J. Chen, S. (Tony) K. Lam, K. Panciera, L. Terveen, and J. Riedl, “Creating, destroying, and restoring value in wikipedia,” in *Proceedings of the 2007 international ACM conference on Conference on supporting group work - GROUP '07*, 2007, p. 259.
- [9] B. Butler, L. Sproull, S. Kiesler, and R. Kraut, “Community Effort in Online Groups: Who Does the Work and Why?,” *Leadersh. a Distance*, pp. 1–32, 2003.
- [10] T. Schoberth, J. Preece, and a. Heinzl, “Online communities: a longitudinal analysis of communication activities,” *36th Annu. Hawaii Int. Conf. Syst. Sci. 2003. Proc.*, pp. 216–225, 2003.
- [11] J. Preece and B. Shneiderman, “The reader-to-leader framework: Motivating technology-mediated social participation,” *AIS Trans. Human-Computer Interact.*, vol. 1, no. 1, pp. 13–32, 2009.

- [12] C. Haythornthwaite, "Learning relations and networks in web-based communities," *Int. J. Web Based Communities*, vol. 4, no. 2, p. 140, 2008.
- [13] K. Panciera, A. Halfaker, and L. Terveen, "Wikipedians are born, not made: a study of power editors on Wikipedia," *Hum. Factors*, pp. 51–60, 2009.
- [14] S.-W. Huang, M. (Mia) Suh, B. M. Hill, and G. Hsieh, "How Activists Are Both Born and Made," in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI '15*, 2015, pp. 211–220.
- [15] danah boyd and K. Crawford, "Critical Questions for Big Data," *Information, Communication & Society*, vol. 15, no. 5. pp. 662–679, 2012.
- [16] A. McAfee and E. Brynjolfsson, "Big data: the management revolution.," *Harv. Bus. Rev.*, vol. 90, no. 10, 2012.
- [17] N. Gillani, T. Yasseri, R. Eynon, and I. Hjorth, "Structural limitations of learning in a crowd: communication vulnerability and information diffusion in MOOCs.," *Sci. Rep.*, vol. 4, p. 6447, Jan. 2014.
- [18] S. Boccaletti, G. Bianconi, R. Criado, C. I. Del Genio, J. Gómez-Gardeñes, M. Romance, I. Sendina-Nadal, Z. Wang, and M. Zanin, "The structure and dynamics of multilayer networks," *Phys. Rep.*, vol. 544, no. 1, pp. 1–122, 2014.
- [19] A. Maireder, B. E. Weeks, H. G. de Zuniga, and S. Schlo gl, "Big Data and Political Social Networks: Introducing Audience Diversity and Communication Connector Bridging Measures in Social Network Theory," *Soc. Sci. Comput. Rev.*, p. 0894439315617262–, Dec. 2015.

Implementing an Online ESL program for Off-line Schools in Putumayo-Colombia.

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Abstract

One of the main challenges for online or virtual implementation of learning strategies in rural areas has been the quality of Internet access. In this document we will present the case of an educational infotronic strategy used in the Putumayo Department (Colombia), where the implementing agencies created an off-line strategy using an Intranet and local-storage/remote-management strategies designed to prioritize Internet access and the advantages of web design in order to overcome the lack of the required broadband Internet access in twenty-five schools of the region to implement an online ESL program. We will present this case, both as a model for other implementing agencies to repeat, but also, as a cautionary tale of different elements that government institutions and implementing agencies should take into account when developing technology appropriation projects, particularly in educational settings, in order to have more successful programs.

1. Introduction

In today's hyper-connected society, Internet has begun to be considered a public service, or even more, as an essential right of the population [1]. International organizations have called for governments and private institutions to take advantage of Internet's potentialities in social and economic development projects [2]. Within those projects, Education, and mainly Online Education has been seen as a key element that might guarantee equality and increased access.

However, having entered the second decade of the 21st Century we have realized that there is an inherent problem with using Internet as a tool to increase equality: Quality of access to Internet affects the level of access to education [3]. Contrary to the original idea, Internet access has become another criterion for separation; the so-called digital divide is nothing else than the differentiation of two segments of the population marked by their access and pertinent use of information available in digital networks [4]. Furthermore, it is now clear that having a bad Internet connection, although it allows people to use the Net, it does not appear to foster social and economic development [5]. Cultural aspects and technological infrastructure seem to affect a person's ability to pertinently use technology and therefore, their possibility to close the digital divide.

Thus, without investment in infrastructure and cultural appropriation, Online Education can become an element that potentiates those with a good access to Internet, and segregates those without it, or even those with a bad connection.

In this document, we want to present a particular case, in which a governmental program in technological appropriation was presented with the problem of having insufficient Internet access to achieve the project's educational goals; and how the implementing agencies re-aligned key components of the program in order to overcome this problem, and managed to implement a solution pertinent to the region, and to the satisfaction of the community. The project in question was the "Tabletas para Educar" (Spanish for Tablets for Learning, hereinafter TPE) program in Putumayo – Colombia.

To present this case, we will follow this structure: First, we will present the Background of the Project, highlighting the situation of Putumayo, the specifics of the Program, as well as the initial conditions in which the Project supposed to be implemented, the reality of the schools at the moment of the implementation; in a second part, we will present how the use of an Intranet and the implementation of an Educatronic strategy were key to overcome the difficulties; and finally, we will present the results of the implementation of the Educatronic strategy and will make a series of recommendations to implementing agencies and Government offices for future technology appropriation programs.

It would be pertinent, before entering into the specifics of the case, for the reader to familiarize with the concept of Educatronics; an idea that was fundamental in the creation of the initial program, and the evolution of the infotronic strategy to overcome the problems.

The concept of Educatronics was originally developed to identify the usage of Educational Robotics in face-to-face learning [6], later applications of the concept, however, broadened the concept to include different strategies of educational practice in online scenarios, mostly furthering the concepts of e- and b-learning.

In this sense, the definition used by Cote is particularly apt, as it resumes Educatronics as a model of educational infotronics that includes e-learning (as the learning of theory), e-training (as the learning of practice), and trainer-devices (as tools to consolidate learning) [7]. This approach focuses on the creation of a didactic model that can be implemented to learning scenarios in which high levels of interactivity are needed between the teacher and the learner.

Developed from this idea of Educatronic didactics, the definition of Educatronics used by the LatinCampus Organization incorporates the concept to the idea of integral learning solutions, to create strategies that do not necessarily require high-quality Internet connection to create interactive scenarios. Under this perspective, there are four key characteristics in any Educatronic strategy: Desynchronization, Multiple spaces, Individual rhythms and Multiple styles; the presence of these four elements indicates the existence of an educatronic learning strategy, if and only if, the information presented to the student is mediated by an infotronic tool, in the form of Pedagogic Mediators, Digital Trainers or Educatronic-Devices [8]. By this perspective, when creating an educatronic solution, the four key characteristics must be evaluated in order to assess if a strategy truly responds to an infotronic strategy.

For the purpose of this case, we consider Educatronics to be a didactic model that aims to create educational strategies supported by infotronic tools that allows desynchronization, use of multiple spaces for learning, and fosters the creation of individual rhythms and multiple styles of learning. Educatronic strategies can be structured under three categories:

e-learning, e-training and/or trainer-devices. Having defined Educatronics, we can now begin the presentation of the case.

2. Background of the Project

Putumayo is a department located in the southwestern region of Colombia, being part of the border of Colombia with Peru and Ecuador. The department is geographically located in the Colombian Amazonia, and most of its territory is comprised of dense Tropical Forest, with some mountainous range in the northern region, part of the Andean Node. The department has a territory of 24,885 km² divided in thirteen municipalities, and it houses a population of 337,054 inhabitants, making it one of the least densely populated departments in Colombia [9].

Given its location and terrain, entering Putumayo is difficult by itself. Putumayo's most populated city is its capital Mocoa, located at 478 km of Bogotá, Colombia's Capital District, administrative and economic center, however, the travel distance between Bogotá and Mocoa is of 618 km, and it usually takes between 11 and 12 hours via National Road. This Road is the only terrestrial access to Mocoa (and to Putumayo). Regarding aerial access, only one commercial airline enters Putumayo, but it only has one programmed flight per day. Furthermore, Putumayo's social instability has made access even more complicated.

Perhaps as a result of its distance from the Capital and the difficulty of access itself, or, as some authors argue, due to the difficult transition for Colombia to become a fully consolidated State [10], Putumayo has been marked by the presence of guerrilla, counterinsurgent and, for the last two decades, drug trafficking and smuggler groups [11]. Considered a "red zone" by the authorities [12], Putumayo has been a target for illegal groups that control large territories, mainly near the borders with Ecuador and Peru. The constant power struggles of these groups with the Colombian Government, and among themselves usually have a heavy toll on civilian infrastructure, mainly access roads and bridges; a situation that has further isolated Putumayo.

This isolation, added to the social instability of a debilitated state and heavy insurgent presence has turned Putumayo into a socially and economically depressed department, ranking usually below-average in social equality [13], technological development [14] and educational achievements [15]. This is why projects aiming to increase any of those indicators must present particular strategies that do not require access to large technological infrastructure.

The TPE program is a governmental initiative created by the ICT Ministry and the Education Ministry, in which Departments and Municipalities were asked to present technological provision projects for institutions. The program is mainly a technological provision program, this is, the expected result of the program is mainly the installation of the equipment, in this case the tablets, to the beneficiary institution, and a basic training in its use [16]. Academic results or usage impact are rarely evaluated in these strategies.

Within this program, the LatinCampus Organization, a not-for-profit knowledge industry focused on educational research, and I3NET, a private corporation focused on developing technological infrastructure, [hereinafter the Implementing Agencies] established an alliance with the Government of Putumayo to provision 25 schools of the Department with 4000 tablets for students and 250 laptops for teachers. To increase the aggregated value of

the project, the implementing agencies agreed that the project needed to include an educational component: The implementing agencies would conduct a Diagnostic Test in English as Second Language (ESL) on the students to measure the level of the student's skills, and the implementation of series of online resources complementing the results of the Test. The main idea of this educational component was to allow institutions to appropriate the provided technology in order to prevent the storage and lack of use of the technology, a common problem in technological provision problem, according to the Government.

Thus, the project as was presented and approved to be implemented started with the provision of the technology to: 1) perform a series of online Diagnostic Tests to measure student's skill in ESL; 2) to train teachers and students in the use of the technology used during their free time; 3) to support teachers in the implementation of the resources in their English classes during a period of 1 year; and 4) to perform a final Test to measure the impact of the project in technological appropriation and ESL skills.

The content of the ESL resources and the Tests to be implemented were managed and stored directly in the implementing agencies Central Servers in California – USA, so the program was structured upon the belief that the institutions in which the program was to be implemented had Internet. In fact, the selection of the beneficiary institutions was done by the Government taking into account three criteria: 1) That the project had the largest territorial impact possible; 2) that the project benefits the largest amount of students; and 3) that the schools had the needed infrastructure to support the project, particularly connection to the electric grid and Internet access.

Despite these criteria to be the basis for the selection, when the Implementing Agencies arrived to the schools two problems became evident: the lack of quality Internet access in the selected schools, and the lack of communication from the local administration with the institutions. These two problems threatened to seriously affect the implementation of the project.

The most vexing problem was the lack of the desired quality of Internet access in the institutions. Local government had selected the institutions based on their internet access and infrastructure. According to governmental records the twenty-five institutions were beneficiaries of the “Vive Digital” program, a nation-wide program to guarantee broadband Internet access to education institutions [17]. Theoretically, these institutions had a high-speed wireless broadband internet access available to students, and each institution had –at least– one “ICT room” with an average of 30 terminals with Internet access. These were the expected conditions at the moment of the design of the project.

However, when implementing the project, out of the twenty-five institutions, only two had internet access available to students and teachers. Other twenty-one institutions only had Internet connection from a single terminal, usually located in the Principal's Office or the Teacher's Lounge, and the terminal was restricted to administrative purposes. The remaining two institutions (located in Puerto Leguizamo) did not have any form of Internet connection. In this scenario, the ESL resources and the tests were almost impossible to implement.

Looking at this problem –ex-post– one of the main reasons why this problem occurred in the first place, was the lack of proper validation done by the Government before selecting the institutions. The Government had implemented the Vive Digital program, but it had not reviewed the quality or the effective *in-site* implementation; and, when selecting the

institutions to be beneficiary of the TPE program, the government officials were only concerned with the fact that the institution “had Internet” according to their records, without visiting or consulting the beneficiary institutions on whether they effectively had the service, nor reviewing with the Implementing Agencies if the quality of the service the institution had was enough to serve the purposes of the program.

And this consideration takes us to the second problem the Implementing Agencies faced, the lack of communication to the beneficiaries which created misconceptions as to the purpose of the program. Local authorities failed to develop promotion and community awareness strategies regarding the purpose and scope of the project. Even after the selection of the beneficiary schools, these institutions had no knowledge of the project. When the implementing agencies arrived to the institutions there were a series of mixed feelings and expectations regarding the purpose of the program. Some teachers believed the project was implemented to increase Internet access to the institutions, while others believed the program was implemented as a replacement for the English Class.

These misconceptions created awkwardness in the initial work with teachers and educational institutions, because the initial expectations were far from the real scope of the project. Even worst, the educational community felt excluded from the project and thus began to actively work against the implementation of the project, to the point that the Teacher’s Union of the Department threaten to start a strike if the project was not stopped.

Decided to find a solution to these two problems, the implementing agencies turned to the basic concepts of Educatronic solutions to consolidate a strategy that allowed students and teachers to access and seize the benefits from the technology and the ESL resources.

3. Intranet and Educatronic Teacher Training Programs as an Educatronic Solution.

The designed solution had three purposes: First, to reduce the need for Internet connection; second, to increase the involvement of the local teacher with the ESL resources; and third, to increase teacher and student interest in infotronic educational content. To achieve these purposes, two new aspects were included in the solution; first, the installation of an Intranet system to manage the Tests and ESL resources in order to improve data-transfer speed and reduce the need for internet connection; and second, the creation of a teacher training program in development and management of Virtual Learning Resources, focused on creation of learning strategies with the ESL resources to increase teacher interest in educatronics and involvement in the project.

The Intranet system was conceived as a strategy to better improve the use of resources within the school, in order to serve a larger group of students and teachers without having to depend on internet connection or transfer velocity. The main problem with existing Internet access was that most of the educational population was underserved as only a small number of teachers and administrative staff had access to Internet, and the access they had did not allow for high download/upload speeds required to properly interact with the ESL resources.

To solve this, each school was provided with a local server, called LatinServer, in which the Learning Management System (LMS) and Content Manager (LCMS) platforms were installed to administer the ESL resources. The LatinServer manages a local wireless

network to serve only to the Tablet PCs, which would work as user-terminals for the students. For the implementing agencies to have the possibility to recover, update and manage the ESL resources, and to follow the developments of the implementation of the project, the LatinServer would need to be connected to the Internet. Out of the 25 schools, only the two Puerto Leguizamo institutions required the sporadic presence of a technician to recover the information and update the resources locally; the other 23 schools' Vive Digital Internet Access was sufficient to allow the remote management of the ESL resources.

This local-storage/remote-management strategy allowed the Implementing Agencies to conduct all the activities programmed with the students and teachers, while reducing Internet velocity requirements for downloading/uploading resources; at the same time, the use of an Intranet significantly increased the number of terminals that students could use simultaneously; in the initial conditions, most institutions could have two or three terminals with simultaneous access to Internet content; the wireless Intranet network could support up to 40 students simultaneously accessing the resources and other content in the LatinServer, without significant hindering to transfer velocity. The inclusion of the LatinServer also allowed the Implementing Agencies to have increased control over the access and usage statistics, and the data recovered from these aspects served to create a research report on technological appropriation for educational purposes [18].

The second part of the strategy to overcome the issue of lack of communication and awareness for the project was the incorporation of teacher training programs aimed to increase involvement and channel expectations. To achieve this, the implementing agencies developed an educatronic teacher training program in creation management of Virtual Learning Resources.

In order to develop an educatronic strategy, we evaluated the four characteristics of educational infotronic tools: desynchronization, multiple spaces, individual rhythms and multiple styles. Given the problems faced in this scenario, and our need to increase teacher involvement in the ESL resources, we considered that it was key for this strategy to work, that we focused on increasing the teacher's liberty in determining its own rhythm of learning.

Taking advantage of the Intranet, instead of implementing the online program, two solutions were incorporated; first, the digital content of the courses was adapted to the LMS installed on the LatinServer, allowing the teachers to use the wireless network to access the course while they were in the institutions; at the same time, the teachers were each given a laptop with a pre-installed local software with the same content, so they could study the courses on their own time and rhythm. The content installed in the laptops was developed as Pedagogic Mediators built in a Web environment similar to the LMS to help the teacher familiarize with the environment, and with local access to Comprehension Test for self-assessment.

Once the teacher finished their study, they would have access to Final Exams and Programmable Activities (One per Pedagogic Mediator) to be accessed online or via the LatinServer Network. These activities and exams were then remotely accessed by the tutors (in Bogotá), and feedback was sent to the teacher's account. The final activity of the training program was the development of an activity using the ESL resources and taking advantage of the installed technology. This allowed the teachers to be more involved with the program and to increase usage of the technology by the local communities.

The changes introduced to the proposed project allowed the agencies to move from a potential failure of the aggregated value of the project, to a project of technological appropriation in which local teachers created new educatronic strategies based upon the ESL resources installed.

4. Results and Recommendations

The main results of the implementation of this program, taking into account the adjustments made by the educatronic strategy, can be analyzed based on the purposes described above:

First, the solution aimed to reduce the need for Internet connection; the creation of the Intranet increased the data-transfer speed, particularly when compared to the options of access to online resources using available Internet access. Similarly, this system allowed for the prioritization of the use of Internet in the institutions allowing the Server to use most of the bandwidth increasing transfer velocities and efficiency in communication, updates and management of the resources.

Second, the solution needed to increase the involvement of the local teacher with the ESL resources; the local-storage/remote-management strategy used in the LatinServers created a need for constant communication and contact between the central human resources and the local teachers, which in turn increased knowledge transfer and local appropriation of the technologies. In addition, the inclusion of teachers through the teacher training programs motivated the local teachers to become tutors in the usage of the ESL resources, increasing the student's use and appropriation of the resources, as well as allowing the diffusion of potential implementing issues originated from the lack of initial communication of the program.

And third, the solution sought to increase teacher and student interest in infotronic educational content, according to the interviews and polls conducted with the beneficiaries by the Implementing Agencies, the importance of technology in learning (particularly Tablet PC and Internet) increased significantly (12% increase) amongst students and teachers. Furthermore, awareness of the importance of the project and expectations on future projects also increased (9%) mainly amongst students [18].

Finally, I would like to include two aspects of consideration or self-criticism that might allow future implementers to avoid common pitfalls, and that if taken into consideration might have improved the implementation of this project.

The first element is the ignorance – both from the implementing agencies and the central administration – of the realities in the region when designing the technological implementation programs. Regardless of the fact that this program was executed and finalized with high levels of satisfaction, it is a source of concern the evident ignorance displayed by all of the actors on the realities of the region. It is a fundamental aspect to every process of technological appropriation, before presenting or designing any solution, to evaluate and assess all the conditions of the region. More importantly though, is that this analysis of the conditions must be done “in the field”, with the communities to be benefitted. One of the major obstacles of this project was the obvious discrepancy between the official statements regarding the supposed internet access and the actual situation of the institutions.

Thus, the first consideration for the reader and for future implementers of rural or remote programs is the need for in-situ validation of the information presented of the program, prior the design of a strategy in order to have a more realistic management of expectations and to have a real understanding of the needs of regions.

The second consideration is the need to include awareness and promotion strategies in all technological appropriation programs. It is a fundamental element to integrate the communities in all appropriation programs in order to increase the long-term impact of the projects. Failure to do so might result in the community rejecting the project and working against its implementation, as it happened in the early stages of this project.

5. Conclusions

Perhaps the main conclusion of this case is the need for implementing agencies to allow themselves to be dynamic in their solutions to the problems of technological implementation in rural areas. Despite the best efforts of all parts, unexpected problems might arise and they need to be able to respond with ingenuity and resourcefulness in order for the projects to be successful.

From an educational perspective, it is important to note that although online education is more and more common, and the potential benefits communities might extract from using Web 2/3.0 are exciting; off-line strategies using an Intranet designed to prioritize Internet access and the advantages of web design might become an interest solution for areas with a poor connection to the Web.

Furthermore, this case of study has allowed us to draw other conclusions and recommendations:

- Educatronics, this is, the idea of Education based on infotronic tools, is a concept that allows for the creation of strategies traditionally underserved by concepts like e-learning or online-education.
- The prioritization of Internet access in order to use it only for management and update services in a local-storage/remote-management strategy increases data transfer speed and can help institutions increase the number of users served by a local network without requiring large investments in Internet access fees.
- Communities need to be more actively incorporated into technology provision programs in order to increase long-term impact of these programs.
- Local government and central administration agencies need to have a larger commitment in the review of the reality of regions before designing technology appropriation programs.

Finally, I will end this paper calling Higher Education Institutions to review teacher education programs in order to include courses and specialization programs on technology appropriation in the classroom, so that teachers can increase their involvement in technological development projects, and further the appropriation of social and economic development programs using ICT in schools.

To the date of the writing of this paper, there are less than ten Masters or Doctorate Degree programs focused on Technological Education, Educational Infotronics, Educatronics or Online Teaching; and those areas are seldom the focus of the undergraduate teacher education programs in Colombia. This means that Colombia has

little to no researchers looking into new technologies for education, and recently graduated teachers seldom know how to use the existing technologies in their classroom.

However this trend might be changing, in 2015 the Universidad de Santander started offering the Master in Educatronics program (the first in this area in Colombia); and the LatinCampus Organization, created the Center for the Neuro-Educatronic Thinking, a center for professional education internships in Educatronics aimed to increase teacher skills in the use of educatronic solutions. These two examples show that the academic community has started to interest in Educatronic, and the Ministry of Education and the Higher Education Institutions need to further this kind of initiatives, since the future of Education is directly linked with the technological advances in Education.

References

[1] United Nations, “Report of the Special Rapporteur on the promotion and protection of the right to freedom of opinion and expression” Human Rights Council. 2011. Retrieved from http://www2.ohchr.org/english/bodies/hrcouncil/docs/17session/A.HRC.17.27_en.pdf

[2] OECD, OECD Digital Economy Outlook 2015, OECD Publishing, Paris. DOI: <http://dx.doi.org/10.1787/9789264232440-en>. 2015

[3] OECD, Assessing the Effects of ICT in Education: Indicators, Criteria and Benchmarks for International Comparisons, OECD Publishing, Paris. ISBN: 9789264079786. 2010.

[4] Norris, P, Digital Divide: Civic Engagement, Information Poverty and the Internet Worldwide. Cambridge University, 2001

[5] PressVan Deursen, A., Van Dijk, J. A, “The digital divide shifts to differences in usage”, *New Media and Society* 16 (3), DOI: 10.1177/1461444813487959. 2014.

[6] Ruiz-Velasco, E., *Educatrónica: Innovación en el aprendizaje de las ciencias y la Tecnología [Educatronics: Innovation in Science and Technology Learning]*, Ediciones Díaz de Santos, México, ISBN: 978-84-7978-822-3, 2007.

[7] Cote, E. “The “Corporate University” as Technological and Scientific Support of the Virtual Education in Latin America” In C. Ho & M. Lin (Eds.), *Proceedings of E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2011* (pp. 1132-1142). 2011

[8] LatinCampus Knowledge Industry, “Educatronica” [Web Document], Retrieved from: http://www.educatronica.net/websites/website_05_educatronica/Paginas/Barra_1_Modelo_Conceptual.asp

[9] Gobernación del Putumayo, “Nuestro Departamento [Our Department]”. Website of the Gobernación del Putumayo. Retrieved from: <http://www.putumayo.gov.co/nuestro-departamento/informacion-general.html>

[10] González-Gonzalez, F. E., *Poder y Violencia en Colombia [Power and Violence in Colombia]*. ODECOFI-CINEP. Bogotá-Colombia, ISBN: 978-958-644-171-1. 2014.

[11] The UN Refugee Agency (ACNUR). “Diagnóstico Departamental del Putumayo [Departmental Diagnosis of Putumayo]”. [Web Document]. Retrieved from http://www.acnur.org/t3/uploads/media/COI_2183.pdf?view=1

[12]Unidad para la Atención y Reparación Integral de Víctimas. Putumayo, Informe Departamental de Hechos Victimizantes, 2012 [Putumayo, Departmental Reporto on Victimizing Situations, 2012]. Presidencia de la República. Retrieved from: <http://rni.unidadvictimas.gov.co/sites/default/files/Documentos/Putumayo.pdf>

[13] DANE, Encuesta de Calidad de Vida [Life Quality], 2014.

[14] DANE, Encuesta de Desarrollo e Innovación Tecnológica [Technological Development and Innovation], 2015.

- [15] Ministerio de Educación Nacional. Resultados por Regiones de las Pruebas Saber 11. 2014. Retrieved from: <http://www.mineducacion.gov.co/cvn/1665/w3-article-347318.html>
- [16] Ministerio de Telecomunicaciones. Website of the Tablets Para Educar Program. Retrieved from <http://micrositios.mintic.gov.co/tabletas/>
- [17] Ministerio de Telecomunicaciones. Website of the Vive Digital program in Putumayo. Retrieved from: <http://www.mintic.gov.co/portal/604/w3-article-2322.html>
- [18] García, A. Cote, L., Cote, O., et al., Final Research Report “Putumayo Bilingüe”. Research Report. Gobernación del Putumayo. 2014

Project Accelerate – Blended partnerships for STEM success

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Abstract

Underserved high school students in many urban, rural, and small suburban communities don't have access to Advanced Placement[®] (AP[®]) courses either because of a lack of trained teachers, limited or no AP[®] program, or a school history of low participation, especially among low-income students. These students lose out on the opportunity for advancement that is critical in developing student interest in STEM and their success in college and future STEM careers. Project Accelerate blends together formal educational structures from the student's school with the latest online learning through an edX AP[®] Physics private online course (derived from a Massive Open Online Course) and weekly tutoring and laboratory experiences at the university. A key feature is that the AP[®] designation automatically allows any school in the nation to add Project Accelerate to their curriculum, providing in-school time and digital access for students, official grades on transcripts, and faculty and staff support, all without any district or additional administrative approvals. During the 2015-2016 academic year, Boston University is piloting this model with 4 Boston Public Schools (BPS) high schools and 3 small suburban high schools. All participating schools are from high needs school districts and do not offer their students the opportunity to enroll in AP[®] Physics 1. 25 weeks into the pilot, we have an 88% retention rate, 90% recitation attendance, and an average GPA of 3.3. Project Accelerate is designed to scale to any of the 14 STEM edX AP[®] courses and to any urban or rural underserved school.

1.0 Critical STEM educational need; project research background; structure of *Project Accelerate*:

Nationally, there is a critical need to develop STEM competencies among youth from demographic groups underrepresented in the STEM workforce (e.g., low income, racial/ethnic minorities, students with disabilities). While underrepresented youth make up more than 50% of today's high school population, African-American/Black and Hispanic/Latino youth each comprise only 7% of STEM graduates and 6-7% of the STEM workforce [1]. Similarly, persons with disabilities represent only 7% of the science and engineering workforce [2]. In a global economy increasingly dependent on STEM competencies, failing to prepare all students to enter STEM fields undermines economic competitiveness and falls short of delivering on the nation's promise to provide all children opportunities for success. Underserved high school graduates are just as likely as non-underserved populations to be interested in STEM – 49% in each case. However, underserved students are far less prepared for college STEM coursework than are students overall (e.g., only 25% of underserved STEM students met the ACT College Readiness

Benchmark in science compared to 59% of students who are not underserved). These data indicate that a program to increase academic readiness can succeed in increasing participation in STEM baccalaureates and career pathways [3].

1.1 Providing structured and challenging AP courses improves long-term performance:

Evidence exists that students who score 3 or higher on AP exams have greater success in college than students who did not take an AP[®] course. However, students who receive scores lower than 3 do not perform noticeably better than a comparison group of high school students who did not take a STEM AP[®] course [4,5,6]. This indicates how critically important quality curriculum, prepared teachers, and appropriate scaffolding are to student success [7].

1.2 Underserved students are denied the opportunity for advanced courses that are gateways to STEM success:

Underserved high school students in many urban, rural, and small suburban communities either don't have access to AP[®] courses, or don't participate in AP[®] programs when they are available [8]. The most recent reports indicate schools with predominately low-income students, both rural and urban, lag in offerings by a 2:1 margin and underrepresented groups lag by a factor of two to four versus whites and Asians [8,9]. There is also recent evidence that in schools that do offer AP[®] programs, there is a large gap in participating between low- and medium and high-income students, regardless of race. There is some controversy in the literature, and an overall lack of research, as to why offerings are limited and why when offerings exist, low-income and minority participation is low. What is clear is that these students, who share an equal interest in STEM as non-underserved students, are too often denied the opportunity to access these gateway courses to success in physical science college programs and STEM careers [3]. Robinson *et al.*, has shown that “taking advanced courses in mathematics and the sciences in high school, e.g., AP[®] courses, is good preparation for university work in engineering and other STEM careers.” [10]. More recently, the State of California and the College Board have collaborated on bringing more AP courses to underserved students. The latest data indicate that a large fraction of underrepresented students (30% or 8,800) could potentially succeed in AP[®] STEM courses but are not enrolling due to lack of opportunity [11].

Locally, the Boston public school system (a typical urban school system) has 34 regular and charter high schools serving 51,393 students. Of these 34 schools only 2 high schools offer algebra based AP[®] Physics 1 (the curriculum supported by Project Accelerate), and a total of only 60 BPS students took the AP[®] Physics 1 exam during the 2014-15 school year. Of the 60

AP [®] Mechanics Exam	State & BPS Comparison	No. of Schools	No. of Students	% Score 1 & 2	% Score 3, 4 & 5
AP [®] Physics 1 (algebra based)	Massachusetts PS	145	3559	61	39
	Boston PS	2	60	85	15
	Nation (whites & Asian)		119388	56	44
	Nation (black & Hispanic)		35048	84	16
AP [®] Mechanics C (calculus based)	Massachusetts PS	112	1643	22	79
	Boston PS	3	62 ⁽¹⁾	26	75

Massachusetts' data obtained from mass.gov 2015 Department of Elementary and Secondary School

website. National data from College Board, 2015.

Table 1: Comparison of National, Massachusetts statewide and Boston Public Schools AP[®] Physics Mechanics exam scores from 2015. Note on the AP[®] Physics 1 exam that BPS students significantly underperform relative to the statewide average. ⁽¹⁾The BPS AP[®] Physics Mechanics C test scores result primarily (52 out of 62) from the prestigious Boston Latin exam school.

students who took the AP[®] Physics 1 exam, only 9 (15%) earned a 3 or better, with 10% earning a 3 and 5% earning a 4 (see Table 1). The BPS AP[®] Physics 1 passing rate is less than half the Massachusetts state average. Boston Public Schools, with demographics of 32% black, 42% Hispanic, 9% Asian, 14% white and 3% other shows an AP[®] Physics 1 profile score similar to the National AP[®] Physics 1 scores for under-represented minority data shown in the table. BPS provide neither widespread access to AP[®] Physics, nor the structure required to produce broad academic success.

2.0 Project Accelerate - A scalable solution to a critical STEM educational need: *Project Accelerate* is a partnership between Boston University (BU) and area schools that provides a structured, supportive, and rich educational opportunity for underserved students. *Project Accelerate* blends together formal support structures from the student’s home school with the latest online learning through an edX AP[®] Physics Private Online Course (a derivative of the approved edX AP[®] Physics 1 Massive Open Online Course that we developed and have taught twice) and weekly tutoring and laboratory experiences at the university.

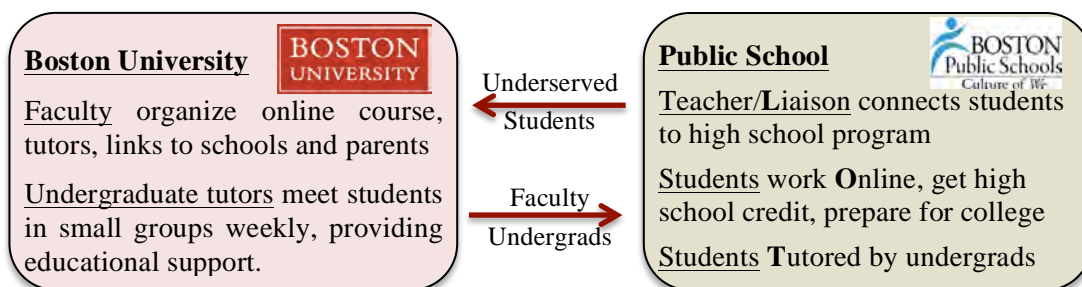


Figure 1: A schematic of *Project Accelerate*, showing the university ↔ public school partnership, the structural support within the student’s school, and the weekly tutoring students receive at the university.

Each participating high school has a **site liaison** (e.g., science teacher, outreach coordinator, or guidance counselor) to facilitate communications between the University site liaison, participating students, and students’ parents/guardians. The Boston University AP[®] Physics 1 online course is an official College Board (CB) audited and accredited course and hence participating schools are able to provide their students with AP[®] credit. All participating schools add AP[®] Physics to their program of study and students are assigned a time in school to work on the online program. Students receive midterm progress reports, quarterly grades and AP credit on their high school transcript. Students, school liaisons, and students’ parents/guardians meet together on the BU campus three times per year (e.g., September, January and May) to gather as a community to share dinner, experiences and aspirations.

Students from high schools within public transportation commuting distance are required to attend weekly **small group tutoring sessions** on the University campus. Sessions give students

an opportunity to use university equipment to explore ideas, work on guided problems, develop strategies for problem solving, and receive additional support based on individual learning needs. Sessions are facilitated by trained and supervised undergraduate Learning Assistants. See fig. 1.

2.1 Project Accelerate can scale to a national model: Thousands of our nation's high schools cannot provide opportunities for underserved students to access AP[®] Physics, and AP[®] STEM courses generally. Fortunately, hundreds of schools are within commuting distance of the 50 universities that could easily host a *Project Accelerate* site, and which may well already have connections with local school systems. A key feature is that the AP[®] designation allows a school to add Project Accelerate to their curriculum without any district or additional administrative approvals. This feature is nearly unique among STEM improvement projects. In addition to expanding access to AP[®] Physics, *Project Accelerate* can be expanded from physics to the other fourteen AP[®] high school subjects, already available and created through edX's High School Initiative [12].

3.0 Project Accelerate research questions and hypotheses: Project Accelerate is based upon the compelling need to provide access to AP[®] Physics for underserved students, on the research that shows that providing high quality education is critical to student's success in the future, and on the growing body of evidence that blended course structures, combining online learning with in-person sessions, can be very effective in improving student learning outcomes (see a review by Means, [13]). In addition, several studies have demonstrated that technology improves access to information, and hybrid or blended models engage students more effectively [14,15,16,17].

Our research questions explore student success as well as efficacy and scalability of the model. We explore student outcomes in terms of their learning and traditional academic measures of success, including course completion and performance, AP[®] exam performance, and longitudinal college acceptance, STEM course performance, and retention. We additionally explore the structure of the blended model and university↔school partnership both in the local pilot program, and in terms of whether it can be replicated at other sites around the country.

4.0 Using an edX AP[®] MOOC: The BU course was created through a partnership with edX and Boston University's Digital Learning Initiative, as part of edX's High School Initiative. PI Andrew Duffy, Mark Greenman, and four high school teachers from the Boston area created a massive open online course (MOOC) on the edX platform aimed at preparing students to succeed on the AP[®] Physics 1 exam. The course is running now for the second time (September 2015 – May 2016). The first run of the course, from January – May 2015, attracted over 11,000 registrants from almost 150 countries. The design of the course emphasized interaction and de-emphasized video lectures. Our goal is to have the students be as engaged as possible, so there are many opportunities for self-assessment; for interacting with the course staff and other learners on the discussion forum; for using interactive simulations built right into the platform; and for giving students authentic lab experiences in the online environment.

After the first run, we asked participants to self-report their AP[®] Physics 1 test score. 49% of respondents reported receiving a 4 or 5, compared to 17% of all the students who took the test. Of those who scored a 5, 32% said that our online course was either absolutely critical or very helpful to their success, and a further 56% said that the course was quite helpful. In addition, we used the Force and Motion Conceptual Evaluation as a pre-test and post-test, and the matched

students (those doing both the pre-test and post-test) had an average normalized gain of 61%, similar to what is obtained in a high-quality, university-based active-learning classroom.

Mark Greenman of Project Accelerate has reworked and divided some larger modules into smaller multiple modules, providing greater scaffolding and assistance to students. This has proved critical to success.

4.0 Pilot project: School/student demographics, retention, and performance through third term reports: During the 2015-2016 academic year, Boston University is partnering with seven high schools in four districts to deliver a blended AP[®] Physics 1 course to underserved secondary school students who would otherwise not have access to AP[®] Physics 1. This *Project Accelerate* pilot includes four (4) Boston Public School (BPS) high schools and three (3) small suburban high schools. All participating schools are from high needs school districts that do not offer their students the opportunity to enroll in AP Physics. A total of 24 students are participating in this pilot project. Seventeen attend four high schools in the BPS system, and seven attend three schools in central and western Massachusetts. The demographics by specific race, ethnicity and gender are: 1 Asian, 9 black, 14 white; 6 Hispanic (white); 7 female (1 Asian, 3 black, 3 white).

Overall retention: Six months (25 weeks) into the pilot program, we have an 88% retention rate (82% urban and 100% rural and suburban). At week 7, a student withdrew and commented, “The course is more work than I want to do. I am a senior.” A second student withdrew in week 15 with the comment, “Just not comfortable having to direct my own learning. I prefer having the teacher tell me what to do while I’m in class.” A third student, dealing with personal issues, withdrew in week 17.

Student Recitation Attendance (only pertains to Boston Public School students): BPS students attend a weekly 2 and ½ hour recitation block on the BU campus, facilitated by trained and supervised undergraduate Learning Assistants - physics undergraduates trained in STEM pedagogy through a 2-credit, one-semester course, plus the experience of being a near-peer teacher in an active-learning classroom. The attendance rate is 90%.

Student progress and performance: Grades are shown for two terms and indicated below as T1/T2. Note the overall success, even for the BPS students whose pre-test scores were 20% on average. This is very strong evidence for success of the Project Accelerate model.

District	Number of Participants	Grade Distribution					
		A	B	C	D or F	Incomplete	Withdrawn
BPS	17/14	7/6	6/4	3/1	1/3	0/0	0/3
Mohawk Trail	4/4	2/3	2/1	0	0	0	0
Ware	2/2	2/2	0	0	0	0	0
Home Schooled	1/1	1/1	0	0	0	0	0
Totals	24/21	12/12	8/5	3/1	1/3	0/0	0/3

We are seriously evaluating and testing the students, both to ensure a successful course, and to correlate with AP[®] scores and future STEM success.

4.0 Conclusions -- Vision for Project Accelerate:

Thousands of our nation's high schools cannot provide opportunities for underserved students to access AP[®] physics [11]. *Project Accelerate* blends together the supportive formal structures of a student's home school, immediate acceptance into school curricula through the AP[®] designation, a private online course, derived from an edX MOOC, designed specifically with the needs of underserved populations in mind, and small group laboratory, mentoring, and tutoring experiences at a local university campus to make AP[®] Physics accessible to underserved urban students. *Project Accelerate* offers a potential solution to a significant national problem of too few underserved young people having access to high quality physics education, resulting in these students being ill prepared to enter STEM careers and STEM programs in college. Finally, *Project Accelerate* is a scalable model of STEM success, replicable at sites across the country, not only in physics, but potentially across fourteen AP[®] subjects. It can therefore set up for success tens of thousands of motivated but underserved students every year.

References:

- 1 Landivar, 2013, National Census Report, found at <https://www.census.gov/prod/2013pubs/acs-24.pdf>
- 2 National Science Foundation, 2015: National Center for Science and Engineering Statistics (2015). Women, Minorities, and Persons with Disabilities in Science and Engineering: 2015. Special Report NSF 15-311. Arlington, VA. Available at <http://www.nsf.gov/statistics/wmpd/>.
- 3 ACT, 2014 “Understanding the Underserved Learner,” at <https://www.act.org/stemcondition/14/pdf/STEM-Underserved-Learner.pdf>
- 4 Scott, Timothy P., Homer Tolson, and Yi-Hsuan Lee. “Assessment of Advanced Placement Participation and University Academic Success in the First Semester: Controlling for Selected High School Academic Abilities.” *Journal of College Admission* 208 (2010): 26-30.
- 5 Klopfenstein, Kristin, and M. Kathleen Thomas. “The advanced placement performance advantage: Fact or fiction.” Texas Christian University and Mississippi State University (2005).
- 6 Sadler, Philip M., and Robert H. Tai. “Advanced Placement Exam Scores as a Predictor of Performance in Introductory College Biology, Chemistry and Physics Courses.” *Science Educator* 16.2 (2007): 1-19.
- 7 Klopfenstein, Kristin. “Recommendations for maintaining the quality of advanced placement programs.” *American Secondary Education* (2003): 39-48.
- 8 C. Theokas and R. Saaris, “Finding America’s Missing AP and IB Students,” The Educational Trust, 2013. Available at https://edtrust.org/wp-content/uploads/2013/10/Missing_Students.pdf
- 9 P. Handwerk, N. Tognatta, R. Coley, and D. H. Gitomer, “Access to Success: Patterns of Advanced Placement Participation in U.S. High Schools,” Educational Testing Service, 2008. Available at: <https://www.ets.org/Media/Research/pdf/PIC-ACCESS.pdf>
- 10 Robinson, Mike, et al. “AP mathematics and science courses as a gateway to careers in engineering.” *Frontiers in Education IEEE*, 2003.
- 11 College Board, 2015: California and the College Board: “A Partnership That Gets Results,” <https://www.collegeboard.org/california-partnership/ap-expansion>
- 12 edX High School Initiative has 40 courses. More at <https://www.edx.org/high-school-initiative>
- 13 Means, B., Toyama, Y., Murphy, R., Bakia, M., and Jones, K, (2010). Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies. Washington D.C., U.S. Department of Education. Retrieved from www2.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf
- 14 Delialioglu, O. and Yildirim, Z. (2008). Design and development of a technology enhanced hybrid instructions based MOLTA model: Its effectiveness in comparison to traditional

instruction. *Computers & Education*, 51(1): 474-483. Retrieved from <http://www.sciencedirect.com/science/article/pii/S0360131507000668>

- 15 Sanders, D.W., Morrison-Shetlar, A.I., (2001). Student attitudes toward Web-enhanced instruction in an introductory biology course. *Journal of Research on Computing in Education*, 33 (3I): 251–263. Retrieved from <http://www.iste.org/jrte/33/3/abstracts/sanders.cfm>
- 16 Gunter, G.A. (2001). Making a difference: Using emerging technologies and teaching strategies to restructure an undergraduate technology course for pre-service teachers. *Educational Media International*, 38 (1): 13-20.
- 17 Tuckman, B.W. (2002). Evaluating ADAPT: A hybrid instructional model combining web-based and classroom concepts. *Computers & Education*, 39: 261–269. Retrieved from http://all.successcenter.ohio-state.edu/references/evaluating_ADAPT.htm

Mapping Learning in Games: Using Content Model Frameworks to Advance Learning Game Design

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Abstract

The field of learning game design has made tremendous strides in the past decade, but moving to the next level will require much more thoughtful and strategic mapping of the learning experiences and outputs in games. While research has shown that games are powerful tools for learning, the field needs better ways to describe how and why learning is happening in the game experience for a number of reasons—including the better identification and implementation of games by educators in the classroom, more meaningful feedback for educators on the learning experience for each student, and better data to inform the further design of educational games. The call and demand by educators and other stakeholders for 'assessment' in games and better evidence of learning is pushing the field in this direction. Yet it is also creating a divide among learning game designers who cringe at the use of the “a” word in their work. In this paper, we draw to light that 'assessment' has been arbitrarily pulled out as a distinct element in learning game design, when in fact we need to seek a better mapping of overall learning pathways and experiences in games. Building on the work of evidence-centered design and other frameworks, in this article we offer a framework that can be used to map the learning in each game. Using such a standard framework across the field would have far-reaching implications—including a shared improving in understanding what it means to map a learning experience in a game, more strategic and coordinated development of learning games across the education landscape, and easier way to access and implement learning games in real world classrooms.

1. Introduction

Learning games are not just a genre of games, but a unique and emerging field of game designers, learning designers, subject matter experts, developers and researchers that collaborate to produce innovative and powerfully engaging learning experiences. In the past 10 years, the field of learning games has grown dramatically. In that time, we have had many successes and more than our share of failures. We have largely spent this past decade fleshing out the possibility space, with examples of what's possible in learning games across the spectrum—from flash-based to mods, from small apps to large MMOs, and many things in between. Yet we are just beginning to crest the horizon on what is truly possible for leveraging games as deeper and formative learning experiences both in and out of school.

Moving the field forward in dramatic ways, to create games that produce deeper learning as well as evidence of learning, and games that can drive better learning experiences both individually

and socially, both in and out of school, will require the field to take a big step forward. What tools, structures and methods will help us do that?

In short, there are specific assessment frameworks that are not a constraint on game design but rather offer a powerful frame for designing deep, engaging, and meaningful learning in games. And as a result of using such frameworks, we can see the entire field of learning game design take a giant step forward.

Achieving this new plateau will require better articulation, design, and evidence of learning goals and performance with the games. Teachers, parents, and learners all need, and often request of game designers, a better understanding of what a game is targeting, how that situates into a larger learning sequence, and how they know what they've learned from the game (Klopfer, Osterweil & Salen, 2009). It will require a more robust learning framework at the core of the game design. Many have argued that assessment design is a key mechanism that will propel the field forward (Phillips & Popović, 2012); yet there still exists a large chasm between general assessment design – and even game designers leveraging rigorous assessment methodologies – and the rest of the field. In this article, we propose an approach and framework to help build this bridge by facilitating a more robust and coherent design of games for learning.

In this paper, we will discuss a general overview of methodologies being used by the field, and present a design framework that can easily be used by any learning game design group and project. Finally, we discuss the need and implications of using the framework as a way for mapping learning games more systematically in this way.

1.2 'At an Impasse': The Next Generation of Learning Games

In many ways, the field is approaching its own adolescence—an inflection point, poised for growth and a large step forward. We've built a wide array of games, *but why aren't they used more? How can they have more impact? How can we better document and demonstrate the actual learning in a given game experience?* These questions cannot be ignored; in fact, we believe it is these questions, and their elusive answers, that are defining and driving the next developmental phase of the field.

This adolescence is perhaps not so coincidentally aligned with an unprecedented interest, emphasis, and outright demand for innovation in assessment in education. Just about any student, parent and teacher can cite at least one if not many of the challenges and negative side effects created by our educational assessment pipeline. Whether we choose to leverage new digital technologies or not, it is clear that better assessments are critical to short- and long-term success of our students and our educational system itself. This emphasis and demand has placed quite a spotlight on games and their potential as assessment mechanisms, and as we will suggest in this article, such a focus can actually be what catapults the field to the next level—of more engaging, more mindful, and more impact.

In discussing this potential, Vicki Phillips of the Gates Foundation, and Zoran Popović the lead designer of the profoundly-impacting game *Fold.it*, offer what they believe a key set of design principles that learning games must adopt in order to be effective (Phillips & Popović, 2012):

- Stay true to learning science principles, not just game design principles;

- Optimize engagement and learning transfer simultaneously and avoid creating an uninteresting game or one with little learning;
- Continuously improve over time — the initial design of a game cannot be permanent;
- Include continuous in-game assessment, including assessing its own effectiveness for all learners; *and*
- Be optimized for multiple learning audiences: teachers and students in classrooms, parent- child learning, peer play and individual play.

These principles outline the shortcomings and the larger demand for certain elements in current learning games, echoing a greater demand and gravitas of learning and assessment.

2. Assessment in Education, Assessment in Games

In the last several years, the discourse on using games as assessment engines has grown tremendously, with numerous examples and approaches emerging from a variety of groups—including both traditional assessment organizations such as CRESST (the National Center for Research on Evaluation, Standards, and Student Testing), ETS¹ (the Educational Testing Service), to those more directly associated with the gaming community such as Center for Games and Impact² led by Sasha Barab and Jim Gee. Perhaps the interest and emphasis on the intersection of assessment and game design was catalyzed this past year with the opening of GlassLab³ (The Games, Learning and Assessment Lab)—a large-scale research and development effort with support from the Bill & Melinda Gates Foundation, the John D. and Catherine T. MacArthur Foundation, Electronic Arts (EA) and Entertainment Software Association (ESA).

For many learning game designers, the mention of the word “assessment” is an automatic deal-breaker—it the surefire sign of any hope of a well-designed and engaging learning game. For many game design teams, the idea of discussing how to create an assessment in the game is certain death to the potential of fun and playful mechanics. And indeed, at a surface level ‘assessment design’ and ‘good learning game design’ are diametrically opposed. Yet the opportunity lies when you go below the surface and look at how the mindful and critical mapping of an assessment can also serve as a very robust frame or ‘spine’ of a learning game design. In this way, an assessment-like learning framework at the heart of a learning game design can help the game not only have much deeper impact on student learning but help educators have a much better understanding of what the game is targeting and exactly how it is helping students.

Since ‘assessment’ can be a loaded term for many audiences, and often means different things to different people, we prefer to use ‘evidence of learning’ or ‘evidence that the learning goals have been met’ in framing the approach we are advocating for here.

2.1 Assessment design for games: An introduction

The work in assessment design has also seen significant advances in methods of over the past decade. Prominent frameworks that have emerged include the Assessment Triangle (Pellegrino, et al., 2001) and Evidence-Centered Design (ECD; Mislavy et. al. 2003; Mislavy & Haertel,

¹ <http://www.cse.ucla.edu>; For an example of their work in this space, see Wainess, Koenig & Kerr, 2011.

² <http://gamesandimpact.org>

³ <http://glasslabgames.org>

2006)—both which provide a formal, multi-layered approach to designing a coherent assessment. Of these advancements, ECD in particular has stood out as a promising approach that has not only captured the attention of the assessment arena, but that of learning game design as well.

ECD has become particularly useful because it creates useful structures for formalizing the procedures generally done by expert assessment developers (Shute, Hansen, & Almond, 2008). ECD builds on years of advancements in statistical modeling, cognitive psychology, and work on validity in assessment design, but more generally speaking, it reflects the same processes of evidentiary reasoning—if we make a claim about a student’s ability, we must provide relevant evidence and criteria for relevance and validity for each (Mislevy & Riconscente, 2005). To do this, the ECD framework breaks this down into three key elements called models:

- *the student model* – defines the knowledge/skills/abilities targeted
- *the evidence model* – describes potential observations and behaviors of students that would give evidence of their ability
- *the task model* – aspects of assessment situations that are likely to evoke and provide such evidence

In practice, when designing true statistically valid assessments, completing these models is no small task. Conducting the domain analysis and modeling needed in order to these models can take months (Shute & Ventura, 2013). As such, while the popularity of using ECD has increased, most projects developing assessments using digital media have adapted the framework to assess interactions and trajectories (e.g. Shute & Torres, 2011; Clarke-Midura, Code, Zap, & Dede, 2012, Rupp, Gushta, Mislevy, & Shaffer, 2010; Conrad, Clarke-Midura, Klopfer, 2014).

2.2 A bridge too far?

These advancements in assessment methodology have demonstrated their strength and value in constructing innovative assessment modules—including in relation to game design as well. When we step back and look ‘under the hood’ of these approaches, we can see how and why they offer us a powerful toolset for designing better and deeper learning and assessment frameworks for any learning experience.

The challenge is that much of this discourse, the text and language of the materials, etc., is largely inaccessible to a general audience—or really anyone not experienced or formally trained in this domain. In reality, ECD may be the gold standard and offer a tremendous asset to the field of game design, but it is largely inaccessible to mainstream game designers—be they veterans of the field of learning games or not. Collectively, we may see that the field of learning games needs to take a large step forward, and move towards more centralized approaches to mapping learning and assessment models that undergird these games, but we will need supports to bridge this chasm. ECD is a rigorous and complex methodology. Yet we believe it is a valuable overall design frame, even for learning games that don’t seek to serve as a true assessment. As such, we offer a streamlined framework based on this called Balanced Design (see Figure 1).

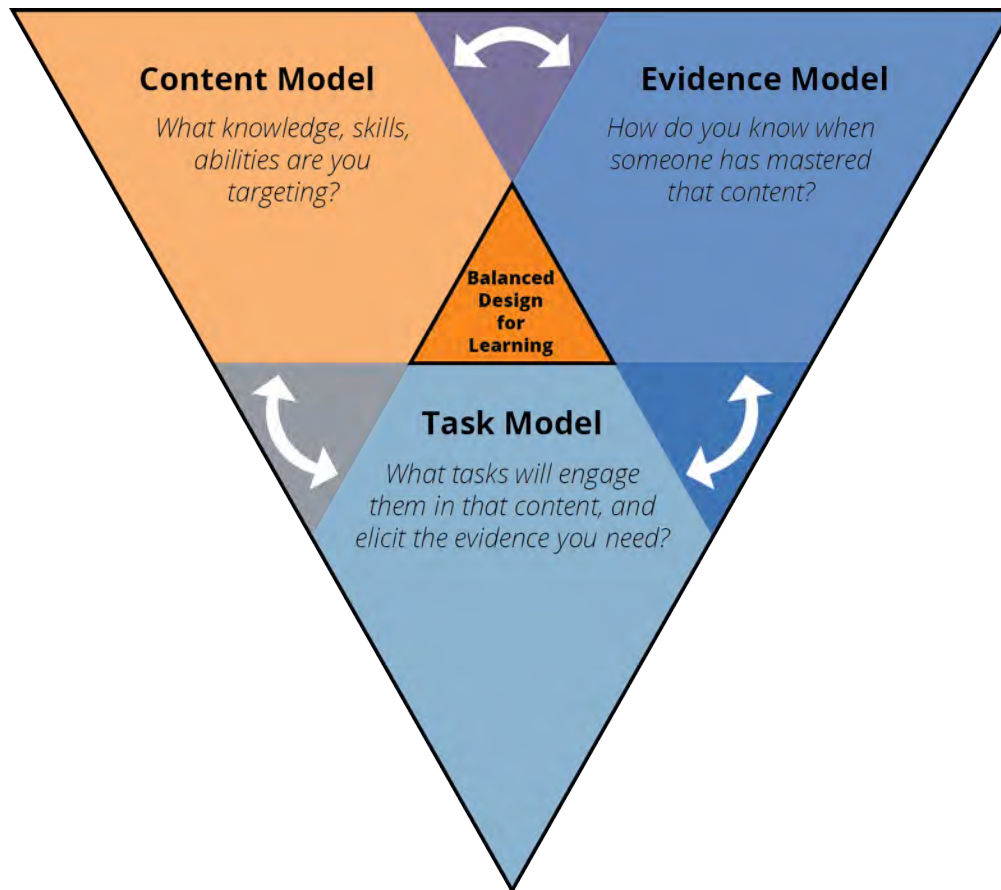


Figure 1. Balanced Design Framework for the design of learning games.

In this paper we will discuss how the Balanced Design framework can serve as a powerful tool and frame for the design of a learning game, as well as the impact and opportunities for the designers as well as the educators and students if this approach is used.

3. A Second Generation of Learning Game Design: A Unified Model

Presently, there is no shared way that we document and map the learning in a game. At best, a learning game design team will outline learning goals or learning objectives or curriculum standards that the game targets or was built for. If you were to take a handful of different learning games and look at what content and learning that each game is designed for to compare or look across that set is actually no easy task. Getting to a new generation of learning games, and being able to embody the principles outlined previously by Phillips and Popović will require that we place much deeper design emphasis on mapping the learning and assessment structures of a game. Ideally, each game design group would have a strong, interdisciplinary team of game designers, assessment developers, learning sciences and content experts to collaboratively develop rich and engaging learning experiences that are built on complex content models that are provide rigorous assessment feedback. But for most organizations and current groups of learning game designers, that is a tall order—one that for the near future, is unachievable. However, we believe that these rigorous advances in assessment and game design can be distilled into a

framework and methodology that not only is able to help us achieve many of those goals laid out by Phillips and Popović, but that by collectively using such a new framework we are better able to document, map and share knowledge about the games we are building and the learning we are producing, thereby enabling a quantum leap as a field.

3.1 Designing Better Learning in Games

What makes for a quality learning game are two elements deeply intertwined: learning dynamics with game mechanics. However, too often we don't give enough detailed attention and documentation to the learning dynamics part. Very often when designing a learning game, particularly those smaller in scope, the game design process might spend some time identifying the learning concepts, but most of the time fleshing out the game design.

What an Balanced Design framework offers us is a straightforward and strategic way of thinking much more deeply about the learning construct and how to create deeper, more meaningful learning experiences for that construct—so much more deeply that we can have a much clearer understanding of what the learners knows and can do (i.e. performance assessment). Starting with a deeper content model sets a much different foundation for the game design experience.

Although many learning games designers describe using an iterative approach to game design, that balances the learning goals with the game mechanics, in reality this rarely plays out as a deep and on-going push and pull between the learning and game mechanics throughout the entire process to game completion. The emphasis of the Balanced Design approach places a much heavier emphasis upfront on outlining the learning and content model that serves as the foundation of the game, and the on-going negotiation between the learning targets and the tasks (game mechanics), as we will discuss below.

3.2 Using the Framework: A New Game Design Methodology

The Balanced Design framework presented here not only serves as a 'backbone' and structure for the design of our learning games, but it also creates a process that facilitates how we approach designing our games. This is predicated on long-standing tenets of design practices, including:

- Assembling a well-balanced, interdisciplinary team of game designers, learning designers, content experts and producers.
- Exploring the learning goals and content and designing game mechanics specifically for that content.
- Iterative design process, where multiple rounds of user testing helps to refine our ultimate game design.

3.3 Example: Designing Quests in *Radix*, a MMO for STEM

The Radix Endeavor is a Massively Multiplayer Online Game (MMOG) being developed by The Education Arcade at the Massachusetts Institute of Technology, designed to improve learning and interest in STEM in high school students. The content specifically focuses on statistics, algebra, geometry, ecology, evolution, genetics, and human body systems. Players take on the role of mathematicians and scientists and embark on quests that encourage them to explore and interact with the virtual world through math and science. Players become embedded in a narrative in the world where they encounter a villain who does not believe in the practices of

science. Players have to reason about science issues applicable to game characters' everyday lives, refute the unscientific claims of the villain, and make choices based on what they consider to be valid evidence.

Currently, there are seven quest lines in Biology and six in Math. Each quest line contains a series of quests around a specific content area (i.e. human body systems, geometry, etc.). The quests start out easier and get progressively harder, building off what is learned in the previous quest. The goal is to have a culminating quest activity at the end of each quest line where students will apply what they have learned to a problem or new situation. Using the Balanced Design framework as a guide for quest design, the Radix team then modified it to fit the project in a way that ensures the method by which evidence is gathered and interpreted in game play is consistent with the learning objectives the game is attempting to teach. What ECD describes as “work products”, the Radix team refers to as “experiments”. Each quest is designed around one or more experiments that a student completes over a series of steps. For example, students may be asked to breed a particular type of flower or to build a scale map of a city. These experiments have inputs (the flower or object a student tries to breed) with particular properties. The outputs of the experiment (e.g. the flower or object that is bred) also have these properties. These data are captured and stored on the back end and can be evaluated in real time to see what kinds of experiments students are conducting—are they breeding the right objects? Are they producing the right proportion of offspring? Thus, in the quests, the experiments allow the Radix team to assess students’ understanding of the content.

This information can then be used formatively, to provide feedback to both students and teachers as a way to ensure students learn the content. It can also be used to assign “side quests” in particular content areas where students are struggling. In the culminating quests, which are essentially a performance assessment, the team will use the data to summatively assess what a student knows after working through the quest chain. Some of the variables being measured in the culminating quests will also be evaluated with external measures. This method of using Evidence-Centered Design for the design experiment-based game design we refer to as XCD, and has allowed the team to account for the use of experiments in game play, and perhaps more critically, to make the process accessible to the various people involved (designers, content experts, programmers).

In order to articulate this process, the Radix team uses Quest Templates and tables (see Figure 2). Each application of the template is modified as necessary through an iterative process to ensure that the team knows (1) what data to capture from the student interacting with quests, (2) if students understand the concept, *and* (3) whether or not we need to give feedback or have the student repeat the quest.

Content Model	Task Model		Evidence Model	
<i>Learning Objective</i>	<i>Quest</i>	<i>Task</i>	<i>Data Collected</i>	<i>Interpreting Evidence</i>

Recognize patterns in data sets	ST1.1	Turn in data summary to support/refute government claim	Data summary (see Table 1.7 for possible data summary submissions)	Correct: Player knows to use a large enough sample size and the correct measure. If Incorrect: Species other than blackburn: Player likely does not know what a blackburn is Trait other than body length: Player did not understand what needed to be measured If result does not agree with their answer in Tumbler 1.2: See Quest 1 7a If sample size is too small: Player does not understand the importance of a large enough sample
Use models and simulations to make inferences and conclusions	EV3.3	Students use a simulator to see how environmental pressures can affect trials.	Students turn in EvoGlobe and respond to questions. Data collected includes Globe setting and responses.	Correct: See EvoGlobe settings EV3.3a table. Potential reasons for Incorrect EvoGlobe: They don't understand principle of natural selection. They don't understand how to interpret EvoGlobe. They don't understand how to use the EvoGlobe.

Figure 2. Example of quest template developed for the *Radix Endeavor* using the Balanced Design approach.

4. The Value of This Approach

The framework discussed here demonstrates how a Balanced Design framework can help guide a much more coherent learning game design in a way that also affords the ability to create, collect and respond to behaviors as assessment markers; however it also affords us a methodology to better map the design of learning games to fundamentally help the field move forward.

4.1 Tenet #1: Setting a better foundation of learning in game design

The ECD framework has demonstrated its ability to guide more meaningful and deeper learning design that affords assessment outputs from learning game experiences. This represents not just a promising step forward, but evidence of true ‘alignment’ that largely has not been present in the field of learning games to this point. This lack of ‘alignment’ is framed, perhaps not so ironically, quite well by Robert Mislevy and colleagues (the lead developers of ECD) in reference to assessment design:

“One can not simply construct ‘good tasks’ in isolation, however, and hope that someone down the line will figure out ‘how to score them.’”

(Mislevy, Almond & Lukas, 2003)

In reality, this happens all the time in learning game design. We focus on teaching and learning the content of the game, but often give little if any thought on how we might be concerned with knowing how the student is advancing in understanding that content. We leave that job solely to the teacher. While we certainly believe this is one of the key tasks of a teacher – to observe, assess, and appropriately guide the next steps for the learner – we can not just hand them a learning game – a ‘black box’ of a learning experience which they didn’t have a hand in creating – and expect them to figure it out. Assessment is just a term for the ‘other side of the coin’ of

learning. The two are one. Learning can be defined by two interrelated questions that drive a never-ending cycle of improvement:

- What are you trying to teach?
- How do you know you know it?

As a field, we have largely ignored the second question. The second question is critical, but not just because it helps a teacher or student know where they stand, and what they might need next. Indeed, those are essential. However it's critical because when we ask the second question *at the beginning of the design process*, it changes our foundation. Asking, and answering, that question, sets a content model and conceptual foundation for the design of the strategic learning experience we call learning games. Without such an explicit and defined model, we are making judgments about the game design without a developed evidence model about the actual learning processes involved. As a result, the learning design results from our best judgment rather than from evidence on learning. The Balanced Design framework offers a coherent model that aligns the parts of a given learning construct. We may often start a learning game design with learning goals in mind, but using the Balanced Design framework offers the learning goals and the remaining elements of a complete learning construct as the blueprint for the learning experience at hand.

4.2 Tenet #2: Setting a standard for mapping and documenting learning games

The proposed design framework here offers us something even further and more critically useful to the field: by documenting the learning model undergirding a game, along with other general metadata, we can collectively as a field do a much better job of documenting and sharing knowledge about our work and the actual 'bones' of the games we build. Currently, if I asked you "what are the learning goals?" of a given learning game, that answer may or may not be easy to find; and chances are, it will take a fair bit of poking around a website or attached documents to find it. More broadly, the field of education is moving toward standards in data and the representation of data. A prime example is the Learning Resource Metadata Initiative (LRMI) tasked with creating a unified tagging structure for learning content on the web so that it is aligned with schema.org and can better enable search engines to find and display learning content available on the web (see <http://www.lrmi.net>). Of course, this includes games and learning games are already being tagged and mapped using this structure. However, there are further reasons for the field of learning games to look at taking this practice deeper. Learning games are designed closed- and open-ended experiences. They vary in depth, shape and size. In a quality learning game, the learning is embedded and intertwined in the game experience, and learning content may not be so evident to the user—be they a teacher, student, or parent. By utilizing a shared documentation method, not only will critical information about an existing learning game be mapped out and accessible, it will be done in a way that allows an individual to very easily see what's happening "under the hood" of a game because they are familiar with the documentation format. Allow the framework would not need to be rigidly followed, if such a framework was generally used to map the contents of a learning game in similar ways it would benefit everyone using, working with, creating and studying learning games.

5.0 CONCLUSIONS: Moving Towards the Next Generation of Learning Games

Although ECD has its roots in formal assessment, and was initially leveraged in the field of learning game design as a means for created assessments that were game-based, we believe this framing of ECD is too narrow and it offers us a toolkit that much more broadly serves the learning design in learning games. A fundamental followed by many in the field is that what makes a quality learning game is when you find the playful game mechanics in the learning content and fuse the two for a quality game—the other end of the spectrum from games where the learning is explicit and then the student is rewarded with game play. Learning game designers may fear that the focus on assessment in games will push their designs towards the latter rather than the former. However, we suggest that in fact, using a modified ECD framework called Balanced Design as presented here, affords you the ability to set a much better foundation for the learning game design, enabling you to avoid this problem and design strategically for game mechanics in the learning content itself.

As we look ahead as to how we may grow as a field, we must be vigilant to focusing growing in ways that better serves the learning in games—and we must work to build bridges between these complex methodologies so that it is accessible to all members of our very diverse, and interdisciplinary design teams.

REFERENCES

- [1] Baker, R. S. J. D. & Yacef, K. (2009). The state of educational data mining in 2009: A review and future visions. *Journal of Educational Data Mining*, 1(1), 3-17.
- [2] Behrens, J. T., Mislevy, R. J., DiCerbo, K. E. & Levy, R. (2012). Evidence centered design for learning and assessment in the digital world. In M.C. Mayrath, J. Clarke-Midura, D.H. Robinson, G. Schraw (Eds.), *Technology-based assessments for 21st century skills: Theoretical and practical implications from modern research* (pp. 13-53). Charlotte, NC: Information Age Publishing.
- [3] Clarke-Midura, J., Mayrath, M., Dede, C. (2012). Thinking outside the bubble: Virtual Performance Assessments for Measuring Inquiry Learning. In M. Mayrath, J. Clarke-Midura, D. Robinson (Eds.) *Technology Based Assessment for 21st Century Skills: Theoretical and Practical Implications from Modern Research*. New York, NY: Springer-Verlag.
- [4] Halverson, R. & Owen, V.E. (in press). Game-Based Assessment: An Integrated Model to Capture Evidence of Learning in Play. *International Journal of Learning Technology*.
- [5] Halverson, R., Owen, V.E., Salmon, A., Kasemodel, C. & Torrisi, B. (2013). *ADAGE: An Assessment Data Aggregator for Gaming Environments*. Presented at the Games+Learning+Society Conference, June 12-14.
- [6] Klopfer, E., Osterweil, S. & Salen, K. (2009). *Moving learning games forward: Obstacles, opportunities & openness*. An MIT Education Arcade white paper.
- [7] Mislevy, R. J., & Haertel, G. D. (2006). Implications of evidence-centered design for educational testing. *Educational Measurement: Issues and Practice*, 25(4), 6-20.
- [8] Mislevy, R. J., & Riconscente, M. M. (2006). Evidence-centered assessment design: Layers, structures, and terminology. In S. Downing & T. Haladyna (Eds.), *Handbook of test development* (pp. 61-90). Mahwah, NJ: Lawrence Erlbaum Associates.

- [9] Mislevy, R. J., Steinberg, L. S., & Almond, R. G. (2002). On the roles of task model variables in assessment design. In S. Irvine & P. Kyllonen (Eds.), *Item generation for test development* (pp. 97-128). Mahwah, NJ: Lawrence Erlbaum Associates.
- [10] Mislevy, R. J., Steinberg, L. S., & Almond, R. G. (2003). On the structure of educational assessments. *Measurement: Interdisciplinary Research and Perspectives*, 1, 3-67.
- [11] Owen, V.E., Halverson, R., & Wills, N. (2012). CyberSTEM: A Game-Based Evidence Model. In A. Ochsner (Ed.), *Proceedings of the 8th Annual Games+Learning+Society Conference*. ETC Press: Pittsburgh, PA.
- [12] Pellegrino, J., Chudowsky, N. & Glaser, R. (2001). *Knowing what students know: The science and design of educational assessment*. National Academies Press.
- [13] Phillips, V. & Popović, Z. (2012). More than child's play: Games have potential learning and assessment tools. *Kappan*, 94(2), 26-30.
- [14] Rupp, A.A., Gushta, M., Mislevy, R.J., & Shaffer, D.W. (2010). Evidence-centered Design of Epistemic Games: Measurement Principles for Complex Learning Environments. *Journal of Technology, Learning, and Assessment*, 8(4).
- [15] Shute, V., Hansen, E., & Almond, R. (2008). You can't fatten a hog by weighing it—or can you? Evaluating an assessment for learning system called ACED. *International Journal of Artificial Intelligence and Education*, 18(4), 289-316.
- [16] Shute, V. & Ventura, M. (2013). *Stealth Assessment Measuring and Supporting Learning in Video Games*. The John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning. Cambridge, MA: MIT Press. Accessible at <http://mitpress.mit.edu/books/stealth-assessment>
- [17] Shute, V. & Torres, R. (2011). Where streams converge: Using evidence-centered design to assess Quest to Learn. In M. Mayrath, J. Clarke-Midura, & D. H. Robinson (Eds.), *Technology-based assessments for 21st century skills: Theoretical and practical implications from modern research* (pp. 91-124). Charlotte, NC: Information Age Publishing.
- [18] Squire, K. (2006). From content to context: Videogames as designed experience. *Educational researcher*, 35(8), 19-29.
- [19] Wainess, R., Koenig, A. & Kerr, D. (2011, January). *Aligning instruction and assessment with game and simulation design*. The National Center for Research on Evaluation, Standards, and Student Testing. CRESST Report 780.

Automated Detectors of Learner Engagement and Affect: Progress towards Personalized Learning

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Abstract

To determine whether automated detectors of learner engagement and affect present a promising development towards personalization of student learning experiences, we assess their cost-effectiveness relative to more traditional observation methods and their readiness for broader use. We compare the costs and reliability of automated detectors applied to educational software user log files to three established methods of collecting learner engagement and affect data: classroom observations using pen and paper observation protocols; classroom observations using a smartphone to record observations; and video analysis. We compare the methods with respect to costs and accuracy as represented by kappa coefficients. We present various cost metrics including a cost per "observation label," where a label is defined as a single record of engagement or affect. We conclude that automated detectors are vastly less costly than traditional methods per unit of affect or engagement data collected but are currently low in reliability. Given their significant potential for contributing to the development of personalized and adaptive software, we recommend strategies for improving reliability.

1. Introduction

As the use of technology for delivering instruction has grown, opportunities have arisen to develop educational software and intelligent tutoring systems (ITSs) that adapt to individual student performance by altering the student's trajectory through the content and activities, and providing personalized support along the way. Although efforts to automate the tailoring of instructional experiences to individual students remain relatively unsophisticated, results have generally been promising. Kulik and Fletcher's [1] meta-analysis of 50 controlled evaluations of ITSs finds a median effect size of 0.66, equivalent to an improvement in standardized test scores from the 50th to the 75th percentile. This is more than twice the effect size of 0.31 found for computer-assisted instruction tutoring [2]. Even human tutoring by adults, often considered the gold standard for instruction, is not consistently more effective. Van Lehn's [3] meta-analysis of ten tutoring studies yielded a mean effect size of 0.79 with individual study effect sizes ranging from -0.24 to +1.95.

In addition to creating systems that are responsive to students' academic performance, researchers have been able to take advantage of educational technology platforms to experiment with strategies for holding students' attention and keeping them engaged in the learning materials [4], [5], [6]. Numerous studies have affirmed the link between student engagement and better educational outcomes [7], [8], [9], [10]. If engagement is indeed a prerequisite to learning, educators must constantly monitor the extent to which learners are engaged and find ways to increase it. Traditionally, engagement has been assessed through student self-reports, teacher

reports, or observational measures [11], [12]. More recently-developed observation protocols are usually associated with electronic data collection procedures. Fredericks et al. [9] observe that most studies of student engagement attempt to capture one or two dimensions of engagement but they argue that, ideally, all three - behavior, emotion, and cognition - should be measured.

1.1. Automated detectors of affect and engagement

D’Mello, Duckworth, and Dieterle [13] describe state-of-the-art approaches to assessing student cognition, affect, and motivation. They suggest that automated computer-based assessments of engagement derived from sensor signals such as keystrokes, log files, facial or eye movements, posture, or electrodermal activity offer the advantage of objectivity and reliability compared with human assessments. Sensor-free approaches measure engagement by relying on the log files of students working on computer-based activities [14], [15], [16], [17], [18]. Sensor-light approaches use inexpensive, ubiquitous, and relatively unobtrusive devices such as webcams or microphones to collect signals [19]. Sensor-heavy approaches utilize expensive equipment such as eye trackers, pressure pads, and physiological sensing devices [20] which are hard to use in the field at scale. Software is used to read and automatically categorize the signals collected by the sensors. While all these approaches require some initial labor-intensive data collection, once machine-learning models have been built to detect patterns of behavior associated with specific states of affect or engagement, they can be applied at scale to new student data collected by automated sensors, incurring negligible marginal costs.

Automated sensor-free detectors are sequences of computer code that detect patterns of user activity in log files generated by educational software platforms. These detectors are specific to the software and are developed in multiple stages. Initially, human coders observe and record the learners’ states of engagement and affect as they use the software. These data may also be collected by analyzing video recordings of learners [21] or from self-reports [22], [23]. The resulting observation labels (a label is a single record of engagement or affect) are synchronized with the user log files to match the time of the observation label with keystrokes recorded in the log file. Patterns of keystrokes that are associated with particular states of engagement or affect are identified. For example, confused students may repeat steps more often, off-task students may register longer pauses, and students who are gaming the system may enter answers without completing intermediary steps. These patterns are used to develop programming code that recognizes the same patterns in log files collected from other learners using the same software. The detector “reads” the log file data and assigns an engagement or affect label at regular intervals, usually every 20 seconds.

If automated detectors of engagement and affect can be built into educational software, the possibility arises of real-time automated responsiveness to the student’s emotional state as well as academic performance. Given the substantial programming and instructional design resources required to build detectors and adaptiveness into any one software program, the question arises as to whether this strategy is economically viable within the price range generally tolerated for educational software. If such adaptive and responsive software is to be widely affordable to schools and learners, the most cost-effective development strategies must be adopted and they must be applied to software programs or ITSs used at scale. Cost-effective strategies in this context would be those in which the least amount of resources are used to develop responsive ITSs that lead to the greatest improvement in student learning. We set out to assess the cost-effectiveness of automated detectors of learner engagement and affect compared with traditional

observation methods used for determining students' affective states to determine whether they present a promising development towards personalization of student learning experiences.

1.2. Accuracy of observations of affect and engagement

Key questions for any method of assessing learner engagement and affect are the extent to which observations are reliable and valid. Validity is particularly difficult to assess for indirectly observable constructs such as affect and engagement because a definitive “ground truth” cannot be established. Additionally, Ocumpaugh, Baker, Gowda, Heffernan, and Heffernan [24] provide evidence that affective states may be susceptible to cultural variation. Ary and Suen [25] document that momentary time sampling with intervals set at the shortest possible length yields the best estimate of duration of a behavior of interest. Accordingly, studies of student engagement and affect often record observation labels every 20 seconds. Hintze and Matthews [26] concluded that, to achieve adequate levels of reliability with regard to learner engagement, students should be observed for 15 minutes each four times per day over four weeks. This is substantially more time than planned for many classroom observations.

Hintze [27] asserts that coefficient kappa [28], an estimate of agreement between two or more observers corrected for chance, is the most robust measure of interobserver agreement. In practice, it is the most widely used measure of reliability for direct observation data. D’Mello [29] reviewed interobserver reliability in affective computing studies and found an average kappa of 0.39, indicating only fair agreement between observers (based on [30]). However, even when acceptable levels of interobserver agreement are achieved, these judgments do not coincide well with the learner’s self-assessments. Graesser et al. [31] found only slight agreement (kappa = 0.12) between learners’ self-assessments of affect and the judgments of trained judges. Difficulty in obtaining reliable and valid observations of affect and engagement presents an obstacle to the development of adaptive and personalized educational programs.

2. Methods

Our goal was to assess how well automated detectors of affect and engagement currently stack up against traditional measures of the same constructs with respect to accuracy and to costs of development and application. The traditional observation methods we compared with were: classroom observations recorded using pen and paper; classroom observations recorded using a smartphone, and video analysis. We based our investigation of each method using two or three published studies so that we could tie the resource requirements for data collection and processing to the actual number of students observed and the amount of data collected. Table 1 summarizes the selected studies and the observation codes used in each case. Our selection criteria for studies to include were the following: the study collected data on regular learners; the data collected included records of learner engagement and/or affective state at intervals of 60 seconds or less; and the study was recent enough that we could interview the researchers and reasonably expect them to recall enough details of implementation.

The standard methodology for estimating costs for the purposes of economic evaluations of educational interventions is the “ingredients method” developed by Levin [32] and further refined by Levin and McEwan [33]. This approach estimates the opportunity costs of all resource components required to implement the intervention. It has been applied to a wide range of educational interventions including computer-assisted instruction [34], [35] blended learning programs [36], and massive open online courses [37]. We used the ingredients approach to

estimate the costs of each of the four methods of observing student affect and/or engagement and compare them with respect to total implementation costs, cost per student, cost per hour of observation, and cost per observation label. In all cases but one, the learners were observed while using computer-based educational programs.

Our cost analyses estimated the cost of replicating the specific implementation of each selected study in order to collect the quantity and quality of engagement and/or affect data reported. We first used information from the methods sections of each of the published studies to develop a list of ingredients (personnel, materials, equipment, facilities, etc.) required to collect the observation data. We included any resources used to customize the observation instrument, to train observers, to organize logistics, to collect and to summarize the data. In situations where the study took place in a regularly scheduled classroom setting, we considered only costs above and beyond the resources that contributed to the regular instructional activities. Subsequently, we interviewed one or more researchers from each of the eight studies selected for analysis to gather further details on personnel qualifications, work experience, amount of effort required to collect the data, types of equipment, materials, and facilities utilized, transportation needs, and so on. We focused only on the resources required to collect the engagement and affect data and to process them to the point of summarizing them in table format. We conducted a total of 15 interviews with 11 individuals. Nine interviewees were researchers or computer programmers and two were information technology personnel. Interviews were conducted face-to-face, by telephone, or by Skype between October 2014 and January 2015. Interviews ranged in length from 35 to 128 minutes. Follow-up questions were sent via email.

We calculated the amount of each ingredient used in each study and identified a national average U.S. price for the ingredient sourced from a publicly available survey. We used national prices to render costs comparable across studies. Details on methods for assigning values to different types of ingredient are provided in [38]. All prices were converted to 2014 dollars for consistency. We entered each ingredient amount and its price into the CBCSE Cost Tool Kit, a set of Excel spreadsheets developed for the purpose of estimating costs of educational programs (an online version is available at <http://www.cbsecosttoolkit.org/>). We calculated the total cost of each implementation and divided this by the number of students observed, the number of hours of observation time, and the number of observation labels collected. A report of results was sent to each interviewee for comment.

Most studies we identified provided a report of interobserver agreement in the form of kappa statistics. For the classroom observation studies we reviewed, the kappa statistics report the agreement levels between human observers. In one study that involved peer judgments of a learner's affective state, the kappa statistic reported agreement between peer assessments and the learners' self-assessments. For the studies involving automated detectors, the kappas indicate agreement between computer and human coder judgments. The studies differ in the specific constructs that were coded and it is important to note that some learner states are harder than others to judge accurately [39].

3. Results and discussion

Table 2 summarizes our estimated costs for each method of collecting engagement and/or affect data and the average kappa across the constructs observed in each study. Detailed tables of ingredients and their associated costs are available in [40]. Our cost estimates indicated that the resources required for collecting observation data on learner engagement and affect vary widely depending on the method employed. Costs per observation label collected ranged from as low as

1c when using automated detectors for ASSISTments to as high as \$7.36 for a classroom observation of students using DynEd software. Overall costs of data collection in the studies we analyzed ranged from a few thousand dollars for in-person classroom observations recorded using pen and paper protocols or smartphones, to almost \$88,000 for the development of automated detectors for ASSISTments and their application to log files. Within each of the four observation methods we considered, results varied depending on factors such as the number of students and schools involved, total observation time, effort required to develop an observation instrument, amount of observer training, types of personnel involved, and travel time.

Efficiency of data collection was greatest when observation labels were assigned more frequently, when both affect and engagement were recorded simultaneously, or when multiple observers were trained together and applied their skills to more observations. For labor-intensive observation methods such as classroom observations and video analysis, there is clearly a trade-off to be considered between costs and the ability of the observations to reliably reflect each student's behavior over time. In the three studies for which data were recorded using a smartphone, students were each observed for less than 10 minutes. While this results in low costs per student, it is questionable whether such brief observations are adequate to capture student behavior. Similarly, there is an apparent connection between costs and accuracy depending on the observer's level of experience and training. For example, in the studies that involved video analysis, both costs and kappa coefficients increased as judgments of affect were made by teachers instead of students and then by trained judges instead of teachers.

Developing automated detectors of affect and engagement requires a significant upfront investment. Our cost results were reasonably consistent across detectors developed for two ITSs: \$13,490 for each of six detectors for ASSISTments, and \$12,460 for each of four detectors for Inq-ITS. Applying the detectors to student log files costs several thousand dollars, comparable with the costs of the classroom observation studies we analyzed. However, given the ease with which the detectors can be applied to many hours of log files for many students, they can yield several hundred thousand to several million observation labels at a cost of 1c -28c per label, \$23 - \$47 per student, and \$4 - \$50 per hour, with the magnitude of cost being inversely related to the scale of application.

Inter-rater reliability was more or less comparable for observations recorded using a pen and paper protocol and those recorded using a phone application. All of them fell into Landis and Koch's [30] "substantial agreement" range, with one achieving a kappa at the top of this range, most likely because the observers were more experienced in the use of the observation protocol. For the video analysis studies we analyzed, the inter-rater reliability for affective states recorded at pre-determined intervals was low, falling into Landis and Koch's "slight" or "fair" agreement range. This may be partially explained by the fact that these studies included a "neutral" construct which is hard to assess accurately [41]. Other studies involving video analysis have reported substantial interobserver agreement for constructs that are easier to assess such as happiness, frustration, and anxiety, with kappas ranging from 0.65 to 0.80 [42].

While the low costs of applying automated detectors at scale are clearly attractive, accuracy of these detectors is less compelling. Agreement between the machine-assigned labels and the human coder labels averaged around kappa = 0.35 across all detectors, falling into Landis and Koch's [30] "fair agreement" range. Until this level of accuracy can be improved, automated detectors are likely to misread a student's state of affect or engagement too often to merit their integration into ITSs for routine use by students. However, given their potential for efficient use at scale, it is worthwhile investing in strategies to address this deficiency.

4. Future directions and conclusion

One strategy that may improve accuracy of automated detectors is to collect the initial observation data using two experienced observers who display a high level of interobserver agreement and subsequently only use the observation labels on which they show agreement to develop the detectors. Additionally, given Hintze and Matthews' [26] findings regarding desirable frequency and duration of student observations, more extensive initial data collection per student should yield more reliable assessments of student affect and engagement while using an ITS. We also recommend further investigation as to whether detectors need to be built specific to a population given Ocumpaugh et al.'s [24] finding that automated detectors do not generalize well across different student populations. Population-specific detectors would be more costly than a universal set of detectors developed from data collected across several populations, but should yield higher accuracy in assigning states of affect and engagement, and could lead to better results for students.

An unresolved issue with respect to any observation method is the question of how well it can truly assess engagement and affect, that is, how close the method can get to ground truth. One interviewee suggested that the most accurate assessment of a learner's state would be obtained by using a combination of physiological sensors and self-assessments to capture a predictable response to a contrived stimulus. While this would be prohibitively costly for everyday purposes, it could be a worthwhile investment to develop a master set of observation data reflecting different states of engagement and affect that could be shared across researchers who are building automated detectors for a variety of ITSs.

We conclude that automated detectors of affect and engagement are vastly less costly per unit of data collected than traditional observation methods and allow analysis of many students and observation labels at minimal marginal costs. Large datasets of observation labels aligned to student activity and performance in the learning environment will be invaluable in the development of adaptive and responsive software. However, automated detectors are currently low in reliability and we recommend several strategies to improve their accuracy. As automated detectors become more reliable in assessing learners' affect and engagement, we expect they will be embedded in the software itself so that the learner's state can be detected real-time, and the software will respond accordingly with personalized messages, talking agents, or alternative activities. Automated detectors of affect and engagement represent a potentially significant step towards the goal of affordable personalization of learning at scale.

References

- [1] Kulik, J.A., & Fletcher, J.D. (2016). Effectiveness of intelligent tutoring systems. *Review of Educational Research*, 86(1), 42-78. doi: 10.3102/0034654315581420.
- [2] Kulik, C. L. C., & Kulik, J. A. (1991). Effectiveness of computer-based instruction: an updated analysis. *Computers in Human Behavior*, 7(1), 75-94.
- [3] Van Lehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist*, 46(4), 197-221.
- [4] Arroyo, I., Woolf, B. P., Royer, J. M., & Tai, M. (2009). Affective gendered learning companions. In *AIED* (Vol. 200, pp. 41-48). doi: 10.3233/978-1-60750-028-5-41
- [5] D'Mello, S., Craig, S., Fike, K., & Graesser, A. (2009). Responding to learners' cognitive-affective states with supportive and shakeup dialogues. In *Human-computer interaction. Ambient, ubiquitous and intelligent interaction* (pp. 595-604). Berlin, Heidelberg: Springer.

- [6] Rebolledo-Mendez, G., du Boulay, B., & Luckin, R. (2005). "Be bold and take a challenge": Could motivational strategies improve help-seeking? In *Proceedings of the 2005 conference on Artificial Intelligence in Education: Supporting Learning through Intelligent and Socially Informed Technology* (pp. 459-466).
- [7] Karweit, N., & Slavin, R. E. (1981). Measurement and modeling choice in studies of time and learning. *American Educational Research Journal*, 18(2), 157-171.
- [8] Baker, R. S., Corbett, A. T., Koedinger, K. R., & Wagner, A. Z. (2004, April). Off-task behavior in the Cognitive Tutor classroom: when students game the system. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 383-390). ACM.
- [9] Fredericks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59-109.
- [10] Marks, H. M. (2000). Student engagement in instructional activity: patterns in the elementary, middle and high school years. *American Educational Research Journal*, 37(1), 153-184.
- [11] Fredericks, J., McColskey, W., Meli, J., Mordica, J., Montrosse, B., & Mooney, K. (2011). *Measuring student engagement in upper elementary through high school: a description of 21 instruments*. (Issues & Answers Report, REL 2011-No. 098). Washington, DC: U.S. Department of Education. Retrieved from http://ies.ed.gov/ncee/edlabs/regions/southeast/pdf/rel_2011098.pdf
- [12] Volpe, R. J., DiPerna, J. C., Hintze, J. M., & Shapiro, E. S. (2005). Observing students in classroom settings: a review of seven coding schemes. *School Psychology Review*, 34, 454-473.
- [13] D'Mello, S., Duckworth, A., & Dieterle, E. (under review). Advanced, analytic, automated measures of state engagement during learning.
- [14] D'Mello, S. K., Craig, S. D., Witherspoon, A. W., McDaniel, B. T., & Graesser, A. C. (2008). Automatic detection of learner's affect from conversational cues. *User Modeling and User-Adapted Interaction*, 18(1-2), 45-80.
- [15] Pardos, Z., Baker, R., San Pedro, M., Gowda, S., & Gowda, S. (2013). Affective states and state tests: investigating how affect throughout the school year predicts end of year learning outcomes. *Proceedings of the 3rd International Conference on Learning Analytics and Knowledge* (pp. 117-124).
- [16] Bixler, R., & D'Mello, S. (2013, March). Detecting engagement and boredom during writing with keystroke analysis, task appraisals, and stable traits. *Proceedings of the 2013 International Conference on Intelligent User Interfaces (IUI 2013)* (pp. 225-234). New York, NY.
- [17] Baker, R. S. J., Kalka, J., Aleven, V., Rossi, L., Gowda, S. M., Wagner, A. Z., . . . Ocuppaugh, J. (2012). Towards sensor-free affect detection in Cognitive Tutor algebra. In K. Yacef, O. Zaïane, H. Hershkovitz, M. Yudelson, & J. Stamper (Eds.), *Proceedings of the 5th International Conference on Educational Data Mining* (pp. 126-133). International Educational Data Mining Society.
- [18] Sabourin, J., Mott, B., & Lester, J. C. (2011). Modeling learner affect with theoretically grounded dynamic Bayesian networks. In *Affective computing and intelligent interaction* (pp. 286-295). Berlin, Heidelberg: Springer.
- [19] Whitehill, J., Serpell, Z., Foster, A., Lin, Y. C., Pearson, B., Bartlett, M., & Movellan, J. (2011, June). Towards an optimal affect-sensitive instructional system of cognitive skills. In *Computer Vision and Pattern Recognition Workshops (CVPRW), 2011 IEEE Computer Society Conference* (pp. 20-25). IEEE.
- [20] Kapoor, A., & Picard, R. W. (2005, November). Multimodal affect recognition in learning environments. In *Proceedings of the 13th annual ACM international conference on multimedia* (pp. 677-682). ACM.
- [21] D'Mello, S. K., Taylor, R., Davidson, K., & Graesser, A. (2008). Self versus teacher judgments of learner emotions during a tutoring session with AutoTutor. In B. Woolf, E. Aimeur, R. Nkambou, & S. Lajoie (Eds.), *Proceedings of the Ninth International Conference on Intelligent Tutoring Systems* (pp. 9-18). Berlin, Heidelberg: Springer.
- [22] Conati, C., & Maclaren, H. (2009). Modeling user affect from causes and effects. In *User Modeling, Adaptation, and Personalization* (pp. 4-15). Heidelberg: Springer Berlin.

- [23] Arroyo, I., Woolf, B. P., Burelson, W., Muldner, K., Rai, D., & Tai, M. (2014). A multimedia adaptive tutoring system for mathematics that addresses cognition, metacognition and affect. *International Journal of Artificial Intelligence in Education*, 24(4), 387-426.
- [24] Ocumpaugh, J., Baker, R., Gowda, S., Heffernan, N., & Heffernan, C. (2014). Population validity for educational data mining models: a case study in affect detection. *British Journal of Educational Technology*, 45(3), 487-501.
- [25] Ary, D., & Suen, H. K. (1983). The use of momentary time sampling to assess both frequency and duration of behavior. *Journal of Behavioral Assessment*, 5(2), 143-150.
- [26] Hintze, J. M., & Matthews, W. J. (2004). The generalizability of systematic direct observations across time and setting: a preliminary investigation of the psychometrics of behavioral observation. *School Psychology Review*, 33(2), 258-279.
- [27] Hintze, J. M. (2005). Psychometrics of direct observation. *School Psychology Review*, 34(4), 507.
- [28] Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20(1), 37-46.
- [29] D'Mello, S. K. (in press). On the influence of an iterative affect annotation approach on inter-observer and self-observer reliability. *IEEE Transactions on Affective Computing*.
- [30] Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics* 33, 159-174.
- [31] Graesser, A. C., McDaniel, B., Chipman, P., Witherspoon, A., D'Mello, S., & Gholson, B. (2006). Detection of emotions during learning with AutoTutor. *Proceedings of the 28th Annual Meeting of the Cognitive Science Society*, (pp. 285-290), Vancouver, Canada.
- [32] Levin, H. M. (1975). Cost-effectiveness analysis in evaluation research. In M. Guttentag & E. Struening (Eds.), *Handbook of evaluation research* (Vol. 2, pp. 89-122). Beverly Hills, CA: Sage.
- [33] Levin, H. M., & McEwan, P. J. (2001). *Cost-effectiveness analysis: methods and applications* (2nd ed.). Thousand Oaks, CA: Sage Publications.
- [34] Levin, H. M. & Woo, L. (1981). The costs of computer-assisted instruction. *Economics of Education Review*, 1(1), 1-25.
- [35] Levin, H. M., Glass, G. V., & Meister, G. (1987). Cost-effectiveness of computer-assisted instruction. *Evaluation Review*, 11(1), 50-72.
- [36] Hollands, F. M. (2012, April). Using cost-effectiveness analysis to evaluate School of One. Paper presented at the Annual Meeting of the American Educational Research Association, Vancouver, Canada.
- [37] Hollands, F. M., & Tirthali, D. (2014). Resource requirements and costs of developing and delivering MOOCs. *The International Review of Research in Open and Distance Learning*.15(5), 113 - 132. Retrieved from <http://www.irrodl.org/index.php/irrodl/article/view/1901>
- [38] Author et al. (2015)
- [40] Authors. (2015).
- [41] D'Mello, personal communication, July 20th, 2015
- [42] Lehman, B., Matthews, M., D'Mello, S., & Person, N. (2008, January). What are you feeling? Investigating student affective states during expert human tutoring sessions. In *Intelligent Tutoring Systems* (pp. 50-59). Berlin, Heidelberg: Springer.
- [43] Gobel, P. (2008). Student off-task behavior and motivation in the CALL classroom. *International Journal of Pedagogies and Learning*, 4(4), 4-18.
- [44] Ocumpaugh, J., Baker, R. S. J. D., Gaudino, S., Labrum, M. J., & Dezenorf, T. (2011). Field observations of engagement in Reasoning Mind. *Proceedings of the 16th International Conference on Artificial Intelligence and Education*, (pp. 624-627), Memphis, USA.
- [45] Paquette, L., Baker, R. S. J. D., Sao Pedro, M. A., Gobert, J. D., Rossi, L., Nakama, A., & Kauffman-Rogoff, Z. (2014). Sensor-free affect detection for a simulation-based science inquiry learning environment. In *Intelligent Tutoring Systems* (pp. 1-10). Springer International Publishing.
- [46] San Pedro, M., Baker, R., Bowers, A., & Heffernan, N. (2013). Predicting college enrollment from student interaction with an intelligent tutoring system in middle school. *Proceedings of the 6th International Conference on Educational Data Mining* (pp. 177-184).

Table 1. Summary of observation studies selected for analysis, and coding options

Method and study	Learning activity	Coding options	Duration of coding intervals	Frequency of coding
Classroom observation using pen and paper				
Hintze & Matthews, [26]	Math and ELA	<i>Behavior:</i> on/off-task (+/-)	Momentary	Every 15 secs
Gobel, [43]	DynEd	<i>Behavior:</i> on-task, on-task teacher/peer help, off-task non-software, off-task software help, off-task inactive, off-task gaming	60 seconds	Every 60 secs
Classroom observation using phone application (HART)				
Ocuppaugh et al., [44]	Reasoning Mind	<i>Behavior:</i> on-task, on-task conversation, off-task, gaming, other <i>Affect:</i> boredom, confusion, delight, engaged concentration, frustration, other	20 seconds	Every 20 secs
Pardos et al., [15]	ASSISTments	<i>Behavior:</i> off-task, gaming, other <i>Affect:</i> boredom, frustration, engaged concentration, confusion	20 seconds	Every 20 secs
Paquette et al., [45]	Inq-ITS	<i>Affect:</i> boredom, frustration, engaged concentration, confusion, "?" (other)	20 seconds	Every 20 secs
Video analysis				
Self-judgments Graesser et al., [31]	AutoTutor	<i>Affect:</i> boredom, confusion, delight, flow, frustration, neutral, surprise	Momentary	Every 20 secs
Peer judgments Graesser et al., [31]	AutoTutor	<i>Affect:</i> boredom, confusion, delight, flow, frustration, neutral, surprise	Momentary	Every 20 secs
Trained judge judgments Graesser et al., [31]	AutoTutor	<i>Affect:</i> boredom, confusion, delight, flow, frustration, neutral, surprise	Momentary	Every 20 secs
Teacher judgments D'Mello et al., [21]	AutoTutor	<i>Affect:</i> boredom, confusion, delight, flow, frustration, neutral, surprise	Momentary	Every 20 secs
Automated detectors				
Paquette et al., [45]	Inq-ITS	<i>Affect:</i> boredom, frustration, engaged concentration, confusion	20 seconds	Every 20 secs
Pardos et al., [15]; San Pedro et al., [46]	ASSISTments	<i>Behavior:</i> off-task, gaming the system; <i>Affect:</i> boredom, confusion, engaged concentration, frustration	20 seconds	Every 20 secs

Table 2. Summary table of costs and accuracy of observation methods

Method and study	Total cost	Hrs of observation	# of students observed	Observed time per student (mins)	Cost per student	Cost per hour	# of labels	Cost per label	Kappa index
Classroom observation with pen and paper									
Hintze & Matthews, [26]	\$6,286	63	14	270	\$449	\$100	15,120	\$0.42	0.65
Gobel, [43]	\$5,302	12	30	24	\$177	\$442	720	\$7.36	nm
Classroom observation with phone application (HART)									
Ocuppaugh et al., [44]	\$3,609	2	130	1.5	\$28	\$1,804	569	\$6.34	0.68
Pardos et al., [15]	\$6,325	17	229	9	\$28	\$372	6,150	\$1.03	0.79
Paquette et al., [45]	\$7,551	23	326	4.25	\$23	\$328	4,155	\$1.82	0.64
Video analysis									
Self-judgments Graesser et al., [31]	\$11,548	15	28	30	\$412	\$770	2,688	\$4.30	na
Peer judgments Graesser et al., [31]	\$11,548	15	28	30	\$412	\$770	2,688	\$4.30	0.06 ^a
Trained judge judgments Graesser et al., [31]	\$15,621	15	28	30	\$558	\$1,041	2,688	\$5.81	0.31
Teacher judgments D’Mello et al., [21]	\$11,898	15	28	30	\$425	\$793	2,688	\$4.43	0.12
Automated detectors									
Paquette et al., [45]	\$56,480	1,139	1,196	57	\$47	\$50	204,960	\$0.28	0.35 ^b
Pardos et al., [15] & San Pedro et al., [46]	\$87,576	19,510	3,747	625	\$23	\$4	7,023,776	\$0.01	0.34 ^b

Note. nm = not measured; na = not applicable.

^aThis kappa indicates agreement with self-judgments. ^bThese kappas indicate agreement between automated detector assessment and human coders.

Exploring the Efficacy of Digital Learning for Providing Access to Education to Underprivileged Children: A Case Study from Pakistan

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Abstract

This study investigates the impact of digital learning using mobile technology by observing the performance of thirty underprivileged out-of-school children over a period of four months in a rural area of Pakistan. Two focus areas of the study were to observe (1) Change in participants' perception towards digital learning through mobile technology and (2) Content knowledge and skill development of participants. Children were given devices (iPads, QMobile Tablets and laptops) with pre-installed apps and a learning management system to take online lectures. A hybrid learning framework was used to measure their performance in three knowledge areas: foundational, meta and humanistic skills. Both qualitative and quantitative data was used to compare their performance with their peers who attended school. The overall findings suggested that after four months, the participants had increased cognitive, metacognitive and social-cultural skills compared to school going students indicating the effectiveness of digital learning through mobile technology.

1. Introduction

1.1. Adoption of mobile technology to empower students: With the ubiquitousness of mobile technology, such as smartphones and tablet computers, digital learning promises to provide children with greater access to education, hereby ensuring that no child is left behind from getting quality education.

Since their release in 2010, mobile technologies have become extremely affordable and functional partly explaining their attractiveness in education [1]. One of the primary incentives of integrating mobile technology into learning is that it supports cognitive, metacognitive, affective and social-cultural development in students [2]. The use of digital learning also provides students with a self-directed learning environment promoting learner control, self-management, autodidaxy and personal autonomy which bolsters learners' readiness and capacity to take responsibility of their own learning activities [3][4][15]. The various impacts of learning through mobile technology have been highlighted by numerous authors:

- a) It offers students innovative ways to study. [5][6][7][8]
- b) It piques students' interest to learn. [8][9][15]
- c) It encourages autodidacticism.[9][10][11][15]
- d) It increases access to information. [6][11][12][13]
- e) It promotes collaborative learning. [8][11][12][13][14][15]

This approach to learning finds a lot of use in areas where children don't have access to formal schooling due to lack of resources, security concerns and societal pressures. According to

UNICEF’s ten point proposal on e-rights for children, every child has a right to personal development and education by making use of new technologies for educational purposes.

1.2. Need of digital learning through mobile technology in Pakistan: According to an estimate, Alif Ailaan, an NGO working for education in Pakistan, reported that 47% children are out-of-school between the ages of 5 and 16, and 68% of out-of-school children have never been to school. One of the primary reasons for this, according to UNICEF’s report on out-of-school children is that families living below the poverty line lack resources to send their children to school. According to UNDP’s Human Development Report of 2015, Pakistan’s HDI rank is 147 with 45.8% of the population earning \$2 a day. In such a scenario, the need for affordable distance education at the primary level cannot be emphasized enough. Although the positive impact of mobile technology on education in primary schools has been extensively recognized globally[16], in Pakistan digital learning is mostly limited to higher education, and that too faces many problems, such as lack of infrastructure, resources, socio-political conditions and internet access [17][18][19][20].

1.3. The Present Study: The purpose of the present study is to investigate the potential benefits of online education using mobile technology for underprivileged children. It has been framed as an experimental research where out-of-school children were given tablets and their performance was measured over a period of four months to determine the effectiveness of digital learning. The findings are based on a comparison of their performance with that of the school-going students, using the learning framework suggested by Mishra and Keriluik (2011) [21].

1.4. Framework for measuring efficacy of digital learning in children: Many authors and groups have called into question the efficiency of traditional education that focuses on teacher-centered methods of rote learning and memorization [22][23]. These authors advocate that schooling should encourage critical thinking, creative and collaborative problem solving, and adaptability among other metacognitive processes. William and Flora Hewlett Foundation called this approach ‘deeper learning’. In tandem with this are proponents of ‘21st Century Skills’- learning and innovation skills, media and technology skills, life and career skills- that many consider to be imperative for one’s success in the 21st century. Advocates for 21st century skills are educators and writers such as Howard Gardner and Daniel Pink and organizations such as European Union and the Partnership for 21st Century Learning.

For this study, we considered a hybrid learning framework that combines metacognitive and 21st century skills in order to measure three key knowledge areas: foundational, meta and humanistic for each student (Table 1).

Table 1: Hybrid Learning Framework Suggested by Mishra and Kereluik, 2011

Categories	Sub-categories	Skills
Foundational Knowledge	Core Content Knowledge	High Academic Standards Mathematical and Scientific Competence Core Subjects (basic and advanced knowledge) Financial and Business Literacy Quantitative Literacy Environmental, Health and Civic Literacy Disciplined Mind
	Information Literacy	Technology Concepts and Operations Digital Age Literacy /Digital Competence Using Tools Interactively Information Literacy

Categories	Sub-categories	Skills
	Cross-Disciplinary Knowledge/Synthesis	Research and Information Fluency Digital Citizenship Synthesizing Mind Symphony Synthesis Across Studies Story and Meaning
	Problem Solving/ Critical Thinking	Critical Thinking, Problem Solving, Decision Making Cognitive Skills Inquiry and Analysis Risk Assessment Problem Solving
Meta Knowledge	Communication/ Collaboration	Communication in Mother Tongue Communication and Collaboration Interacting in Heterogeneous Groups Teamwork and Problem Solving Creativity and Innovation Critical and Creative Thinking Initiative/Entrepreneurship Play and Design
	Life/Job skills	Skills that Cannot be Outsourced Learning to Learn High Productivity and Quality Foundations and Skills for Lifelong Learning Life and Career Skills Acting Autonomously
Humanistic Knowledge	Cultural competence	Intercultural Knowledge Skills for a Global World Communication in Foreign Language Civic Knowledge and Engagement Social Civic Competence Global Awareness Cultural Awareness and Expression
	Ethical/Emotional Awareness	Ethical Reasoning Constructive Management of Feelings/Empathy Initiative Emotional Intelligence

2. Methodology

2.1. Participants: The research was conducted on thirty out-of-school underprivileged children (including 16 girls and 14 boys, aged between eight and eleven years) in Barakahu, Islamabad. They were previously attending the second grade in a school funded by the Chinese government and private donations, which provided free education to underprivileged children in the area. In 2015, the funding stopped due to political concerns and the administration decided to combine all twenty-five branches into one centralized school in Islamabad. Since the parents couldn't afford to send their children to the centralized branch, they dropped out altogether. The thirty students and were all in the second grade.

2.2. Structure: The research took place from October 2105 to February 2016. Underprivileged out-of-school students (the experimental group) were provided mobile technologies and their progress was compared with students attending the centralized branch of the Chinese school (the

control group). Since resources were limited, only 8 tablets (iPads and QMobile tabs) and 10 laptops were distributed. These devices were either personal or borrowed from the authors' families and friends. Also, children from the same household shared a device. The family of every participant signed an affidavit to ensure the safety of the devices. Students in the experimental group were also given workbooks to practice the content by hand to ensure maximum learning. To ensure access to online content, they were also provided with Wi-Fi dongles.

The two main purposes of the research were to observe:

- a) Change in participants' perception towards digital learning through mobile technology.
- b) Content knowledge and skill development of participants.

This was achieved through interviews which were conducted at three stages: before, during and after the study period, as well as summative assessment through class tests (Table 2).

The purpose of interviewing the participants thrice followed by assessment was to analyze attitude changes towards digital learning as well as measure increase in functional, meta- and humanistic knowledge.

At the conclusion of the study period, the results obtained from the experimental group were compared against the performance of the control group based on the learning framework.

Table 2: Timeline and Phases of the Study

Stages	Time	Participants	Method
First Interview - Before study	October 28-31 - November 1, 2015	<ul style="list-style-type: none"> ● Parents ● Teachers ● Experimental group 	The participants were asked about their understanding of and opinions on the purpose of computers and smart technologies and their use for education.
Intervention - Phase I	November 1-30 - December 1-31, 2015	Experimental group	The students were provided with the required technology, software and other educational resources and were given training on how to use them.
Second Interview - During Study	January 1-3, 2016	<ul style="list-style-type: none"> ● Parents ● Teachers ● Experimental group 	The participants were asked about their current understanding of and opinions on the purpose of computers and smart technologies and their use for education.
Intervention - Phase II	January 4-30 - February 1-25, 2016	Experimental group	Social events were organized for the students in order to develop their social skills through games, sports and other academic activities.
Third Interview - Post Study	February 26-28, 2016	<ul style="list-style-type: none"> ● Parents ● Teachers ● Experimental group 	The participants were asked about their final understanding of and opinions on the purpose of computers and smart technologies and their use for education.
Evaluation & Data Analysis	February 29 - March 1-3, 2016	<ul style="list-style-type: none"> ● Experimental group ● Control group 	At the end of the study period, both qualitative and quantitative data of the experimental group were compared with that of the control group to see the efficacy of digital learning using the learning framework.

2.3. Content: Since one of the main goals of this research was to compare the performance of students learning through digital technology with the performance of students attending school, care was taken to ensure that participants were learning the same content that was being taught at the Chinese school. We used a learning management system (CourseSites by Blackboard) to upload content of all the six courses taught at school - English, Science, Social Studies, Mathematics, Ethics and Urdu.

In addition to these subjects, we included various apps that targeted the three key skills of our learning model (Table 3). An Android for Windows software was installed on laptops enabling students to access these apps on the laptops.

Table 3: Digital Instructional Material

Skills	App	Purpose
Foundational Knowledge Skills	Berenstain Bears Lite	The user narrates the story and learns new vocabulary.
	Khan Academy	Users watch videos on key subject areas and takes assessment tests.
	Pop Maths/ Bubbling Math/2048	The user can practice math in a fun way through games.
	Mr. Phonics	The users learn to read phonetically correct English.
Meta Knowledge Skills	Slice It!	Users slice shapes into equal sized fragments using critical thinking.
	Pirate Treasure Hunt	Users apply math and literacy skills to solve clues, and find treasures.
	Play Art/ MoMA Art Lab	Based on famous art work, the user can create their own art pieces.
	Where's my water?	The user has to find creative ways to get water to the alligator.
Humanistic Knowledge Skills	Talking Tom and Ben News	The user can make their own news videos.
	SimpleMind	A mind mapping tool that a user can apply to synthesize information.
	Kids World Culture	Users learn about world cultures through stories, games and quizzes.
	My LifeSkillsBox	The user learns everyday life and social skills.

2.4. Intervention and Data Collection: The research was divided into six stages (Table 2):

First Interview - Before the Study: Participants were asked five research questions to see their level of familiarity and perception towards digital learning through smart devices. The following research questions were asked of the primary participants of the study (out-of-school students) as well as their parents and teachers teaching at the Chinese school.

RQ1: What do you think is the purpose of computers and smart technologies?

RQ2: Have you ever used a computer for learning/playing?

RQ3: Do you know about distance learning through mobile technologies?

RQ4: Do you think children can study autonomously through computers?

RQ5: Do you think digital learning through mobile technologies is a good idea?

Intervention – Phase I: The preliminary interviews were followed by the first intervention phase. Tablets and laptops with pre-installed apps, workbooks and Wi-Fi dongles were handed out to students. Students attended two sessions to become familiar with the devices, apps and the learning management system. Since the devices were borrowed, in order to protect personal data of the owners, students' profiles were created and they were given access to only relevant content.

A camera was added in the classroom to live stream the lecture through Skype and record it for future use. Students would attend the virtual lecture, practice on the provided workbooks, take pictures through their devices and upload the assignment on the learning management system. During the first intervention phase, students took one test at the end of Phase 1 in an exam setting with an invigilator present to ensure transparency. The tests were then graded by the teachers teaching at the Chinese school. The decision to conduct only one test during Phase 1 was to observe the autonomous learning behavior of the students.

Second Interview - During Study: At the end of the first intervention phase, the students were interviewed to find out how their experience with digital learning was progressing. The parents and teachers were interviewed to see changes in their perceptions based on the students' performance (through assignments, class test and interaction with the learning environment). The following research questions were asked:

RQ6: How has your opinion on digital learning through mobile technologies changed?

RQ7: What changes would you recommend to make in the course design?

RQ8: Does this mode of learning offer any drawbacks compared to conventional learning?

Intervention – Phase II: A picnic was arranged on the second interview day where participants interacted with each other. The students were asked to bring their devices with them and two new apps ‘Pass the Drop’ and ‘Story Dice’ were installed on them. The students were then asked to run the app and learn to use it together. The aim of this was to observe how students collaborated with each other to understand the app. Also, weekly get-togethers were arranged, where students played various games and sports. This was done to develop their social skills. Also, based on students’ recommendations from the preceding interview, a teacher was arranged to help students with their queries during these weekly get-togethers.

For the school taught courses, in the second intervention phase students took weekly tests organized in the same way as Phase 1. Also, in this intervention phase, students were required to submit the assignments by hand to be graded by the teacher weekly. These weekly tests and assignments were arranged on the same day as the weekly get-togethers (usually the weekend) and the purpose of more class tests was to observe the students’ behavior in a more conventional class setting.

Third Interview - Post study: At the end of the study, the primary participants, their parents and teachers were again interviewed to record their final responses. The following research questions were asked:

RQ9: How has your opinion on digital learning through mobile technologies changed?

RQ10: What changes did you observe in the students/yourself after going through this study?

RQ11: Would you consider using digital learning as a primary source of education for students who can’t afford formal schooling?

Evaluation and Data Analysis: At the end of the study, the data was analyzed using KNIME, V3.1 and Windows Excel, and following consecutive steps of analysis were followed.

Firstly, both qualitative (interviews/games) and quantitative (tests/assignments) data of the experimental group were compared against the learning framework to evaluate if all knowledge areas had been effectively targeted.

Secondly, the experimental group and the control group were brought together and were assigned a series of mental exercises to assess their foundational, meta and humanistic knowledge skills. To ensure validity of the comparison, all the assessment and tasks were pencil-and-paper based or conducted through oral interviews for both groups of students. This eliminated the advantage the experimental group would have had over the control group, had the assessment been done using mobile technology.

3. Results

In this section, we present the results sorted according to the stages of the research.

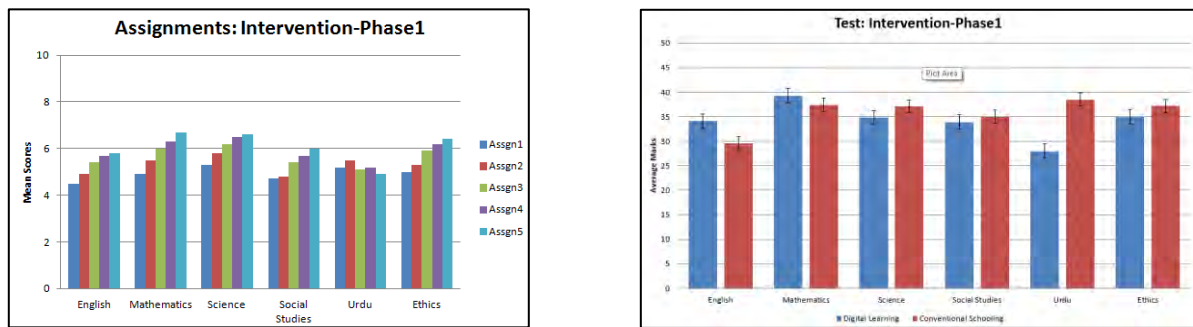
3.1. First Interview – Before the Study: Based on the responses to the research questions, 76.6% of the students had never used a computer or smart device before; 40% of them didn’t know what the purpose of a computer was and 60% thought it was only used for gaming or movies. None of the students knew about digital learning. Of the 40 parents who were interviewed, 42% thought a computer was only used for office work, 97% didn’t know about digital learning and all 100% thought that students were unable to study autonomously. When asked if digital learning is a good

idea for education, 71% of the parents and 80% of the teachers responded against it. 100% of the teachers also thought that students cannot study autonomously.

3.2. Intervention-Phase 1: The students submitted five online assignments during the first intervention phase. The results show that there was a steady increase in the students’ performance over the weeks in all courses except Urdu (Figure 1). This is because there aren’t a lot of educational apps for Urdu to help students practice. Mathematics showed the fastest increase possibly due to the interactive math learning apps. English, Social Studies and Ethics showed a slower increase. This trend can be associated with students’ difficulty of adjusting to the accent and the time taken to get acclimated to the learning management system.

The results for the test conducted at the end of Phase 1 showed that the experimental group’s performance in English was better than the control group (Figure 1). This is attributed to the various English learning apps that students used to develop speaking and writing skills. The biggest difference between the performances of both groups was observed in Urdu. That is because the control group had access to a teacher daily whereas students learning at home had to rely on limited online resources and their workbooks. Also, lack of Urdu apps proved detrimental for their progress for this course.

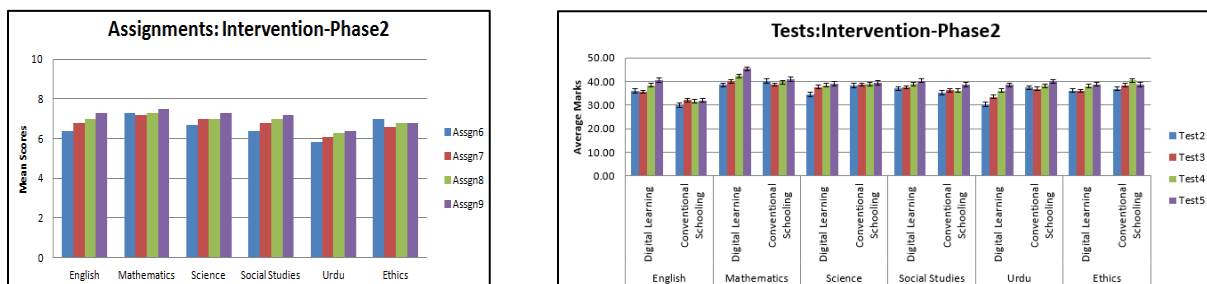
Figure 1: Intervention - Phase 1



3.3. Second Interview-During Study: 85% of the parents said that they had observed an ‘increased sense of responsibility’ in their children towards their studies. 90% of the parents were of the opinion that their initial perception of children not being able to learn autonomously was wrong and that this medium made kids ‘independent’, ‘aware’ and ‘confident’. 100% of the teachers observed that these students displayed ‘refined critical thought towards problems’ compared to the control group, but that these students ‘lacked proficiency in Urdu which should be addressed in the future’. 43% of the parents and 52% of the students commented that the biggest drawback of digital learning was lack of access to a teacher. The students felt that weekly or bi-weekly sessions should be arranged where the teacher can address their problems in person.

3.4. Intervention-Phase 2: Four assignments were hand submitted in Phase 2 and it was observed that Urdu was the most improved subject (Figure 2). The possible reason for this is the weekly tutoring session during the get-togethers. Students’ performance in other courses also increased significantly.

Figure 2: Intervention – Phase 2



Four class tests were conducted, once at the end of each week which showed improvement in all courses, especially Urdu. The experimental group continued to show higher level of skill in Mathematics and English compared to the control group and were at par with them in Science, Social Studies and Ethics. (Figure 2)

For the meta skills, the response time of students solving puzzles and clearing levels improved. 80% of the students who had previously solved a beginner level of ‘Slice it!’ in 5 minutes, were able to solve an intermediate level puzzle in 3-4 minutes and an advanced level puzzle in under 6 minutes.

3.5. Third Interview – Post Study: 97% of the parents said that their children were more ‘well-mannered’, ‘respectful of others’, ‘social’ and ‘confident’ than they were four months ago. 100% of the teachers restated that these students had greater command over the ‘English language’, were more ‘competent at Mathematics’ and more ‘resourceful at solving problems’. 85% of the parents showed approval for using digital learning for their children’s education. 100% of the students said that digital learning through smart technologies is an effective way for acquiring education since it helped them in not only the key subject areas, but also in developing their skills at using computers, internet and various digital resources and ‘it made learning fun’.

3.6. Evaluation and Data Analysis: The results of the final evaluation between the control and experimental group showed that the experimental group exhibited increased levels of meta and humanistic skills as opposed to the control group. Where students in the control group were better in some areas within the foundational skill domain, they lacked advanced meta and humanistic skills. (Figure 3)

Figure 3: Evaluation Results

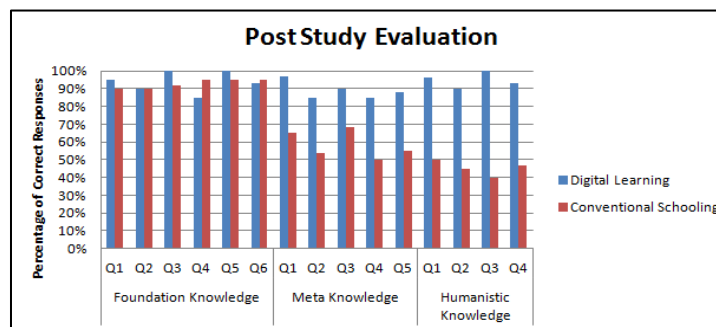


Table 4: Team Challenge Results

	Experimental Group	Control Group
Response Time (minutes)	26	45
Graders Assessment		
Collaboration	A	B
Critical Analysis of Problem	A	B
Design Procedure	A	A
Out-of-box Thinking	A	C
Attitude while solving the problem	A	C
Organization	A	B
Feasibility of Proposed Solution	A	A

The students were also given a team challenge and they were asked to propose a solution for it as two teams. Two independent graders were asked to grade both groups based on seven criteria and their response time (Table 4). The decision to choose independent graders who weren’t involved in

the study was made to eliminate any biases. Grading was done based on the Chinese school rubric where A:90-100, B:80-89, C:70-79, D:60-69 and E: less than 59. The experimental group proposed a solution in less time than the control group (Table 4). The teachers observed that the experimental group was more methodical and organized in their approach. Where the control group were all shouting to get their ideas across and the procedure was generally chaotic, the experimental group took a more collaborative approach: a team lead and a scribe were selected and everyone's idea was heard without interruption. The teachers also observed that even though the solutions from both teams were feasible, the experimental group employed out-of-box thinking to come up with a solution that was more innovative.

Table 5a: Descriptive Statistics with Significance

	Digital Learning	Conventional Schooling	Significance*	
	M(SD)	M(SD)	t value	p value
English ($\alpha = 0.05$)				
Test1	34.13 (5.264)	29.56 (5.758)	3.206	0.003
Test2	36.03 (4.047)	30.00 (5.017)	5.127	0
Test3	35.63 (4.406)	32.03 (3.577)	3.475	0.002
Test4	38.40 (3.420)	31.63 (3.548)	7.521	0
Test5	40.60 (2.699)	32.00 (2.626)	12.509	0
Mathematics ($\alpha = 0.05$)				
Test1	39.33 (4.596)	37.36 (3.409)	1.882	0.069
Test2	38.50 (4.273)	40.10 (3.241)	-1.634	0.105
Test3	40.03 (2.748)	38.70 (2.706)	1.894	0.068
Test4	42.33 (2.397)	39.70 (3.505)	3.396	0.002
Test5	45.30 (2.120)	41.00 (3.636)	5.925	0
Science ($\alpha = 0.05$)				
Test1	34.76 (7.152)	37.10 (3.377)	-1.616	0.108
Test2	34.50 (2.789)	38.20 (3.044)	-4.909	0
Test3	37.63 (2.205)	38.63 (3.557)	-1.309	0.168
Test4	38.40 (2.660)	39.00 (3.206)	-0.789	0.290
Test5	39.13 (2.300)	39.40 (3.013)	-0.385	0.368
Social Studies ($\alpha = 0.05$)				
Test1	33.90 (6.150)	34.96 (5.518)	-0.707	0.308
Test2	37.00 (4.068)	35.13 (4.249)	1.738	0.089
Test3	37.60 (3.847)	36.23 (4.141)	1.324	0.165
Test4	39.03 (3.157)	36.03 (3.135)	3.694	0.001
Test5	40.33 (3.304)	38.73 (2.664)	2.065	0.049
Urdu ($\alpha = 0.05$)				
Test1	27.96 (3.755)	38.53 (5.144)	-9.087	0
Test2	30.40 (2.647)	37.40 (3.784)	-8.303	0
Test3	33.50 (1.961)	36.93 (3.723)	-4.47	0
Test4	36.20 (2.041)	38.20 (3.145)	-2.922	0.007
Test5	38.53 (2.113)	40.00 (2.853)	-2.263	0.033
Ethics ($\alpha = 0.05$)				
Test1	34.96 (5.672)	37.23 (3.607)	-1.847	0.074
Test2	36.20 (4.460)	36.90 (3.407)	-0.683	0.314
Test3	36.00 (3.760)	38.43 (2.873)	-2.817	0.009
Test4	37.93 (3.393)	40.50 (2.957)	-3.124	0.004
Test5	38.83 (3.030)	38.70 (3.697)	0.153	0.393

*Degrees of Freedom = 58, $T_{crit} = 2.002$

Table 5b: Testing of Hypothesis to determine if Digital learning is Efficient than Conventional Learning

	One Tailed Conclusion					
	English	Mathematics	Science	Social Studies	Urdu	Ethics
Test 1	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT
Test 2	ACCEPT	ACCEPT	REJECT	ACCEPT	REJECT	ACCEPT
Test 3	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	REJECT
Test 4	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	REJECT
Test 5	ACCEPT	ACCEPT	ACCEPT	ACCEPT	REJECT	ACCEPT

Based on the statistical analysis, it was observed that digital learning is an efficient tool for out of school students. However, Urdu is one course that students had trouble in since the LMS is in English and major learning material and apps online are in English as well (Table 5a & 5b). A tutor was arranged to help them with their Urdu assignments and later tests showed that the performance of the experimental group increased even if it wasn't at par with the control group.

Also, we can see that the experimental group was better than the control group in English and Mathematics and was almost at the same level with the control group in Social Studies (Figure 2). Improvement in Mathematics can be attributed to apps that helped students learn about various concepts in a fun and interactive way ensuring that their concepts were stronger than in school students who learned the concepts through rote learning. For Science, the control group were at an advantage since they had access to basic experiments and models which the experimental group didn't have access to. For ethics, the control group was learning the theory of Ethics and applying it in their daily life as they were interacting with other students, teachers, etc. Since the experimental group didn't have a lot of interaction with anyone else, their progress in this course was slow.

4. Discussion

The aim of this research was to examine the effectiveness of digital learning as a means of providing education for students who didn't have access to formal schooling. Findings provide significant information on the positive impacts of digital learning which are discussed below:

4.1. Changes in perception: An important observation made during the study was the change in people's perception towards mobile technology. During the preliminary interviews, parents and students were unaware of digital learning and everyone discouraged the idea of autonomous learning. However, during the second interviews perceptions had begun to change and by the end of the study students were excited about using digital learning as a primary mode of education. They were more computer literate and were able to perform advanced operations on their devices. These findings are consistent with available literature on the efficacy of digital learning [4][14].

4.2. Changes in skills: The results of the study indicated that digital learning had a positive impact upon students' foundational, meta and humanistic knowledge skills. Students displayed increased knowledge in key subject areas and were at par with in-school students. In terms of meta and humanistic skills, students learning through digital technology had advanced affective, cognitive, metacognitive and social-cultural skills. According to Sandra's mother, 'Ever since my children participated in this study, they have become more confident and independent. They have developed an increased camaraderie and they help each other with various tasks. Their general knowledge is more than their peers and they are more disciplined now.'

4.3. Feasibility: Since the smart devices used to conduct the study were borrowed from the authors' friends and family and the outings were arranged in public parks that were accessible to everyone on foot, the only cost incurred was internet expense. If every student is given their own

device, the total estimated cost of the intervention comes out to approximately \$285 per child (Table 6a). Other models of Qtab are also available (between \$60-\$120) as well as internet packages (between \$10-\$25). Another important equipment required for the study was the use of a webcam. A modest estimate for an effective webcam is \$350.

Table 6a: Annual Cost Estimate per Student (Digital Learning)

Activity/Item Description	Cost (\$USD)	Total (\$USD)
1 1 Qmobile Qtab V11	\$85.00	\$85.00
2 1 WiFi Dongle/3G connection	\$15.00/month	\$180.00
3 Workbooks and stationery	\$20.00	\$20.00
Total		\$285.00

The estimated cost incurred by the Chinese school comes out to \$220 per student (Table 6b). Our model eliminates daily lunch for each student (since the students will study from home) which is the biggest expense for the Chinese school and replaces that with smart devices and an internet connection. Even though the digital learning model is a little expensive than conventional learning, it should be noted that the experimental group gained valuable computer skills by using smart devices which the control group didn't have access to. Also, the cost per student for digital learning can be reduced to \$200 if inexpensive alternatives are chosen.

Table 6b: Annual Cost Estimate per Student (Conventional Learning)

Activity/Item Description	Cost (\$USD)	Total (\$USD)
1 1 Uniform	\$20.00	\$20.00
2 Workbooks and stationery	\$20.00	\$20.00
3 180 Lunch meals per year (9 school months) @ \$1/meal	\$20.00/month	\$180.00 (9 months)
Total		\$220.00

In order to scale this project for the future, the major expenses are the smart devices and internet connections which are a one-time expense. We will continue to make use of open source learning management systems (e.g. Moodle, Sakai and Course Sites), and existing online educational resources and free apps. This maximizes sustainability, as course content and learning resources are self-sustained.

4.4. Study limitations and future research: This study has three main limitations:

- a) First, since there aren't enough online resource material and apps for Urdu language learning, the students' proficiency in Urdu could not be increased as much as other subject areas. Different Learning Management Systems and app developers were contacted who showed interest in developing an Urdu language platform for students.
- b) Second, since the study considered a small sample due to limited funding, the findings cannot be generalized to a larger sample set. Since a majority of our sample set consisted of underprivileged children, results can vary based on a number of variables: location of study, mindset of people and various other socio-economic and political factors. We have applied for funding to implement this project on a bigger scale to validate our findings and also to give our current sample set their own smart devices so that they can continue their education.
- c) Third, parents of five out-of-school female students didn't allow them to participate in the study because the girls were working as housemaids and having them participate in the study would have affected the household income. We have decided to incorporate an incentive-based approach where children are given a stipend if they decide to partake in this mode of education. The stipend would increase with improvement in their quarterly performance. This idea is based on a current government-initiated model that was

implemented in Lahore where underprivileged children are given a stipend if they attend school.

5. Conclusions

This research showed that the impacts of digital learning using mobile technology are multifaceted. Digital learning can provide an effective learning tool in environments where students don't have access to conventional methods of learning due to financial constraints, societal pressures, safety concerns and health reasons. In addition to addressing key subjects taught at school, it provided students with an opportunity to develop their cognitive, metacognitive and humanistic skills which are imperative for success in the 21st century. Also, this mode of education increased students' motivation towards learning since it provided them knowledge in fun and interesting ways. It was also evident that students were keen on teamwork and showed great awareness in self-regulating their learning.

Acknowledgment

We would like to thank Dr. Sajid Siraj from University of Leeds, UK for his assistance with the statistical analysis, and his comments that greatly improved the manuscript.

References:

- [1] Kinash, S., Brand, J., & Mathew, T. (2012). Challenging mobile learning discourse through research: student perceptions of blackboard mobile learn and iPads'. *Australasian Journal of Educational Technology*, 28(4), 639e655.
- [2] Kucirkova, N., Messer, D., Sheehy, K., & Fernandez, C. (2014). Children's engagement with educational iPad apps: Insights from a Spanish classroom. *Computers & Education*, 71, 175e184.
- [3] Candy, P. C. (1991). *Self-direction for lifelong learning: A comprehensive guide to theory and practice*. San Francisco: Jossey-Bass
- [4] Li, S. C., Pow, J. W., Wong, E. M., & Fung, A. C. (2010). Empowering student learning through Tablet PCs: a case study. *Education and Information Technologies*, 15, 171e180.
- [5] Murphy, G. D. (2011). Post-PC devices: a summary of early iPad technology adoption in tertiary environments. *E-Journal of Business Education & Scholarship of Teaching*, 5(1), 18e32
- [6] Furio, D., Juan, M. C., Seguí, I., & Viv_o, R. (2015). Mobile learning vs. traditional classroom lessons: a comparative study. *Journal of Computer Assisted Learning*, 31(3), 189e201.
- [7] Jahnke, I. & Kumar, S. (2014). Digital Didactical Designs: Teachers' Integration of iPads for Learning-Centered Processes. *Journal of Digital Learning in Teacher Education*, 30(3), 81-88.
- [8] Yang, X., Li, X., & Lu, T. (2015). Using mobile phones in college classroom settings: effects of presentation mode and interest on concentration and achievement. *Computers & Education*, 88, 292e302.
- [9] Gerger, K. (2014). *1:1 tablet technology implementation in the Manhattan Beach Unified School District: A case study*. Long Beach: California State University.
- [10] Lu, J., Meng, S., & Tam, V. (2014). Learning Chinese characters via mobile technology in a primary school classroom. *Educational Media International*, 51(3), 166e184.
- [11] Boticki, I., Baksa, J., Seow, P., & Looi, C. K. (2015). Usage of a mobile social learning platform with virtual badges in a primary school. *Computers & Education*, 86, 120e136.
- [12] Murphy, G. D. (2011). Post-PC devices: a summary of early iPad technology adoption in tertiary environments. *E-Journal of Business Education & Scholarship of Teaching*, 5(1), 18e32.
- [13] Churchill, D., & Wang, T. (2014). Teacher's use of iPads in higher education. *Educational Media International*, 51(3), 214e225.
- [14] Marta Gómez Domingo, Antoni Badia Garganté (2016): Exploring the use of educational technology in primary education: Teachers' perception of mobile technology learning impacts and

applications' use in the classroom. *Computers in Human Behavior* 56: 21-28

[15] Sandy C. Li, Jacky W. C. Pow, Emily M. L. Wong, Alex C. W. Fung (2010): Empowering student learning through Tablet PCs: A case study. *Education and Information Technologies*, 2010, Volume 15, Number 3, Page 171

[16] Falloon, G. (2013). Young students using ipads: app design and content influences on their learning pathways. *Computers & Education*, 68, 505e521.

[17] Shahid Farid a, Rodina Ahmad a, Iftikhar Azim Niaz b, Muhammad Arif c, Shahaboddin Shamshirband, Muhammad Daud Khattak d Identification and prioritization of critical issues for the promotion of e-learning in Pakistan (2015). *Computers in Human behavior* 51(2015) 161-171

[18] Bhuasiri, W., Xaymoungkhoun, O., Zo, H., Rho, J. J., & Ciganek, A. P. (2012). Critical success factors for e-learning in developing countries: A comparative analysis between ICT experts and faculty. *Computers & Education*, 58(2), 843–855.

[19] Nawaz, A. (2012). E-learning experiences of HEIs in advanced states, developing countries and Pakistan. *Universal Journal of Education and General Studies*, 1(3), 72–83.

[20] Nawaz, A., & Khan, M. Z. (2012). Issues of technical support for e-learning systems in Higher Education Institutions. *International Journal of Modern Education and Computer Science (IJMECS)*, 4(2), 38.

[21] Punya Mishra, Kristen Kereluik (2011). What 21st Century Learning? A review and a synthesis. 2011 SITE Conference.

[22] Keengwe, J., Onchwari, G., & Wachira, P. (2008). The Use of Computer Tools to Support Meaningful Learning. *AACE Journal*, 16(1), 77-92.

[23] Zhao, Y. (2009). *Catching up or leading the way*. Alexandria, VA: ASCD.

Miracles in Education through innovation: An Empirical Analysis for Pakistan

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Abstract

From the last decade researchers have tried to explore many striving research and development (R&D) policies in order to enhance innovation and economic growth in Pakistan. The question arises whether these policies are paying off or not. In order to reach a minimum threshold level of research in education sector, this paper addresses few important questions. The key question is how to develop education, training systems and learning practices in order to increase economic development and growth in Pakistan.

The main objective is to develop science and technology index and innovation index for some selected Asian economies for the period of 10 years during 2002-2012. In order to analyze the impact of some macro-educational variables on innovation index, we have applied generalized method of moment (GMM) technique for empirical investigation. Knowledge stock, travel grant funded by HEC and PhD produced show significant impact on innovation. The results also indicate that R&D expenditures and university level education in Pakistan are also positively associated with innovation. The continuation and vigor of this association is, however, reliant upon investment incurred by HEC on R&D activities, which affect the capacity of each institution to make over R&D investment into innovation, which ultimately leads towards economic development and growth.

Keywords: Innovation, Education, R&D, Government Policy.

JEL classification: O32, I23, I18.

1. Introduction:

“The key to our success...will be to compete by developing new products, by generating new industries, by maintaining our role as the world’s engine of scientific discovery and technological innovation. It’s absolutely essential to our future.”

– President Barack Obama, November 17, 2010

Innovation may be defined as “the execution of a new course (Schumpeter, 1934)” played a viable role in enhancing development. At present, Innovation capabilities are seriously challenged in most of the developing countries, and in almost all socio and economic setup demanding by the current government of Pakistan. Overall macroeconomic at large scale and governance plays a fundamental role in creating innovation climate and consequently will be helpful in the economic development of an economy. To attain novelty in education sector particularly, every economy requires huge investment in exploration and modernization in R&D to cope with international standard. However, planned and well *executed* innovation strategies are very useful for under developed countries like Pakistan for designing her own innovation policies. For the process of innovation, human capital is key factor. There is no adequate method given in literature, which could be used for the measurement of human capital's role in enhancing innovation (OECD 2001). Few studies indicate that countries with high level of education or having high share of population with tertiary level education have more capacity to stimulate innovation. Role of learning played a vital position in enhancing innovation process explained in Innovation-related literature¹.

Pakistan is faraway in R&D process and requires strong policies to enhance and promote innovation strategies for the sake of economic growth and development. For example, only 3000 PhD doctors were produced from the last 55 years even after passing a long span of time (1947-2002). Due to such low developmental rate in innovation, Government of Pakistan took initiative and introduced few organizations for the promotion of innovation process. One of the examples is Higher Education Commission (HEC) established in 2002. The main function of the organization was to provide funding for education and training purposes to the university students at local level or abroad after year 2002. Recent educational policy includes call for education and training policies to provide "innovation skills" and "innovation-friendly environments" e.g. through adopting modernization in the education systems for higher level and provides different reforms in general education as a whole. One of the key factors of economic growth in the Pakistan is the upshot of the higher education commission (HEC), which was the first-step towards the competition with those having better innovation systems and processes.

Improving the performance of the education sector in terms of innovation is a goal that is high on the policy agenda. Education sector plays a key role in enhancing competition and ultimately growth in the economy. Public education is usually provided by the state of any economy. Therefore, it is mandatory to overview the behavior of the government towards innovation processes, and see what important decisions has been taken by the current government during the period for the provision of public education and research activities. There is possibility of existence of positive and negative externalities as well from the adoption of a new innovation policy.

Few innovation policies by the different governments have tried to implement but most of them have not survived to reach the deadlines. In this study we have analyzed some policies, and how much they are helpful in implementing and increasing the innovation process. Study also explores why public sector innovation is crucial for development. If ideal policies are helpful in innovation, why governments could not adopt these ideal policies? We also discuss the evidence based issues on innovation. This paper provides a brief overview of the theoretical

¹ Lundvall, B. E. (2000), “Europe and the learning economy: On the need for reinventing strategies of firms, social partners and policy makers”, Department of Business Studies. Aalborg.

foundations in innovation in the context of education. It provides an overview of research on innovation, especially for creative learning and innovative teaching. The study also provides the last ten years of science and technology development index (STDI) for some selected Asian economies.

It is hard to articulate that only government of any country play a vital role in enhancing innovation process through education. For example, in order to make sytem properly workable, government may smooth the R&D institutes, which provides the basic and applied research, for which the higher education commission gives more incentive to grow and implement through different strategies funded by different financial institutions. Small and then large enterprises and industry use these innovation strategies and ideas to make and tranfer technologies and may help the government further to complete this cycle as it is shown in Figure 1.

Also innovation in education or any field is not an easily adaptable object. For this, we have some base techologies, copied them and then try to adapt them as it is in order to develop our own policies in a healthy environment. It's a long process and time involving (see Figure 2).

Figure 1: Technology Transfer and Innovation system Participants

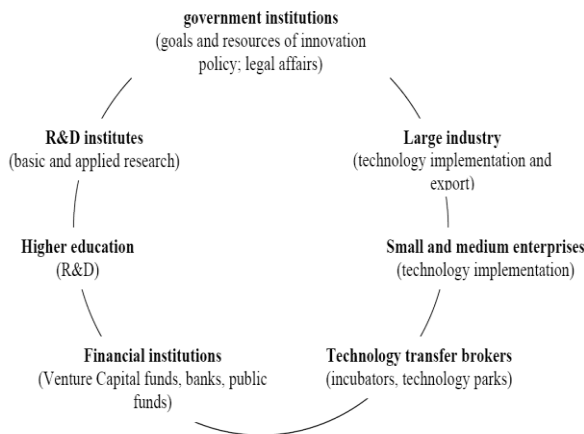
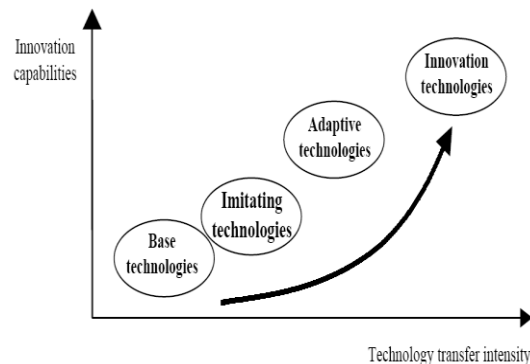


Figure 2: Technology inflow specifics and country's innovation capabilities



Source: based on *The Interrelationship between Investment Flows and Technology Transfer*, UN, 1992, p. 14.

We can hardly find any study which discussed innovation index and related indices to see the impact of research and educational oriented variable so innovation at higher level for Pakistan through out the history. This study tries to fill this gap by analyzing innovation and S&T index looking at the HEC's performance for the period of 10 years.

Objectives

Our main objectives include

1. To determine Science and technology development index and innovation index.
2. To see the impact of Innovation on some macroeconomic variables.
3. To appraise, is there a need for governments and education institutions to consider the significance of "education for innovation" in current policies and programs?
4. To explore the ideal polices to foster innovation process

2. Literature Review

This study presents a framework of solid policy intervention for innovation. However, we draw a numerous theoretical and empirical literature around the world education-based

innovation. No doubt, there are numerous educational policies which provide the skills and training to the next generation which affect the rate and success of innovation. Related to educational innovation we have compiled the literature that may be helpful for the policy makers for the betterment of an economy. Every rationale innovation policy can be ideal policy. A good policy intervention endowed with net benefits to the nations after implementing in a proper way, which requires ideal management practices as well. We are lack of good governance, therefore the government may not be able to implement them, rather adapt them using imitating policy at its earlier stage and later may be design own policies using domestic resources and information. In our study, we ignore these issues despite their obvious importance. What is relatively important here is that economics of public sector research, which leads towards innovation, consequently leading towards economic growth and development.

Aubert (2004) provides a theoretical structure to examine the technological innovation and its dispersion in LDCs. Author emphasized on country's economic activities, not only in terms of development level, but also needs to consider administrative and cultural mores to enhance and implement strong innovation strategies. Ulku (2004) analyzed growth models based on R&D and viewed that innovation can be developed in the R&D sectors, which leads towards sustainable economic growth applying constant returns to innovation in terms of R&D. He employed panel data technique and used patent and R&D data for 30 countries (20 OECD and 10 Non-OECD) for the period of 17 years (1981–97). He found the positive linkage exists between GDP per capita and innovation whether OECD or non-OECD countries, whereas the effect of R&D reserve on innovation is significant only for OECD countries. Stewart and Feldman (2007) argued that knowledge is the most important element of the modern economy. They viewed that universities have made for the purpose of creating and disseminating knowledge to all students. Now it is the responsibility of higher educational institutions is to create effective mechanisms to transfer knowledge for the sake of social or economic development to enhance competitiveness or knowledge stock. Beñat and Andrés (2010) examined the European governments R&D policies in order to enhance innovation and economic growth in European regions. The findings reveal that investment on R&D and on higher education in peripheral regions of the EU is positive and significantly related with innovation.

Braun et al (2006) used assessment as a basic tool to observe the students progress. It is emphasized that if policymakers could access to reliable information on educational quality in specific schools and provide this information to common people, parents for their children may choose best educational system. Gault (2012) viewed that advanced knowledge creation is dealt with science and technology development diffusion. The advance knowledge is produced through research and development (R&D) and investment on research and development is the main source of Science and technology development. The financial support for R&D comes through government using direct and indirect channels, including higher education institutes, research institutes and some private organizations as well. Numerous past studies have examined the link between technology uses and impact on innovation, such as (Rao, et al., 2001; Fagenberg, 2002; Radosevic, 2004). Many theoretical and empirical efforts have been made to assess the impact of Information and communication technology (ICT) in educational performance. Aristovnik (2012) studied efficiency of educational outcome through (ICT). For this purpose, the Data Envelopment Analysis (DEA) technique is applied for empirical investigation using some selected OECD and EU-27 countries. The findings reveal that ICT oriented counties have more efficiency in education sector. U. S. Commerce Department (2013) tinted that the education can play vital role in creating entrepreneurial attitudes, behaviors,

proficiency and in making innovation competence. They presented different approaches, which allow policymakers to devise, examine and assess national policies to instigate and permit individuals to start and to grow entrepreneurial endeavors.

3. Role of Higher Education Commission in Enhancing Innovation Process in Pakistan

To promote innovation, HEC started functioning since 2002, it launched many local and foreign programs in order to promote education internationally and made possible competition with international researchers. These emerging policies are the first step towards the innovation progress. Further HEC provides incentives and fully funded scholarships for PhD in Pakistan as well as in all developed countries in the world. Hundreds of Phd holder joined the Pakistani skilled man power in the university and institution etc. Before 2002 higher education faced many challenges and took initiative to increase PhDs by providing local and foreign scholarship in almost all disciplines for five years. More than 100% PhDs increase in 2003-2012 as compared to 1947-2002 by HEC (HEC Report 2012-13). Pakistan hired 594 foreign Professors for PhD program in local universities.

Government of Pakistan hired 594 foreign Professors for PhD program in local universities. Many “Ideal policies” adopted by HEC such as, need based scholarship, indigenous scholarship scheme, PM tuition fee scheme, free laptop scheme etc. in order to increase environment in research and produces many research papers in high impact factor journal (See HEC Report 2012-13). Different educational policies and regulations have been established to support the educational promotion in S&T at micro and macro level in Pakistan. Another most attractive and wonderful task has been done by the current government in order to make environment more and more research oriented; they provided 100,000 free laptop schemes in the first year for the graduate students in Punjab's universities and after the success of this scheme federal government launched this scheme for next year 5 years all over in the Pakistan. They provided 100,000 free laptops with internet device to all graduate, Mphil and Phd students studying in different universities in all disciplines obtain 70 % and more marks in running semesters. These are so-called the "Ideal Policies" and step forward towards enhancing R&D and promoting ST&I and innovation process in order to compete internationally (see Table 1)

Table 1. Free distribution of Laptops by Govt: Step towards Innovation

Year		Free Laptop	Distribution
2012	Punjab government	100,000	Only in Punjab
2014	Federal government	100,000+ Internet USB	All over the Pakistan

Pakistan government started Post-doc program in 2012 and provided excellent opportunity of Pakistani scholars; they augmented the researcher skills and published papers in reputed journals of the world which increase ranking of Pakistan as well. Total 580 scholars joined the host countries university and 546 scholars are successfully completed the post-doc and become part of R&D in Pakistan

These “Ideal policies” are considered as “hub of the innovation sector”. It is also of the view that through attending international and national Conferences and seminars, providing the cultural exchange and give chance to most of the researchers, students and faculty of all universities in Pakistan to share the scientific knowledge from such a prestigious innovation platform. Pakistan has also organized different conference on all disciplines including Social, physical, biology, and

medical sciences etc invited different foreign scientists and researcher from well known universities MIT, Harvard University, Oxford University etc to make the conferences more successful and valuable. For the purpose, Pakistan Govt allocated Rs 52.177 million during 2012-13 is another step towards development in educational sector (See Figure 6). HEC also encourages organizing such prestigious conferences and seminars in Pakistani universities to promote research culture. HEC has also international linkages with well reputed universities and higher educational institutions, which may be distributed province-wise due to division of work by HEC. Punjab has the maximum linkages, while Balochistan has least (HEC Report 2012-13). Not only PhD scholarships are provided to the talented students all over the Pakistan equally, but also travel grant is equally distributed based on their talent and conference as reported by HEC in report 2012-13

4. Methodology

A. Variables description and Data Sources

The empirical analysis has done by using data from 10 Asian countries over a period of ten years (2002 – 2012) including Pakistan, India, Bangladesh, Singapore, Nepal, Sri Lanka, China, Japan, Saudi Arabia and Malaysia. This study developed a science and technology development index using five potential variables; Research and development expenditure (% of GDP), publications Scientific and technical journal articles, Internet users, Telephone lines, and High-technology exports (current US\$). Most of the data are taken from World Development Indicators, other web sources, HEC annual Reports and Wikipedia as well. Values for these selected S&T index for Pakistan for the year 2003 is mentioned in Table 2 and summary statistics is well presented in Table 3.

Table 3. Summary Statistics of Science and technology development index (STDI): Pakistan as an Example

Indicators	Mean(μ)	STDV (σ)	Standardized	Area under curve
Research and development expenditure (% of GDP)	0.965	1.014	-0.663	0.254
Scientific and technical journal articles	13892.28	23631.1	-0.572	0.284
Internet users (per 100 people)	32.12	27.71	-0.977	0.166
Telephone lines	43.61	94.27	-0.419	0.340
High-technology exports (current US\$)	60291.92	102125.3	-0.589	0.281
			Average	0.265

Note: Mean for all countries under study (\square); Standard Deviation for all countries under study (\square)

For empirical analysis, we have constructed certain variable and due to non availability of some variables, we use proxies as well to fulfill the gap. First lag of the patent stock is used as knowledge stock, university education is defined as the education higher than grade 14, O&I Exp is called outgoing and incoming expenditures given by HEC or government to finance students for phd completion and for attending conferences seminars and for postdoc etc., number of research publications in HC recognized journals accepted internationally as well. total number of PhD produced during the study period in all disciplined domestically and foreign degree holders and total travel grant given by HEC for the research purpose to the students studying in the universities and faculty as well and research and development expenditures as a percentage of GDP are the explanatory variables used for empirical investigation after employing GMM technique.

B. Estimation of Science and Technology Development Index

Innovation through R&D cannot be done in isolation. Government of any country needs enough resources to implement. Production process may take place after implementation and get output for users through distribution in a proper way. We may apply vertical technology process for best innovation achievements. The vertical technology flow may be defined as below:

R&D → implementation → production process → distribution → final buyer

In the recent literature on development index, a number of techniques have been used to measure the composite index, such as, principal component analysis (PCA), factor analysis (FA) etc. This rigorous study measuring each indicator's performance with latest Z-sum score technique. The Z-sum score is the standardized score, which has different mean and different variance. The higher the Z scores means more developed in region.

In this approach, equation for the normalized value (Kothari, 1978) is as follows:

$$z = \frac{x - \mu}{\sigma}$$

The values of the science and technology development index (STDI) vary between 0 and 1; if values close to 0 indicate country have very low level of Science and technology development. On the other hand, values close to 1 indicate that the country has a very high level of Science and technology development.

We have also developed Innovation Index, which is used as a dependent variable in order to regress on other explanatory variables using GMM technique. The GMM defers consistent estimators given the data do not have autoregressive of order 2 and also regressors should be independent of error term [see Arellano and Bond (1991), and Arellano-Bond Linear GMM]. we have also used human capital, which could be proxied by university education, patent stock, R&D expenditures, I&O (incoming & outgoing expenditures on research through attending conferences, Phd doing). The first lag of patent stock is served as an instrument for knowledge stock; In addition, university level enrolment are included in the analysis to capture the effect of overall human capital of a country on its innovation level.

Regression equation for the purpose of estimation is as follows:

$$I_n I_n = \alpha + \beta \ln KS + \gamma \ln PT_{t-2} + \varpi \ln UE_{t-2} + \vartheta \ln I \& O + \rho \ln RP_{t-1} + \zeta \ln TG + \psi \ln R \& D + \varepsilon$$

Where: $I_n I_n$ (Innovation Index), KS(knowledge stock), PT_{t-2} (second lag of patent stock), UE_{t-2} (second lag of university education), I&O(incoming and outgoing expenditures on phd produce), RP_{t-1} (first lag of research publications), TG(travel grant for paper presentation abroad by HEC), R&D(research and development expenditures by HEC and government).

5. Empirical Results and Discussion

In this paper, empirical estimation has done with Z sum score. Based panel data we first generate the STDI for the Asian regions. After calculating the mean and standard deviation for ten year; we standardized values for each indicator for each year, the values areas under the standard normal distribution curve must be determined but here developed only one year science and technology development index. The standard normal distribution values vary between -1 and 1. The total area under a standard normal curve is lie between 0 and 1. As we see, all standardized values are negative total area under the curves varying 0 to 0.50. If standardized

² Where: Z = Standardized values, X = value you want to normalize, μ = arithmetic mean of the distribution, and σ = standard deviation (S.D) of the distribution.

values is positive area under the curves varying 0.50 to 1. We have analyzed Science and technology development index for all countries under study and shown in Table 4.

It shows that Japan and China are leading in S&T marvelously as the value is very close to one. These two countries are progressing in R&D tremendously as well shown in figure. Singapore lies in the third in ranking followed by, Malaysia, UAE, and India. Nepal, Sri- Lanka and Pakistan lie in the lowest category and values are close to zero mean very low in S&T and require such strong policies to enhance S&T as we are not only lacking behind among the developing countries but also could not stand in any category in comparison with developed country. Innovation index is also generated for the same countries and the result is very much similar to S&T index

Singapore, Japan, china and Malaysia are at the top in S&T Index. Empirical evidence is shown from the recent literature that Japan and Malaysia obtained development in many sectors and did miracles in enhancing economic growth. The countries having more and more S&T index and Innovation index are also fast growing economies in the world as well. It is the need of the hour to look at the matter seriously and do serious actions in enhancing both indices for Pakistan in order to enlist in the countries having more research and innovation in the world.

Table 4. Science and technology development index (STDI) of Asian countries

Rank	Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Pakistan	0.265	0.2727	0.2805	0.2882	0.296	0.2928	0.2896	0.2864	0.2832	0.280
2	India	0.359	0.3646	0.3702	0.3758	0.3814	0.387	0.3935	0.40	0.4065	0.413
3	Nepal	0.238	0.2386	0.2392	0.2398	0.2404	0.241	0.2505	0.26	0.2695	0.279
4	Sri Lanka	0.248	0.2492	0.2504	0.2516	0.2528	0.254	0.2615	0.269	0.2765	0.284
5	Singapore	0.57	0.5862	0.6024	0.6186	0.6348	0.651	0.6557	0.6605	0.6652	0.670
6	Saudi Arab	0.257	0.2714	0.2858	0.3002	0.3146	0.329	0.3425	0.356	0.3695	0.383
7	Malaysia	0.398	0.4106	0.4232	0.4358	0.4484	0.461	0.4752	0.4895	0.5037	0.518
8	Japan	0.782	0.7898	0.7976	0.8054	0.8132	0.821	0.8237	0.8265	0.8292	0.832
9	China	0.627	0.662	0.697	0.732	0.767	0.802	0.8215	0.841	0.8605	0.880
10	UAE	0.314	0.3328	0.3516	0.3704	0.3892	0.408	0.414	0.42	0.426	0.432

Source: Author's calculation

We have applied GMM technique for the analysis and results are presented in Table 5. Results are not very unexpected as only stock of knowledge and patents, travel grant during the 10 years show the significant result with P values close to zero, while the all the other variables including university education, I&O, PhD produce and R&D expenditures show positive but not very appealing, which implies huge investment is required in education sector particularly in high education.

Table 5: General Methods of Moments (GMM) Regression Analysis of Innovation Index: (2002-2012)

Dependent Variable: Innovation Index

Independent Variables	Co-efficient	Standard error	P value
Knowledge stock	0.786*	0.324	0.000
Second Lag of Patent Stock	0.543*	0.231	0.001
Second lag of university education	0.029	0.019	0.520
Openness	0.001	0.001	0.012
PhD produce	0.265	0.340	0.234
Travel grant	0.508*	0.091	0.002
R&D Exp	0.013	0.010	0.765

6. Conclusion and Policy Recommendations

Education is considered as public good, if government provides financial and physical support all over the regions equally. It means innovation enhancement would be a good or Ideal Policy and promising drivers of national economic development. The government of Pakistan have invested heavily on few projects and improving the innovation process through providing quality of education at higher level. Though Pakistan has made wonderful progress in innovation enhancement in post-HEC era, but still serious attention is required. However, copious bottlenecks are still there in the system, such as lack of timely funds announced but practically not implemented. Moreover, promoting research culture to all parts in Pakistan is a serious challenge. Over the last two decades many Pakistan governments have trailed ambitious R&D policies with the aim of fostering innovation but with the little success.

No doubt, HEC has done a great job in raising innovation strategies in Pakistan. Therefore, HEC solid policy has provided a hope for development of a country in near future. Rapid technological advances in the last decade have sparked educational innovation, personal computer as a major tool to improve student learning. In this case, technology as an instrumental tool to enhances student learning and educational outcomes. Past research suggests that compared to their non laptop students, talented students in schools, colleges and universities government provide all students free laptops schemes, spend more time involved in collaborative work, improve research analysis skills, innovation, and spend more time doing homework on computers. Those Researchers, who have own laptops may spent more time as compared to other who have not, this more flexible uses of technology may leads to increase research environment and ultimately publications. However, free laptop distribution scheme is considered as Best scheme of this Era. One of the great achievements, which are chain of this scheme as shown in Table 7, in which Pakistan is ranked as number 33 and included among those countries spent 100 million dollars annually on research and development, but still Nepal and Sri Lanka could not be the part of this list.

Looking at this scenario, government should play a leading role in developing reforms in Science, Technology and Innovation (ST&I) in education sector that makes HEC more

functionable. Co-ordination among universities, different research organizations and private firms are strongly recommended in order to increase the innovation process, which practically requires mobility of researchers and academics between universities and firms, and encouraging greater involvement by firms in the development of ST&I educational strategies and planning for ST&I human capacity development.

Reference

- [1] Aristovnik, A (2012) “the Impact of ICT on Educational Performance and its Efficiency in selected EU and OECD countries: A Non-Parametric Analysis”, *The Turkish Online Journal of Educational Technology*, 11 (3), 144-152.
- [2] Aubert, Jean-Eric (2004), “Promoting Innovation in Developing Countries: A Conceptual Framework”, World Bank Institute.
- [3] Beñat Bilbao-Osorio and Andrés Rodríguez-Pose, “From R&D to innovation and economic growth in the EU”, European Union, 2010.
- [4] Braun, Henry, Anil Kanjee, Eric Bettinger and Michael Kremer (2006), “Improving Education Through Assessment, Innovation, and Evaluation”, Project on Universal Basic and Secondary Education, American Academy of Arts and Sciences, Cambridge, MA, USA
- [5] Fagerberg, J. (2002) “Technology-gaps, innovation-diffusion and transformation: an evolutionary interpretation” *Research policy*, 31(8-9), 1291
- [5] Gault ,F. (2012) “Social impacts of the development of science, technology and innovation indicators” *UNU-MERIT Working Papers*.
- Gurbiel, Roman (2002), Impact of Innovation And Technology Transfer on Economic Growth: The Central and Eastern Europe Experience Warsaw School of Economics, Center of International Production Cooperation, Poland
- [6] HEC (2014) Annual Report 2012-2013, Pakistan.
- [7] Kothari, C. R. (1978) “Quantitative Techniques,” 3rd edition. NewDelhi: Vikas Publishing House PVT LTD,99.
- [8] Radosevic, S. (2004) “A Two-Tier or Multi-Tier Europe? Assessing the Innovation Capacities of
- [9] Central and East European Countries in the Enlarged EU” *Journal of common market studies*, 42(3), 641.
- [10] Rao, S. et al. (2001) “The Importance of Innovation for Productivity” *International Productivity Monitor*, 2, 11.
- [11] Schumpeter, J. (1934) “*The Theory of Economic Development*”, Harvard University Press, Cambridge,MA. English translation of *Theorie der Wirtschaftlichen Entwicklung*, by R.Opie, 1912.
- [12] Ulku, Hulya (2004), “R&D, Innovation, and Economic Growth: An Empirical Analysis” IMF Working Paper, Research Department, September 2004.
- [13] U.S. Department of Commerce (2013), “Higher Education, Innovation & Entrepreneurship in Focus”, prepared by: Office of Innovation & Entrepreneurship Economic Development Administration. In consultation with: National Advisory Council on Innovation and Entrepreneurship, July 2013.
- [14] World Bank (2010) Innovation policy: a guide for developing countries. Washington, USA.

App Inventor – An Ideal Platform to Empower Anyone to Create Useful Things

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Abstract

App Inventor is a visual programming platform for mobile applications in the world, and has more than 4 million registered users. This paper focuses on two main aspects of App Inventor: the introduction to and training for computational thinking, and a thorough analysis of the representation of computational thinking among outstanding work in Chinese App Inventor competitions. We discovered most of the amazing apps from competition submissions, including games and useful tools, were created by students who hadn't coded before prior using App Inventor. We investigated the apps which taken from these competition and came to the conclusion that App Inventor provides a totally new mobile application development model. Novice developers can utilize App Inventor as platform to create their personalized mobile applications to further utilize and develop technology.

1. Introduction

App Inventor is an online visual programming platform for mobile applications [1, 2]. It enables users without prior programming skills to create mobile applications by pulling up the components. Since the user does not need to understand the grammar of programming languages or any relevant details which may cause syntax errors, people who use App Inventor can focus on how to solve their current problem and the logical design of their solution.

As of December 2015, there are more than 4 million registered users, nearly 180 thousands active weekly users, and a total of 13 million projects using App Inventor [3].

2. The features of App Inventor

There have been many courses, trainings, summer camps and competitions around the

world involving App Inventor [4-16]. The research resulting from these activities show:

1) the ease-of-use performance of App Inventor can stimulate students' enthusiasm 2) the combination of App Inventor's powerful functions and mobile applications' practicality enables students to create their own mobile applications willingly and stimulates subjective learning initiatives and foster creativity; 3) that mobile applications can be shared, enhances students' sense of accomplishment, self-confidence, and perseverance to improve their own mobile application.;

The two most important features of App Inventor are: 1) personalized creation and 2) computational thinking training.

2.1 Personalized creation

Different from desktop computers, each phone is a portable mini-computer that brings mobile applications closely into contact with everyday life, and the individual nature of mobile usage also determines the individual needs which applications uniquely address. Meanwhile, the touch screen and sensors that only exist in mobile phones make the experience of using mobile applications more diverse. This offers powerful technological support for personalized app creation. App Inventor is a platform and it provides functions that are easy enough even for novice developer to use to design and create mobile applications. These apps can solve the problems they encounter in their life so that they are motivated to participate in finding solutions.

2.2 Training computational thinking

App Inventor shapes children's computational thinking in the following ways when they use App Inventor to create mobile applications:

1) Abstract: Using abstractions to design programs in terms of modular pieces that can be combined and recombined.

In App Inventor, the screen is an abstract user interface, and each component of a screen is the abstract of a corresponding function. Since some components can be reused, using combination can reduce the complexity of app development.

2) Data management: Representing data so it can be effectively manipulated and logically organized and analyzed.

App Inventor provides List, DB and other data structures that can manage data effectively.

3) Algorithm design: Representing problem solutions as algorithms and learning important patterns for structuring algorithms.

App Inventor has two parts, the UI designer and the blocks editor. The UI designer focuses on the visual layout of the apps and the blocks editor takes care of the functionality. Inside the blocks editor, there is a type of block named Procedure. It can be used to clearly design one or a set of algorithm procedures. More importantly, these procedures can be reused in other cases.

4) Debugging: Isolating errors and mastering basic techniques for debugging.

App Inventor has the companion app which reflects changes in real-time. Once users change something in the designer or block editor, the companion app reflects the changes on the phone instantaneously. In addition, users can debug the app step by step.

3. The representation of computational thinking on applications created by App Inventor

From 2014 to 2015, MIT and Google China have launched nationwide CS4HS projects, starting App Inventor training courses across the country to train high school information technology teachers. At the same time, they organized the 2014 and 2015

competitions. The 2015 App Inventor contest for middle and high school students is the highest level in China and is the first large-scale application of App Inventor in high/middle school in China.

The contest got submissions from 1,095 teams (more than doubling last year's numbers; one team included one or two students) from 258 schools, which is an 80% increase compared to last year's number. 10 high school teams and 10 middle school teams were selected for the final on-site competition. Out of those 20 teams, five were female teams.

The numbers of different kind of applications which compete in the final online competition are showed in Figure 1.

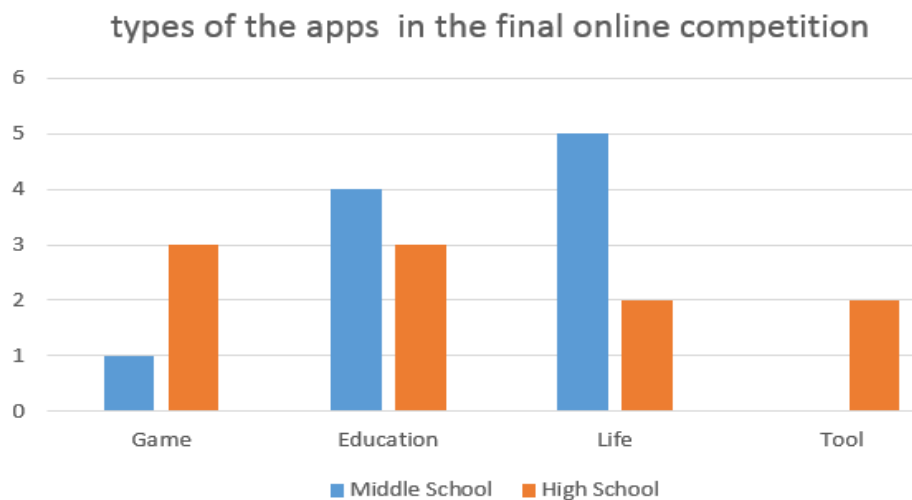


Figure 1. Types of the apps in the final online competition

In the following sections, we will demonstrate how the aspects of computational thinking are realized by different applications of four types above selected from the 2015 App Inventor contest.

3.1 Algorithm design

Fresh Food is an application used for family's food management, a life type application. What it does is abstracting repetitive work to an algorithm so that users can be liberated from repetitive work.

The author came to this app's idea from her experience: The food in her family refrigerator was often ignored even when the expiration date passed. She did a survey and found that the problem occurred in most families she surveyed.

In ordinary food management, people use a notebook to record the foods' information, such as expiration date, and check the notebook every day to see if there is any expired food can be thrown away. The author wants to make it simpler so she creates this application, which is an implement and extension of the notebook.

This application abstracts the ordinary food-manage steps into an algorithm. With this application, users only need to concentrate on the input, the foods' information, and the application will do the rest, such as reminding users of the foods' expiration.

Questionnaire for refrigerator use

What is the population in your family: 5 How many fridges do you have: 2

Please choose answers for the following questions. Thank you.

No.	Question description	Never happened	Happened	How many times happened monthly
1	With time past, I often forget what's remain inside, and often buy something again even there are still lots in fridge.		✓	1
2	I don't know what things in fridge will be in date or expired.		✓	3
3	When I organize things in fridge, I find something expired and have to throw it away.		✓	1
4	Are there mistakes happened to eat bad food or expired food?	✓		
5	Unknown information for food status, repeat buying or short of buying happens.	✓		
6	No alarm remind me the food close to bad time. I have to open fridge to check one by one to figure out the food time status.		✓	2
7	Forget to buy birthday food in advance for family members.(Usually kid's birthday will not forget but parents' forget)	✓		

Figure 2. Survey form

3.2 Abstraction and Data Management

Review Master is an educational application. In its development, abstraction and data management are essential.

The authors are two students from middle school. They were preparing for the high school entrance examination in a strained state. When they saw some students holding a bunch of review books in subway, they came to the idea that they could create a mobile app for reviewing knowledge anytime and anywhere.

Based on the rich features of App Inventor and their learning experience, the authors built this app for both teachers and students. Teachers could use the app to publish exam tasks, and students could do the exam, review what they had done, take notes, share and so on.

1) Abstract: the app is divided into two module pieces at the top level: teacher module and student module. Teacher module is divided into sub-modules of publishing exam and reviewing students' statistics; Student module is divided into doing exam, adding exam, and reviewing wrong-answer record. All these modules are divided based on the "Screen" component of App Inventor.

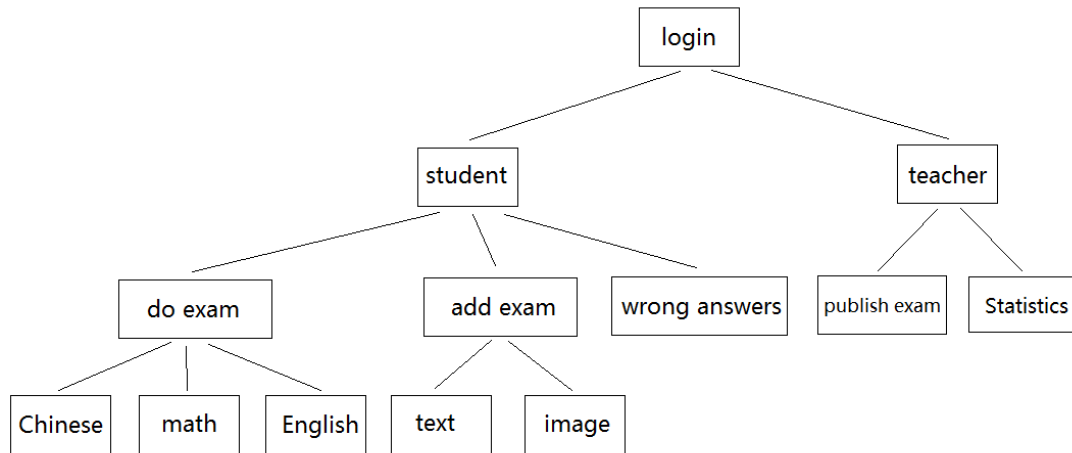


Figure 3. Module division

In each sub-module (or Screen), the logic is divided into logic-components using abstraction and modularity and some of these components can be reused using combination and recombination. Take the module of adding exam as example, there are two methods to add exam: Text and Image.

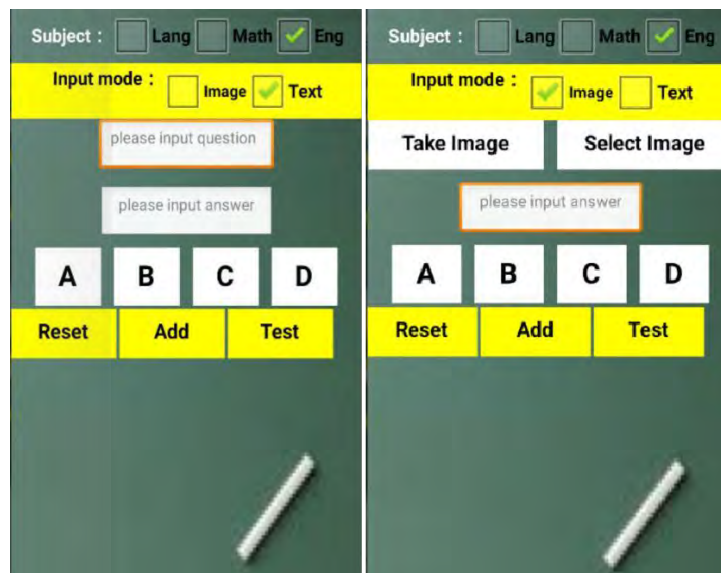


Figure 4. Add text question or add image question

The logic of the two methods is similar: obtaining the exam data first and storing the data. They are only different in the first part where one obtains the data using text input and the other one using image. So the authors abstracted the logic into two components: obtaining and storing. The storing component was reused and when combining different obtaining components with the storing component, app could offer multi-features for users. For example, if they want features of adding exam using voice or video, they just need to add a voice-obtaining component or video-obtaining component.

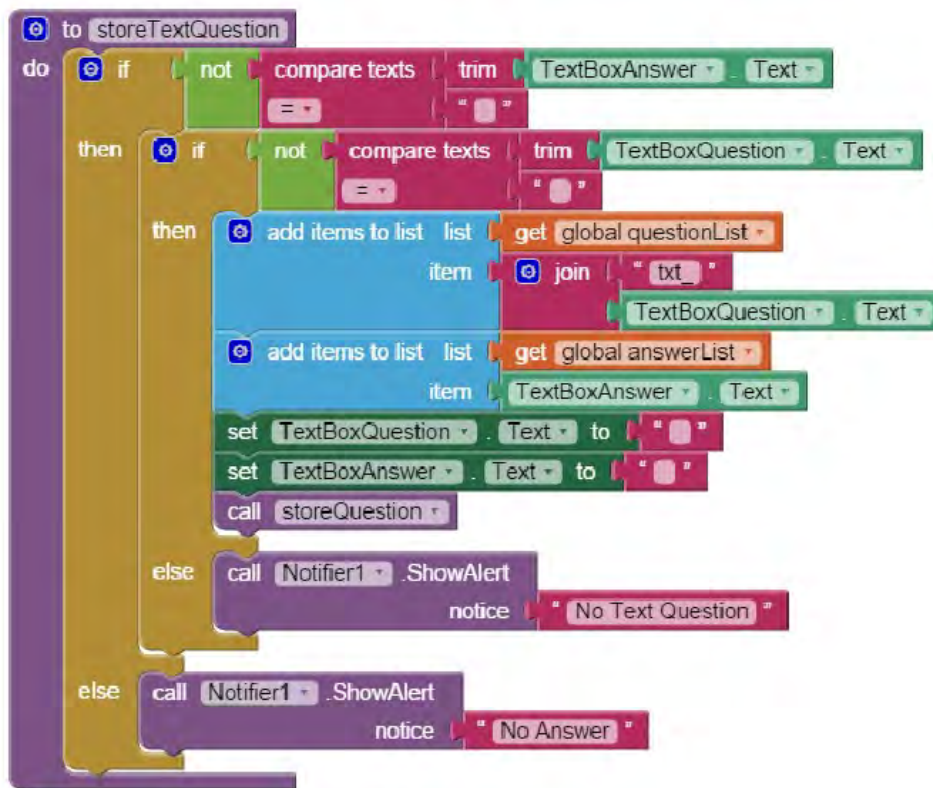


Figure 5. The logic of Add text question

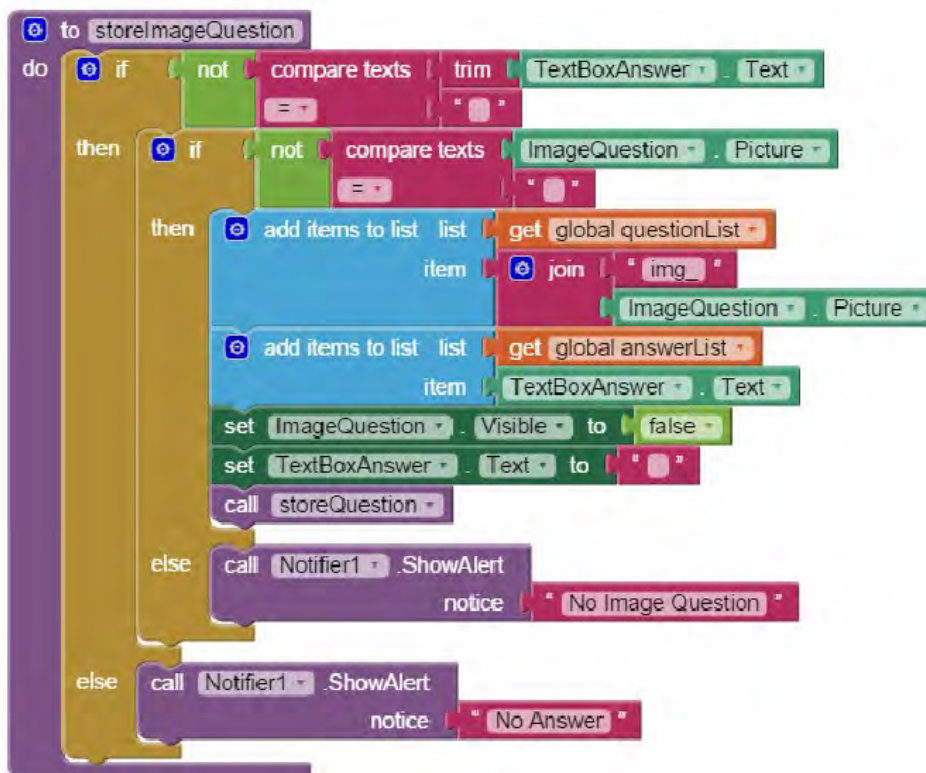


Figure 6. The logic of Add image question

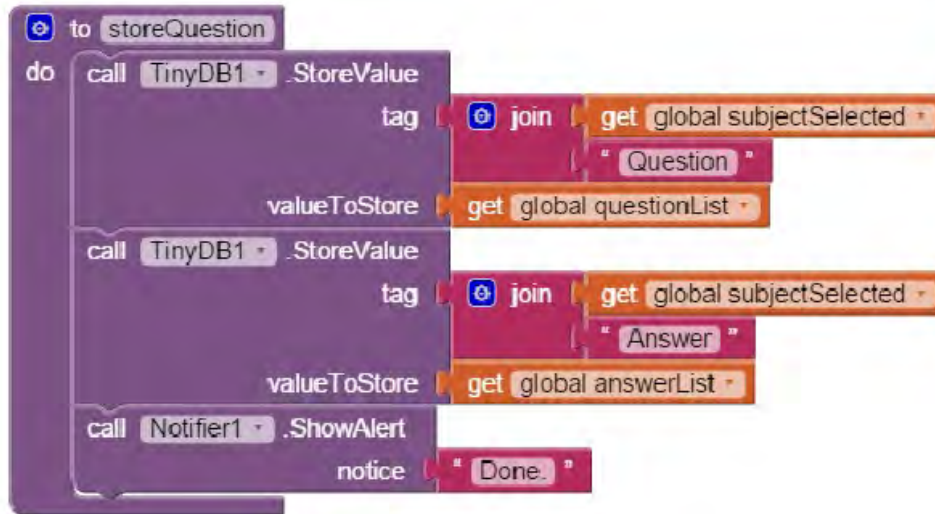


Figure 7. Question data storage

2) Data Management: In the student module, app is based on data: adding exam is adding data, doing exam is querying data, and removing exam is deleting data. If we use a data structure to abstract all these data operations, the user wanting to manage data only need to understand the interface instead of the details. TinyDB is such a data structure and app could use it to do all operations about exam data.

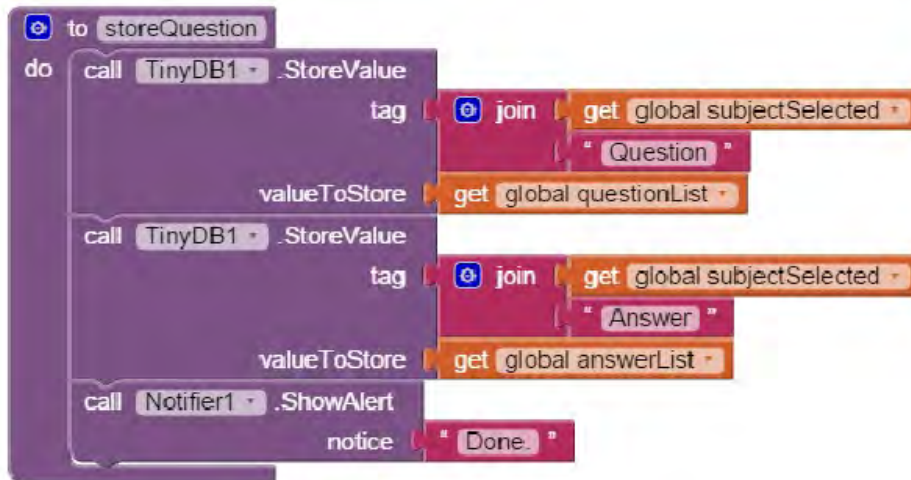


Figure 8. Use TinyDB for data management

3.3 Algorithm design and Debugging

Labyrinth is a game created by a male high school student, who wanted to play a labyrinth game in a novel way. Algorithm design and debugging are realized in its development.

Different from traditional labyrinth games, this game shows only the current labyrinth information around the player, and the player needs to use these partial data to move in the right direction until finding the exit.

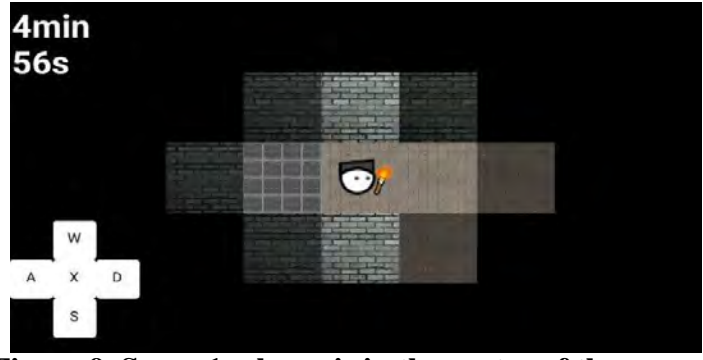


Figure 9. Scene 1, player is in the center of the screen

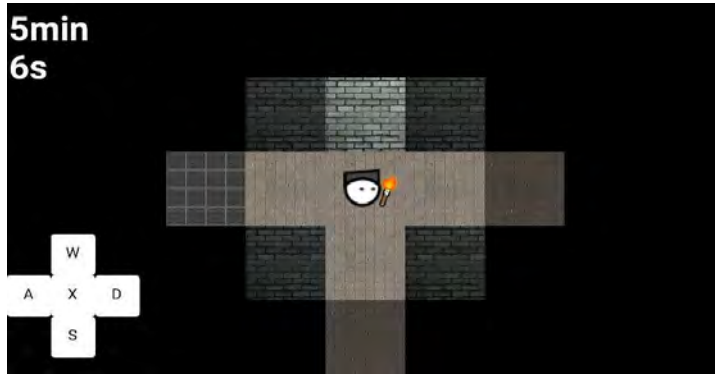


Figure 10. Player moves one more right step from scene 1

1) Algorithm: The logic of this game is difficult to design since it needs to judge the current state when the player moves one step: hitting the wall, moving, or reaching the exit. When getting the right state, the game needs to refresh the photos to the screen. The photo below shows how the game deals with this logic.

```

when ButtonA .Click
do
  if
    call PlayerCollideCheck
      PlayerPos
      get global Player - 1
  then
    set global Direction to 1
    set global Player to
      get global Player - 1
    call init_getPicture
    call generateLightMap
    call updateImages
    call ExitCheck
  
```

Figure 11. Press the ButtonA, that is turning left and move a step forward

The author divided the process into several parts and each part deals with a particular logic. It is useful to understand the thinking and debugging clearly. The logic is showed in the following figure:

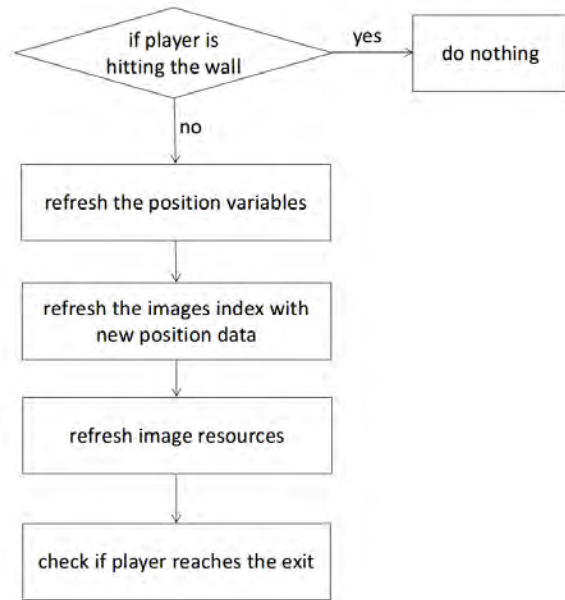


Figure 12. The logic of button-pressed event

2) Debugging: Since the logic of this game is a little complex, when an error occurs, such as a player not being able to move forward even when hitting the wall, it's quite difficult to find the code errors in the entire app. The author needs to shrink the range according to the current information such as position, direction and others.

3.4 Abstract

Virtual reality is a tool app that could talk to users. It's built by a male high school student using the web interface provided by a professional company called Tuning Machine (<http://www.tuling123.com/>).

Using web API is a good example of abstract: the implement was divided into two modules, the web module and the client module. The web deals with the data process and the client deals with the data showing. These two modules are independent and communicate with the interface. It's a high abstraction of designing the interface since the web hides all the details and the app only needs to understand the input and output.

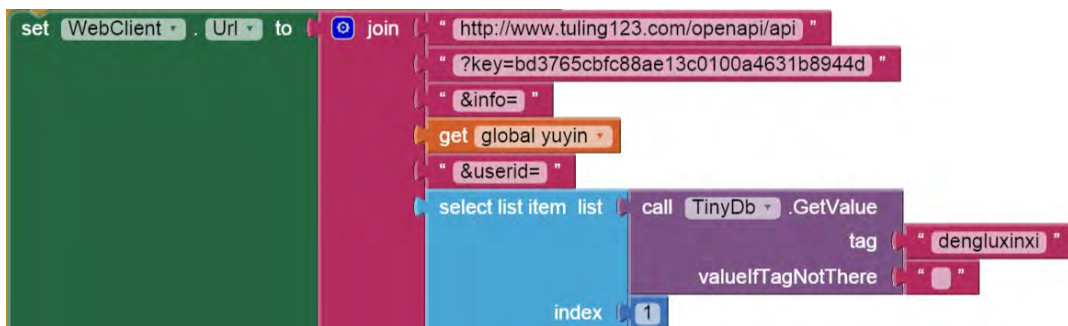


Figure 13. The interface of server

4. Conclusion

As smart mobiles become popular, more and more people will benefit the convenience provided by mobile apps. With this in mind, App Inventor shows us a new developing

mode which is quite different from traditional app development. In this mode, consumers become creators and develop apps for their own lives. Additionally, the computational thinking learned could help them in other tasks in life or work. Besides, App Inventor will change the traditional way of teaching, where students will be the designer and creator of the content and teachers will be advisors. Learning will be truly student-centered. In our further work, we will concentrate on how to access the development of computational thinking.

Acknowledgments

This paper wouldn't be possible without the helps from many parties. In particular, we want to take this opportunity to thank Jeffery Schiller (MIT App Inventor), DaoQuan Yang, KunYang Fang and ZanJian Li(GuangZhou Education Information Centre) for their continue support of the App Inventor GuangZhou Server and AiMing Zhu and Qiang Deng (Google China) for supporting the national App Inventor contest in China.

References

- [1] H Abelson, M Chang, E Mustafaraj, F Turbak, "Mobile phone apps in CS0 using App Inventor for Android: pre-conference workshop", Journal of Computing Sciences in Colleges, 2010, 25(6):8-10.
- [2] J Gray, H Abelson, D Wolber, M Friend, "Teaching CS Principles with App Inventor", ACM-SE '12 Proceedings of the 50th Annual Southeast Regional Conference, 2012:405-406. [3] <http://appinventor.mit.edu>.
- [4] F Maiorana, D Giordano, R Morelli, "Quizly: A live coding assessment platform for App Inventor", IEEE Blocks & Beyond Workshop, 2015.
- [5] B Walters, V Jones, "Middle school experience with visual programming environments", IEEE Blocks & Beyond Workshop, 2015.
- [6] M Sherman, F Martin, "Learning analytics for the assessment of interaction with App Inventor", IEEE Blocks & Beyond Workshop, 2015.
- [7] K Roy, "Position statement: App inventor instructional resources for creating tangible apps", IEEE Blocks & Beyond Workshop, 2015.
- [8] M Sherman, "Process-oriented assessment of development in app inventor", IEEE Symposium on Visual Languages & Human-centric Computing , 2015, 9(7):349-356.
- [9] J Scott, A Bundy, "Creating a New Generation of Computational Thinkers", Communications of the ACM, December 2015, Volume 58 Issue 12:37-40.
- [10] M Sherman ,F Martin, "The Assessment of Mobile Computational Thinking", Journal of Computing Sciences in Colleges,2015,30(6):53-59.
- [11] M Gao, J Johnson, D Reed, C Sheller, F Turbak, "Using App Inventor in Introductory CS Courses", Acm Technical Symposium on Computer Science Education, 2015:346-347.
- [12] D Wolber, H Abelson, M Friedman, "Democratizing Computing with App Inventor", Acm Sigmobile Mobile Computing & Communications Review, 2015, 18(4):53-58.
- [13] F Turbak, M Sherman, F Martin, D Wolber, SC Pokress, "Events-first Programming In App Inventor", Journal of Computing Sciences in Colleges, 2014, 29(6):81-89.
- [14] S Grover, R Pea, "Using a discourse-intensive pedagogy and android's app inventor for introducing computational concepts to middle school students", Proceeding of Acm Technical Symposium on Computer Science Education, 2013:723-728.
- [15] A Wagner, J Gray, J Corley, D Wolber, "Using app inventor in a K-12 summer camp", Proceeding of Acm Technical Symposium on Computer Science Education, 2013:621-626.
- [16] A Soares,NL Martin, "Teaching non-beginner programmers with app. inventor: survey results and implications", Proceedings of the Information Systems Educators Conference, 2014.
- [17] <http://appinventor.mit.edu/explore/blogs/karen/2016/01-0.html>

GamerLab™: Rethinking Design Education

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Abstract

In this paper, we introduce GamerLab™ as an innovative way to train present and future generations of virtual architects by transforming architectural design education into an “affinity space” within higher education. We consider online, infinite game models to incentivize research, reward creativity, and promote collaboration and achievement in architectural design practices. We show how within university level design education, games and gamification offer an invaluable theoretical and practical solution to pedagogic problems entertained by architects and other design professionals. We support this claim by turning to cognitive science which shows how our human brain actually learns and adapts to creative problem-solve.

Keywords:

Gamification, Collaboration, Teamwork, Cognitive Neuroscience, Epic Challenge, Virtual Reality, Design Education, Affinity Space, Virtual Architect

1. Introduction

Today, whether one is engaged in entrepreneurial business development or evangelizing a new era of education, “online” games are at the forefront of cultural trends and economies. From **Fallout** to **Portal**, we are witnessing the explosion of an online game industry offering the kind of mass embrace of entertainment unmatched by even film today. A 2014 Nielsen report shows that about two-thirds of the U.S. population (64%) plays video games on some device. As Gautum Radurai at *Google Think* (2014) has pointed out,

Interest in gaming is also soaring on YouTube. In 2014, the second-most searched topic on YouTube is actually a game: Minecraft. What's more, it's not just the volume of views that is impressive. It's the level of engagement and time spent with gaming content that should make marketers do a double-take.

Gaming pleasure translates into both intentional and unintentional skill building with scores totaled in hours and dollars spent online. Researchers at the Entertainment Software Association (2015) claim social games count for one third of games played reinforcing by social media behavior arguing: “The most frequent gamer feels that computer and video games provide more value for their money (47%) compared to DVDs (28%), going to the movies (14%), AND music (12%).” The gender difference too, is significant: Female purchasers of games constitute 41% compared to the male purchasers amounting to 59% of the total composite number. All this might explain why 2015 American market research firms are interested to run statistics on a game entertainment economy estimated at \$25 billion US a year; with the introduction of Virtual Reality headsets, another 4.6 billion is predicted to add to investor and stockholder pleasure by 2017. From an economic standpoint, there may be no better time for content developers, designers and programmers of future games and game environments.

Despite parental scare around internet and game addiction — no thanks to Nick Carr’s 2010 book **The Shallows** — neuroscience research offers educational leaders a different read on game value. Games, like our brains, operate off of incentivised, reward based challenges or a chance to “level up” in achievement. Daphne Bavelier’s lab has targeted visual/spatial perception using **Call of Duty** and **SIMS** in a landmark 2010 study; other leading neuroscience research labs like Posit Science, UCSF Gazzaley Lab and the UCI Stark Lab are currently engaged in designing and testing games to activate visuomotor, attention and the speed and acuity of memory with health and education implications.

The cognitive neuroscience story is not lost on futurists, thought leaders and game developers in K-12 education, higher education and business training sectors. Both successful game design and neuroscience research studies work off of an established evolutionary theorem: Rewards matter, especially to ensure further pursuit of a challenging trajectory towards a goal. Rich in reward dynamics, games engage viewers precisely because they offer immediate feedback. As futurist and game designer Jane McGonigal contends, “When you strip away the genre differences and the technological complexities, all games share four defining traits: a goal, rules, a feedback system, and voluntary participation.” With new Massive Open Online Course (MOOC) systems on many minds, online games and gamification have earned the respect of curriculum designers and learning theorists like James Gee whose work we will turn to later on in this paper. For now, let us consider the directive given by McGonigal who asks, ‘How we can use games for real world problems recognizing our need for epic challenge and to be super better?’

Following McGonigal, we ask: First, how can we use gaming mechanics to improve design pedagogy to improve student learning experience and cognitive development? Second, how can we use Virtual Reality (VR) interface game mechanics to train designers working online, given triumphant design educational paradigms? Here we are speaking directly to multiple pedagogic challenges met in today’s design education culture: In this paper we are particularly concerned with ideological ossification of architectural education built out of two

theoretical systems, namely Graham Harman's Object Oriented Ontology (OOO) and Patrick Shumaucher's theory of Parametrics. As evidenced in today's reigning architectural schools SCI-Arc and the Architectural Association School of Architecture, curriculum designers of OOO and Parametric approaches tend to theorize away the privileged human dimension in object making, making room instead for robotic or metric driven design. The consequence? Digital natives are kept in the dark regarding emergent theories in gaming and neuroscience that shed light on empowering first person, spatial perception perspectives deemed useful even in a design age that has begun to question the role of the "starchitect." What we are suggesting is for future curriculum designers to consider a "both/and" solution that brings the human factor back into architectural design and reexamines its status through new online game mechanics. It is humans, after all, using their brains in design studios, basements and garages and gaming their way to crowdsource coding for imagined futures of robotic and genetic replication of architectural shapes, patterns and forms.

In order to tackle architectural education in a relevant and timely manner, we propose a rethinking of design research curriculum and formal pedagogy from the systemic standpoint of GamerLab™ -- a gamified design curriculum, pedagogic method and online VR enhanced platform that "levels up" student learning and ushers them into design education as an *affinity space*. For those navigating disruptive e-learning avenues in higher education, GamerLab™ signals a paradigmatic shift into new pedagogic methods and research questions regarding how we teach innovative courses to enhance collaboration skill sets, research skill sets and design skill sets. Together, these skill sets constitute the new digital tools of trade for transformations in architectural and related urban Industrial and future product design practices. As mentors and thought leaders of future stewards building global architectural, urban planning and product design communities, we believe it is our duty to provide relevant and engaging opportunities to skill up and be ready for online collaboration futures -- futures powered up by VR and gamified platforms that make possible user generated content and sharing on existing social media. The GamerLab™ educational mission: Game and change the way design is taught and critiqued anywhere in the world.

II. GamerLab™ Working Assumption #1 Better Games for Better Brains

Consistent with the premise that online gaming makes a positive impact on cognitive development, is the claim that it can make positive impact on our neurological development. As noted earlier, neuroscience labs like the Stark Lab are paying serious attention to the cognitive, specifically spatial memory potential of 3D game worlds. McGill University's Bohbot Lab also researches spatial memory -- a key skill used by architectural designers -- uses a 3D game design to research strategic procedural memory function in contrast to automatic procedural memory. Space may not be the last frontier for as Posit Science / Brain HQ researcher Michael Merzenich reminds us, "We hang our memories on the curtain of space and time." Thus, to seriously

consider both cognitive and neurological development within contemporary architectural education is to call for nothing less than a revolution in today's architectural - spatial design education afforded by gaming technologies. We do this by taking into consideration evidence-based research by testing both gaming hardware and software.

With changing brains in mind, we advocate for architectural education to be based on neuroscience supported game mechanics. We speculate this will make possible epic challenges within intellectual and creative opportunities opened up by crowdsourcing and by reward based, spatial learning systems. Using the GamerLab™ system for new architectural and urban design education, we envision the potential of gamified education mechanics upending the centuries of design education practice -- especially old master/apprentice relationships. Our GamerLab™ directive: Free up space, student thinking and student action to allow for the introduction and adoption of egoless avatar identities to imagine, collaborate and design new environments, new worlds. The goal? Shift the power and influence of academic professors and mentors to impact student creative initiative and skill building played out in game worlds.

As a team made up of veteran educators and a recent architectural graduate, we recognize power positions are not easily abnegated nor are students fully on top of locus of control issues. Consequently we start with the premise “apprehension fills the void where skills do not yet exist,” and presume design education operates in a neuro-psychological reality with groups of both fixed and growth mindset learners. Well established within edu-psych literature by Stanford psychologist Carol Dweck, a growth mindset describes a gamer attitude with its “take up a challenge attitude.” Skill development thus sets the course for entry into the GamerLab™ learning system that hands students programmatic directives and growth mindset skills necessary for the truly epic challenge of building the future they wish to see and the locus of control they desire to achieve. In other words, we offer students a state of the art, gamified curriculum that tests personal agency and social dynamics.

III. GamerLab™ Working presumptions #2 Identity meets Software; Software meets Hardware

As GamerLab™ creators, we therefore must waste no time in fomenting change in learning systems and in design practices that set up the conditions for equal amounts of curiosity and criticality within professional design circles and in design education institutions regarding how design can and should be taught and how as it is currently practiced today. We recognize, for instance, the digital design and spatial skills of young architects are now being called for in entertainment, business and clinical application --a trend noticed by commentators of *Arch Daily* (2016) and the 2016 Unity VR/AR Summit, where we learned of Google's intent to share free SDK versions of Project Tango and bore witness to Unity engineers and designers using VR enhanced architectural design to enhance cognitive development.

We argue design education will follow Unity and other architectural software entertainment companies in adapting new Virtual Reality (VR) tech — the **Vive**, the **Gear**, the

Oculus, the Cardboard — for immersive world building and design learning experiences. By leveraging the ever increasing sophistication of VR viewing devices with new and improved game mechanics, we call for an unfolding professional future made possible by a change in how we educate architectural students. To quote Unity Summit speaker, JPL presenter Jeff Norris, “We are designing for the future and the future is NOW. We follow asking: How does the emergent NOW of new VR / AR hardware and software precisely contribute to the disruption of design education for the benefit of student learning and student preparation for leadership in future design worlds?”

Forgive our Don Quixotesque imagination, but we can see VR invigorating student play with new shapes and forms, imagined from the inside out, first-person perspective. With VR interface design, gone are the days of architects presuming a god’s-eye point of view. In other words, VR enhanced game design with architectural goals can open up fascinating new portals for young students to leap through and discover spatial centric design skills and elements of spatial choreography and spherical storytelling into their design workflow. For generations of architects working to establish architecture as an experimental studio discipline and who abide master/apprentice relations, we make a call-to-action: It is time for a new generation to strap on their headsets and enter new non-Euclidean worlds waiting to be imagined, rendered and gamified for interactive response!

A recent **New York Times / Google VR Initiative** provides a journalistic example of how, by arming student readers with a Google Cardboard and a downloaded NY Times VR app, reading experience can become embodied and spatial. Readers are empowered to enter action from a first person perspective. With VR and gamification, the possibilities of provoking empathy and social sharing are multiplied and the potential to cultivate generations of Google Cardboard users as virtual stewards of future civilizations is enormous. Visualize, for a moment, the social, political and spatial possibilities of inhabiting virgin, virtual worlds and the interaction with those worlds towards the creation of a virtual place. Weigh out the value of boosting spatial perception. Now with new educational possibilities abundant, one can be sure: Developers of VR (and AR) hardware and software claim future 3D platforms will improve the fidelity and options of smartphone and laptop representation turning them from black mirrors into what David Rose calls “enchanted objects.” As stewards of the virtual, we are interested in VR working in tandem with a gamified curriculum as a new platform for architectural and other design collaborations.

IV: GamerLab™ : An Affinity Space for Virtual Architects

This past Spring (2016), we beta tested the GamerLab™ curriculum in SCI-Arc and Arizona State University (ASU) architectural design studios. These two studios represented a comparative opportunity to run and examine GamerLab™ in application sizing up curriculum demands, student financial commitment and career expectations: SCI-Arc, a renowned private

experimental college setting (with a class size of 13 students) presented a different picture from ASU, a large public university course (with its 27 students). Recognizing gaming mechanics is neither a regular academic feature of either school studio nor a skill set that all students bring into the studio setting, we set out on our own epic challenge of disrupting the status quo.

Our beta testing led us further to hypothesize a new found joy young Virtual Architects would uncover testing their imagination, skill, talent and deep social values by sharing within a VR equipped GamerLab™ “affinity space” platform -- a platform that brings together academic colleagues across institutions and geographies. By *affinity space*, we draw from ASU learning theorist James Gee who imagines the future of education in social spaces inspired by game dynamics that build personal character and “me-we” awareness along with a host of intellectual and problem-solving skills -- all of which are activated and toned through deep play and social cohesion and exchange. In future beta-testing studios we plan to test the “joy” and social cohesion factors with self reporting tests found on the University of Pennsylvania Authentic Happiness site. As of now, we are unable to report measured degrees of joy based on current technological constraints of real time sharing within 3-D virtual worlds, constraints we are addressing by way of generating a proprietary software platform.

In the meantime, taking Gee’s directive into our gamer hearts, we introduce Virtual Architects to GamerLab™ affinity space rule sets and principles that guide spatial research, experimentation, production and innovation. We propose eight principles of Virtual Architecture to be explored in the GamerLab curriculum: *Genesis, Exploration, Collaboration, Resilience, Crowdsourcing, Networks, Place-making, Stewardship*. Each principle alone speaks to a game play in epic challenge and with infinite game mechanics. Together the principles speak to three categorical meta needs articulated within virtual game worlds, each carrying with them relevant philosophic currency for architectural design education: The need for an Epic challenge call to action: (genesis / exploration); the need for Teamwork aka using a collective brain (collaboration / crowdsourcing / resilience); and the need for Legacy: Developing robust future hives (place-making / networks / stewardship). As categories of guiding principles, Epic Challenge, Teamwork, and Legacy arm today’s design students with game-based concepts that enable them to envision a design practice as a collection of finite, multi-player online games within an infinite game. These finite games are represented in weekly compounding activities (levels) that must be completed successfully before the team is allowed to move onward. In this way students learn through resiliency in a system that not only allows for failure but cultivates it in a way which is academically constructive. Like any gamer starting a new game, the Virtual Architect is given a chance to insert him or herself into a world born and ready to be explored; the need for a story of origins with a mission to “go where no one has gone before.”

In GamerLab™ we approach this call-to-action through the use of an *avatar* — a projected protagonist creating and entering newly designed spaces and architectural sites. Each student is required to create a fictional character for themselves, a heteronym in the spirit of famed Portuguese author Fernando Pessoa. Donning this avatar sets up a dynamic for students to

tap less practiced brain circuits to imagine and spatialize their surroundings through the point of view of their avatar. Our hope is that much like players in **Second Life** or **EVE Online**, students can be freed from neurotic impulse and the personal liability of a project's success. They may even take more risk and in turn, learn more about themselves. We like to think of this as a chance to acknowledge our inner "inventio!" -- the agent of curiosity, wonder and invention spirited on to create (and argue for) new materials, new tools, new methods, new concepts, new worlds.

V. GamerLab™ Methodology: Alliances and Corporations

Inspired by the social contract practice within serious game culture and informed by behavioral / neuroeconomics, Gamer Lab™ creates an organizational hierarchy that allows each member to follow his or her own desires within an infrastructure that actually allows for teaching skills necessary to collaborate and build professional relationships. The relational infrastructure presumes a shared end goal of designing an architectural program for a proposed environment or space. GamerLab™ borrows from organizational models often found in multiplayer online games — Alliances and Corporations. Alliances and Corporations are not equal in their studio function and each player (or in this case, student) has varying levels of commitment and responsibility afforded to them. What they do share is an agreed upon mission statement, bylaws, and power structure. There is a virtue of bringing in a social contract: Research and design skills as well as responsibilities are spelled out within the context of the actual game. The rule based logic of gaming lends itself sweetly to the neuroeconomics of creating clarity and fair play. It also taps into human, evolutionary neural-networks that process the efficiency quotient of rule-based experiences.

Rule based experiences are shaped by student Alliances forming around a specific research topic; Corporations build on Alliance research and reinforce the competitive edge in a gamified professional practice. During Spring term 2016, SCI-Arc and ASU joined in a friendly collaborative and competitive GamerLab™ initiative: Design the 21st century gifted children's school. SCI-Arc students organized Alliance research around educational theories to explore Confucius education, online education, STEM Magnet education, John Dewey's model of 'learn by doing,' Humanistic Therapeutics, and Deconstruction of Educational Theory assumption. ASU alliances looked at similar theories informed by face to face interviews with student and teacher experience from the Herberger Young Scholars Academy. Corporate groups at each institution generated visual models of an architectural program or plan for solving a real world problem. Here we don't presume "real" indicates offline time space coordinates, but rather a problem of pressing need. For SCI-Arc and ASU students, pressing need was interpreted as specific programmatic design for more blended hands-on learning spaces, gardens that bolster and inform moral and ethical character and built spaces that encourage holistic engagement with the natural environment enriched by lessons in sustainable, cradle to cradle culinary cultures.

The purpose of the Alliance research is to incentivize programmatic inquiry prior to the introduction of the architectural project itself by forming research competition between various groups of students. The same is also true of the Corporations which are similarly tasked with unpacking specific site and contextual topics that will ultimately lead into the development of an initial concept for the project. To dramatize Alliance and Corporate skill building during this research period, we introduce *trading cards* -- a gamer strategy deployed to encourage “leveling up” with tangible rewards -- a break away studio practice not otherwise recognized by architectural masters known for their reserve in offering rewards for work yet accomplished. Yet, as in infinite games, so in life: at SCI-Arc, one Alliance broke down due to work habits and personality differences that bled egotism through the virtual skin of egoless avatar identities and made trading cards superfluous. Using an infinite game mechanic of immediate and infinite feedback for epic wins and epic failures, we challenged students to “level up” their self-assessment and reconstitute Alliances to proceed with the epic challenge of researching and designing a gifted school complex. However, reconstituted and original Alliances do not presume to continue as a Corporation.

By that we mean, within Corporations, Alliance research information is exchanged out of necessity working as competitive teams. Why competition? Narrative gamification brings with it an algorithmic model wherein competition operates according to rules of rivalry *and* collective survival. Insuring a contest of inquiry and ingenuity, GamerLab™ sets the ethical goal of the entire studio: Work together as a collective intelligence towards the complete understanding and spatial development of the design prompt. In our ASU / SCI-Arc beta tests, for instance, this directive instigated a live round table meet up for midterm presentations made by members of both SCI-Arc and ASU. As pedagogically calculated, the joint pin up session gave rise to fresh programmatic insights in teams from each school. With the academic reality of end of term facing these virtual architects, competition leveled up team reflection on notes for iteration; it also provoked self-assessment of skills and focus on goals. As players within GamerLab™ we too, had new insights regarding the use of the avatar within Corporate structures in relation to other gamer culture strategies, namely, trading cards tagged “wizard” or “dunce” as both tracking and coaching devices to level up in design and collaborative team skills.

In a bio-ecology of ritual, rhythm and consistency often follow calendars of the moon, the rain, the passing of seasons. In the ecology of architectural education rituals, final reviews play a central role in confirming one’s status as a member of the architectural community. Reviews implement rules of master-apprentice relations thereby upping the sibling rival-like competition between students. By contrast, within GamerLab™ methodology of Alliances and Corporations, the final review operates as an affinity space. For how can one reconcile a master-apprentice model or the juried defense in a technocratic society that hosts self-paced, digital skills education on Lynda.com or the coordination of 7,548 players during the realtime space battle BR5RB in **EVE Online**. Today we live, work and take classes on a Web that supports multiple affinity spaces for every topic (Rule 43: If you can imagine it, there is a website for it). As the Web

becomes its own affinity space for Reddit users and social activists, medieval rituals of architectural education at both undergraduate and graduate levels are put in question. What proved profitable for guilds in late Middle Age, now loses social cache for digital natives who do not presume subjective connoisseurship nor the passing of power down to a mentee or protégé. In other words, GamerLab™ signals an end to architectural regimes and the disruption of rituals which ‘consolidate power into a fossilized system of education and aesthetic’ to quote UCLA architect Natasha Bajc (who trained as an architect within the Serbian education system). The “virtual architect,” operating through an avatar in VR space and teamed up with colleagues in gamified alliances and corporate missions, can now approach architectural education as an *affinity space*. Our colleague Alex McDowell put it best at a recent Inventio!Brains Chat, "We are experiencing the end of the author and returning to the age of collaborative storytelling." This is also true for the world of architecture. The age of the "starchitect" is over and the era of open source collaborative design is just beginning -- extended now by VR interface with game mechanics, greased by avatar risk-taking and storytelling.

VI. GamerLab™ Methodology: Storytelling

Steeped in a long illustrious history of world building, architects have not always shown signs of risk taking nor embrace of noble ends yet when they do, they leave us with singular examples of award winning city center, schools and museums, stories of embedded meaning abound. Stories and embedded meaning are precisely what we are after in GamerLab™ and so we work to bring infinite game narrative values into the architectural storytelling context. This simple pedagogic innovation cements the narrative foundation on which the virtual architect bases his or her research goals for an avatar’s design project. Taking advantage of story boarding, students are more likely to assume a “client” or user perspective moving through space from “the inside out rather than the outside in” point of view. In this way any formal characteristics are the direct result of the student *as* avatar interacting with the program as “a day in the life” of one of its future inhabitants. Within our beta test, for example, “GamerLabbers,” as we affectionately refer to them, conceived of research--influenced, building designs and programs brought to life through constructed storyboards to show movement and action through space: The Confucian Education team, inspired by the four moral attributes of Confucian character building, rendered a navigational walking pattern through the school in question, starting with a ride on the Gold Line Metro stretching from Pasadena to Chinatown. A day in the life in the Confucian school includes walking through school hallways that lead to garden spaces, the hallways themselves are lined with Confucian quotes on the four attributes of character: *loyalty, compassion, truthfulness and fairness*.

Storytelling practiced in GamerLab™ thus departs from current rituals of architectural student explanation enshrouded in “Post Kantian” OOO theory or attempting to reinforce Parametric assumptions that straitjacket thinking into purely functionalist, metric terms.

Recognizing the narrative power of games to incentive avatar skill building and imagination, we hold to the idea that stories speak of time /space experience tapping the listener's spatial memory and gamer logic. In other words, the intellectual and cross-cultural benefits of storytelling from an avatar standpoint should not be underestimated. As in infinite games, students can step into new identities online, finding divergent ways to approach a problem and mine the confidence it takes to share a good story, one that compels a listener to enter into a contract of belief. Suited up in an avatar identity, the otherwise timid or introverted student can bypass attempts to make up pseudo architectural theory or worse, parrot of a mentor's point of view.

By inserting strategies of storytelling and avatars as players of multi-dimension and varying moral intent, GamerLab™ thickens the personal and social dynamics of collaborative group design challenge. Where stories activate imagination and depart from academic nausea of poorly mounted rhetorical argument, the avatar character base optimizes the potential of each student to free themselves from an immobilizing, self-critical persona. Taking into account Rene Girard's reading of ancient narratives and sibling rivalry, we recognize the inherent narrative element driving competition within gamer worlds just as we recognize the ways in which **Second Life** or other Virtual Reality worlds build self-confidence and compassion by taking up avatar identities. Conceived as affinity space for ramping up design skills and social development, GamerLab™ makes room for learning as symbolic and deep passion play.

VII. GamerLab™ Speculation: Time for a breath of fresh virtual air.

Passion and play are what we sorely need if design education is going to meet the architectural, urban and product demands of changing technologies available 24/7 on the Web. It is with the fullness of heart and mind that we propose GamerLab™ as a galvanizing force of change within higher education. It is charged with new social, perceptual, aesthetic and pedagogic dynamics set in motion by emergent 3D virtual technologies. With its gamified mechanics, it mirrors the systemic and emergent connectivity of our brains, and our social networks. We argue it is precisely the shared virtues of systems that operate according to principles of connectivity and emergence that set a new high bar for measurable and evidence based education platforms accessible wherever a stable Internet signal can be found. We also contend that online learning platforms generated to meet the needs of a future design generation must take into account the shared systems principles of connectivity and emergence in order to give rise to opportunities afforded by VR enhanced representation. This in turn will empower a new generation to learn and work online for online design purposes as suggested by increasing demand for spatial designers of game environments. As a curriculum and a pedagogy that privileges systemic and emergent connectivity, GamerLab™ models out a new global e-learning system, making room for the influence of cognitive neuroscience, the application of data smart technology and game based learning platforms to infiltrate and redefine the proposition of affordable, online design education.

Furthermore, having entered an age of ever increasingly sophisticated connected, emergent and available VR hardware and software, we present the GamerLab™ platform as an easily accessible and viable affinity space training for Virtual Architects entering into twenty-first century design education and career opportunities. As we have claimed, educating Virtual Architects requires full recognition that we are training a measurable cognitive skill set that can alter perceptual worlds and rock two-dimensional assumptions about space and time. Just as the microscope and the telescope redefined our understanding of scale and spatial relations at micro and macro levels, VR game environments are equipped with the potential to push the naive, Virtual Architect to reimagine spatial relations in buoyant, spherical landscapes, leaving design OOO and Parametric theory to be entertained with the GamerLab™ affinity space.

Our beta tests in two higher education institutions have certainly afforded a glimpse of the hurdles and unanticipated benefits we face in our attempt to disrupt pedagogic power structures. Perhaps the tallest hurdle to overcome is the institutional position against games themselves. Institutions while built to provide maximal broadband access to every student, they often block sophisticated gaming platforms like Steam that empower autodidact and social learning strategies. Be that as it may, the lack of technological facility conversely afforded pedagogic opportunities to gamify online and offline model and drawing exercises that could be quickly and easily transposed into online modeling opportunities with the aid of one's smart phone. With game mechanics as its default engine, our GamerLab™ platform models out a learner centered pedagogy for current and future design schools. Grounded in the neuroscience of growth mindset and armed with meta-need categories as drivers of avatar, alliance and corporate action, GamerLab™ makes room for *iteration*, a cherished design value needed to achieve the imagined programmatic goal. Future beta tests with software collected metrics should prove out pedagogic propositions named within.

In the meantime, by aligning cognitive, technological with aesthetic demands, we are paving the way for designers to spatialize the virtual, drawing on 40,000 years our bodies and minds moving, manipulating and interacting with our physical environment. We imagine a global future where aspiring young designers in Warsaw, Johannesburg, Hong Kong and LA will meet first online, in a game world and seek out GamerLab™ affinity spaces online and in their 'hoods' in order to enter VR enhanced and technologically enchanted spaces. Grounded in relative time space coordinates, they will strap on a Cardboard, Vive, Oculus or Gear, inhabit a new avatar, fly through strange new portals and join colleagues to test their spatial perception against the competitive, social creativity odds of civilization building and online design education.

References

- [1] Bajc, Natasha, Personal Interview, Spring 2016.

- [2] Carse, James P. (1986). *Finite and Infinite Games*. Ballantine. NY.
- [3] Clemenson GD & Stark CEL (2015). Virtual environmental enrichment through video games improves hippocampal-associated memory. *Journal of Neuroscience*, 35(49): 16116-16125; doi: 10.1523/JNEUROSCI.2580-15.2015.
- [4] Dweck Carol (2006). *Mindset: The New Psychology of Success*. Random House. Print.
- [5] ESA Essential Facts 2015 brochure.
- [6] Gaudiosi, Jim (2015) "Mobile game revenues set to overtake console games in 2015." *Fortune Jan Web* <http://fortune.com/2015/01/15/mobile-console-game-revenues-2015/>
- [7] Gee, James and Hayes, Elizabeth (ND). "Nurturing Affinity Spaces and Game Based Learning." Unpublished paper.
- [8] Girard, Rene (1972). *Violence and the Sacred*. Edition Bernard Grasset, Paris.
- [9] Greenstein, M A (2011) "Conversation with Michael Merzenich," *Mind and its Potential Conference*, Sydney.
- [10] Harmon, Graham (2011). *The Quadruple Object*. N.p.: Zero. Print
- [11] Lenhart, Amanda (2015). Chapter 3: Video Games are Key Elements in Friendships for Boys, *Pew Center for Research*, 6 August.
- [12] Long, Nels, Greenstein, M A, Clemenson, Dane, Rotondi, Michael (2015). "Buoyant Memory: Neuroscience for a Virtual Architecture" *eCAADe proceedings* Sept.
- [13] McDowell, Alex (2016). *P E R C E I V E*, *Inventio!Brains Chat Los Angeles* 29 Jan live guest talk produced by RotoLab and the George Greenstein Institute.
- [14] McGonigal, Jane (2011). *Reality is Broken*. Penguin Press.
- [15] Praseuthsut, Lily (2016). "#Trending: VR and AR Classrooms." <http://www.wearable.com/trending/trending-vr-ar-classroom> 11 Feb.
- [16] Ramdurai, Gautam (2014). "Think Gaming Content is Niche. Think Again." *Think With Google*. December.
- [17] Rose, David (2014). *Enchanted Objects: Design, Human Desire, and the Internet of Things*, Simon and Shuster.
- [18] Say, Angel (2016) *Virtual Reality for Architecture Predicts Patterns, Drives Business Decisions*, March <http://www.archdaily.com/tag/virtual-reality-for-architects>
- [19] Shumacher, Patrick (2011). *The Autopoiesis of Architecture: A New Framework for Architecture*. West Sussex: John Wiley & Sons. Ltd. Print.
- [20] Somaiya, Ravi (2016). "The Times Partners With Google on Virtual Reality Project." *The New York Times*, 20 Oct.
- [21] Stewart, Bart (2011) "Personality And Play Styles: A Unified Model." *Gamasutra*. N.p., 1 Sept. 2011. Web. 07 Feb. 2016. [24] Statistica. 2014) "Forecast revenue for virtual reality products* worldwide from 2014 to 2018 (in million U.S. dollars)" <http://www.statista.com/statistics/426276/virtual-reality-revenue-forecast-worldwide/>
- [22] West GL, Drisdelle BL, Konishi K, Jackson J, Jolicoeur P, Bohbot VD. (2015). Habitual action video game playing is associated with caudate nucleus-dependent navigational strategies. *Proceedings of the Royal Society of London - B*. 282(1808): 1-9.

How Uruguayan Classroom Teachers Learn English together with their students within *Plan Ceibal en Inglés*: a win-win situation that favours inclusion and equality

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Abstract

Within the highly innovative programme Plan Ceibal en Inglés, whose aim is to reach State Primary School students in all corners of Uruguay by means of remote teaching, Uruguayan classroom teachers whose knowledge of English is limited learn the language online through a self-access course with the help of e-moderators. In this way, not only are they empowered to facilitate their pupils' learning of English but they also assist distance teachers by conducting two 45-minute lessons per week. The author of this paper has been working as an e-moderator and English course designer since the beginning of the Ceibal en Inglés Project in 2012 and intends to describe here how the programme contributes to inclusion and teacher development. This paper will not provide details of the work done by school students or remote teachers. Instead, it will focus on the learning process and teaching practices of the Uruguayan classroom teachers and on the role of the e-moderator as a fundamental actor within the Project.

1. Introduction

In 2006, Uruguay launched *Plan Ceibal*, a pioneering programme targeted at closing the digital gap between the country and other nations, as well as among its own citizens, favouring digital literacy and inclusion across all social strata and improving access to education and culture [1]. Delivered since 2012 by The British Council, *Ceibal en Inglés* was conceived within this long-term strategy to provide 4th to 6th (pre K-12) grade State Primary School students with quality and sustainable education of the English language despite the scarcity of qualified teachers, making use of cutting-edge technological resources such as the computers facilitated by the One Laptop per Child (OLPC) organisation, videoconferences, digital materials and online training platforms.

The project involves three lessons per week: Lesson A, a 45-minute slot following a detailed plan taught via videoconference by a remote teacher of English who may be in Argentina, Uruguay, the United Kingdom or The Philippines, and Lessons B and C, two 45-minute periods conducted by the classroom teacher, which are devoted to reviewing, checking, practising and reinforcing content [2]. Given that most of the Uruguayan Primary School classroom teachers have very limited or no knowledge of English, this turns out to be one of the most innovative aspects of the programme since they are improving their own English by delivering the lessons and mainly through a self-access course, LearnEnglish Pathways (LEP). This online course is

supervised and monitored by a team of e-moderators who support, motivate and aid participants through their work. Darío Banegas, the first Project Manager of *Ceibal en Inglés*, has stated that “*Plan Ceibal seeks to demonstrate that lessons delivered by remote teachers (RTs) via videoconferencing with support from classroom teachers (CTs) with little command of English can facilitate successful learning outcomes in learners, including effective interaction with the RT, CT and between learners*” [3].

Year after year, the programme has seen a growing number of volunteers. As shown in Table 1, more than three thousand CTs were enrolled in 2015. Their commitment to learning English together with their students gives *Ceibal en Inglés* a unique quality that distinguishes it from other educational schemes.

Table 1. The programme’s 2015 key numbers

Number of schools participating in the project	571
Number of classroom teachers	3,144
Number of groups	3,360 (25 Primary School children on average each)

2. Online English Courses

The British Council, a highly experienced organisation, was chosen after an open international bid as a partner for the *Ceibal en Inglés* Project. A fundamental aim of the programme is to support the work done by the Uruguayan CTs who were never formally trained as teachers of English and hardly speak the language themselves.

In order to offer guidance and assistance, the British Council provides CTs with an 8-level self-access online course, LearnEnglish Pathways [4], and three other courses especially designed for true beginners and for more advanced users of the language. This is a key feature of the Plan since these online courses are scalable and accessible to users at any time, regardless of their location.

Each teacher who signs up for the Project has their present command of the language measured by means of a Placement Test that renders results in keeping with the CEFR (Common European Framework of Reference for Languages). After that, they are placed at one of the eleven available course levels: A0, Elementary 1, Elementary 2, Pre-Intermediate 1, Pre-Intermediate 2, Intermediate 1, Intermediate 2, Upper-Intermediate 1, Upper Intermediate 2, Upper Intermediate Plus 1 and -recently added upon the request of a group of hard-working teachers- Upper Intermediate Plus 2. The last two courses are specifically designed for the more advanced users of the language. A high percentage of teachers are streamed into Elementary 1 either because they hardly remember what they learnt as a young student or because they want to review content and accompany their students’ learning process by starting from scratch just like them.

Except for A0 and the last two levels, which are specifically designed for true beginners or for more proficient language users, all other levels are part of LEP (ending at approximately B2 level).

3. The role of the e-moderator

E-moderators are experienced teachers of English themselves and highly qualified distance learning tutors based in different countries. For this Project, they were asked to help teachers who do not know any English to teach precisely English, something that sounded shocking to most tutors, as this practice was rather unthinkable within the frame of mind of an EFL (English as a foreign language) teacher. That is what I myself initially felt when I was approached to join the team, but then I remembered Jacques Rancière's *Le maître ignorant*, in which the author recounts the story of Joseph Jacotot, a schoolmaster that developed a method for illiterate parents to teach their children how to read [5].

Therefore, I decided to embark on the Project as I prioritised the major goal of Ceibal, which has always been to offer equal educational opportunities to Uruguayan kids and in the particular case of *Ceibal en Inglés*, educators are also included as potential learners of English. This justified the need to gain flexibility of one's own assumptions and to explore areas completely unknown. Tutors from Argentina or Uruguay, who had been trained as EFL teachers, had never before had to use L1 (Language 1, i.e. Spanish as their mother tongue) so frequently to communicate with their tutees. LEP tutors have to find strategies to slowly and very carefully move into L2 (Language 2, i.e. English, the target language) trying to avoid scaring CTs away and making them feel that little by little they can understand what they read or hear. We gently lead them by the hand to make their own attempts at speaking and writing a few words in English and focus our attention on the communicative achievement of their production to boost their confidence.

3.1 Teacher Support

The classroom teachers study English at their own pace while tutors offer academic and emotional support. This aspect is essential since there is a lot of fear enrooted in the teachers' lack of knowledge both of English and information and communication technologies (ICTs). Not only do classroom teachers have to help their own students exercise with their *ceibalitas*, low-cost durable laptops that run on Linux which are provided by the government to public school students, but they also have to deal with their own computer-related issues when browsing the internet, participating in the online course and accessing their email, among other digital tasks required to successfully complete their training. In many cases, as well as with the students, some teachers hardly had any contact with computers prior to the Ceibal initiative.

Regardless of whether they own multiple devices or only have the programme's laptop, the majority of the teachers are not normally used to regularly checking their personal accounts or setting up their camera and microphone for a video call. The inherent use of technology as a means of communication with the remote teacher and the LEP tutor has shaped and nurtured the digital habits of classroom teachers. *Ceibal en Inglés* requires furthering their computer skills as they have to check their email periodically or log into CREA2, the virtual space provided by

Ceibal to save resources and communicate both with the remote teacher and the tutor. Above all, Uruguayan teachers who embark on *Ceibal en Inglés* have to discover and familiarise themselves with their own 'online voice'.

At this point, the e-moderator is a crucial actor whose aim is to guarantee the teachers' engagement, commitment and satisfaction, a delicate balance of feelings that may either encourage or frustrate CTs and could ultimately lead them to drop out if mishandled. As an online tutor, one has to be present but not intrusive, supportive but not insistent, firm but understanding at the same time. All these variables add up to the success of the e-moderation, which is measured in terms of the progress made by the teachers, who are not only responsible for the face to face classes B and C of the weekly plans but also for their own learning process to improve their command of the English language.

3.2 How e-moderation works

The duties of the e-moderator include answering participants' emails, posting to CREA2 groups, issuing digital certificates at the completion of each LEP level and sending reports to the British Council and Ceibal to account for the group activity and progress. Simple technical issues are solved by the the British Council officer. More complex problems are sent to the course developers, who provide a solution through the tutor. All academic content is clarified by the e-moderator, who also provides extra explanations and practice whenever necessary.

Since early 2016, two essential aspects of the learning process have been included in the Project. As a major development, classroom teachers are now able to participate in Oral Practice Sessions led by the tutors via BigBlueButton, a web conferencing system embedded in CREA2. These sessions have proved to be very enriching for all the participants and CTs find them invaluable. The other latest inclusion is the tutors' assessment of Writing since this skill cannot be automatically evaluated by the platform.

Any teacher of English who has received proper training as an e-moderator would know how to fulfil these duties. However, there is a lot more to the job. Educators who take this huge challenge of working with CTs for *Ceibal en Inglés* have to develop a very refined sensitivity to cater for the teachers' needs and embody a kind of ubiquitous virtual presence which tutees can depend upon.

Likewise, there is a need for sensibility to type the right word at the right time, to use the exact tone, to send a timely response in order to include CTs rather than exclude them and to make them feel capable of achieving their goals. Behind each of the e-moderator's actions there is this idea that the more classroom teachers volunteer to join the programme, the more kids will have access to English lessons.

How is that done? At the beginning, when teachers join *Ceibal en Inglés*, they are likely to have heard about it from a colleague who is already working in the programme. It all sounds tempting and so they join in voluntarily. No educator is compelled to be part of *Ceibal en Inglés*. Cts are part of the Project if they truly want to be. This is a positive aspect since their involvement is engrained in their own needs and beliefs as educators.

4. Teachers' motivation

It is hard to know what mechanisms are activated when an adult comes back home after a long day at work and sits down at the computer to study a foreign language, which in many cases implies a huge effort. Many of the classroom teachers involved in the Project express the idea that their motivation stems from their frustration when they look back at their own schooling, at a time prior to the advent of ICTs, when English was not a priority for them and they easily forgot what they studied at the *Liceo* (Uruguayan Secondary School).

The end of a working day, weekends, holidays, winter or summer breaks have all become ideal times for the teachers to study English and advance in their courses. During the times when everybody is supposed to be resting and recovering energy, Uruguayan teachers are more active than ever, preparing themselves to improve their practices at school. *Ceibal en Inglés* has certainly had an impact on their daily routines and leisure activities. However, they are extremely grateful as now *Ceibal* has also given them not only a genuine purpose for learning the language but also the tools to do so. Classroom teachers are determined to give their pupils better opportunities while they fulfil their own long-forgotten dreams.

It is very moving and rewarding to hear them describe the emotion they feel at seeing the progress made by their own students who learn more and more English every week and at witnessing the impact on their parents, who in some cases, are hardly literate. As one of the classroom teachers said in an email to her tutor: “*Este viernes 5 estaremos con los niños de 9.25 a 10.10 en el salón de VC. Estamos todos muy ansiosos, niños, padres y maestra.*”¹ (April 4th, 2013).

Evidently, the common goal is to present all the students with equal opportunities and to include the most vulnerable social groups in a quality educational programme that integrates Information Communication Technologies and English as an additional language. The Uruguayan teachers who enrol for the Project are committed educators who understand that in order to be literate in the 21st Century, learners not only have to know how to read and write but also develop the skills and competencies needed to become global citizens in this increasingly fast-paced ever changing world.

It so happens that another source of motivation seems to be the teachers' own unfulfilled dreams of studying English and achieving some kind of certification of their knowledge. The *Ceibal en Inglés* Project gives the Uruguayan teachers the opportunity to satisfy this necessity and enhance their career with new qualifications. As soon as they have covered 100% of the activities in each of the units of a LEP level, teachers are awarded a certificate signed by the Head of *Ceibal en Inglés* and the British Council Country Manager. Teachers take pride in this accomplishment, which is proudly shared with their students in class. At the same time, the ultimate goal of *Ceibal en Inglés* is to empower Uruguayan teachers to one day become teachers of English themselves, for which they need to certify their knowledge and skills.

¹ On Friday 5 the children and I will be in the VC [videoconference] room from 9.25 to 10.10. We, children, parents and teacher, can hardly wait,.

5. The work done by classroom teachers and the impact on their learners

The channels of communication between teachers and e-moderators depend on access to the Internet. The British Council, in partnership with Ceibal, has installed a reliable system to guarantee connectivity in all the schools that take part in the Project so teachers whose home Internet access is faulty or non-existent, can work at school in their free time. And they do.

We have to bear in mind that the Project is implemented not only in big cities such as Montevideo (the capital of Uruguay) but also in remote areas where there are vulnerable groups. In many cases, these include the teachers themselves. This lack of resources makes CTs even more worth of praise since they make every effort to access the English course and do their online activities despite the adverse circumstances they sometimes find themselves in.

Both students and teachers are studying English together, setting their own goals, pursuing their dreams and helping one another to turn their wishes into realities. Jeremy Harmer, a renowned ELT trainer, states in an article: *“There’s another crucial feature of this Plan Ceibal – Inglés, the distance teachers interact with the classroom teacher who is right there in the room – but really there! And the special thing about her (or him) is that she probably doesn’t speak much –or any – English. So the classroom teacher is learning English along with the children. A win-win situation”* [6]. This new group dynamics creates new roles, establishes different relationships within the class and redefines education in that new strategies are constantly being developed to make the most of the whole experience, including the bond with the remote teacher, which is worth exploring outside this paper.

Classroom teachers then step aside and take a new role within the group. All actors become teachers and learners motivated by a common objective. Their shared effort pushes them forward towards the final goal. And far from losing the respect of their pupils, CTs turn into a role model who children look up to more than ever as they see the rewarding nature of making an effort throughout one’s life to improve one’s lifestyle and to gain autonomy. In short, apart from learning English, children *learn how to learn*. As Nicky Hockly points out: *“ [...] there have been some notable successes, such as the Plan Ceibal en Inglés initiative in Uruguay. Initial evaluations of the project have found that students in the programme score better on tests and examinations than previously”* [7].



Figure 1. A Uruguayan class teacher and her students working on a laptop during class B.

6. Social Media

Ceibal en Inglés began in 2012 as a pilot project with just 20 classrooms involved. There were a handful of teachers who ventured into unknown territory and a tutor whose assumptions had been challenged. The decision to join in required a great deal of faith in the potential of the Project by all parties involved. In 2013, after a remarkable response and seeing wonderful results of the pilot phase, the Project expanded to 500 schools. As the number of Uruguayan teachers increased considerably and other e-moderators joined in, there was a new need: to use a virtual environment to achieve some kind of group cohesion and do collaborative work. At the beginning, we made use of Facebook Groups to share interesting material, experiences, concerns and to give teachers - students in this context - extra practice. We even used the wall of the group to post a congratulations message whenever a teacher completed a LEP level. The FB group wall became a sort of Honour Board and, like children, teachers were proud to be publicly mentioned for having accomplished their goals.

The social network was useful in our initial stage as it served the purpose of strengthening the bonds between e-moderators and teachers and provided us with a virtual space to offer emotional support while the CTs ventured into their new learning experience. We found out that teachers checked FB more readily than any other account, so the messages sent there reached them faster and had a better impact on the whole *Ceibal* community. In fact, LEP tutors and remote teachers also created groups on Facebook which are still active today.

As the programme grew, it called for a more formal virtual context, in keeping with the official profile of the Project. In 2015, all the LEP groups were given their own virtual spot on CREA2, a Schoology learning platform within the *Ceibal* ecosystem, which offers the possibility to communicate internally via email, distribute and pin useful content, engage in online discussion and work on assignments and assessment. Each teacher has their own profile bearing a picture and a personal description and can be easily reached by e-moderators and colleagues.

This virtual space gives the group a feeling of unity and offers encouragement in that those who tend to lurk the virtual areas are influenced by the posts of more active teachers who celebrate their achievements publicly and in this way, they gain confidence to do their own work on the course.

7. Upper Intermediate Plus and APTIS test for more advanced language users

Launched in March 2015, the Upper Intermediate Plus course is specially designed for teachers whose level of English is B2 or higher. It is done on CREA2 and is organised on a weekly basis to develop five skills: Reading, Writing, Use of English, Listening and Speaking (through a one-hour conference per week).

Those teachers who are actively involved and do more than 60% of the activities throughout the year are given a certificate of completion plus the possibility of sitting five components of the British Council APTIS test [8]. The first group of ten teachers who signed up for the course were highly engaged, completed all the tasks, submitted all the drafts of the Process Writing activities, participated in the web conferences on a regular basis and finally sat APTIS in December 2015.

So rewarding did this experience prove to be for them that they requested a follow-up level to continue studying and thus become more proficient users of the language to help their learners

even further. The more advanced level is therefore now divided into two courses, Upper Intermediate Plus 1 and Upper Intermediate Plus 2, with more challenging content and activities. The British Council and *Ceibal en Inglés* are willing to offer all the teachers who wish to study the opportunity to do so regardless of their level of English.

8. Conclusion

Since its inception back in 2012, *Plan Ceibal en Inglés* has continued to grow and has rendered surprising results so far. State Primary School children, either in the big cities or in the most unfavourable rural areas, are given access to quality education and equal opportunities by learning English through remote lessons. Uruguayan teachers play a key role in the programme when assisting the remote teacher during lesson A and when delivering lessons B and C themselves.

I have tried to highlight the effort these teachers are making and the crucial role they play within the *Ceibal en Inglés* Project. I also tried to show the support offered to them by the e-moderators, who help them achieve their goals by encouraging them to believe in their own potential, not only to be actively involved in the English lessons at school but also to enhance their career paths by learning English themselves.

This paper has tried to give a glimpse of the intense work that is done all year round by thousands of Uruguayan teachers who believe in the power of Digital Learning and make every effort to help *Plan Ceibal en Inglés* achieve its ultimate aim of inclusion and equality.

Further research on the implementation and outcomes will throw light on the effectiveness of remote teaching and the educational impact of the new role of classroom teachers who assist in the teaching of English while learning English together with their students. In the meantime, thousands of kids are being given unfathomable opportunities.

9. References

- [1] Plan Ceibal. Historia. Retrieved April 27, 2016
<http://www.ceibal.edu.uy/articulo/noticias/institucionales/Historia>
- [2] British Council. Ceibal en Inglés. Retrieved April 27, 2016
<https://www.britishcouncil.uy/en/programmes/education/ceibal-en-ingles>
- [3] Banegas, D.L. “ELT through videoconferencing in primary schools in Uruguay: first steps”, *Innovation in Language Learning and Teaching*, Routledge, 7:2, 2013, pp. 179-188.
- [4] British Council. LearnEnglish Pathways course. Retrieved April 27, 2016
<http://courses.britishcouncil.org/LEpathways/>
- [5] Rancière, J. *El maestro ignorante: cinco lecciones sobre la emancipación intelectual*, Libros del Zorzal, Buenos Aires, 2007.
- [6] Harmer, J. “Something big in Uruguay – how do YOU react?”. Retrieved April 27, 2016
<https://jeremyharmer.wordpress.com/2013/08/23/706/>
- [7] Hockly, N. “Digital technologies in low-resource ELT contexts”, *ELT Journal*, Oxford University Press, 2013.
- [8] British Council. APTIS Test. Retrieved April 27, 2016 <https://www.britishcouncil.org/exam/aptis/take>

Engineering Education Online: Our Approach, Challenges & Opportunities (A Case Study of KNUST)

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Abstract

KNUST is the foremost Science and Technology University in Ghana, and has been in the frontier of transforming access to education with the blend of eLearning and classroom sessions since the implementation of eLearning in the year 2005 [1]. Currently, KNUST has established the Institute of Distance Learning mandated to spearhead the transformation of education through technology. The IDL has been able to mitigate internet access which used to be a major bottleneck, and continues to be successful in the development of content for the programmes. KNUST has gradually dealt with these earlier challenges and has taken up the challenge or opportunity in offering quality and respected Engineering Education via E-learning / Distance Learning. This paper aims to share the experiences of KNUST IDL in offering Engineering Education through E-learning, the challenges it faces, which will help build on literature on the subject whilst recommending an approach to deal with the challenges and opportunities it offers.

Background

Kwame Nkrumah University of Science and Technology through the IDL offers 8 Engineering programmes¹ at the undergraduate level for holders of Higher National Diploma (HND) who on account of their location and work schedule will find it quite impossible to attain a degree programme which is in high demand by the industry. These students are periodically offered a blend of online and face-to-face sessions on weekends (Saturdays and Sundays) at the IDL Centres across the country. The Engineering undergraduate programmes offered through distance learning are BSc. Geomatic Engineering, BSc. Agricultural Engineering, BSc. Mechanical Engineering, BSc. Computer Engineering, BSc. Telecommunication Engineering. However, KNUST has taken the bold step of offering some of the programmes strictly online i.e. BSc. Petroleum Engineering and BSc. Chemical Engineering.

Admissions Requirements

Applicants into the KNUST IDL programme are expected to have completed a three-year diploma i.e. Higher National Diploma from any of the 10 Polytechnics in Ghana, and have a minimum of five years working experience. The HND is a technical higher education programme where more focus is placed on practicals than theory. It is expected that the applicant must have at least 5 (five) credits in GCE “O” Level, including English Language and Mathematics and at least 6 (six) credits in SSSCE/WASSCE² subjects in the relevant areas, including English Language, Mathematics and Integrated Science with an aggregate not exceeding 24.

¹Entry Requirement in KNUST IDL Programmes. <http://goo.gl/7qpOs2>. Accessed on February 10, 2016

²West African Senior School Certificate Examination. <http://goo.gl/SiLZIR>. Accessed on January 1, 2016.

The B.Sc. in their preferred Engineering programme hence becomes a top-up degree to enable them meet the high demand of a Bachelor of Science Degree. Example, an applicant into the B.Sc. in Mechanical Engineering will need an HND or its equivalent diploma certificate in any of the following Mechanical Engineering disciplines i.e. Production Engineering, Plant Engineering, Automobile Engineering, Refrigeration and Air-Conditioning, and Foundry Technology.

One of the graduate engineering programmes offered online is the MSc. in Petroleum Engineering. The one-year MSc. Petroleum Engineering programme is aimed at candidates who wish to gain a well-focused and applied technical background that prepares them for a professional career in geophysics. The programme also enables candidates who are already working in the petroleum industry and wish to enhance their technical skills and qualifications the opportunity to do so. Applicants should have a degree, minimum of second class lower from a recognized university in any of the following fields: Physics, Engineering Physics, Geology, Earth Science, Mathematics/Statistics, Engineering or other related fields.

Mode of tuition

The IDL offers a blend of online and classroom sessions for all its Engineering students. Students are given a branded USB internet modem³ which gives them 7GB of internet access per month to enable them access their online courses, submit assignments and in some instances take quizzes. This internet provision is so important in mitigating or at least managing one of the major bottlenecks in access to technology-enabled education [2]. This arrangement was entered into by the KNUST IDL with Vodafone as the service provider.

KNUST IDL has 11 centres across the country to facilitate the classroom sessions of the blended learning. The classroom sessions are organized on Saturdays and Sundays in all centres. This is mainly to meet the demand of the students who are already professionals in their field and whose work schedule would make it quite impossible to be in regular campus-based degree programme sessions. However, most of the course work is covered through the online platform which has enough content (i.e. PowerPoint presentations, video tutorials, simulations, etc.) with assignments, quizzes to enable them access all the opportunities that comes with blended learning. In some instances, there are live lecturer's/instructor sessions with the students via the online platform.

Examinations

Examinations are conducted at the IDL centres at the end of the semester with the same supervision like any of the campus-based programmes. Lecturers are incentivized to take up IDL courses which demands their availability on Saturdays and Sundays in the remote IDL centres. The grading is not different from the mainstream campus-based programmes and taken through the scrutiny of the Examinations office and academic board to ensure that quality education and respected degrees are offered albeit via a blend of classroom and online/digital technology. However, in some instances, they are conducted online especially the quizzes and assignments.

³ KNUST IDL USB internet Modem. <http://goo.gl/18PgRz>. Accessed on December 25, 2015.

Graduation

The Engineering programmes in KNUST IDL running for 8 years now have graduated qualified engineers offering world-class graduates on the subject area. The final certificate presented to students is not labeled as a programme offered through blended learning mainly to mitigate the complexity associated with degrees or access to education through distance learning or digital technologies.

Opportunities

- KNUST IDL has been able, so far to successfully offer various opportunities through its blended learning approach to offer professionals a quality university education without the demand of a campus-based approach.
- The programmes are on-demand and tuition is higher than the mainstream campus-based programmes, hence serves as a sustainable revenue stream for the university.

On the account of students under the Engineering Education Online at KNUST, below are some randomly selected notes:

“I had no time to continue my education. I heard about KNUST’s distance learning programme in Computer Engineering. I decided to put in my application thinking I will just walk through. I was very surprised when I had to go to the laboratory as well. It has really enhanced my career”

“I was skeptical at first, since there was no other engineering programme which I could do only on weekends and at home, I decided to give it a try. I had no regrets. The dedication of the lecturers is second to none”

“The data dongles I was given was very useful. I was worried about how I was going to submit assignments and watch lecture videos. Mobile data is very expensive here”

Challenges

Generally, there are several reasons why a lot of higher educational institutions do not offer undergraduate engineering programs via distance delivery. The main obstacle is the professional accreditation agencies, who require students to have a very high level of laboratory classroom time in a program before accepting a degree for professional accreditation. However, KNUST IDL continues to strive in this demand gradually with selected engineering programmes.

Distance or online courses already have an issue with credibility in our society. KNUST IDL, therefore does not discriminate the degrees or certificates offered and does not label them as online since the course work meets the general standards of the university academic board.

There is also the belief that engineering is very much a hands-on profession and needs personal supervision within a laboratory context. Presence of a laboratory assignment or experiments are lost in the distance learning, hence the likelihood of students actually grasping the concept is very debatable even though video content and simulation applications are blended into the online platform.

Another obstacle is the very high cost of designing laboratory simulations in engineering that might replace physical labs for online students.

References

- [1] J. S. Marfo and R. K. Okine, "Implementation of e-Learning in Ghanaian Tertiary Institutions (A Case Study of KNUST)," in *The Fifth Conference of MIT's Learning International Networks Consortium*, Cambridge, 2010.
- [2] R. K. Okine, A. S. Agbemenu and J. S. Marfo, "Access to Internet Connectivity: the Major Bottleneck to the Adoption of Technology-Enabled Education (The Case of KNUST)," in *The Sixth Conference of MIT's Learning International Networks Consortium*, Cambridge, 2013.
- T. de Jong, M. C. Linn and Z. C. Zacharias, "Physical and Virtual Laboratories in Science and Engineering Education," *American Association for the Advancement of Science*, vol. 340, no. 6130, pp. 305-308, 19 April 2013.
- Y. Astatke, J. O. Ladeji-Osias, P. James, F. Moazzami, C. Scott, K. Connor and A. Saka, "Improving and Expanding Engineering Education in the Middle East and Africa Using Mobile Learning Technology and Innovative Pedagogy," *In Advances in Engineering Education in the Middle East and North Africa*, pp. 235-260, 2016.
- B. Balakrishnan and F. S. Low, "Learning Experience and Socio-Cultural Influences on Female Engineering Students' Perspectives on Engineering Courses and Careers," *Minerva*, pp. 1-21, 17 March 2016.
- S. L. Murray, A. M. Henslee, G. R. Olbricht, D. K. Ludlow, M. E. Hays and H. M. Nelson, "Assessing Freshman Engineering Students' Understanding of Ethical Behavior," *Science and engineering ethics*, pp. 1-18, 16 January 2016.
- V. Potkonjak, M. Gardner, V. Callaghan, P. Mattila, C. Guetl, V. M. Petrović and K. Jovanović, "Virtual laboratories for education in science, technology, and engineering: A review," *Computers & Education*, vol. 95, p. 309–327, April 2016.

Evolution And Advancement In Massive Open Online Courses (MOOC) To Revolutionize Education: The Case Of Pakistan

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Abstract

Massive Open Online Courses (MOOC) is a recent addition and advancement in the distance learning online education. With the strategic collaboration of the founders of MOOC, Harvard University and MIT, now many universities across the world offer a variety of courses in numerous disciplines and domains. This is a magnificent milestone to provide access to online learning and research opportunities to the people across the world inclusive of the under-privileged to the rich. The special features of MOOC consist of state-of-the-art pedagogies, assessment tools, and interactive cum engaging learning sessions. This probe aims to discover the opportunities and inclination of adult students in Pakistan inclusive of professional executives toward MOOC, especially their awareness, perception, peer advice, and self-motivation and commitment to do such courses appear in focus. It applies in-depth interviews, phenomenology approach, and Delphi method in this qualitative investigation being exploratory in nature. It is a multi-stage, multi-technique enquiry to learn about MOOC from university students (many of them do jobs as well) who have never done such a course, those that did some course in MOOC (including professional executives), and field experts (of distance learning and online learning about their models) under Delphi technique. The data is analyzed via descriptive method to explore common themes and undertake constant comparison of data. The findings uncover that the inclination of the students toward MOOC is at an inception stage and there should be a systematic program to nurture MOOC to revolutionize education in Pakistan and minimize the education divide among the under-privileged and privileged students, and to especially foster it among working professionals in all the sectors of the economy.

Keywords: MOOC; Evolution and Advancement in MOOC; Education Pakistan

“1. Introduction”.

Online education as a modern form of distance education has become a popular term in the field of education especially over the last decade. These extensions of former education system were

added by universities to facilitate their part timer students. The lectures are recorded and later made available to the student as and when needed. Its purpose is also to facilitate the faculty members in keeping a record of the knowledge delivered. Over the last decade, online education has evolved in several forms, all with the objective to make the student-teacher interaction more convenient and flexible. It also promises delivering the quality education as does any physical setting of a classroom. However, research studies have compared and contrasted the critics of each of the system. One of the newly emerged forms of online education platform is MOOC (Massive Open Online Courses), which emerged as a consequence of strategic collaboration between Harvard and MIT^[1] and later on, many other universities across the world joined their hands. Coursera, edX, Udacity, and Udemy are the most popular MOOC platforms. Coursera and Udacity are for-profit companies, while edX and Udemy are non-profit organizations.^[2]

The problem in nexus with this probe is that a big chunk of the Pakistani student population is deprived of quality higher education, due to the unaffordable fee structure of private sector institutions. Moreover, the female population of the sub urban areas is, due to cultural myths and family restrictions, not allowed to pursue higher education. Many immigrants and the expatriates who travel abroad in search of job opportunities lack behind in terms of quality education of international standards. That gap can be fulfilled if a candidate has some job-specific certification courses from a well-reputed international university. These unserved or struggling masses can avail the opportunity from MOOC to study online at affordable rates and at the same time get the privilege to be certified from a reputable institute(s). ***The purpose of this research*** is to find out various dynamics, opportunities, learners' experiences, and inclination of adult students in Pakistan (inclusive of professional executives) toward MOOC, especially their awareness, perception, peer advice, and self-motivation and commitment to do such courses. Further, it aims to inquire about the features of traditional on-site education, distance learning, online learning, and MOOC; and to discover the ways to avail MOOC opportunity for revolutionizing the education system in Pakistan, since it can help them in learning and making a better career and future.

“2. Historical Developments / Literature Review”.

Distance education dates back to the use of mail/postal services used to deliver study material to the students and for submission of assignments by the students.^[3] Developments in distance education have evolved with the emergence of each new communication technology. In the late 90s, recording devices were used to record lectures delivered in the class. Students could access them as and when required. Sometimes, with the help of the state, the lectures were telecasted on education-related TV channels. With the development of online media and video conferencing tools, the concept of online education emerged and the virtual universities were established. Lectures were conducted in the physical classroom setting with students in the class; however, distant candidates could be an active part of the lecture using video conferencing packages. This innovation opened room for cost effective education for both the education provider and the learner, as the administrative costs were reduced or economized. It provided access to learners in far flung areas where physical delivery of education was otherwise not feasible. In the evolution of online education, Khan Academy takes the lead. It started free tuition class rooms to teach school and college students. The lectures were recorded and shared on YouTube. Now it serves millions of students worldwide. Many universities avail hybrid approaches by offering class room education and online education.^{[4] [5]}

Some researchers conducted a study based on meta-analysis for evaluating the effectiveness of online learning courses.^[6] Their views and of those of the proponents of online education were contemplated. A strong demerit shared by the proponents is that the drop out or failure rates may increase in the case of online courses because, students who are not regular at studies or do not take their assignments seriously take them lightly, as the student-teacher physical interaction element is missing. Advocates of online education posit that it is more beneficial for the students as it provides access to education, flexible timing option, and offers courses at subsidized rates.^{[6][7][8][9]} Many students appear satisfied with MOOC.^[10] It is found very effective even for undergraduate students.^[11] The learning outcomes for students of fully online and hybrid courses have been equal to or better than the traditional face-to-face instructional courses.^[12] Success in online courses requires high levels of motivation, self-efficacy, persistence, communication skills, and computer literacy on the student's end.^[13] Therefore, the common beneficiaries are assumed to be those who are traditionally underserved, such as low-income, rural, first-generation, or academically under-prepared students. These students may struggle with a variety of challenges that limit their ability to attend classes on campus: child care and other family responsibilities, full-time employment, prohibitive transportation costs, or a time-consuming commute. Thus it seems reasonable that the convenience and flexibility of fully online learning will particularly benefit them. In nexus with pedagogical foundation of MOOC, the principle feature of MOOCs is that they take place online. The students interact with peers and instructors via social media and peers do each others' assessment too. The short video clips or recorded lectures can be viewed at any time, rewinded, forwarded, and paused, and video conference facility can be availed. The prevailing argument is that online courses are at least as effective as face-to-face courses. Online learning offers flexibility of access to course materials from anywhere at any time.^{[12][14]}, which is not possible in a solely face-to-face learning, which becomes impractical when the class strength exceeds a limit in terms of available physical room capacity or overly crowded situation. Some researchers determined that achievement in distance education for high school students is comparable to traditional physical instructions-based education and concluded that educators should not anticipate any significant differences in performance as a result of online learning.^[15] These finding were supported by comparative studies that also found no difference in academic achievement. It was found that online learning pedagogy may even be superior in the overall effect on student performance.^[16]

Some researchers presented an analysis on the working model and teaching methodology of various courses offered by MOOC. The key feature of MOOC that distinguishes it from other online education platform is that it follows the principle of connectivism and connective knowledge. The instructional elements of MOOC set the broad objectives that such courses should remain problem centered, practical, interactive, and applied to work environment.^[17] Connectivity as described by as an approach to learning whereby, learning is perceived to take place through making connections to knowledge resources and people in the network. The earlier constructivist MOOC where only the instructor derived courses were taught was called the c-MOOC. When it allowed openness and creativity (i.e. open for all to do a course and students can comment by reviewing the creative course contents), it was renamed as x-MOOC.^[18] Since the year 2012, a number of global universities have been offering MOOC and it has created an academic discourse. Some experts have declared MOOC as a disruptive technology and serious threat to the institutions of higher education.^{[19][20]} It is also entertained as 'the flipped classroom' and serious to traditional education. The inherent features of MOOCs which distinguishes it from

other online education platforms are ‘Openness’ and ‘Reputation’. Openness here refers to open for all to do a course and even no accreditation is obtained, whereas reputation refers to the perceived image for an institution of higher education that attracts the students toward it.^[21] Some experts expressed the term MOOC as ‘The Educational Buzzword of 2012’, and conducted a systematic study on MOOC to analyze its literature from 2008-2012 and found it very effective.^[22] It is getting popular even in developed countries as well.^[23]

“3. Research Methodology”.

It applies the post-positivism research philosophy and inductive approach in this qualitative investigation being exploratory in nature.^[24] It is a multi-stage, multi-technique enquiry to review the extant literature, conduct in-depth interviews to learn about MOOC from university students (many of them do jobs as well) who have never done such a course, applies phenomenology approach on students that did some course in MOOC (including professional executives) to learn about their lived experiences, and field experts (of distance learning and online learning about their models) under Delphi technique.^[25] The data is analyzed via descriptive method to explore common themes and issues, practices, and undertake constant comparison of data in text form. Triangulation method is applied to find any deviations in secondary data (theories, models, and notions) and the results derived through primary data (from in-depth interview, phenomenology, and Delphi technique). The population of the study includes people of all ages except kids under twelve, illiterate people, and those unfamiliar with computer and the Internet. Twelve students from management sciences department of SZABIST University Karachi are selected randomly from a class for in-depth interviews by ensuring that they have never done a course on MOOC. Another twelve students from the same department and university were selected through judgmental sampling method by ensuring that they have done one or more courses on MOOC. Finally, ten experts on distance education and online education were selected through snowball sampling method.^[26]

“4. Data Analysis and Findings”.

“4.1 Findings from University Students having No Experienced with MOOC”.

The university students (many of them do jobs as well) from the management sciences department of SZABIST University were interviewed in in-depth fashion. They never did such a course. Their awareness about such programs is of minimum level. They have no clear perception of the possible benefits derived from the course like knowledge gain, skills and expertise gain, professional development, opportunities for learning and research, employability and usefulness of these skills at job, possible advantage of such certificates in job and career development. Even, many of them have no idea that many of these courses are absolutely free, whereas they can be upgraded, which means they can receive a verifiable certificate upon payment of a certain fee. (The fee ranges from US\$25, 50, 100 or up to 500, provided they qualify all the mandatory requirements of submitting the assignments, quizzes, research projects, exams, etc. when they fall due). They do believe that those interested in MOOC need to build self-motivation and self-commitment.

“4.2 Findings from University Students having Experience with MOOC”.

The university students (including corporate and professional executives) who did some course(s) in MOOC during recent years had basic awareness and positive perception of MOOC. The majority disclosed that it was an amazing experience of doing a course via MOOC. “At the outset of a course, we faced difficulties in downloading the lectures, case studies, articles, related stuff, short videos, submitting assignments and research projects, and giving exams, but gradually we developed expertise and the overall process turned convenient and user-friendly for us. The learning is very interactive and of high quality. There are Facebook groups and messenger service on the course website where we can post our comments and queries, or contact the course instructor and his/her aides. There is a peer review process in which we assess our peers’ assignments and projects, while they do ours. Above all, we study at our own pace. The courses are either at introductory level or intermediary level. High school to university graduates can undertake them. They are online and often non-credit courses, except few. A young man, Akshay did such courses and got a job at Microsoft. Many complete them and qualify for pass certificates, others discontinue in the middle due to their other commitments, lack of time, usually no money at stake. Many learn by audit i.e. visiting the files during the course or later on in the archive database, which remains available. They do believe that those interested in MOOC need to build self-motivation, personal values, individual goals, determination, persistence, satisfaction, and commitment. The working class of students stated that sometimes their companies ask them to do a course related with their work via MOOC. The participants identified that the missing factors in MOOC are that in physical class room teaching environment, many instructors gradually know each and every student in person, so many of them lavishly praise their strengths to motivate them and strive to remove their weaknesses. This is like personalized learning provided the class size is limited. Secondly, as class attendance is mandatory, there is forced presence for learning. Regarding their suggestions to improve MOOC, they posited that the instructors should provide feedback or appreciation to individual learners and highlight their weak areas. Moreover, a strong advice via word-of-mouth communication (i.e. viral marketing campaign) from reliable friends and family members cum teachers can push potential learners to courses like MOOC. MOOC is required for all the domains of knowledge and with a huge variety of courses, since countries like Pakistan have dire need of it. There are courses for technical and vocational education, women education, adult literacy, and there should be courses for special people too. MOOC is a blessing and splendid opportunity for the non-affording to less affording learners. At a certain age, people do not have time to do degrees and courses, they are deeply overwhelmed as working professionals, and at that time MOOC can be very helpful for them in building knowledge, skills, and career advancement.

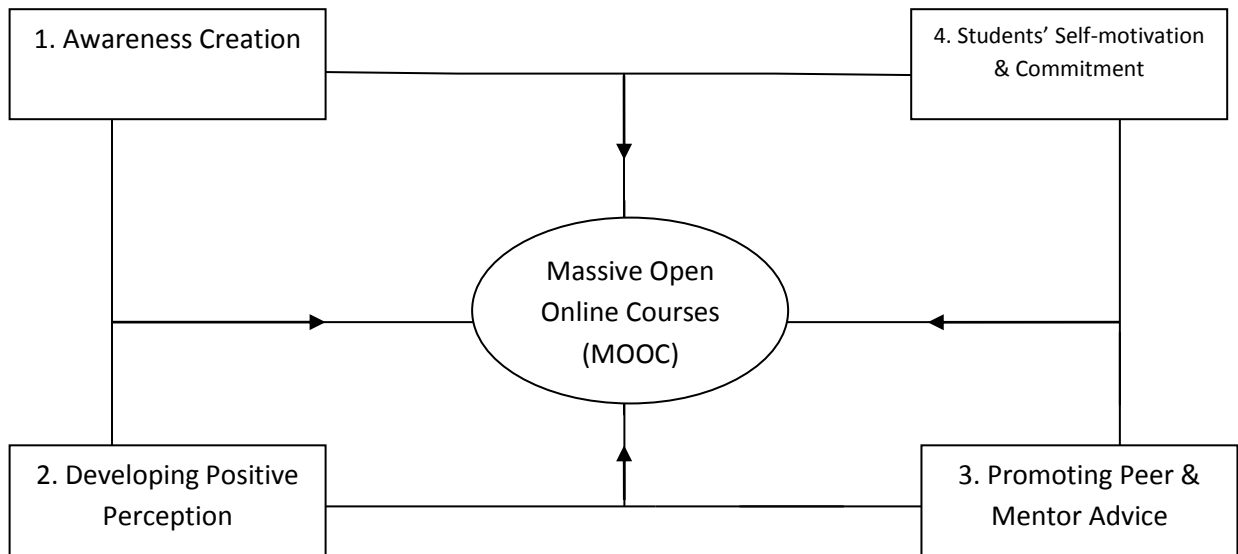
“4.3 Findings from Field Experts of Distance Learning and Online Education”.

In line with the Delphi method of research, in-depth interviews are taken from the field experts in distance learning and online education to learn about the pertinent current practices and issues. Allama Iqbal Open University is the oldest and the biggest varsity in Pakistan in the distance learning. It has branches all across Pakistan to facilitate students with basic insights on their degree programs and educational system. One million students are enrolled in its various programs containing degree, diploma, and specialization certificate courses in various disciplines. The programs range from 10th and 12th grade to PhD programs. The students receive lectures, notes, videos, and other stuff. They can contact the university officials on phone, courier, or email. They submit their assignments when they fall due. The examinations

and other tools of assessment are standardized. Some courses have regular classes option too at select campuses. The experts posited that they remain in touch with the students enrolled in their programs and create a loop to share information. The faculty members keep a track on monitoring the performance of individual students and notify them about their progress and overall evaluation. They endeavor to motivate students to pursue their study goals. Many of them drop out in the middle of the program. “If they do so, we are helpless, but all that we can do is to enhance their internal motivation and self-commitment to fulfill their study-related goals. We assist them in devising strategies for their continuous learning and development. People living in far flung territories of the country are unable to attend big universities and afford their fees cum boarding and lodging costs. Distance learning and online education are the cost effective and quality alternates to help them pursue higher education and advance their careers. Our programs are also suitable for working professionals in public, private, and non-profit sectors. The courses are tailor-made and updated periodically to provide modern learning with contemporary pedagogies.” Regarding MOOC, they opined that it has its own merits and demerits but the main issue is that its drop out ratio is very high. It does not offer the degree programs. The courses are usually non-credit. As the students are submitting assignments and solving exams online, so always there remains some doubt that they can involve some of their colleagues for cheating by the means of seeking their assistance. Virtual University (VU) is the second biggest varsity in Pakistan in the distance learning and indeed online education. It also has branches all across Pakistan. One hundred thousand students are enrolled in it. Their lectures, notes, videos, and other stuff are available online and anyone can freely access that data. They charge fee against a certificate course, diploma, or degree program (ranging from undergraduate to postgraduate level) in various disciplines. The educational model of the VU resembles with that of the Allama Iqbal Open University – the market leader. VU experts claim that their system is far modern and updated than that of the market leader. Regarding MOOC, they have similar opinions (as of the market leader). There is no physical interaction and engagement is weak. At the outset, the universities offering MOOC announced free courses but later on after few years, now many of them charge a mandatory fee to register and pass to earn a certificate. Hence, the purpose of MOOC is undermined. In comparison with the large-scale distance and online education promoting giant universities like Allama Iqbal Open University and Virtual University, some other universities in Pakistan primarily focusing on on-site teaching also have programs of distance education. But, they have relatively small number of enrollments in their programs, and they also face the similar problems. In the matrix of Pakistan, the conventional class room-based teaching and learning are more successful than distance and online education. But the bottom line is that such models in education are the need of the era and there can be a time in future, where these platforms including MOOC may dominate the world of education, since with the advent of the Internet and globalization, planet earth is taking rapid strides in development.

The figure 1 exhibited beneath comprises of some essential variables about MOOC, which are extracted from this qualitative enquiry. The three groups of participants identified various themes regarding MOOC, out of which some essential variables have been emerged. They comprise of: awareness creation (about MOOC), developing positive perception (about its benefits), promoting peer and mentor advice (from their colleagues and teachers), and students’ self-motivation and commitment (about doing such courses), and MOOC.

“Figure 1. Framework of Variables to Nourish MOOC in Under-developed Countries”



“4.4 Results and Discussion”.

When MOOC is compared with traditional on-site education, distance learning, and online learning, it has substantial edges. It is the most modern form of education. It offers quality education and is either free or subsidized, hence it squeezes the education divide among the rich and poor or under-privileged, and is open for all. Thousands of students around the world are enrolled in its individual courses. They are getting state-of-the-art education from world class institutions and universities with the best pedagogies and from the team of specialists. The class timing is flexible and interactive simultaneously. In some cases, even credits are transferred. However, class-room based education has the edge of relatively less drop out ratio. Distance and online education have the edge of a variety of courses and program offerings inclusive of certificate courses to diplomas, and degree programs. Online learning is the modern form of distance learning, whereas the e-learning tools are now applied in on-site education too. By comparing the results of the data obtained from three distinct groups, it is learnt that the students that never did a course on MOOC were not properly familiar about it, in contrast those did such course(s) built its positive image, and were willing to do more such courses in future. The academicians from distance and online education described about their models and discouraged MOOC by highlighting its high dropout ratio. The cumulative results derived from findings indicate that a vast population of youth in Pakistan is not fully familiar with MOOC. Hence, there appears a dire need to develop its positive perception by highlighting its features and benefits. This can be best done by nurturing it via peer and mentor advice, which can lead to students' self-motivation and commitment.

“5. Conclusion”.

In line with the research problem and purpose, it is concluded that the advantages of MOOC are marvelous and countless, as it provides a platform of learning and development to people across the globe for free or charges some fee for a verifiable certificate. There are numerous courses in

a variety of disciplines. State-of-the-art technology is availed for teaching. The course stuff is downloadable. Instructions are given in reader-friendly manner. Step by step guidance is available. Peer network is assured via the messenger service and Facebook groups. The ordinary people from the under-developing countries (like Pakistan) can envisage and dream but (in many cases) never get the opportunity to have world class education in the best universities of the world. The professionals heavily engaged in their work lives usually do not have time for further studies. Their dream can come true with the advent of MOOC. There are courses for tradespeople or technical and vocational education, women education, and adult literacy. A vast population of youth in Pakistan is not fully familiar with MOOC. Hence, there appears a dire need to develop its positive perception by highlighting its features and benefits. In this regard, peer and mentor advice play a pivotal role, which is also helpful in minimizing drop out ratio, which can lead to students' self-motivation and commitment. Whereas, the students that successfully did some course(s) via MOOC seem to be delighted from it. Besides class room-based universities, distance and online universities also consider MOOC as a direct threat to them. The emergence of distance education offered a new and cost-effective substitute to the students with flexibility of timing. The online education offered even better solution, as the course contents were available online. MOOC is the most modern form of it, as these courses attract massive population of thousands of people around the world, which are either free or subsidized. Its demerits include strategy to minimize the student drop out ratio that tends to be very high, since there is no financial binding (in several cases) and no physical interaction that causes a weak engagement of students. The students are provided feedback but word of appreciation by the instructors is missing. When the students are submitting their assignments or giving exams, as no one physically monitors them, so there is a risk of cheating since some of them can seek assistance of their pals. When MOOC evolved, the universities offering MOOC announced free courses but after few years, now many of them charge fee. The option of free education is no more there and one cannot register in such courses. In such a case, the fee to earn a verifiable certificate exceeds US\$ 100 to nearly \$500; hence, the purpose of MOOC remains unserved and jeopardized. The ordinary (Pakistani) students to professionals, executives, and tradespeople, poor to rich, women, and people in remote areas can do courses of their interest via MOOC to upgrade skills, develop expertise by learning advance cum practical concepts. This attainment can offer significant benefit to them in career building domestically and internationally. This will reduce the education divide between the under-privileged to the fortunate ones by studying in world class institutions with the most modern pedagogies.

“5.1. Recommendations”.

Keeping in view the ever-escalating significance of MOOC in the world, this probe intended to discover its various dynamics by comparing it with distance learning and online education platforms; to gain insights about learners' experiences and their inclination about MOOC; and to discover the ways to avail MOOC opportunity for revolutionizing the education system in Pakistan. The key proposals for the policy makers and proponents of MOOC operators and the authorities in education system of Pakistan include: the pedagogies of MOOC should be regularly updated and modernized. To enhance interactive learning, on specific days of a week during the program, there should be options of student-instructor and student-to-student interaction on webcam. To assure personalized teaching, the instructors and their aides should regularly track the performance of the students, pay attention to individual learner's strengths

and weaknesses, appreciate the good performers, and encourage the under-performers. In addition to the free courses, in case of fee for getting a verifiable certificate, the fee needs to be curtailed to US\$100 (ranging from \$25-100), otherwise the purpose of MOOC will be dead and as its name implies 'Open Courses' will be the wrong title. MOOC operators should consider adding a variety of courses in multiple disciplines for all, including access of such courses/education to women, and some specific courses for special people as well. They should offer credit courses and go one step ahead and offer degree programs too. They can do such initiatives by offering scholarships to some deserving students who fulfill some need cum merit based criteria. To foster the awareness and positive perception of the students, peer and mentor advice is a must. There should be MOOC-related groups (general and country or region specific) on social networks that should spread a positive word-of-mouth communication, which will be like viral marketing program. To help the registered students complete their courses via MOOC and to inhibit or reduce their dropout ratio, the instructors and their team need to emphasize on their self-motivation and commitment to themselves. There can be videos in every course about global students sharing their personal experiences (about any course in MOOC), internal goals, determination, satisfaction, and benefits derived by completing such courses. By the time students are attempting to solve their exams, there can be a mandatory requirement for turning on webcam, so that at any time any course team member can check him/her (by applying random sampling technique) to ensure that he/she is not seeking any assistance of a pal to solve the questions. This is a possible preventive measure to discourage cheating. In addition, plagiarism needs to be checked for all the assignments submitted by the learners. In the developing and under-developed countries like Pakistan, the Higher Education Commission (HEC) Pakistan should publicly recognize MOOC in terms of the features of providing free, modern, and standardized education to the world to eradicate the education divide. HEC must appreciate its role in knowledge gain, cultural integration of the global online community, and the benefits of these courses in skills and expertise development, which provide an edge in the job market.

“5.2 Delimitation and Areas of Further Study”.

The delimitations of the study include: the pertinent themes and variables are ascertained here through a qualitative enquiry with a limited number of samples and techniques. However, selected factors have been identified to develop a scale later on, so that they can be empirically tested via a quantitative enquiry for their generalization and validation. They include: quality of education, cost effectiveness (for learners), flexibility in timing, interaction with peers and instructors, personalized feedback, certificate courses to degree programs, number of enrollments, and students drop out ratio, which will be measured in the matrix of traditional onsite education to distance education, online education, and MOOC.

References

- [1] A.D. Ho, J. Reich, S.O. Nesterko, D.T. Seaton, T. Mullaney, J. Waldo, and I. Chuang, “HarvardX and MITx: The first year of open online courses, fall 2012-summer 2013”, HarvardX and MITx, Working Paper No. 1, Boston, 2014, pp. 1-33.
- [2] L. Yuan, and S. Powell, “MOOCs and disruptive innovation: Implications for higher education”, eLearning Papers, 33(2), e-learning Europa, Barcelona, 2013, pp. 1-8.
- [3] C.A. Annabi, and M. Muller, “Learning from the Adoption of MOOCs in Two International Branch Campuses in the UAE”, Journal of Studies in International Education, SAGE Journals, UK, 2015.

- [4] M. Noer, "One man, one computer, 10 million students: How Khan Academy is reinventing education", *Forbes*, USA, 2012, pp. 1-8.
- [5] C. Thompson, "How Khan Academy is changing the rules of education?", *Wired Magazine*, 126, UK, 2011, pp. 1-6.
- [6] S. Jaggars, and T.R. Bailey, "Effectiveness of fully online courses for college students: Response to a Department of Education meta-analysis", Columbia University, New York, 2010, pp. 1-16.
- [7] M. Bali, "MOOC pedagogy: gleaning good practice from existing MOOCs", *Journal of Online Learning and Teaching*, 10(1), MERLOT, Cairo, 2014, pp. 44-56.
- [8] R. Wellen, "Open access, mega-journals, and MOOCs", *SAGE Open*, 3(4), UK, 2013, pp. 1-16.
- [9] F.G. Martin, "Will massive open online courses change how we teach?", *Communications of the ACM*, 55(8), ACM.org, USA, 2012, pp. 26-28.
- [10] H.C. Davis, K. Dickens, U.M. Leon, S. Vera, M. del Mar, and S. White, "MOOCs for Universities and Learners an analysis of motivating factors", University of South Hampton, UK, 2014, pp. 1-12.
- [11] N. Dominguez-Flores, and L. Wang, "Online learning communities: Enhancing undergraduate students' acquisition of information skills", *The Journal of Academic Librarianship*, 37(6), Science Direct, Elsevier, Philadelphia, 2011, pp. 495-503.
- [12] B. Means, Y. Toyama, R. Murphy, M. Bakia, and K. Jones, "Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies", US Department of Education, USA, 2009, pp. 1-93.
- [13] R.A. Croxton, "The role of interactivity in student satisfaction and persistence in online learning", *Journal of Online Learning and Teaching*, 10(2), MERLOT, California State University, USA, 2014, pp. 314-325.
- [14] P.A. Kurzman, "The evolution of distance learning and online education", *Journal of Teaching in Social Work*, 33(4-5), Taylor & Francis, UK, 2013, pp. 331-338.
- [15] D.G. Glance, M. Forsey, and M. Riley, "The pedagogical foundations of massive open online courses", *First Monday*, 18(5), University of Illinois, Chicago, 2013.
- [16] S. Baglione, "Online Classes: An Evaluation by Traditional-Aged Students", *Advances in Business Research*, 4(1), University of Arkansas – Fort Smith, USA, 2013, pp. 68-76.
- [17] A. Margaryan, M. Bianco, and A. Littlejohn, "Instructional quality of massive open online courses (MOOCs)", *Computers & Education*, 80, Elsevier, Philadelphia, 2015, pp. 77-83.
- [18] O. Rodriguez, "The concept of openness behind c and x-MOOCs (Massive Open Online Courses)", *Open Praxis*, 5(1), International Council for Open and Distance Education, Madrid, 2013, pp. 67-73.
- [19] K.M. Alraimi, H. Zo, and A.P. Ciganek, "Understanding the MOOCs continuance: The role of openness and reputation", *Computers & Education*, 80, Elsevier, Philadelphia, 2015, pp. 28-38.
- [20] G. Boyd and N. Kasraie, "Can MOOC fires bring light to shadow education?", *International Journal of Learning and Development*, 3(4), Macrothink Institute, USA, 2013, pp. 87-95.
- [21] L. Abeysekera, and P. Dawson, "Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research", *Higher Education Research & Development*, 34(1), Taylor & Francis, UK, 2015, pp. 1-14.
- [22] T.R. Liyanagunawardena, A.A. Adams, and S.A. Williams, "MOOCs: A systematic study of the published literature 2008-2012", *The International Review of Research in Open and Distributed Learning*, 14(3), Athabasca University, Canada, 2013, pp. 202-227.
- [23] T. Liyanagunawardena, S. Williams, and A. Adams, "The impact and reach of MOOCs: a Developing countries' perspective", *eLearning Papers*, 33(1), e-learning Europa, Barcelona, 2013, pp. 1-8.
- [24] M.N. Saunders, *Research methods for business students*, 5/e, Pearson Education, India, 2011.
- [25] C. Okoli and S.D. Pawlowski, "The Delphi method as a research tool: an example, design considerations and applications", *Information & Management*, 42(1), Elsevier, 2004, pp. 15-29.
- [26] W. Zikmund, B. Babin, J. Carr, and M. Griffin, *Business research methods*, Cengage Learning, Boston, 2012.

The CLIX Open Story Tool: Reflections on Design

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Abstract

This paper argues for the use of technological interventions to supplement traditional language learning modes that democratize the process of education and make learners appropriate learning tools to become producers of content in the process of acquiring language skills. It draws its argument from the CLIX Open Story Tool, developed by the Connected Learning Initiative (a collaboration between TISS, Mumbai; MIT, USA; and Tata Trusts, India), which enables students to focus on Task-Based Language Learning (TBLL) within the framework of Computer Assisted Language Learning (CALL) design for Second Language Acquisition (SLA).

Based on Constructionist paradigms of learning, the Open Story Tool allows students to create individualized narrative stories in the form of a slideshow-movie by incorporating images, generating captions and recording audio for each image that showcases their accomplishment of the assigned task. It also enables them to edit, reorder or delete slides, based on specific task prompts, thereby facilitating a variety of language use skills such as organization and summarization of ideas. Further, the tool permits use in either single user activities facilitating reflection or a pair or small group activities encouraging dialogic collaboration.

This paper, therefore, articulates the value of the Open Story Tool designed to support, simultaneously, open ended production by learners and invigorate close ended tasks as a pedagogical aid to language acquisition and reflection-based learning.

Keywords: Story, CALL, Open Story, Constructionism, TBLL, Tool Design, SLA.

The Conventional Classroom Mindset

The typical learning model followed around the world involves a unidirectional lecture from the teacher, the passive reading of the textbook and the mechanical-rote filling up of notebooks by students. This system denies students autonomy and variations in the learning processes and offers limited scope for reflective engagement with the language, which is a key aspect of language use. The drill method, introduced in the 1950s, continues to be used in Indian classrooms to teach language, as one memorizes grammar concepts such as conjugation of a verb or the formation structure of an adjective from a noun. The focus on practice is one reason why courses and books espousing the audio-lingual method of drill-based learning are popular even today.

However, a plethora of studies beginning with Noam Chomsky's 'Review of B.F. Skinner's *Verbal Behaviour*' [3] have proved that language acquisition is a dynamic, engaging process that involves para-language skills in addition to various sub-skills of Reading, Writing, Listening and Speaking (RWLS) that cannot be encapsulated in a narrow focus method of Receive, Recall and Reproduce.

Locating Task Based Language Learning (TBLL) in Second Language Acquisition (SLA)

In countries where students have to acquire second or third languages in a formal set-up, this receive and reproduce model is even more disconcerting since the first language (L1) structures often vary from the second language (L2) ones and there is no allowance for errors, even the 'developmental' ones [4], in the conventional classroom. Studies have established the need for better learning methodologies such as the task-based approach [9] that believes in engaging the students' faculties to complete a given task and in creating an environment of incidental learning, in the process.

Prabhu, in his Bangalore Project, proved that language learning can be facilitated by making students focus on achieving an end goal, a task that has been designed to draw out the students' inherent linguistic abilities. Ellis [6] defines a task as one which has pragmatic value that necessarily possesses a 'gap' that the students need to fill in using linguistic resources and that has an end result independent of linguistic outcomes.

This approach aligns with the Constructionist theory of learning [7] in which students acquire subject concepts as results of completing an authentic task that engages their cognitive problem solving faculties, enables them to reflect, and allows them to review their solutions or ideas in different contexts. Papert and Prabhu argue for the need to support the students in their endeavors to make them confident in attempting the task.

Computer Assisted Language Learning (CALL) in the Blended Approach

Papert went on to work on the famous *One Laptop per Child* initiative begun in 2005 propagating the use of technology to inculcate the practice of project-based learning in the classroom. A few proponents of SLA have embraced the method of digital technology

facilitating language learning. This theory has gained ground as the digital revolution has paved the way to 'level the playing field' and allow the privileged and the underprivileged access to the same kind of resources required for learning.

However, proponents also understand the need for human interaction since language use is primarily a social act of establishing and maintaining relationships, and values such as tolerance for others' viewpoints, helpfulness in aiding others, sharing ideas, and negotiating for mutually beneficial outcomes are some of the foci of communication. These aspects are better learned in the course of face-to-face (F2F) interactions. A combination of CALL and F2F learning environments lead to an enriching experience for students accessing the best of both modes of learning in the blended approach model of education. This approach is currently gaining ground around the world.

The CLIX Open Story Tool

The CLIX Open Story Tool is a digital aid to facilitate a computer-aided peer-learning environment using a task-based approach. It is a tool developed for the Connected Learning Initiative (CLIX), a collaborative effort by Tata Trusts (India), Massachusetts Institute of Technology (MA, USA), and Tata Institute of Social Sciences (India) to bring opportunities to students in the underserved regions of India using digital interventions and promoting Teacher Professional Development. The CLIX English team has identified production oriented activities as enablers of language production and assimilation that also act as scaffolds allowing students to produce content, based on their interests, at their individual levels of proficiency.

This tool is a creative/generative one with several variants in its design. This application lets students create and modify slideshows with images, captions, and audio. It is simpler and more focused than other presentation and movie-making software, despite its open-ended and flexible structure. The format of discrete slides each with its own sound byte and caption allows students to break their language production into bite-sized chunks that feel more accessible. At the same time, students who become very involved in their projects can tell longer-form stories and present in-depth ideas if they wish. Telling these stories requires students to use all four language modalities - reading, writing, listening, and speaking - and gives them the chance to produce language and express themselves in a creative way.

The Tool Design

The tool is a browser-based, locally hosted application. This is a necessity in the Indian government schooling system wherein internet connectivity is intermittent at best and non-existent in general.

The tool excites student imagination by allowing a variety of media production or selection sub-tasks. There are a variety of ways to add media. The students can upload a picture from a gallery or take one using a webcam. They can also upload an audio file or record their thoughts. Students can further explain their thoughts using text as each slide allows for captioning. The main interfaces used to create and edit slides are shown in figures 1 and 2.

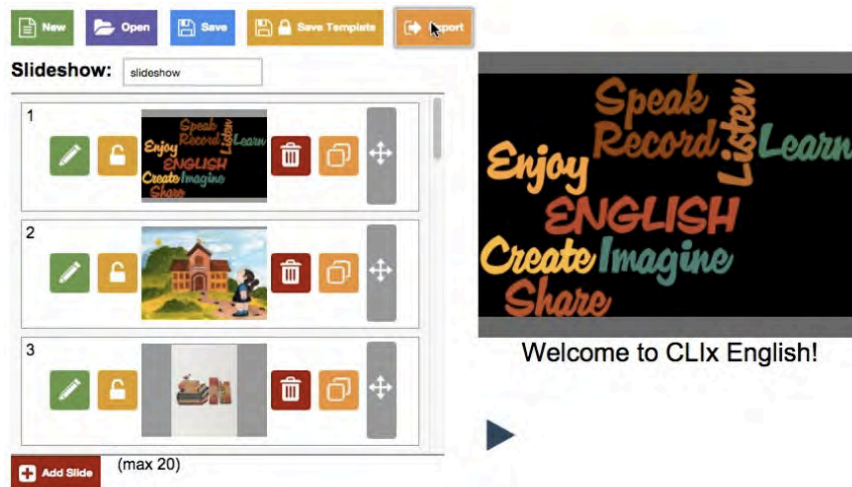


Figure 1. The Open Story slide management interface.

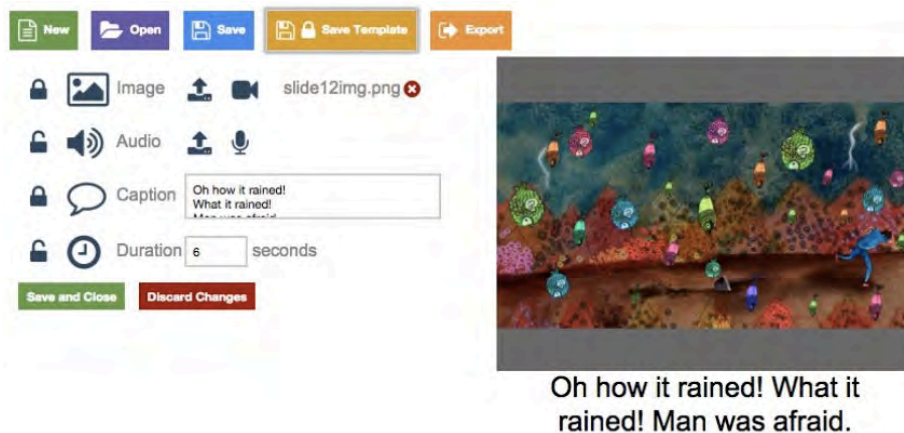


Figure 2. The Open Story slide editing interface.

The projects completed by the students are stored for later analysis by self, peers and/or experts to evaluate the students on various criteria such as novelty of an idea, the presentation style, the organization of thoughts, and the use of language.

Curriculum designers can also scaffold the experience by creating a slideshow template where certain fields are locked while others are meant to be filled in by students. This is one way to focus the activity on a specific skill while still letting each student group have a unique final product. Variants in this tool comprise slides with captions that act as hints towards a preconceived story, slides without captions that allow flexibility (and thereby openness) to generate any form of a tale, delete options from a set of slides that can be used to sharpen an existing story, and open ended tales that permit the option of creating multiple endings. Students,

in the process, are encouraged to turn creators, make their own stories and allow imaginative creativity to guide their engagement with language learning.

Open Story focuses on open-ended production. With a marked absence of ‘correct’ answers, this tool offers space to celebrate the innate talents and potential for self-expression in every child. Listening to other students’ stories within a collaborative learning environment is intended to foster tolerance and peer-learning without the learner being under the pressure to perform or reach an expected, pre-determined goal within a binding timeframe. Audio recording of stories provides additional opportunities for students to build self-confidence and take pride in their acts of production. This tool also holds potential to hone editing and narrative skills through tasks that require students to delete or choose from a given number of slides to generate a coherent presentation of ideas. Language learning goals include writing and speaking practice as well as critical thinking.

The Pedagogy

The CLIX English course is designed to cater to students with varying levels of language proficiency. The Open Story tool can be used to generate a variety of tasks that would allow for different experiences to be articulated and thus lends a voice to the ‘marginalized’. Furthermore, the tasks can be designed with more or less detailed scaffolding tailored to suit the students so that they may be able to complete the tasks in a given lesson. Tasks such as reading the given captions aloud and recording themselves would enable them to practice speaking skills with a focus on pronunciation, intonation, and the rate of speech. Since the tool incorporates editing features, the students would be able to hear themselves and re-record, if they wish to. This would inculcate the practice of self-reflection and self-correction in a non-threatening environment. These are values that CLIX ascribes to as well as ideal life skills to possess and develop.

Similarly, tasks that ask students to type the captions for a series of given slides would focus on vocabulary choice and sentence construction skills. A higher order task would engage the students by asking them to either ‘gap fill’ the given slides, provide an alternate ending or improvise the beginning of a given narrative. This task type would focus on the use of cohesive devices such as sequencing of ideas and using transitions to establish connections while also challenging the students’ imaginative capacities to build on an existing database. Tasks focusing on open-ended production, including creating images and uploading them on the slides, entering captions and recording audio clips for the slides, maximize student autonomy and self-expression. The CLIX English curriculum is designed to generate many such opportunities for the students to engage in articulating their ideas.

This tool is designed to primarily enable the 8th to 11th grade students of both English medium and the vernacular medium government schools to discover ways to express themselves using multimedia. To test the efficacy of the tool, trials were conducted in the CLIX selected states of Mizoram, Telangana and Chhattisgarh and Rajasthan with 9th graders. However, this paper refers to the gleanings the team derived from the extensive trials conducted in government run schools in Navi Mumbai, Maharashtra with students of the 7th grade in Marathi medium

schools. This was done to test if the tool could cater to a younger and perhaps less proficient group than the primary target users of the CLIX English course.

The Tool's Features

Image

The Open Story tool allows users to select images from a gallery given within the application or housed in the computer's local drive. The former allows the curriculum designer to restrict the images available for selection and elicit student creativity triggered by a resource crunch. This supports activities such as theme-based essay or story-creation, sequencing activities, selection from the data bank to identify if the said images can be used or should be discarded, awareness of multiple possibilities with limited options, and so on. These tasks encourage the assimilation of skills need to summarize, sequence or categorize ideas.

In one of the local field trials, students were given a story that had been created by the team and asked to delete slides that were redundant. The discussions between the pair of students at each terminal was precisely the aim of the activity as the students argued and negotiated with each other over the slides to be eliminated and the reasons for the same. Since the story had captions in English, the students used English terms even if a few of them resorted to their L1 in the excitement to articulate their points. The inherent focus on the use of words in the captions, the recognition of redundant repetitions, the need for transitions and the attempt to persuade the other to one's point of view combine bottom-up and top-down language sub-skills [2]. These requisite language skills were further enhanced when the students engaged in comparing one pair's rendition to the other pair's, since the ensuing discussion focused on the principles of composition and allowed them to discover, autonomously what traditional classrooms would have dictated as golden rules to be followed in a categorical manner.

The *Upload Image* functionality of the tool allows students to even create their own art projects and weave a narrative around these projects. This tool can even be used in a Science or a Mathematics class as an activity wherein students upload images of their experiments or their mathematical workings and present an argument or a procedure description and share these with their contemporaries. This makes the tool a wonderful application that focuses on articulation of thought in any domain rather than limit to one field. The CLIX project hopes to bring about an awareness of the common pathway of learning that all domains ultimately lead to in their own manner and pace.

Field testing has led to insights about language learning mechanisms not anticipated in the design of the tool. For instance, the picture bank stored in the gallery from which students were expected to upload images had names encoded in English and this facilitated a vocabulary expansion as students who had not prior known what a 'hyena' was, picked it up by noticing that the image of the hyena was self-titled thus. The tool, in this manner, facilitated vocabulary comprehension much as a pictorial glossary would do. This feature also acted as scaffolding for children with poor spelling skills and those who did not know what they could compose referred to the set of images of a category and created a narrative that was more a presentation of classification. The discussions generated therein such as whether a particular image belonged to

the category selected was also a language generative activity, and more importantly, it involved a higher-order reflection capacity building process.

Audio

The audio component of this tool has been found to be a favorite among students in every field trial conducted. The students, irrespective of their proficiency levels, find that they love listening to themselves articulating their thoughts and the facility that this tool provides to listen and re-record oneself allows them the safe space to ‘fail’ since they are able to correct themselves before others listen to their production. This is particularly important in the age group (13-16 year olds) that the CLIX project aims to cater to whose adolescent stage makes them particularly sensitive to feedback. Whether they are recording a provided caption or composing their own narration, the motivation to perfect their recording also results in a greater amount of speaking aloud than students would otherwise be engaged in.

The Open Story tool also allows students to upload existing audio clips from the music gallery or a similar file stored in the computer. This would allow students to explore oral narratives or sounds outside their classroom and bring these into their production, if they so desire. A task such as matching sounds of local fauna to the images they might draw or capture using a camera would enable them to share local knowledge at a global level in the event that these student creations can be shared online at a later stage.

The field trials also led to a design tweak as the time limit of 20 seconds per slide was found to be restrictive since each pair of students shared a mike they had to lean into and the shy ones also paused a lot before they spoke. It was decided through a series of experimentations and discussions that 40 seconds would give the pair ample time to record themselves and yet challenge them to complete articulating their thought or to divide their idea across two or more slides.

This feature further embraces the pedagogy of multilingualism, a desirable component of SLA as argued by Agnihotri [1] and enshrined in the Indian National Curriculum Framework (NCF) [8]. The students can encode their ideas in their own language(s) or use a combination of the target language (TL) along with their mother tongue (MT). This would encourage students not yet comfortable speaking entirely in English (or any TL) to nevertheless engage with and produce some content in the language they wish to acquire.

Text

The caption feature is also similar to the audio feature in that it restricts students to 140 characters per slide. Currently, most students with lower proficiency levels do not engage much in typing out their thoughts or restrict themselves to short phrases that explain the image. They are intimidated by having to spell at times. This has led to an idea for a future design feature of spell check to be built into the tool.

Furthermore, providing students a fairly acceptable length of captions per slide will enable students to draft their ideas in sentences enhancing their semantic abilities.

The character limitation further challenges proficient students to be succinct in articulating their ideas and leads to innovations in expressing themselves or in segregating their ideas into sub-points that could be presented in multiple slides.

Just as the audio recording feature accommodates multilingualism, so does this feature accept captions in any language codified in the Roman script. Indeed, in the field trials, students, without any prompting, used L1 vocabulary, in this case Hindi, in sentences constructed using the English grammar. One such example is “A *charmender* [*sic* the Hindi word for dinosaur] eat the mega stone and the *charmender* was very power(ful)”. This feature could be expanded to allow for indic typing in future iterations of the tool’s design.

Opportunities for Collaboration

In addition to the goals of fostering creativity and language production, the Open Story tool also presents a useful venue for student collaboration in a couple of key ways. Due to the ground realities of using technology in schools, students typically work in pairs (at minimum) on one computer. One of the reasons for designing Open Story and integrating it into the CLIX English curriculum is that it utilizes this student-computer ratio as an affordance. Students working together on a slideshow must discuss what story to tell, what images to use, and what the text should be. While some of this happens in their L1, they necessarily bring in vocabulary and concepts from the target language as well. Then, when they are ready to record their audio narration, the speaker has a built-in feedback mechanism in the form of a partner who is equally invested in making the slideshow and getting the language right. In this way, working in pairs enables students to reflect on their work in new ways while also providing an authentic task for communicative language practice.

In addition to the synchronous collaboration described above, Open Story also enables asynchronous collaboration in the form of remixing other users’ stories. The tool lets users export their slideshows in a format that can later be imported and continue to be worked on. These saved files can be shared via flash drives or simply by students swapping computers, if there is no school server or connectivity. Students can then add onto others’ stories, change the endings, fix any language mistakes they may find, and then re-share with other classmates. This type of remixing is now common in many creative internet communities and has been seen to foster deep learning, so it was important to enable that collaborative experience for CLIX students as well.

Assessment Tools

The tool design promotes self-reflection and self-review as the students can read what they have written, listen to their recordings or chosen clips and review the images uploaded when they play the slide they are working on or play the entire slideshow to preview their creation. If they notice areas they could improve upon, they can re-type or re-record as needed to create a piece that they can proudly share with their peers. The need to incubate the ‘growth mindset’ [5] and promote resilience by enabling students to use an ‘incremental’ approach in problem solving [10] guides the CLIX philosophy.

Peer dialogue is a core value in this initiative and students can share what they produce using this tool with their peers who would provide feedback that could guide the students in their next project. Since this exercise would be a reciprocative task the students would be naturally motivated to give constructive feedback.

The CLix English course would also periodically provide students with rubrics designed for specific tasks to help them recognize and provide insights on the core features necessary for the successful completion of a task. The students would, in the process of completing the assessment task, be able to discern by themselves the linguistic and structural elements that comprise a good media presentation of thought.

The Open Appeal: Future Directions

The Open Story tool is still in the early stages of development and user testing, and the team looks forward to improving the features and implementation in future iterations. Based on the underlying pedagogy as well as feedback that will continue to be gathered from students and teachers, these are some of the key directions the project is hoped to take:

- **Language scaffolding:** When children worked in pairs, they often came up with the idea they wanted to convey in Hindi and then set about translating it into English. Then they often asked the facilitators (CLix staff for the early user tests) for help with this challenge. In a school setting, even a teacher or facilitator may struggle with how to convey certain ideas in English, and the goal of the course is to empower students to produce language, even if it is not grammatically correct. For these reasons, additional scaffolds that help students feel confident expressing their ideas in English could be useful. These could take the form of tools within Open Story, or resources provided outside of the software, and may target vocabulary and grammar, or even simply provide encouragement.
- **Teacher training:** One of the unique challenges of the CLix curriculum is to create a classroom culture where collaboration and creativity are expected and encouraged. This will go a long way toward supporting students' use of Open Story in interesting and personalized ways, in turn leading to deeper learning of the language. Teacher professional development (TPD) is a venue in which these aspects of the tool can be emphasized and the teachers can be prepared with strategies to support students in both language acquisition and confidence. One key aspect of this tool that teachers will need to embrace is allowing students to pace themselves and to encourage the students to allow their imagination full reign. Another aspect that the TPD will have to focus on is the enhancement of the teachers' own creativity using images and sound and the use of technology. An introduction to visual arts appreciation, the relationship of image to text, the use of sound to create atmosphere and so on would need to be included in TPD to enable the teachers to both instruct their students to use the tool better and evaluate the student projects. Furthermore, this would enable teachers to appropriate the tool and design activities to facilitate understanding and use of content knowledge. Therefore, the

TPD experience is an important piece to be designed as a companion to the Open Story tool itself.

- **Assessment:** Since Open Story projects are open-ended, creative endeavors, these learning experiences cannot rely on traditional methods of assessment. As discussed above, self and peer-review are key components that can be incorporated into these activities to prompt reflection and even monitor growth. As students adopt these methods and the processes involved, including mentality shifts required in the classroom, will need to be studied to be better able to formalize these assessment methods and understand better the students' strengths and weaknesses.
- **Features and usability:** Some of the ways to build in scaffolds and assessments may involve building new features into the software itself. In addition, as more students use the tool, additional feature ideas will emerge that can support language production and learning in new ways. Usability is another area of the tool that has not been polished and needs some refining. For these reasons, feature work will continue to be important in the development of Open Story.

While these are the main areas of work for the Open Story tool and its implementation, the most important feature for the success of the tool is really the interplay of all these aspects. For any educational technology tool to have a significant impact, the pedagogy, implementation, assessment, and the tool itself must all support each other. Looking at all of these aspects as part of Open Story itself and considering them together will help the tool gain traction and adoption in the CLIX community.

References

- [1] Agnihotri, Rama Kant. "Multilinguality and the Teaching of English in India." *ERL Journal* 1 (2010): p.1.
- [2] Celce-Murcia, Marianne, and Elite Olshtain. *Discourse and Context in Language Teaching: A Guide for Language Teachers*. Cambridge University Press, 2000.
- [3] Chomsky, Noam, "A Review of B.F. Skinner's *Verbal Behaviour*", *Language* 35, No.1, 1959, pp.26-58
- [4] Corder, Stephen Pitt, and Stephen Pit Corder. *Error Analysis and Interlanguage*. Vol. 112. Oxford: Oxford University Press, 1981.
- [5] Dweck, Carol S., and Allison Master. "Self-theories motivate self-regulated learning." *Motivation and self-regulated learning: Theory, research, and applications*, 2008, pp.31-51.
- [6] Ellis, Rod. *Task-based language learning and teaching*. Oxford University Press, 2003.
- [7] Harel, Idit Ed, and Seymour Ed Papert. *Constructionism*. Ablex Publishing, 1991.
- [8] National Council of Educational Research and Training (2005). National Curriculum Framework. New Delhi. Retrieved from <http://www.ncert.nic.in/rightside/links/pdf/framework/english/nf2005.pdf>
- [9] Prabhu, N.S.. *Second language pedagogy*. Vol. 20. Oxford: Oxford University Press, 1987.
- [10] Yeager, David Scott, and Carol S. Dweck. "Mindsets that promote resilience: When students believe that personal characteristics can be developed." *Educational Psychologist* 47.4, 2012, pp.302-314.

A Self-Determination Theory Approach to Predict Elearners' Intrinsic Motivation and Engagement: An Asian Perspective

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Abstract

Due to continuous advancement in technology, elearning has evolved as a dependable way to provide education to masses particularly to those who lack access to conventional education. Considering the inherent advantages, governments all over the world are allocating substantial budget to elearning for human development. On the other hand, elearners' motivation poses a challenge to all stakeholders. Students' motivation may offset all the efforts if not addressed properly. This study examined elearners' motivation with the help of Self-determination Theory. Through questionnaire survey a sample of 116 subjects were collected which confirmed the parsimonious nature of Self-determination Theory in predicting intrinsic motivation which further helped to explain elearners' engagement. Discussion and implications of the study are presented based on results.

Keywords: Self-determination Theory, Subjective Norm, Self-Efficacy, Autonomy, Intrinsic Motivation, Elearner Engagement

1. Introduction

E-learning has emerged as the most powerful way to inculcate knowledge to diversified segments of society being advantageous in terms of cost and efficiency (Rosenberg,

2000; Wild, Griggs & Downing, 2002). Educational institutes and corporate organizations have incorporated e-learning tools and techniques to enhance the competencies of their respective clientele (Rosenberg, 2000). An online learning environment implies the application of Internet for teaching and learning to disadvantageous persons due to distance, time, culture etc (Dempsey & Van Eck, 2002, p. 283). E-learning has largely facilitated struggling segments of society who cannot continue education due to different bondages (Riaz, Riaz&Hussain 2011). Realizing the key benefits, governments across the world are allocating substantial portion of budget to implement and upgrade e-learning systems and equipment. In addition to efforts at government level, IT and telecommunication companies are also endeavoring to develop user friendly equipments and to establish virtual environment close to reality. Instructors and teachers are also striving to improve their skills according to the teaching demands in online mode (Hansen, 2003). Despite categorical efforts from various stakeholders, all the efforts may go futile if e-learner lack motivation and proper engagement with digital and academic resources (Cross, Cross & Dublin, 2002). All the efforts may go in vain if e-learners are not motivated or interested in using the system and to grab the true spirit of educational resources. Students' motivation is treated as a key predecessor towards learning (Lim, 2004). Empirical evidences validated the influence of motivation to enhanceretention (Lepper & Cordova, 1992) and course satisfaction (Fujita-Starck & Thompson, 1994). This prompted the need to determine the antecedents of e-learners' motivation and engagement from a developing country which has recently experienced a shift from conventional educational system to elearning and hybrid system.

2. Literature Review

Literature shows an influential role of Self-determination Theory in examining individuals' motivation in various domains. Self-determination theory specifically highlights the factors which may stimulate intrinsic motivation. Previously, it provided foundation to examine factors affecting motivation in various settings. For example in social environment, motivation towards psychological need satisfaction (Ferrand, Martinent & Durmaz, 2014), IT adoption behavior (Koo & Chung, 2014), maintenance of tobacco abstinence (Williams et al., 2011), Well-being and physical activity (Gunnell, Crocker, Mack, Wilson & Zumbo, 2014), exercise for overweight women (Hsu, Buckworth, Focht, O'Connell, 2013) have been evaluated using Self-determination Theory. Marketing literature validated the implication of Self-determination Theory to investigate motivation towards retailing through self-service technologies (Leung & Matanda, 2013), consumer behavioral change (Webb, Soutar, Mazzarol, & Saldaris, 2013) and sustainable food choices (Schösler, de Boer & Boersema, 2014). Specifically considering the learning environment, SDT helped to analyze motivation towards creative writing (Enko, 2014), self-regulated learning (Bilde, Vansteenkiste, & Lens, 2011), school achievement (Taylor et al., 2014) and job search after education (Welters, Mitchell, & Muysken, 2014).

Self-determination theory (SDT) highlighted two of the motivational concepts i.e. intrinsic motivation and extrinsic motivation. Intrinsic motivation explicates a drive without any external influence. Intrinsically motivated behaviors are performed due to the inherent enjoyment and satisfaction coming out of it. Intrinsically motivated learners

are engaged in the activities because of their interest rather for the sake of any reward (Deci & Ryan, 1985). At contrast, extrinsic motivation is instrumental in nature and commonly stimulates a person to engage in any activity or behavior for the sake of reward or avoid punishment (Deci & Ryan, 1985).

From the last several years, researches have shown the utility of intrinsic motivation in different domain as compared to extrinsic motivation.

Self-determination theory (SDT) further posits that three factors are the key determinants of intrinsic motivation. These factors include need for autonomy, competence, and relatedness which if satisfied can motivate individuals towards specific behavior and performance.

The need for competence implies individuals' efficacious capacity in performing the behavior. It shows the capacity to achieve external and internal outcomes. The need for autonomy implies the self-organize and self-initiating attribute of person. Individuals high with autonomy are self-directed without any coercion or compulsion. The need for relatedness implies individual's tendency to be associated with important people in his circle. People high on relatedness need wish to have strong and satisfying connections with important persons.

Self-determination theory provided the basic underpinning to this study. In the virtual environment, SDT explicates the need for relatedness, autonomy and competence for e-learner to effectively motivate him or her towards learning in online environment. Additionally, when these needs are satisfied it would further help to engage e-learners in various modern educational activities.

For this study, subjective norm as a construct was used to measure relatedness which implies that important people for elearner wants him to perform or not to person the behavior (Fishbein & Ajzen 1975, p. 302). Competence for e-learner was represented by self-efficacy which broadly refers to one's evaluation about the ability to use a technology for the disposal of assignment or task. Particularly in virtual educational setting, it is a sense of personal ability to successfully using e-learning as a way to acquire knowledge and education (Venkatesh et al., 2003). Autonomy for this study implies the individuals' volitional perception where he can initiate, execute and organize his actions and behavior without any bondage (Ryan & Connell, 1989; Deci & Ryan, 2000).

E-learner's motivation is intrinsic in nature which explicates the inherent enjoyment and satisfaction out of performing the behavior like learning in online mode (Sheldon & Elliot's (1998) whereas e-learner's engagement was defined as an absorbent state whereby student find himself fully involved and extremely engrossed in learning activities. It is a state of learning when time passes rapidly and student finds it hard to leave learning session (Csikszentmihalyi, 1990).

3. Methodology

3.1 Purpose of the Study

The variables of the study are based on the basic underpinning of self-determination theory. Students in collectivist societies may be engaged in education (even at higher level) due to pressure imposed by parents or to secure employment for living. At

contrast, this study was attempted to know the factors causing intrinsic motivation. In particular students fully immersed in studies and enjoy during academic process. Therefore the measures were figured out which could best describe the extent of intrinsic motivation and key factors in this way which were similar to factors prescribed in SDT model (close to SDT but not actual SDT measures). The results of the survey could help to explain the extent of motivation and the role of predictors in explaining intrinsic motivation. Previously, nearly similar models have been applied in different settings (Ho, 2010; Roca & Gagné 2008; Sørenbø et al. 2009).

3.2 Subjects

Elearning in developing world is at emerging stage. There exist very few universities in Pakistan which are thoroughly based on elearning. Most of universities have established elearning mode of education parallel to conventional system. AllamaIqbal Open University (a distance university in Pakistan) enjoys a large student base and a considerable number pursuing education through elearning. During the research process, students enrolled in online mode of education were limited and majority belonged to disciplines which assumingly couldn't understand the spirit of items set. In view of field study constraints, all existing students enrolled in various semesters of the university constituted the best option to solicit response.

3.3 Procedure

Students email was obtained from the programme coordinators and questionnaires were forwarded through email. Students were briefed about the significance of the study and the confidentiality measures taken in this regard. Email addresses made it easy to forward the questionnaire to nearly all the elements falling under respondent criteria. Initially response rate was quite low. Through consistent follow-ups, ultimately a response of 116 subjects was received back which was analyzed using SPSS 15.0 and AMOS 20.

3.4 Measures

Nearly all the measures were taken from previous tested studies. However some modifications were made in view of the elearning context of the study. The construct of autonomy was measured with the help of six items from the study of Standage, Duda and Ntoumanis (2005). Subjective norm was measured with the help of two items from the study of Davis et al. (1989) and later used by Ajzen (1991). Self-efficacy was also measured with two items adopted from the study of Venkatesh et al. (2003). To measure intrinsic motivation, four items were adopted from the study of Standage, Duda and Ntoumanis (2005). The prescribed measures were earlier validated by many authors (Goudas et al., 1994; Ntoumanis, 2001; Vallerand et al., 1992).

For student engagement six items were taken from the study of Schaufeli, Salanova, GonzAlez-Roma and Bakker, (2002). Considering the operationalization needed in this study, only absorption related measures were adopted. All the items were measured on five point likert scale ranging from 1. Strongly Disagree to 5. Strongly Agree.'

4. Analysis and Results

Demographical results of the subjects show that 32% of the respondents belonged to less than 25 years of age. Since most of the programmes were for graduating and graduated students therefore relatively young respondents had more representation. Respondents between the ages 26-35 dominated with the representation (41%). They might be the mid-career individuals studying to enhance their competencies. Above 36 years of age were 27% apprx. Since distance learning and particularly elearning is conceived for disadvantage persons therefore, the results showed a diverse representation from elearners belonged to different age categories. This fact was also reflected from the gender category where 36% of respondents were females as compared to 64%. Pakistan is a male dominated society and females are barely allowed to get higher education especially in the remote areas. Since elearning provided ease to continue education from any place. This might helped to get a sufficient number of females on board.

Students belonged to different semesters. The enrollment is normally high during the first semesters which decline at later stage therefore; we had 41% representation from the 1st semester, 29% from second, 16% from third and 13% from the fourth semester. Precisely, responses reflected the attitude and perception of diverse groups in terms of years spend with elearning mode of education.

Descriptive results (Table-1) revealed relatively positive opinion of respondents about the variables of interest. Students were found moderately motivated and engaged with elearning mode of education. Correlation analysis showed strong and significant relationships between variables of the study. Intrinsic motivation was found highly correlated with autonomy ($r=0.78$, $p<0.01$), self-efficacy ($r=0.84$, $p<0.01$) and subjective norm ($r=0.83$, $p<0.01$). Intrinsic motivation and student engagement also had strong positive relationship ($r=0.87$, $p<0.01$). Since the correlational values were also strong between independent variables therefore Variance Inflation Factor (VIF) was calculated to know any multicollinearity. The VIF values were lower than cutoff value of 5 (Chatterjee, & Price, 1991). The tolerance level was also within range (tolerance > 0.7) (Hair, Anderson, Tatham & Black, 1998).

Table-1

Means, Standard Deviations, Correlations, and Reliabilities						
Variables	Mean	1	2	3	4	5
1 Autonomy	3.59	(0.92)				
2 Self-Efficacy	3.38	0.75**	(0.88)			
3 Subjective Norm	3.80	0.82**	0.78**	(0.93)		
4 Intrinsic Motivation	3.55	0.83**	0.81**	0.82**	(0.89)	
5 Student Engagement	3.70	0.78**	0.84**	0.83**	0.87**	(0.94)

* $p<0.01$; ** $p<0.05$; *** $p<0.001$; Reliability estimates in parentheses.

Regression results (Table-2) showed strong predicting qualities of all of the explanatory variables. Correlation coefficients were calculated as autonomy ($\beta = 0.39$; $p<0.001$), self-efficacy ($\beta = 0.35$; $p<0.001$) and subjective norm ($\beta = 0.24$; $p<0.01$). All the predictors helped to explain 79% variation in the criterion variable (intrinsic motivation). In addition, regression results also highlighted significant influence of intrinsic motivation towards student engagement ($\beta = 0.84$; $p<0.001$).

Table-2

Main Effects of Regression Analyses						
Predictors	Dependent Variable	β	R	R ²	ΔR^2	F
Step-I						
	Intrinsic Motivation		0.21	0.04		1.69
Age		0.01				
Gender		-0.93				
Semester		0.11				
Step-II						
	Intrinsic Motivation		0.88	0.79	0.75	67.07**
Age		0.07				
Gender		-0.10				
Semester		-0.01				
Autonomy		0.39***				
Self-Efficacy		0.35***				
Subjective Norms		0.24**				

Notes: * p < 0.05; ** p < 0.01; *** p < 0.001

The study further examined the moderating effects of gender on the hypothesized relationships. Critical ratios were calculated which highlighted the difference of the path from subjective norm to intrinsic motivation ($z = 2.81$, $p < 0.001$). Females were found more influenced by social pressure due to cultural dynamics. In developing countries, females have to undergo a dominated life by associated males like brother, husbands and fathers. Results of the multi group moderation analysis showed that females are more motivated to use elearning due to the social influence of important people.

Table-3

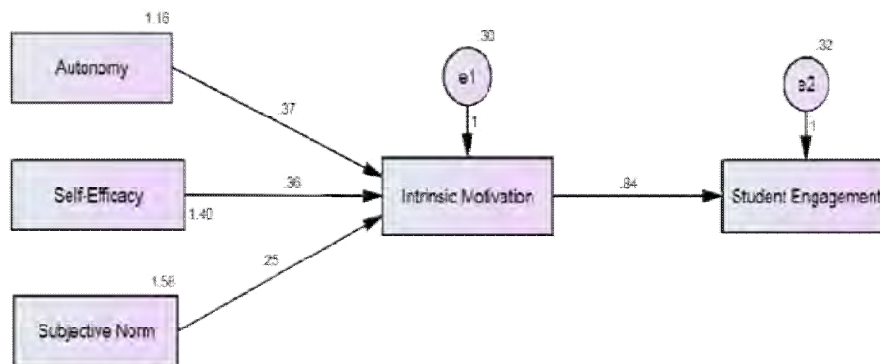
Main Effects of Regression Analyses						
Predictors	Dependent Variable	β	R	R ²	ΔR^2	F
Step-I						
Age	Student Engagement	-0.01	0.18	0.03		1.29
Gender		-0.77				
Semester		0.12				
Step-II						
Age	Student Engagement	-0.01	0.87	0.76	0.73	86.48**
Gender		0.02				
Semester		0.02				
Intrinsic Motivation		0.84***				

Notes: * p < 0.05; ** p < 0.01; *** p < 0.001

Table-4

Paths	Male		Female		z-score
	Estimate	P	Estimate	P	
Intrinsic Motivation <--- Autonomy	0.428	0.000	0.299	0.000	-1.387
Intrinsic Motivation <--- Self-Efficacy	0.350	0.000	0.269	0.000	-0.939
Intrinsic Motivation <--- Subjective Norm	0.182	0.002	0.405	0.000	2.807***
Student Engagement <--- Intrinsic Motivation	0.774	0.000	0.910	0.000	1.156

Figure 1. Path Results of the Research Model



5. Discussions

This study has highlighted some of the interesting facts about elearners' motivation towards education under technology sphere. Motivation has been an area of investigation from many decades due to its wide implication towards technology acceptance and success (Lim, 2004). This prompted strong need to figure out key factors which may impact learners' motivation in either way. Self-determination theory (SDT) has influential role in examining motivation and behavior intentions. Comparatively intrinsic motivation is treated as the key impetus to direct behavior. Considering the determinants prescribed in self-determination theory, this study investigated the role of autonomy, self-efficacy and subjective norms as possible determinants of intrinsic motivation. Intrinsic motivation was further supposed to help elearners' engagement with learning resources.

Students are found motivated due to their close associates who have followed learning through online mode of education. Generally, culture plays an important role in directing the behavior of individuals. Group compliance is the key to stimulate behavior. When individuals feel that their associates especially friends and family members are taking part in education through elearning provided they show satisfaction with online facilities and resources, it stimulates a temptation to experience the advance way of learning.

Learners also highlighted their free will in using elearning. Their motivation is not contingent upon the pressure imposed by external members like their parents or other family members. In collectivist culture, individual behavior may be caused by the instructions of senior member enjoying vested authority. At contrast, students engaged in elearning revealed their motivation is free from any imposition.

The most important factor highlighted during the study is about self-efficacy which is termed as competence in self-determination theory. To use technologically advanced systems and resources, one need to have believe about his abilities. Individuals low at self-belief normally avoids using technological means or takes time to adopt. In knowledge economy, individuals are exposed to different technological devices and gadgets from early stages of life cycle. It helps to enhance self-efficacy. Therefore, respondents of the study not only found high at self-efficacy but their efficacious feel also help to motivate to them to use elearning as a way to get education.

Descriptive results showed fairly balanced motivation and engagement towards elearning but strong impact of all of the independent variables towards dependent variable. Though all the variables were found to be having strong influence towards intrinsic motivation, however autonomy emerged as the most striking variable in explaining elearner's intrinsic motivation. This highlighted the fact that elearners with the perception of freedom and empowerment for their action and behavior might more thoroughly use elearning tools and techniques. Other factors, like rewards and punishment have also been perceived as influential factors towards extrinsic motivation in other studies. However, for self-motivation or motivation by interest and enjoyment, learners need to have the perception of autonomy and independence. It has normally been believed that individuals may consistently perform any behavior provided the alignment of the behavior with self-interest. Individuals duly motivated towards learning under virtual environment may consistently perform such behaviors which were termed as student engagement in this study. Students' with high competence, enjoying autonomy under elearning environment and perceiving a social influence may find high motivation to enhance capabilities. This further make them immersed in studies and they find hard to detach themselves from elearning environment.

6. Conclusion and Implications

Motivation towards learning under online mode is a prime area of concern for nearly every digital based distance universities (Rosenberg, 2005). Reason being the dominant role of motivation in helping to enhance persistence (Vallerand & Bissonnette, 1992) and achievement (Eccles et al., 1993). This study examined the role of autonomy, self-efficacy and subjective norm to predict intrinsic motivation. All the variables showed strong influence to enhance elearners' motivation. Elearners' highly motivated may further keep them fully engrossed in education. These findings call the attention of policymakers to pay due heeds to enhance students' capacities to use technologically advanced resources and promote the advantages of elearning. Acceptance of elearning without any coercion may lead towards better adaptability and fully immersed learning.

7. References

- [1] Ajzen, I. (1991), The Theory of Planned Behavior, *Organizational Behavior and Human Decision Processes*, 50 (2), 179-211.
- [2] Bilde, J.D., Vansteenkiste., M., and Lens, W., (2011), Understanding the association between future time perspective and self-regulated learning through the lens of self-determination theory, *Learning and Instruction*, 21, 332-344.
- [3] Chatterjee, S., & Price, B. (1991). *Regression diagnostics*. New York.
- [4] Chen, K., & Jang, S. (2010). Motivation in online learning: Testing a model of self-determination theory. *Computers in Human Behavior*, 26(4), 741-752.
- [5] Cross, J.A., Cross, J. and Dublin, L. (2002), *Implementing E-learning*, American Society for Training and Development (ASTD).
- [6] Csikszentmihalyi, M. (1990), *Flow. The Psychology of Optimal Experience* Harper, New York, NY: Harper and Row.
- [7] Davis, F. D. (1989), Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology, *MIS Quarterly*, 13(3), 1989, 319-339.

- [8] Deci, E. L., & Ryan, R. M. (2000). The “what” and the “why” of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11, 227–268.
- [9] Deci, E. L., & Ryan, R. M. (1985a). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.
- [10] Dempsey, J. V., & Van Eck, R. N. (2002). Instructional design on-line: Evolving expectations. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (pp. 281–294). Upper Saddle River, NJ: Merrill Prentice Hall.
- [11] Eccles, J., Midgley, C., Wigfield, A., Buchanan, C., Reuman, D., Flanagan, C., et al. (1993). Development during adolescence. The impact of stage-environment fit on young adolescents’ experiences in schools and in families. *American Psychologist*, 48, 90–101.
- [12] Enko, J. (2014). Creative writers’ experience of self-determination: An examination within the grounded theory framework, *Thinking Skills and Creativity*, 14, 1–10.
- [13] Ferrand, C., Martinent, G., Durmaz, N., (2014), Psychological need satisfaction and well-being in adults aged 80 years and older living in residential homes: Using a self-determination theory perspective, *Journal of Aging Studies*, 30, 104–111.
- [14] Fishbein, M., and Ajzen, I. (1975), *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*, Addison-Wesley, Reading, MA.
- [15] Fujita-Starck, P. J., & Thompson, J. A. (1994). The effects of motivation and classroom environment on the satisfaction of students. AIR 1994 Annual Forum Paper.
- [16] Goudas, M., Biddle, S., & Fox, K. (1994). Perceived locus of causality, goal orientations, and perceived competence in school physical education classes. *British Journal of Educational Psychology*, 64, 453–463.
- [17] Gunnell, K.E., Crocker, P.R.E., Mack, D.E., Wilson, P.M., Zumbo, B.D. (2014), Goal contents, motivation, psychological need satisfaction, well-being and physical activity: A test of self-determination theory over 6 months, *Psychology of Sport and Exercise*, 15, 19-29.
- [18] Hair, J., Jr., Anderson, R., Tatham, R., & Black, W. (1998). *Multivariate data analysis* (5th ed.). Englewood Cliffs, NJ: Prentice-Hall.
- [19] Hansen, D. J. (2003). Book review: *E-Learning: Strategies for Delivering Knowledge in the Digital Age* (Author: M. Rosenberg). *Educational Technology & Society*, 6(3), 80-81.
- [20] Ho, Cheng-hsun. (2010). Continuance intention of e-Learning plathform: Toward an integrated model. *International Journal of Electronic Business Management*, 8(3), 206-215.
- [21] Hsu, Y.T., Buckworth, J., Focht, B.C., O’Connell, A.A., (2013), Feasibility of a Self-Determination Theory-based exercise intervention promoting Healthy at Every Size with sedentary overweight women: Project Change, *Psychology of Sport and Exercise*, 14, 283-292.
- [22] Koo, C., and Chung, N., (2014), examining the eco-technological knowledge of Smart Green IT adoption behavior: A self-determination perspective, *Technological Forecasting & Social Change*, 88, 140–155.
- [23] Leung, L.S.K., Matanda, J.M. (2013), The impact of basic human needs on the use of retailing self-service technologies: A study of self-determination theory, *Journal of Retailing and Consumer Services*, 20, 549–559.
- [24] Lepper, M. R., & Cordova, D. I. (1992). A desire to be taught: Instructional consequences of intrinsic motivation. *Motivation and Emotion*, 16, 187–208.
- [25] Lim, D. H. (2004). Cross cultural differences in online learning motivation. *Educational Media International*, 41(2), 163–173.
- [26] Ntoumanis, N. (2001). A self-determination approach to the understanding of motivation in physical education. *British Journal of Educational Psychology*, 71, 225–242.
- [27] Roca, J. C., & Gagné, M. (2008). Understanding e-learning continuance intention in the workplace: A self-determination theory perspective. *Computers in Human Behavior*, 24(4), 1585–1604.
- [28] Rosenberg, M.J. (2005), *Beyond E-Learning: Approaches and Technologies to Enhance Organizational Knowledge, Learning, and Performance*, John Wiley & Sons.

- [29] Rosenberg, M. (2000), *E-Learning: Strategies for Delivering Knowledge in the Digital Age*, McGraw-hill.
- [30] Riaz, A., Riaz, A., and Hussain, M. (2011), Students' Acceptance and Commitment to E-Learning: Evidence from Pakistan, *Journal of Educational and Social Research*, 1(5), 21-30.
- [31] Riaz, A., and Husain, M. (2011), Investigating Open Learning Institute of Virtual Education (Olive) Systems Success, Proceedings of the 2nd international conference on e-learning and distance learning, The National Centre for e-Learning and Distance Learning, Saudi Arabia, Retrieved from <http://eli.elc.edu.sa/2011/en/content/papers>
- [32] Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, 25(1), 54–67.
- [33] Ryan, R. M., & Connell, J. P. (1989). Perceived locus of causality and internalization. *Journal of Personality and Social Psychology*, 57, 749–761.
- [34] Ryan, R. M., & Deci, E. L. (2002). Overview of self-determination theory: An organismic dialectical perspective. In E. L. Deci & R. M. Ryan (Eds.), *Handbook on self-determination research* (pp. 3–33). Rochester, NY: University of Rochester Press.
- [35] Schaufeli, W.B., Salanova, M., GonzAlez-Roma, V. and Bakker, A.B. (2002), The Measurement of Engagement and Burnout: A Two Sample Confirmatory Factor Analytic Approach, *Journal of Happiness Studies*, 3, 71–92.
- [36] Sheldon, K. M., & Elliot, A. J. (1998). Not all personal goals are personal: Comparing autonomous and controlled reasons as predictors of effort and attainment. *Personality and Social Psychology Bulletin*, 24, 546–557.
- [37] Schösler, H., de Boer, J., Boersema, J.J., (2014), Fostering more sustainable food choices: Can Self-Determination Theory help? *Food Quality and Preference* 35, 59–69.
- [38] Sørenbø, Ø, Halvari, H, Gulli, V. F, & Kristiansen, R. (2009). The role of self-determination theory in explaining teachers' motivation to continue to use e-learning technology. *Computers & Education*, 53(4), 1177-1187.
- [39] Taylor, G., Jungert, T., Mageau, G.A., Schattke, K., Dedic, H., Rosenfield, S., and Koestner, R. (2014), A self-determination theory approach to predicting school achievement over time, *Contemporary Educational Psychology*, In press.
- [40] Webb, D., Soutar, G.N., Mazzarol, T., and Saldaris, P. (2013), Self-determination theory and consumer behavioural change: Evidence from a household energy-saving behaviour study, *Journal of Environmental Psychology*, 35, 59-66.
- [41] Welters, R., Mitchell, W., and Muysken, J. (2014), Self-determination theory and employed job search, *Journal of Economic Psychology*, 44, 34–44.
- [42] Wild, R.H., Griggs, K.A., and Downing, T. (2002), A framework for e-learning as a tool for knowledge management, *Industrial Management & Data Systems*, 102(7), 371 – 380.
- [43] Williams, G. C., Patrick, H., Niemiec, C.P., Ryan, R.M., Deci, E.L., Lavigne, H.M., (2011), The Smoker's Health Project: A self-determination theory intervention to facilitate maintenance of tobacco abstinence, *Contemporary Clinical Trials*, 32, 535–543.
- [44] Vallerand, R. J., & Bissonnette, R. (1992). Intrinsic, extrinsic, and amotivational styles as predictors of behavior: A prospective study. *Journal of Personality*, 60, 599–620.
- [45] Vallerand, R. J., Pelletier, L. G., Blais, M. R., Bri-e`re, N. M., Sene`cal, C., & Vallie`ries, E. F. (1992). The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement*, 52, 1003–1019.
- [46] Venkatesh, V., Morris, M., Davis, G., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 27(3), 425-478.

CRITICAL SUCCESS FACTORS FOR MOOCS SUSTAINABILITY IN MALAYSIAN HIGHER EDUCATION: A PRELIMINARY STUDY

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Abstract

Massive Open Online Courses (MOOCs) have gained traction in empowering lifelong learning, democratizing access to top quality education and optimizing educational and operational efficiency of higher education worldwide. Albeit free for mass perusal, the higher educational institutions still have to invest and spend millions to sustain MOOCs in their respective institutions. In the context of Malaysian higher education, The Ministry of Higher Education Malaysia has launched Malaysia MOOC, the first country in the world to implement government-initiated MOOCs for all public universities. Hence, this preliminary study aims to identify the Critical Success Factors for MOOCs sustainability in Malaysian higher education via qualitative approach. Stakeholder analysis and in-depth interviews are conducted with ten interviewees who are the primary stakeholders of the Malaysia MOOCs initiative. The findings are hoped to promulgate extensive research and initiative on MOOCs sustainability for policy makers, practitioners and researchers.

1. Introduction

Massive Open Online Courses (MOOCs) have exponentially gained attention as one of the primary drivers of global learning innovation in higher education (HE). The escalating implementation of Massive Open Online Courses (MOOCs) in higher education worldwide propagates higher knowledge accessibility beyond physical, socio-culture and demographic barriers. Nonetheless, one of the main challenges in MOOCs implementation in HE is to optimize its sustainability as well as catering to myriad needs and demands of the stakeholders [1]. Yet, there is paucity in research analyzing Critical Success Factors in MOOCs Sustainability in HE worldwide. In the context of Malaysian higher education, the stakeholders identified are policy makers, administrators, instructors, lecturers, on-campus and off-campus students. There has been high demands from stakeholders in producing MOOCs that are of high quality, infrastructure efficiency, enhance value proposition of the institutions yet remain cost-effective [2]. As the HE industry is steadily gaining traction in a robust and competitive open market for quality education, the brick and mortar institutions, specifically public universities need to evaluate strategies and operational plans to thrive within this innovative threat. In Malaysia, Malaysia MOOC is steadily gaining traction but there is paucity in research on optimizing its sustainability from the viewpoints of stakeholders. Due to the complexity and diversity of needs and demands of stakeholders, this paper aims to identify the Critical Success Factors (CSF) of MOOCs Sustainability from the viewpoints of the stakeholders in HE, specifically in the Malaysian perspective.

2. Literature Review

2.1 MOOCs Sustainability in Global Higher Education

Sustainability refers to policy, situation, product, process or technology that can be perpetually maintained and sustained for an indefinite time [3]. In the context of MOOCs, sustainability in HE means shifting away from merely higher enrolment of students to making quality post secondary education more cost effective. Based from the ten-principle framework of MOOC instructional quality [4], there is a need to synthesize the correlations between MOOCs quality instructions with learners' gratification and its sustainability in HE. In this context, interdisciplinary collaboration of research fields as well as personalization of student-centered online learning could be the keys to MOOCs sustainability. Since its inception in 2008 [5][6], MOOCs initiative in HE has globally gained traction where some of the leading MOOC platforms are EdX, Coursera, Udacity and FutureLearn. To date, more than 12000 MOOC courses have been offered by higher education worldwide [7] and more higher educational institutions are using MOOCs or initiating MOOC platforms. Albeit large investment injected on MOOC proliferation worldwide, four potential future problems for MOOCs have been identified by Hill in his research which are: (1) revenue models, (2) credentialing, badges or accreditation, (3) course completion rate and (4) student authentication. There has been a gradual shift from studying MOOCs usage behavior to other practical considerations such as their financial viability, sustainability and issues about student retention as more higher educational institutions are seeking ways to optimize MOOCs sustainability that challenge the conventional brick and mortar provision of tertiary education.

2.2 Malaysia MOOC

Malaysia MOOC is initiated by the government in tandem with Malaysian Education Blueprint for Higher Education, National Economic Model and Economic Transformation Programme [8]. It was pre-launched on 19 September 2014 by the then Second Education Minister, Datuk Seri Idris Jusoh. It was a milestone for Malaysian higher education as Malaysia is the first country in the world to implement the government-initiated Massive Open Online Courses (MOOCs) initiative for public universities [9]. Contrasting with main objective of global commercial MOOC providers that specifies on monetization, MOOCs in Malaysia focuses on complementing the blended learning ecosystem with existing on-campus learning environment [10]. In this context, the main objective was to ensure online learning complements the on-campus learning experience and ease accessibility to synchronous and asynchronous learning. The Malaysia MOOC initiative is part of the Ministry of Higher Education strategic plan in expedite the quality and "boost the ranking of Malaysian higher education on global scale" [9].

Prior to Malaysia MOOC, Taylor's University was the first Malaysian higher educational institutions that initiated MOOC courses. Apart from Taylor's University, Open University Malaysia has also initiated MOOC courses [8] and by 2025, all Malaysian universities are expected to adopt MOOCs to add value to on-campus learning experience [10]. Open Learning, an online learning platform based in Sydney, Australia has been appointed by the Ministry of Higher Education Malaysia to be the official platform provider for Malaysia MOOC courses for all the twenty public universities [11]. Up to 1st March 2015, Malaysia MOOC has enrollment of 128,710 users. Four pilot MOOC courses were launched for the first semester in the 2014 session. The four MOOC courses are Islamic Civilization and Asian Civilization (TITAS) led by

Universiti Putra Malaysia, Ethnic Relations led by Universiti Kebangsaan Malaysia, Entrepreneurship led by Universiti Teknologi Mara and ICT Competency led by Universiti Malaysia Sarawak [9]. Figure 2 depicts the timeline of MOOC progress in Malaysian higher education.



Figure 2. Timeline for MOOCs implementation in Malaysian higher education

2.3 Critical Success Factors for MOOC Sustainability in Higher Education

In the context of this research, Critical Success Factors (CSF) are defined as the few things which must go right for sustainability to be executed successfully [12]. In the context of MOOCs sustainability in higher education [13], identifying CSF is integral to optimize MOOCs execution in a long run.

Scalability and sustainability of higher education requires universities to shift away from the focus of increasing the quantity of students in higher education to making a quality post-secondary education more cost effective. This is the highlight of global higher education as it requires reassessment and realignment of the institution's goals, resources and processes in order to address global and national challenges [14]. Due to its rapid growth in expediting access and cost to quality education worldwide, interests on MOOCs sustainability has escalated [28, 29]. Based from the literature review, two major theories are fundamentals in underpinning the MOOCs sustainability in higher education. The theories are Christensen's Disruptive Innovation Theory [17] and Siemens' Connectivism [5]. Christensen outlines 3 major factors in sustaining competitive drive of higher education: (1) Value Proposition, (2) Infrastructure and (3) Financial. Both theories identify four main factors in MOOCs sustainability: (1) educational; (2) institutional; (3) financial and (4) socio-cultural.

a. Education

Quality of education is one of the main aspects in sustainability of MOOC education [4]. Education encompasses pedagogy, methodology, techniques and methods pertaining to MOOCs development, implementation and execution in higher education.

b. Socio-culture

Socio-culture is also one of the vital aspects that analyze the impact of social networking, cultural intervention, language diversity as well as external environment to be variables that could impact sustainability of MOOCs in higher education. Socio-culture aspect is integral in

sustainability as user experience (UX) may be influenced by users' cultural and demographic background. This is linked to MOOC glocalization [18] where the success of MOOC could be determined by the socio-cultural background which could influence User Interface Design (UI) and UX.

c. Institution

Institution refers to the organizations or institutions that are offering MOOCs. In this context, it refers to the HE institutional policy, management, resources and process.

d. Finance

Financing or refinancing of MOOCs is essentially considered in four ways: participant financing, financing from external donors, working with companies or financing through additional courses.

Pertaining to research trends on MOOC scholarship, the review indicated that sustainability as one of the least explored areas albeit being main concern of higher education worldwide. One of the prominent researches conducted on MOOC was carried out by [2] and the top issue for MOOCs highlighted by the research is sustainability, followed by pedagogy, quality and completion rate as well as assessment and credit. This is echoed by research conducted by [19] and [20] that identify sustainability as one of the major apprehensions for global higher education. On top of that, a review conducted by [21] identified lack of evidence, lack of support and unrealistic expectations on beginner learners may lead to issues in MOOCs sustainability. Albeit several attempts studying various issues pertaining to MOOC such as educational, financial, technical and managerial issues, there remains paucity in MOOCs sustainability that has yet been closely examined. These four areas extracted from literature will be the basis for the data collection in identifying CSF in MOOCs sustainability in Malaysian higher education.

3. Research Methodology

Data was collected in September-November 2015. In this context, a preliminary study is conducted to inquire and analyse the standpoints of the stakeholders of MOOC sustainability in Malaysia. This study encompasses four main stages. Firstly, we conducted Stakeholder Analysis for sampling strategy and instrument. Secondly, in-depth interviews are conducted with respondents using purposive sampling method. Next, the data is transcribed, decoded and analysed using Atlas.Ti, a qualitative data analysis software. This is followed by the final stage where the Critical Success Factors are analysed and categorized using Thematic Concept Matrix. The comprehensive and in-depth qualitative analysis will be the foundation for primary data collection in identifying CSF for MOOCs sustainability at selective Malaysian HE.

4. Data Collection

4.1 Sampling Strategy and Instrument

Purposive sampling method was perused to identify the respondents. This method is chosen as scalable organizational strategies and value propositions can be drawn from the synergy of viewpoints. Stakeholder Analysis is chosen in order to study the roles of stakeholders and their influences in identifying the CSF in MOOCs sustainability in higher education. It is

vital to identify and understand the stakeholders of relevance to the organization [22]. As Malaysia MOOC is still at its infancy stage, the sampling is based from two main aspects: level of involvement in Malaysia MOOC development and involvement in Malaysia MOOC execution. Thus, identification of variables on the needs and wants of the stakeholders can be leveraged accordingly.

4.2 Respondents

For this preliminary study, ten stakeholders in Malaysia MOOC are chosen as respondents. 9 of the respondents are Malaysians and one is Australian. From demographic profiling, 8 respondents are currently residing in Malaysia while the remaining two respondents are residing abroad. Each respondent is systematically chosen based on involvement in Malaysia MOOC as policy maker, service provider, trainer, project champion and end users. Table 1 depicts the Stakeholders in MOOCs in Malaysian higher education. From the analysis, in-depth interview is carried out for further data collection.

Table 1. Stakeholders in MOOCs in Malaysian higher education

STAKEHOLDER	ROLE	INFLUENCE
Ministry of Higher Education Malaysia	Policy maker	Possess the executive power to revise national MOOC policy
Open Learning	Service Provider	MOOCs platform provider
MOOCs Master Trainer	Training Provider	Impact the quality and effectiveness of MOOCs implementation
MOOCs Manager	Project Champion	Manage MOOCs at institutional level
MOOC Users	Enrol in Malaysia MOOC pilot study	Peruse MOOCs at institutional level

In-depth Interview

For this research, interview is chosen to identify stakeholders' view pertaining to MOOCs sustainability in Malaysian higher education. There were ten in-depth interviews with semi-structured questions carried out with ten respondents where the interview was audiotaped and transcribed using qualitative data analysis software for qualitative data analysis [23]. Although the semi-structured questions were constructed based on findings via secondary data research. This is to ensure the findings from the interview can be synthesized with literature analysis and secondary data research for final report documentation. Nonetheless, interview with stakeholders will still allow interviewees to opine and construct their views based on prior experience and tacit knowledge.

Eight face-to-face interviews were conducted at the premise of the Malaysian universities where the respondents are working or studying and audiotaped. Two interviews were conducted via Skype as the interviewees are currently residing in Australia and Indonesia. The interviewees are the stakeholders in the Malaysia MOOCs initiative in Malaysian Higher Education as depicted in Table 3. Five interviewees are officially appointed by the Ministry of Higher Education Malaysia to spearhead planning, strategizing and implementing MOOCs nationwide in all public universities in Malaysia. The rest interviewees are active users of MOOCs and have prior knowledge and experience in learning via MOOCs.

5. Analysis and Discussion

The transcribed data were analysed and summarized using Atlas.Ti, a qualitative data analysis software. The comprehensive coding revealed emerging patterns on factors and elements of MOOCs sustainability in Malaysian higher education. The data are synthesized and discussed based from the semi-structured questions.

(a) Educational

The first question posed to the unit of analysis are pertaining to educational area. The majority of the interviewees opined the importance of quality of MOOCs service provision in influencing MOOCs sustainability in higher education.

“In the Malaysian MOOC context, I think it's very clear that MOOC comes in a range of benefits, both to universities and also to the students. Saving time of both of the lecturers and the students, letting students interact with MOOC communities in universities, improving the quality of the online courses being embedded.”

Market positioning and branding is one of the critical success factors opined by the stakeholders. One interviewee emphasized on how MOOCs can promote international students to study in local universities and colleges. The interviewee said, *“When international students discover the quality of MOOCs and instructors in Malaysian universities, they might be interested to come to Malaysia to study.”* This is supported by a few by another interviewee who mentioned *“We can showcase the brand and the quality of the courses.”*

Creating niche subjects for MOOCs is one of the way Malaysian MOOCs can provide competitive advantage to other existing MOOCs platforms from myriad higher education worldwide. Apart from offering niche subjects such as Islamic Banking, Halal Entrepreneurship, and so forth, perusing MOOCs for research is seen by the interviewees as way Malaysian higher education could reposition its core competencies and enhance MOOCs sustainability in the respective institutions.

“MOOC is used for research in higher education. So research in looking at the ways in which students learn and research on various teaching methodologies.”

This is supported by a respondent who stated how MOOCs could enhance the quality of the learners as competent and possessing better collaborative and networking skills.

“ It may improve their (students) soft skills and graduate attributes of the students, by getting them to communicate and work together on projects.”

(b) Institutional area

At the institutional level, the respondents opined that technology architecture, resources and processes that are essential in sustainability of MOOCs in higher education. All of the interviewees opined on the important role of policy makers and top management to champion and implement the Malaysia MOOC initiative in order to influence its sustainability in higher education.

“ If the top management is committed with MOOCs, the initiative can be a success among the staff and students.”

(c) Technical area

Technological architecture is also one of the key elements of MOOCs sustainability based from the interviewees' feedbacks. Accessibility, connectivity and technical support are some of the mentioned aspects pertaining to infrastructure.

“People must be able to access easily, without lag time. So, when they get materials, it is smooth and easy. It would be easy to access the course with any device that they like.”

One interviewee responded that there is a need for more interactivity in MOOCs implemented in Malaysian higher education. Social media enhancement is considered by the interviewee to be the main consideration for MOOCs development in near future.

“I want MOOC to have more social media plug-in because based from what I’ve seen, it’s just a bunch of videos and they have limited features.”

(d) Socio-cultural area

All of the respondents shared views that socio-cultural area is essential to MOOCs sustainability in Malaysia. Some of them expressed how providing multi-lingual courses for Malaysia MOOCs will provide a conducive and a familiar ethos to local users. The majority of the interviewees stated that having local instructors do not impede the quality of the MOOC courses as Malaysian academics are able to deliver the content as effectively as other foreign-produced MOOCs.

“You need to engage both learners and trainers to enhance the quality of learning engagement for MOOCs. Producing our own MOOC will enhance the national branding of top quality education and market local academics to both local and foreign end-users.”

The analysis of the Critical Success Factors are presented in the Thematic Concept Matrix, as shown in Table 2, to further illustrate the factors, constructs and elements from the viewpoints of the stakeholders.

Table-2. Thematic Concept Matrix on the Critical Success Factors for MOOCs Sustainability in Malaysian Higher Education

FACTOR	VALUE PROPOSITION	INFRASTRUCTURE	FINANCIAL
Educational	-Offer niche subjects. -Multi-language MOOCs. -Interdisciplinary collaboration across fields	-Develop course with good instructional design. -Myriad learning resources. -Meet the needs of users.	-Free of charge. -Marketing gateway for potential international students.
Institutional	-Marketing positioning. -Branding. -Distinguish core competencies of HE. -Promote the quality of academics.	-Policy management. -Skillful instructors. -Optimize operational management. -Complement on-campus experience.	-Viable business model. -Government grants. -Corporate partnership. -Revenue through certification.
Technical	-Wide accessibility to users. -Expedite graduation process. -Transferable credit from MOOCs worldwide.	-Ease of access. -Optimum Wi-Fi connection. -Efficient tech support.	-Cost-effective technological infrastructure.
Socio-cultural	-Zero or low-cost MOOC provision.	-Establish global networking. -Expedite knowledge capital.	-Higher revenue by leveraging socio-cultural aspect.

From the Thematic Concept Matrix, nine elements have been identified based from the analysis conducted using qualitative data analysis software. As shown in Table 3, the nine elements derived from four main factors; educational, institutional, technical and socio-cultural. The identified factors, constructs and elements are vital findings of this research on impacting MOOCs sustainability in Malaysian higher education.

Table-3. Critical Success Factors for MOOCs Sustainability in Malaysian Higher Education

MOOCs Sustainability in Malaysian Higher Education		
Factors	Constructs	Elements
Educational	Value proposition	Product Service, Market Positioning, Competitive Advantage.
Socio-culture		
Institutional	Infrastructure	Organization, Core Resources, Technological Architecture, Value-Added Processes.
Financial	Financial	Source Of Income, Revenue Of Income.

6. Conclusion

MOOCs has revolutionized higher educations by offering scalability in lifelong education. One of the major challenges for MOOCs is finding how it can be sustained and optimized over time. With the exponential growth of MOOCs in higher education worldwide as well as the inception of the Malaysia MOOC initiative, research on sustainability is timely and in dire need as it would vindicate the multiplier benefits to all the stakeholders in higher education. Apart from that, there has been increasing concern on shifting the focus of higher education in the aspect of sustainability, yet based on literature and empirical studies, there is a paucity examining MOOCs sustainability in higher education and there is a deficit of studies conducted on the aforementioned topic from the Malaysian perspective. Nonetheless, research on MOOCs sustainability in higher education is limited and represents equivocal results. As Malaysia MOOC is the world first government-initiated MOOCs for public universities, this study is significant, especially by taking consideration of stakeholders' views. Hence, it is vital to analyse the Critical Success Factors for MOOCs sustainability in Malaysian higher education.

Albeit its significance, this research has its limitation. Although there were many issues emanating from MOOC initiatives in higher education, the scope of this research is on the aspect of MOOC sustainability in Malaysian higher education. The scope has been further refined to just public universities as Malaysia MOOC are made compulsory for all 20 public universities in Malaysia. The findings from this research is hoped to provide holistic perspectives from the stakeholders' standpoints in order to identify the factors and elements required for MOOCs sustainability in Malaysian higher education. This research is hoped to offer a guideline for policy makers, academics and researchers in managing MOOCs at their respective higher educational institutions.

7. Research progress and future work

To date, the research conducted on MOOCs Sustainability in Malaysian HE is progressing gradually in phases. Hence, the primary data collection using questionnaire via purposive sampling method at selected Malaysian public university would be the next phase of this research. The findings from the main data collection is hoped to fortify the development of the Conceptual Business Model by rectifying input from the active users of Malaysia MOOCs in the selected public universities. The future studies stemmed from this research will explore the stakeholders, views in developing a conceptual business model for MOOCs sustainability, which optimizes competitive advantage to both institutions and end-users.

References

- [1] A. Mohamed, F. Yousef, M. A. Chatti, U. Schroeder, M. Wosnitza, and H. Jakobs, "A Review of the State-of-the-Art," in *6th International Conference on Computer Supported Education*, 2014, pp. 9–20.
- [2] L. Yuan and S. Powell, "MOOCs and Open Education: Implications for Higher Education," 2013.
- [3] R. Heijungs, G. Huppes, and J. B. Guinée, "Life cycle assessment and sustainability analysis of products, materials and technologies. Toward a scientific framework for sustainability life cycle analysis," *Polym. Degrad. Stab.*, vol. 95, no. 3, pp. 422–428, 2010.
- [4] A. Margaryan, M. Bianco, and A. Littlejohn, "Instructional quality of Massive Open Online Courses (MOOCs)," *Comput. Educ.*, vol. 80, pp. 77–83, 2015.
- [5] G. Siemens, "Connectivism: A learning theory for the Digital Age," *Int. J. Instr. Technol. Distance Learn.*, vol. 2, no. 1, pp. 1–8, 2005.
- [6] D. Gašević, V. Kovanović, S. Joksimović, and G. Siemens, "Where is Research on Massive Open Online Courses Headed? A Data Analysis of the MOOC Research Initiative," *Int. Rev. Res. Open Distrib. Learn.*, vol. 15, no. 5, 2014.
- [7] L. Breslow, D. E. Pritchard, J. DeBoer, G. S. Stump, A. D. Ho, and D. T. Seaton, "Studying learning in the worldwide classroom: Research into edX's first MOOC," *Res. Pract. Assess.*, vol. 8, pp. 13–25, 2013.
- [8] M. Fadzil, L. Abdol, L. Tengku, and A. Munira, "MOOCs IN MALAYSIA: A PRELIMINARY CASE STUDY," in *E-ASEM FORUM: RENEWING THE LIFELONG LEARNING AGENDA FOR THE FUTURE*, 2015.
- [9] "Malaysia first to implement open online courses for public universities," *Malaymail Online*, p. 2020, 19-Sep-2014.
- [10] Ministry of Education Malaysia, *Malaysia Education Blueprint 2013-2025*, vol. 2025. Kementerian Pendidikan Malaysia, 2015.
- [11] S. Sahyoun, "OpenLearning Selected as Malaysia 's National MOOC Platform," *Open Learning*, 2015. [Online]. Available: <https://www.openlearning.com/blog/OpenlearningComSelectedAsMalaysiaSNationalMoocPlatform>. [Accessed: 03-Aug-2015].
- [12] M. Ahmad, H., Francis, A. and Zairi, *Business process reengineering: critical success factors in higher education*, vol. 13, no. 3. Business Process Management Journal, 2007.
- [13] N. Sa'don, N.F., Alias, R.A. and Ohshima, "Nascent Research Trends in MOOCs in Higher Educational Institutions: A Systematic Literature Review," in *International Conference on Web and Open Access to Learning (ICWOAL)*, 2014, pp. 1–4.
- [14] C. Christensen, M. B. Horn, L. Caldera, and L. Soares, "Disrupting College: How Disruptive Innovation Can Deliver Quality and Affordability to Post Secondary Education," *Innosight Inst.*,

- vol. 32, no. February, p. 72, 2011.
- [15] S. Ong and A. Grigoryan, "MOOCs and Universities : Competitors or Partners ?," *Int. J. Inf. Educ. Technol.*, vol. 5, no. 5, pp. 373–376, 2015.
- [16] F. Anderson and R. Thompson, "Title: MOOC's -mass marketing for a niche audience?," University of Northampton, 2014.
- [17] CM Christensen and HJ Eyring, *The Innovative University: Changing the DNA of higher education from the inside out*. John Wiley & Sons, 2011.
- [18] Z. W. Abas, "The glocalization of MOOCs in SouthEast Asia," in *MOOCs and Open Education Around the World*, Routledge, 2015, p. 232.
- [19] F. M. Hollands and D. Tirthali, "Resource Requirements and Costs of Developing and Delivering MOOCs," *Int. Rev. Res. Open Distrib. Learn.*, vol. 15, no. 5, 2014.
- [20] B. zur Hochschulpolitik, *The potential and problems of MOOCs MOOCs in the context of digital teaching*. German Rectors" Conference, 2014.
- [21] J. S. Russell Boyatt, Mike Joy, Claire Rocks, "What (use) is a MOOC?," in *The 2nd International Workshop on Learning Technology for Education in Cloud.*, 2014, pp. 133–145.
- [22] C. Chapleo and C. Simms, "Stakeholder analysis in higher education," *Perspect. Policy Pract. High. Educ.*, vol. 14, no. 1, pp. 12–20, 2010.
- [23] J. W. Creswell, *Qualitative Inquiry and Research Design*. 2013.

Towards the Development of a Comprehensive Online Materials Science and Engineering Curriculum

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Abstract

Massive Open Online Courses (MOOCs) are becoming increasingly common, but complete open online university curricula are not. This paper details our efforts to develop a comprehensive online Materials Science and Engineering curriculum. We outline our current online offerings, discuss both the challenges and the opportunities presented in developing an online curriculum, and outline how these MOOC resources are used in our on-campus classrooms. Finally, we detail our future path forward towards a comprehensive online curriculum.

1. Introduction

Ever since The New York Times declared 2012 to be “the year of the MOOC”, Massive Open Online Courses have become omnipresent [1]. The two biggest MOOC providers, Coursera and edX, currently advertise 1541 and 885 past, active, and future offerings, respectively [2,3]. While individual courses and multi-course sequences (such as edX’s X-Series and Coursera’s Specializations) are prevalent, complete university curricula are not. Here, we present the efforts of MIT’s Materials Science and Engineering (MS&E) department to provide a comprehensive set of online course materials that include both the fundamental courses essential to all MS&E undergraduate students, and the upper-level electives that allow undergraduates to study specific topics of interest in some depth.

There are numerous reasons for our department to aim to develop a comprehensive online MS&E curriculum. Certainly, many of these reasons look to the world outside of our university and reflect a commitment to open education and global outreach. We aim to make as much of our curriculum as possible as available to all interested learners.

Our online development goals are not exclusively outward facing, however. A number of our incentives for curriculum development are focused on internal department goals and reflect a commitment to flexibility and educational innovation for our on-campus students. Because we believe that our on-campus students see significant benefit from our online course resources, our department has additional incentive to develop resources

to be offered for free or at low cost in MOOC form. Our aim is to develop a comprehensive MS&E curriculum that both provides significant benefits to our on-campus students and makes our curriculum accessible to a worldwide audience. Though our efforts are still ongoing, this paper details our efforts to date to provide a comprehensive and freely accessible MS&E curriculum online.

2. Current MOOC Offerings on edX

Our current departmental offerings include six unique courses, and we have offered a total of 14 classes, both first-run and rerun, on edX. Our course offerings to date are detailed below:

3.091x: Introduction to Solid State Chemistry provides students with an understanding of the basic principles of chemistry and their application to engineering systems. *Introduction to Solid State Chemistry* serves as both a general introduction to university-level chemistry and as a foundational course in Materials Science and Engineering.

3.032x: Mechanical Behavior of Materials provides a first course in solid mechanics and the mechanical behavior of materials. All undergraduate students in MIT's Department of Materials Science and Engineering must complete this course to graduate.

3.072x: Symmetry, Structure, and Tensor Properties of Materials is offered to upper-level undergraduates as well as graduate students who are interested in an in-depth exploration of the structure of crystalline materials and the relationship between crystal symmetries and materials properties.

3.15x: Electrical, Optical, and Magnetic Properties of Materials is an upper-level undergraduate elective that explores the relationship between the performance of electrical, optical and magnetic devices and the properties of the materials from which they are constructed.

3.086x: Innovation and Commercialization is an upper-level undergraduate and graduate course that introduces students to the fundamental process of innovation. Students learn about the innovation process while exploring both historical and modern examples of innovation, and they have the opportunity to develop projects based on their own innovative ideas.

3.054x: Cellular Solids: Structure, Properties and Applications is taken by upper-level undergraduate and graduate students who would like to explore the structure, properties, and applications of cellular solids in significant depth. Applications to structural engineering, medicine, and nature are considered in depth.

We divide the essential topics of Materials Science and Engineering into six broad categories: Introduction, Structure, Thermodynamics, Kinetics, Mechanical Properties, and Electronic Properties. Table 1 shows the courses at either the introductory or

advanced level that have been offered by our department in MOOC form on edX. To date, we have MOOC offerings that cover about two-thirds of the essential topics in MS&E.

Table 1. A Summary of MIT MS&E Course Offerings on edX

	Introductory-Level	Advanced-Level
Introduction	3.091x	N/A
Structure	--	3.072x
Thermodynamics	--	--
Kinetics	--	--
Mechanical Properties	3.032x	3.054x
Electronic Properties	--	3.15x
Other Electives	N/A	3.086x

In comparison to our online curriculum, all undergraduate materials science and engineering majors at MIT must complete an introductory chemistry course (usually 3.091), a combined structure and thermodynamics class, a kinetics class, a mechanical properties class (3.032), and an electronic properties class. They also must complete four advanced-level elective courses (such as 3.15, 3.086, 3.072, and 3.054). Required courses outside of the framework given in Table 1 include an Organic & Biomaterials Chemistry class, a Materials Processing class, and several laboratory-based courses (including an undergraduate thesis). Students must also satisfy a mathematics requirement and a computation requirement.

3. Challenges and Opportunities Developing an Online Curriculum

Several challenges and opportunities exist when developing an online MOOC curriculum at the university level. The major challenges to developing a rigorous online curriculum are described below along with the opportunities provided by this online development process.

3.1 Challenges

Providing challenging problems: One of the primary challenges of offering an online curriculum is ensuring we provide students with a rigorous set of homework and quiz problems to develop and test their knowledge. Frequently, MOOC-style courses choose to use multiple-choice problems to test student knowledge [4]. However, we have found

multiple-choice questions to be quite limiting when compared to the variety of assessment approaches we are able to offer an undergraduate engineering student during more traditional assessments. Numerical problem solving, derivation, graphing, and sketching are all typically required of these students on a regular basis.

There are several strategies that we can use to ensure students are provided with rigorous assessment questions. Questions that have answers in the form of either numbers or equations can be easily evaluated by a computer-grader. Because the edX platform gives us only limited ability to give students partial credit for their answers, we typically provide multiple attempts at each problem to allow students to receive credit for a problem even if they make an error in calculation. Graphing and sketching tasks are somewhat more difficult to adapt. However, drag-and-drop style questions and graphing tasks using the MATLAB scientific computing language can be used to test much of the same understanding.

Open-ended questions: Of course, engineering assessment is not limited to problem solving on homework sets. Students must also be able to explain concepts, write research papers, and complete open-ended projects. We have elected to include all of these types of assessment in our MS&E MOOC curriculum. Currently, assessments of this type in our MOOCs are currently graded using peer evaluation, or, occasionally, self-assessment. Piech et al have demonstrated that peer-assessment can provide a reasonably accurate estimate of student performance [5]. However, peer-assessment does not give expert, instructor-based feedback to the learners [4].

Laboratory work: Laboratory work provides another important cornerstone of an engineering curriculum. Many of our department's courses include a laboratory component, and laboratory-specific courses are a required part of the curriculum as well. To date, we have not attempted to include any laboratory-related work in our MOOC courses.

3.2 Opportunities

Though online curriculum development presents a unique set of challenges, it provides a number of opportunities as well.

Developing a broad set of student resources: The development of any online course has the advantage of providing a new set of online resources to students. Video recorded lectures, practice problems, and expanded supplementary materials all serve to support student learning. The development of a full online curriculum further broadens this benefit. Students who lack prerequisite work can be directed to resources developed for other courses. The flexible nature of online resources means that materials developed for one class can be used as supplementary materials in other courses. Students are empowered to take a more active role in their own learning when they have the resources available to review material and ideas from across the curriculum.

Tools to integrate and improve learning: In the previous section, we discussed some of the difficulties encountered translating traditional on-campus learning experiences into an online environment. However, online course development has also allowed us to expand and improve on traditional models of education to deepen student learning. For example, *3.086: Innovation and Commercialization* has introduced online project development software that has allowed student projects to become the cornerstone activity of the course. The course software guides students through important project development steps, and it improves the effectiveness of instructor-student project mentoring sessions, giving instructors information about the evolution of student projects, thus enabling the instructors to give the feedback and guidance that increases the complexity and depth of student projects.

3. Blended Learning on Campus

Our online curriculum utility is not limited to MOOCs offered on edX. All of the resources developed for our MS&E MOOC curriculum are used in various ways in our residential courses.

3.1 Models for On-Campus Hybrid Education

These online resources are used in a variety of different ways in our on-campus courses. Below, we detail the basic models for blended education that we employ.

Digital Textbook: One on-campus use of these MOOC materials is as an electronic course textbook. These courses are otherwise unchanged by the online content: a professor delivers live lectures and students complete pencil-and-paper homework sets that are instructor- or TA-graded. The online resources take the place of a textbook, allowing students to review lectures of confusing materials, practice their problem solving skills with online problems, and review worked examples of problems.

Because Materials Science and Engineering is an interdisciplinary field that incorporates knowledge from the fields of physics, chemistry, and a variety of other engineering fields, the availability of customized MS&E digital textbooks is particularly valuable.

Flipped Classroom: In the flipped classroom model, lectures are provided to students in the form of video, and professors meet with students for interactive classes centered on discussion and problem solving. Additionally, in some of our flipped classrooms, students complete some or all of their homework using the online problems that we originally developed for our MOOC offerings.

In the Fall of 2015, *3.032: Mechanical Behavior of Materials* was offered to our on-campus students using a flipped-classroom model. We surveyed the students to better understand their opinions and experiences, and some of the results are shown in Figure 1. Students generally had a very positive reaction to the introduction of a flipped classroom,

with most of the students preferring the flipped classroom with online problem sets to more traditional lecture and homework.

Integrated Model: In the integrated classroom model, online resources become an essential, integral part of the course pedagogy. Earlier, we discussed the development of new online tools for 3.086: *Innovation and Commercialization*. The introduction of these tools has fundamentally served to alter the focus of the course, allowing student project development to play a more central role in the class than it ever had before.

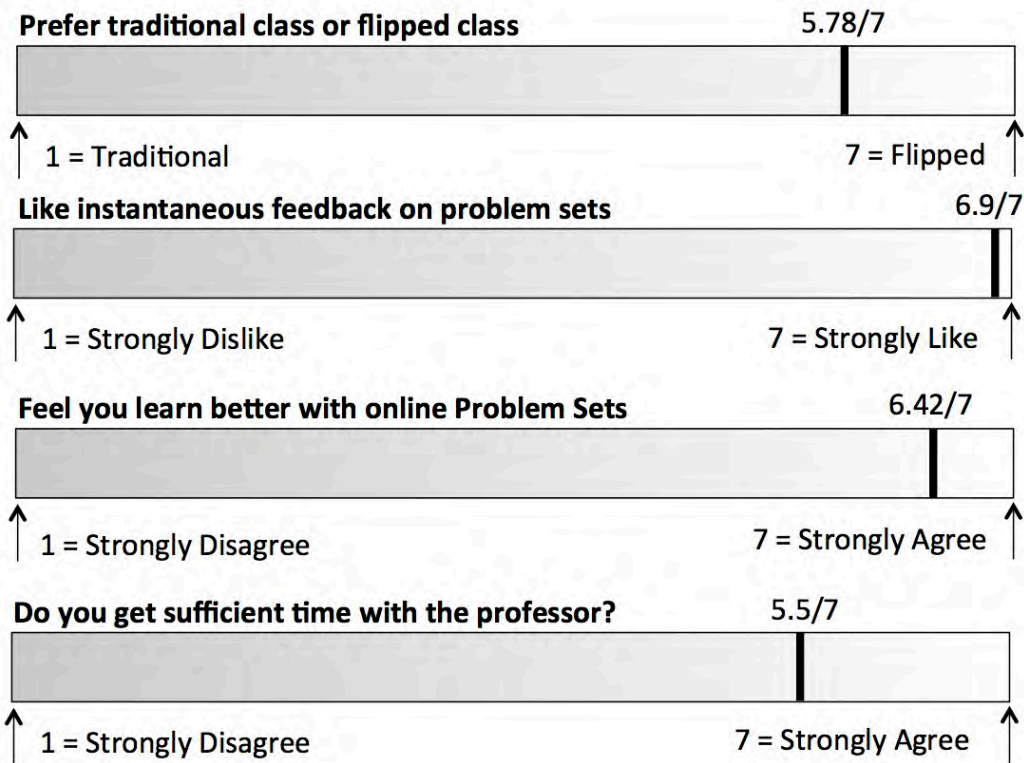


Figure 1. A survey asked the students in the on-campus version of 3.032 to rate their experiences with a flipped classroom on a scale of 1 to 7.

4. Path Forward

Having made significant progress in course development, we now aim to complete the development of our online curriculum. Figure 2 illustrates both our current and our planned online offerings.

Currently, we offer several courses that do not yet have their prerequisite courses online. (Our course development sequence has been based on numerous factors,

including which courses have pre-existing resources and which courses we anticipate being of greatest utility to our on-campus students.) We have plans to undertake the development of these courses in the near future in order to complete our fundamental undergraduate curriculum. Beyond the value that these courses have on their own, we expect that these prerequisite courses will have additional value because they will increase the number of students who are qualified to take our more advanced offerings.

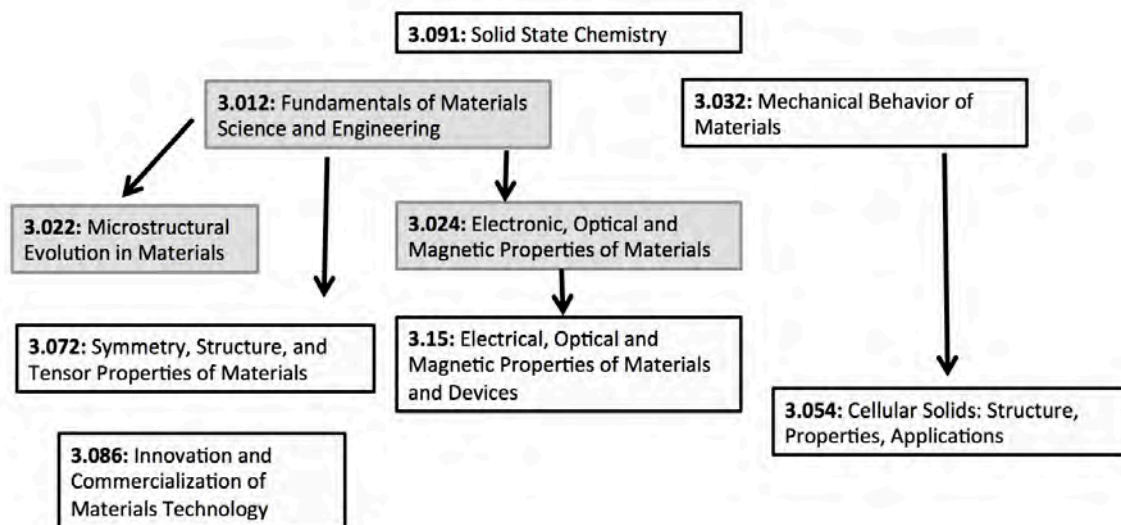


Figure 2. An overview of current online offerings and planned online course development. Courses in grey are planned or in development. Those in white have been previously offered as a MOOC on edX. Arrows indicate courses that are prerequisite to other courses.

In this paper, we have outlined the approach that we have taken to developing a comprehensive online Materials Science and Engineering curriculum. Having established that these courses have value both to the MOOC community and to our on-campus students, we will move forward to complete our development of a fundamental set of online MS&E course offerings.

5. Acknowledgements

This work represents the course development efforts of a large number of faculty and online course development experts. In MIT's department of Materials Science and Engineering, courses were developed and created by Prof. Michael Cima (3.091x), Prof. Lorna Gibson (3.032x and 3.054x), Prof. Eugene Fitzgerald (3.086x and 3.072x), Prof. Caroline Ross (3.15x), Dr. Andreas Wanklerl (3.086x) and Dr. Richard Taylor (3.071x). In MIT's Office of Digital Learning, Lana Scott, Caitlin Stier, Tsinu Heramo, Jessica Kloss, Douglas McLean, Shelly Upton, Lindsey Weeramuni, Geoff Wilson, Brad

Kay.Goodman, Caroline Soares, Lisa Eichel, and Dana Doyle have provided the course development expertise that has made these courses possible.

References

- [1] Pappano, Laura. "The Year of the MOOC." The New York Times. 02 Nov. 2012. Web. 5 Mar. 2016.
- [2] "Coursera" Accessed March 05, 2016. <https://www.coursera.org/courses>.
- [3] "edX.org." Accessed March 05, 2016. <https://www.edx.org/course>.
- [4] A. Margaryan, M. Bianco, A. Littlejohn, Instructional Quality of Massive Open Online Courses (MOOCs). *Computer & Education* 80: 77-83 (January 2015).
- [5] C. Piech, J. Huang, Z. Chen, C. Do, A. Ng, D. Koller, Tuned Models of Peer Assessment in MOOCs, Proceedings of the 6th International Conference on Educational Data Mining arXiv:1307.2579 9 July 2013.

Transforming Advanced Placement High School Classrooms Through Teacher-Led MOOC Models

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Abstract: *The Massive Open Online Course (MOOC) movement--which has typically focused on independent, online learners--has additional opportunities to reach students and teachers in traditional classrooms. Through collaboration between Davidson College, College Board, and edX, we report early findings of a teacher-led model utilizing open online materials in Advanced Placement (AP) classrooms. From the summer of 2014 to present, Davidson Next modules covering AP Calculus, AP Macroeconomics, and AP Physics have been delivered to high school teachers and students in three phases: 1) Pilot: a program prototyping content with teachers and students in North Carolina high schools, 2) edX: open online releases of content through edX.org, and 3) CCX: a new custom-course tool (CCX) offering private instances of MOOC material to teachers for use with students. We report enrollment and backgrounds of learners in each phase, and offering indications our content benefits student performance on externally validated AP exams.*

1. Introduction

The Massive Open Online Course (MOOC) movement has been proclaimed as both higher education's savior and an ineffective waste of limited educational resources. The technological potential to teach students across the world has led organizations like edX and its partners to produce and distribute nearly one thousand MOOCs since 2012. Despite the millions of students enrolled in these courses, the traditional broadcast nature of these online materials has produced mixed educational results and widespread criticism. As with many innovations, MOOC producers are adapting in response to criticism, using core components -- technology and content -- to explore more effective ways to deliver content to students. While the transformative technology of MOOCs can enable the widespread distribution of educational content, this paper illuminates more effective ways to deliver content to specific groups. In our case, high school teachers and their students.

Course surveys have shown that the MOOC movement has unintentionally engaged teachers around the world [1] and some teachers have responded positively to the idea of using MOOC material for in their own instruction [2]. Teachers offer a unique funnel of participation which could reorient criticisms that MOOCs only reach the well educated [3] and potentially allow organizations to more directly interact with the most disadvantaged via teachers. However, technology aimed at delivering MOOC content directly to teachers has generally lagged behind development of purely open online

instruction. Institutions that are energetically developing MOOC content could benefit from distribution models that facilitate both open online and teacher-led instructional models.

In this paper, we describe a unique program aimed at disseminating Advanced Placement content in both open online and teacher-led models of instruction. Called Davidson Next, this project has delivered Advanced Placement high school material to teachers and students around the world through three distinct program phases: 1) a Pilot with high school teachers and students, 2) open online via edX.org, and 3) using a new Custom Course (CCX) tool that allows teachers to manage a MOOC directly in their classrooms. We report enrollments in each phase and highlight analyses showing that usage of our content is correlated with student performance on AP Calculus AP.

2. Davidson Next Overview and Courses

Davidson College, in partnership with the College Board and edX, has created a suite of free, instructional modules addressing the 14 most challenging concepts in three Advanced Placement (AP) subjects. The project -- deemed Davidson Next -- covers challenging concepts from AP Calculus AB & BC, AP Macroeconomics, and AP Physics 1 & 2, where challenging concepts were selected based upon 2011-2013 AP exam data provided by the College Board. All modules are designed to help independent students master difficult concepts in the AP curriculum, while also providing AP instructors content which can be used to supplement (blend or flip) their classrooms.

2.1 Davidson Next

The Davidson Next team spent the summer of 2014 to spring of 2015 developing modules in each subject, overseen by four Davidson College faculty members with more than 80 years of combined experience writing AP curricula and exams, as well as overseeing the national grading of AP exams. Each module addressing a challenging concept was designed and taught by a high school AP instructor or college faculty member who also serves as a College Board consultant (e.g writing curricula, grading exams, etc.). Furthermore, a unique pilot program was administered in the Charlotte-Mecklenburg School district to have students and teachers interact with our content in real classroom settings. The overall design and testing of Davidson Next content represents a departure from many Massive Open Online Courses (MOOCs), in three ways:

Design with Teachers in mind. The original focus of the Davidson Next project was to support AP teachers through content designed to supplement teacher-led instruction in real classrooms (blended learning). Such design remains true, but content has been adapted such that any student with Internet access has the opportunity to access material and thereby gain mastery of difficult topics in the AP curriculum through edX.org. Delivering MOOC content for use in individual classrooms has been a particular challenge over the last year, but new tools from MITx and edX are making this possible.

AP high school teachers developed content. Each Davidson Next course features 14 modules, and each module is designed and delivered by a high school AP instructor, all of whom have worked with the College Board to write AP curricula and exams and/or grade AP exams. Between the

summer of 2014 and the spring of 2015, thirty-eight AP instructors from across the U.S. traveled to Davidson College to film instructional videos and develop content. All instructional material was developed in conjunction with Davidson faculty content-editors. Workflows focused on individual AP instructors first prototyping content in shared Google docs. These templates allowed content editors and module authors to make collaborative changes before and after visiting Davidson College for filming of instructional videos. The Davidson Next staff then loaded content from these templates into edX. In addition, interactive content and simulations were created for modules: vector-drawing problems, data-entry and plotting tools, and mathematical simulations. This content extended the collaborative process to include outside software developers that either created new tools, or adapted existing tools for the edX platform. Such interactive technology has been shown to effectively support student mastery of conceptual and even physical topics in mathematics and science-based courses[4] and was a major focus of this project.

Pilot program in Charlotte-Mecklenburg Schools. The Davidson Next team also initiated a unique “pilot program” with teachers and students in the Charlotte-Mecklenburg School district -- as well as a handful of other school in North and South Carolina. The Davidson Next Pilot Program was designed to both collect feedback from these users and to generate data from which the effectiveness of Davidson Next in achieving its goals (particularly the goal of mastery) would be assessed. In total, the Davidson Next materials were used on a trial basis by a group of 31 teachers and over 1,100 students over the 2014–2015 academic year. By design, the Davidson Next Pilot program collected a substantial amount of qualitative and quantitative data in addition to platform and survey data described above: responses to a series of student and teacher surveys (a pre-semester, mid-semester, and post-AP-exam survey), in-class observations, usage data from edX servers, teacher experience journals, teacher comments on the content, and teacher final reflection reports. The school districts from which the Pilot teachers were drawn have also provided data on student scores, backgrounds, and AP exam scores for all students from 2013-2014 to 2014-2015 school years.

An important aspect of the pilot is that the Davidson Next team was “building the plane as they were flying it.” The team created the module content over the 2014-2015 academic year, with most

Table 1: Curriculum coverage, number of AP instructors designing and leading modules, and number of resources in each Davidson Next course.

	Calculus	Macroeconomics	Physics
Curriculum Coverage	AP Calculus AB / BC	AP Macroeconomics	AP Physics 1 & 2
AP Content Creators	8	14	15
Number of Modules	14	14	14
HTML Pages	349	326	397
Videos	65	62	111
Problems	457	509	593
Interactive Problems and Simulations	50	66	85

classes only starting to use the material in January or February of 2015. The delay in implementation made it harder for teachers to use the online materials extensively, as well as reduced the total time that students could use the materials before taking the AP exam.

2.2 Module Structure and Courses

Davidson Next modules are organized in terms of the 14 most challenging concepts in each subject, as determined by College Board provided exam data from 2011 through 2013. Each Davidson Next course covers topics in the AP Calculus AB/BC, AP Macroeconomics, and AP Physics 1 & 2 curriculums. A challenging concept is one module, and all modules are designed to facilitate both teacher-led and individual-online instruction. The same general outline applies in each module:

- “Let’s See What You Already Know”—a series of pre-assessment questions to help students and teachers gauge their preparation.
- “Learning Cycles”— between 2 and 4 sequences containing an instructor-led video; technology-enhanced activities and questions meant to mimic AP-style exam questions.
- “Let’s See What You Have Learned”—a set of post-assessment questions allowing teachers to gauge student mastery and self-paced students to determine if they need further review.

Table 1 provides counts of the number of HTML pages, videos, problems, and interactive problems/simulations in each course. Efforts were made to insure a substantial number of AP aligned problems in each learning cycle within a module, with interactive problems, simulations, and activities introduced where applicable [5]. Overall content counts are on par with semester long MOOCs from MIT [6]. In addition, we use “course” to describe our content in Calculus, Macroeconomics, and Physics. This description can be problematic since our content is a collection of modules covering challenging concepts intended for dual use in open online and teacher-led settings. However, “course” represents the best term across each phase of our project.

3. Davidson Next Program Phases

Davidson Next has three distinct phases:

1. **Pilot:** The aforementioned Pilot with teachers and students served as both a means of collecting feedback on our content and a means for measuring effectiveness by collecting and analyzing student performance data.
2. **edX MOOCs:** On July 22nd, 2015, Davidson Next released all three MOOCs on edX.org - Challenging Concepts in AP Calculus, AP Macroeconomics, and AP Physics. The self-paced courses are free and open to enrollment by anyone.
3. **CCX (custom courses on edX):** On August 20th, 2015, Davidson Next began offering private instances of its MOOC content for teachers to use with their students. We announced an open call for teachers to beta test the tool in the 2015 – 2016 school year.

Table 2: Key features of the three Davidson Next program phases.

	Pilot	edX	CCX
Dates	Jan. 2015 - Jun. 2015	Jul. 2015 - present	Aug. 2015 - present
Audience	Charlotte-Mecklenburg Students & Instructors	Open Online	AP Instructors & their Students around the world
Recruitment	District agreements / Instructor recruitment	Advertised by edx.org	Communication from College Board and Davidson College
Users (1 click) as of 03/01/2016	1193	22,201	4661
Data Collected	Clickstream via edX Surveys Teacher focus groups Content markup from teachers	Clickstream via edX Surveys	Clickstream via edX Surveys Google Group

3.1 Data Collected in Each Phase

Across each phase we rely greatly on clickstream data collected via the edX platform and survey data collected via the Qualtrics survey platform. Clickstream data from edX are often the largest and most complex data sets, but offer the ability to observe many aspects of student behavior such as click-frequency, time-on-task, and pathways through content [7]. We have a survey embedded in the initial module of each course in the edX and CCX phases intended to gather a wide variety of background and program evaluation information, with particular questions focused on identifying teachers and students. The Davidson Next Pilot program collected a myriad of additional data sets from district data to focus groups. We summarize these data where appropriate.

3.2 Technology used to deliver content in each program phase

The technology of how we worked with teachers and students largely defines the three program phases, and hence, the data collected at each phase. Our most straightforward phase involved releasing our edX MOOCs through the edx.org site. Our courses were released asynchronously with no restrictions on enrollment. We are actively reviewing survey and clickstream data and finding trends comparable to previous reporting on MOOCs [2,7].

The most challenging phase was the Pilot phase, which required the creation of workflows and tutorials for providing teachers content, helping teachers enroll their students in the platform, and periodically updating content for all teachers. Tools to manage small private online courses - sometimes referred to as SPOCs - were essentially non-existent for our model. When providing a SPOC to a teacher, a clone of the original Davidson Next content was created and teachers could only point their students to content. That meant that any time content needed to be updated, all SPOCs had to be updated individually. Since some of our 34 teachers requested multiple SPOCs to facilitate multiple course sections, we had to maintain and update 64 individual instances of our content. Another difficulty of the SPOC process was a lack of content control by the individual Pilot teachers. Without discussing nuances, the SPOC model on edX at the time did not allow our teachers

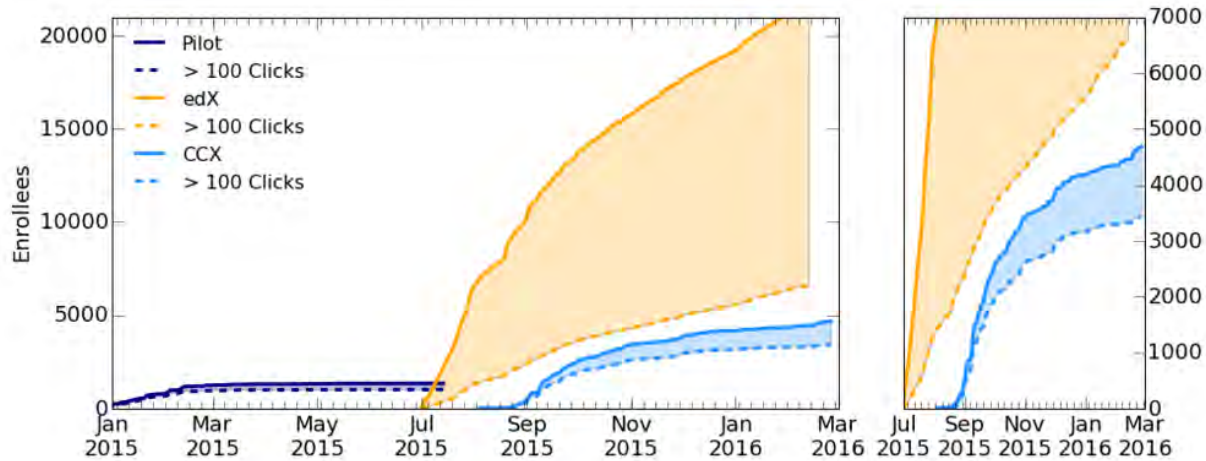


Figure 1: Enrollment by day for each phase of Davidson Next. Two curves are shown for each phase: solid lines indicate all enrollment to date, while dashed lines are users with greater than 100 clicks. The click filter is intended as a rough approximation of engaged users.

to regulate course parameters such as content assignment, due dates, or grading criteria. This meant that Pilot teachers were locked into global content parameters set by the Davidson Next team.

Serendipitously, in late Summer 2015 MITx began piloting a new tool allowing any edX MOOC to contain sub instances of that MOOC led by users separate from the course staff. The so called custom courses (CCX) is lead by a coach - or teacher in our case - who has access to course parameters like due dates and which content appears, while also allowing them to enroll learners and track their progress. In addition, the CCX resides inside the main edX MOOC, meaning any updates to the main course content are automatically inherited by the CCX instances. Hence, the CCX tool eliminated two of largest pain points from our Pilot phase, and immediately provided us an ability to scale our program to classrooms around the world. Table 2 offers a summary of key features for each Davidson Next phase. Throughout the remainder of this article, we will address data from each phase as “Pilot”, “edX”, and “CCX”.

A major concern for the Davidson Next is understanding how we can scale our program. To that end, Figure 1 shows daily overall enrollment (solid) and enrollees with greater than 100 clicks (dashed) in each phase of Davidson Next - the region between curves in a single phase is shaded for clarity and we note that 100 clicks is approximately the number of interactions required for an expert to complete the first module in each course. The edX phase by far enrolls the largest number of users and is still growing, while the Pilot and CCX phases saturate to a steady state of users. The difference between users that only enroll and those that have some minimal level of activity is much more drastic for edX, but can also be considered a natural phenomenon for the freely available, open online format. Saturation of the Pilot and CCX phase can be attributed to marketing; both programs had initial recruitment of teachers and students aiming to reach a minimum number of teachers and students. In contrast, edX marketing continues to recruit users in the open online setting.

Table 3: Cross-tabulation of high school teachers and students participating in each phase and course of Davidson Next. The “**” indicates Qualtrics surveys collected student / teacher and high school / non-high school distinctions. All data are taken as of 02/28/2016.

	Pilot	edX	CCX
Instances	64 instances	3 MOOCs	261 instances
N High School Teachers	34	1187**	261*
N High School Students	1129	2105**	4400
Total Users	1193	22201	4661
<i>N Users by course</i>			
Calculus	681	6929	2425
Macroeconomics	193	7252	479
Physics	319	8020	1757

We are particularly interested in comparing scale between the edX phase - reaching anyone around the world - and CCX phase - reaching teachers and their students in high schools. The right plot in Figure 1 zooms in on enrollment and participation for edX and CCX, and one can see similar structure in how the number of participants grows. We note that marketing for our CCX phase took place over a short window in August 2015, and although we do not draw inferences about participation growth, we postulate that the similar scaling behavior between the two phases from July to October suggests that the CCX tool can also scale instruction effectively.

4. Results

4.1 Are we reaching high school students and teachers?

The short answer is yes. Table 3 summarizes the total number of high school teachers and students in each phase of Davidson Next. For the pilot program, teachers and students are identified through direct interaction. All 34 teachers were recruited for the pilot, and teachers were responsible for enrolling the 1129 students in each of their instances. On edX.org, survey responses identify 1187 teachers and 2105 students. With only a ~31% response rate, there are potentially 3 times the number of teachers and students assuming a random sample. For the CCX phase, 294 teachers have worked with Davidson Next staff to set up custom courses, and like in the pilot, these teachers are responsible for enrolling the 4400 students. Also in Table 3, we highlight the enrollments by course.

For the Pilot and CCX phases, enrollments require direct interaction between teachers and Davidson Next staff, and generally, we regard an instance as a single teacher-led classroom utilizing Davidson Next content. Teachers must request instances, and it is a natural assumption that enrollees are students. There is an off-chance that a teacher would enroll a colleague or some other hypothetical, but we assume “non-student” enrollment to be a negligible factor in our analyses.

4.2 Partnering with Existing Educational Institutions

Partnerships have been a key component of the Davidson Next project, and have helped us more effectively reach high school students and teachers. On August 20th, 2015, the College Board sent targeted emails to AP teachers in these 3 disciplines, letting them know about the Davidson Next courses and how to register for a private instance (CCX). These emails were the culmination of a year and a half of collaboration, and the communication greatly enhanced our ability to reach users. From August 20th to present, there have been 608 requests for CCX versions of Davidson Next's Calculus, Macroeconomics, and Physics. A map showing geolocation of U.S. requests can be found in our recent blog post [8]. The College Board's communication was our only marketing effort.

4.3 Evaluating Effectiveness of Pilot Phase

As a part of our pilot program, we collected student and teacher level data from the Charlotte-Mecklenburg school district in an attempt to measure how student usage data from the edX platform predicts mastery and AP exam performance. The district data include student backgrounds, academic performance, and AP exam scores, while edX data includes various metrics detailing interactions with the platform [2,7]. At this stage our analysis focuses on AP Calculus AB/BC for the 2013-2014 to 2014-2015 school years. The AP Physics data were incomplete, and the AP Macroeconomics data did not contain enough students for reliable analyses.

To study the relationship between usage of the Davidson Next materials and success on the AP Calculus (BC) exam, we fit a difference in differences model [9] to predict the expected AP exam score for each student using only data available from the Charlotte-Mecklenburg School (CMS) system. Our independent variables include each student's gender, race, year in high school, and GPA, along with whether their teacher participated in the Pilot program. This approach compares

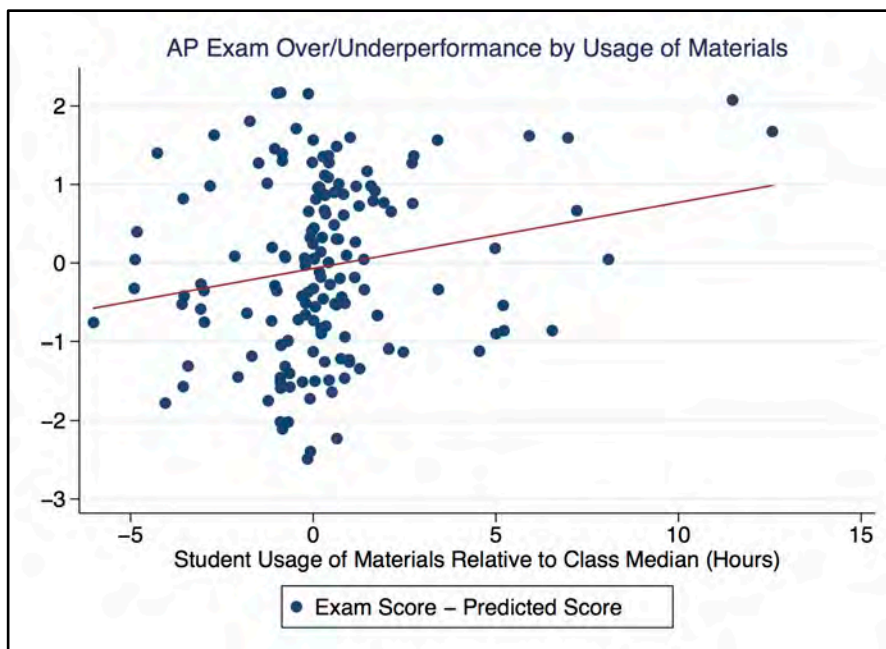


Figure 2: Difference in Differences model comparing student predicted AP exam performance versus usage of Davidson Next for AP Calculus BC students. Exam performance is predicted using district data collected from CMS school system. Exam score residuals are then correlated with student usage relative to class median indicating 0.08 points per hour spent ($p < .05$).

Davidson Next pilot students to students with similar characteristics taking AP Calculus from the same teacher in the year before the pilot. Second, we subtracted students' predicted performance in our first step from their actual performance on the AP exam. This residual variability in performance cannot be attributed to observable differences between students, such as their high school GPA or demographic characteristics. Third, we plotted each student's residual against their actual usage of the Davidson materials *relative to their classmates* (specifically, we compared individual student usage to the class median) - see Figure 2. Our reliance on within-class variation in usage helps us answer the question: Compared to similar students in the same class, did greater usage of the Davidson Next materials explain why some students performed better than expected? We found that it did. We estimate that each additional hour of usage predicted an additional 0.08 points on the AP Calculus BC exam. The findings are statistically significant ($p < .05$) and similar across a variety of usage metrics. While we cannot conclude that this relationship is causal, and measures of usage time in online settings are only estimates, the existence of a relationship between usage and performance *beyond what one would predict based on student characteristics such as GPA* is reassuring evidence of the efficacy of the Davidson Next materials.

5. Discussion

Most open online courses already enroll a significant percentage of teachers. An initial study of spring 2014 MITx courses revealed 28% of survey respondents identified as teachers[1]; a broader survey of both HarvardX and MITx courses indicated 39% of survey respondents were teachers[2]. Surprisingly, Davidson Next has slightly lower rate of teacher enrollment of 23% on edX, with 17% from high school. The edX phase currently has 1187 high school teachers registered.

Table 3 provided the number of high school students in each phase. The average pilot class roughly 20 students - on par with average class size across the United States. For CCX, the number of instances does not quite meet the projected value of 5220 students. The structure of the pilot program - permission slips, regular interaction between Davidson Next and pilot teachers - may have led to the vast majority of students being enrolled. The CCX phase provides far less structured interaction, which may lead to fewer students enrolled. But, the CCX enrollment (with limited marketing) approximates the edX enrollment of 6882 high school students.

Finally, the analysis of our Pilot program indicated that greater usage of our content had a positive relationship with AP exam performance, but we also point out some important caveats: 1) content was being built during the pilot, hence, this was not a full treatment with all Davidson Next content, 2) student usage varied greatly, and 3) teacher motivation and style of usage also varied. To cut through this variability, our analysis examined how usage relative to classmates predicts AP exam performance. Our hope is to continue this analysis by reviewing more of the pilot qualitative data, as well as quantitative evidence from the edX and CCX phase, which will require AP exam scores.

6. Conclusions

In conclusion, Davidson Next innovates in numerous and significant ways, from the data-driven development of content by leading high school AP teachers, to the engaging interactive online content matching established College Board curricula. This matching enables a standardized, authoritative evaluation of content's effectiveness (via the AP exams), which in turn translates into established course credit at U.S. institutions of higher education. These strengths have led thousands of students and teachers across the world to use the Davidson Next materials during its first year.

This widespread adoption is only part of the rapidly expanding wave of digital learning. The most effective of these innovations combine engagement through online interaction and modular personalization to meet each user's needs. These qualities are central to Davidson Next. In a world of increasingly demanding, distracted, and segmented audiences, these qualities will increasingly become necessary conditions for any product aiming to help students access and master challenging material like AP Chemistry, Macroeconomics, and Physics.

7. Acknowledgments

Davidson Next thanks our partners for their time, talent, and financial support: The Laura and John Arnold Foundation, Davidson College, College Board, edX, Charlotte-Mecklenburg Schools, 2Revolutions, OpenCraft, Jean-Michel Claus, Christopher Chudzicki, Analia Barrantes, Elina Hu, Peter Pinch, the Office of Digital Learning at MIT, MITx Engineering, and Priceless Misc. Our sincere thanks to Davidson faculty members who served as lead editors for Davidson Next: Dr. Larry Cain, Dr. Clark Ross, Dr. Stephen Davis, and Dr. Ben Klein. Finally, our sincere thanks to 40 AP teachers and college faculty who traveled to Davidson College to help film and build materials, as well as the more than 30 high school AP teachers who piloted our modules in 2014-2015.

8. References

- [1] Seaton, Daniel Thomas, et al. "Enrollment in MITx MOOCs: Are We Educating Educators." *Educause Review* (February 2015) (2015).
- [2] Ho, Andrew Dean, et al. "Harvardx and mitx: Two years of open online courses fall 2012-summer 2014." Available at SSRN 2586847 (2015).
- [3] Emanuel, Ezekiel J. "Online education: MOOCs taken by educated few." *Nature* 503.7476 (2013).
- [4] Finkelstein, N. D., et al. "When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment." *PRST-Physics Education Research* 1.1 (2005).
- [5] <http://blog.edx.org/davidson-next-interactive-content-for-students-and-teachers>
- [6] Comparison with MIT is made out of convenience. Course reports released in 2014 highlight course structure. For example: Seaton, Daniel Thomas, et al. "8.02 x Electricity and Magnetism MITx on edX Course Report-2013 Spring." (2014). http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2382328
- [7] Seaton, Daniel T., et al. "Who does what in a massive open online course?." *Communications of the ACM* 57.4 (2014).
- [8] <http://blog.edx.org/empowering-teachers-and-students-around-the-world?track=blog>
- [9] Angrist, J. D., & Pischke, J. S. (2008). *Mostly harmless econometrics: An empiricist's companion*. Princeton university press.

**M.A.P. Makers:
Transforming Residential Education
with a Technology Enhanced Pedagogy**

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Abstract

While Massive Open Online Courses have helped expand access to education beyond the traditional system, technology has not been as impactful for residential education, largely because it is being used primarily to provide access to information that students already have through their smartphones. In contrast, the M.A.P. Maker pedagogy uses technology to make learning social, purposeful, and more autonomous, thereby enabling new types of immersive and project based learning experiences such as the Greengineering and Capstone Projects programs. Viewed through this lens, technology enhances residential learning by empowering students to become mapmakers, lifelong learners capable of solving complex problems.

1. Introduction

In the years since their creation it's fair to say that while MOOCs have helped democratize access to education and have given millions of students around the world access to world class courses, they have not had as much of an impact on the residential education system and many of the predicted transformations have yet to be implemented. This outcome shows that transforming residential education – whether in high schools or colleges and universities – requires a different approach to technology than the MOOC in order to create a system that helps every student discover and reach his or her full potential. Instead, this transformation requires new technology-enabled pedagogies, centered around passion and enthusiasm for learning and made possible by technology.

The reason that MOOCs and many of other promising technologies fail to transform residential education is because they are built on a mistaken assumption – that what limits student's learning is access to information. In making this assumption, these technologies are designed to help students access course information in a more personalized manner, but in an

environment where students have access to the world's information in their pockets the truth is that it is not a lack of access that limits learning but a lack of access to *inspiration*. Until recently, what limited a student's ability to solve interesting problems was access to information, and that meant that the best way to prepare students was to give them as much information as possible in advance so that they would be prepared when they came across the problem that inspired them. In contrast, students can now find the information through Google the moment they need it and what limits them is aspiration and perseverance – the desire to find and solve an inspiring problem and the determination to stick with it even when it gets challenging.

The challenge then is to use technology as a tool to teach students the enthusiasm to learn, rather than help them access information they can easily find elsewhere. Having access to the world's knowledge on a smartphone means that now is the single greatest time in history to be a learner. Our theory is that if we as educators can teach a student to become passionate about a topic, then she will go out of her way to learn as much as she can. As best selling author Seth Godin says, "When it's work people want to do less of it, and when it's art students want to do more." [1]. Right now school is something most students want to do less off, and technology will not solve that problem if it only provides access to information. What solves that problem is passion, and as Seth Godin explains, "we can't...digitize passion." [2].

Over the course of the last ten years, we have developed and implemented a new pedagogy that addresses the challenges we raised in both high school and college. This pedagogy is enabled by new technologies, but at its core it is about helping students discover an enthusiasm for learning and in doing so realize that they are capable of more. Sugata Mitra explains this in his research when he writes, "We need a pedagogy free from fear and focused on the magic of children's innate quest for information and understanding." Our pedagogy brings passion and purpose into the classroom and makes school art. It teaches students to take ownership over their own learning and become their own teacher, fulfilling the true purpose of school in preparing students for life beyond the classroom. We have created what we call the M.A.P. Maker pedagogy and in the coming sections will define this pedagogy, then detail its practical application through two programs we've created and scaled, and lastly discuss how technology makes this pedagogy possible.

2. M.A.P. Makers

In his book *Linchpin*, Seth Godin defined a mapmaker as someone who is comfortable navigating without a map, someone capable of first defining where they want to go and then figuring out a way to get there [1]. If we want students who are capable of solving the biggest challenges of the 21st century – energy, clean water, food, healthcare, cybersecurity -- and if we want these students to do all this and also be engaged citizens, then we need to teach our students to be mapmakers, to be comfortable dealing with uncertainty and unknowns. Students who are mapmakers can chart a course to the edge of human knowledge and extend the horizon.

Mapmakers are empowered by the idea that having access to all of human knowledge in their pocket means that now more than ever they have the power to change the world. Our educational system needs to make mapmakers.

There is a map to making mapmakers. This map, first defined by Daniel Pink has three parts: Mastery, Autonomy, and Purpose [3]. What is special about this M.A.P. is that it identifies three essential elements to human motivation. It is also creates the frame by which we can begin to engage students. Once they are engaged they become passionate and that passion propels them to pick a destination and never stop exploring. Each time a student completes that process, they create a map, and after creating enough maps the student becomes a mapmaker. The key to the M.A.P. Maker pedagogy then is grounding all learning experiences in Mastery, Autonomy, and Purpose.

Mastery is defined as the positive feedback from improving at an activity [3]. It is the feeling a student may get from practicing a new piece of music on the violin or piano and finally perfecting the complex melody. The positive feedback that Mastery provides creates a psychological reward for students and makes them hungry for further improvement. While sport and art provide plenty of opportunities for Mastery, most classrooms and assignments provide little or no positive feedback. Chapter tests and alpha-numeric grades can not serve the same function. Most students simply don't get the same excitement from a getting a perfect score on a homework as they do from getting a perfect score on a gymnastic routine. Without opportunities to pursue Mastery, students will not sustain the motivation needed to become lifelong learners.

Autonomy is the universal urge to direct our own lives [3]. It is the about having the freedom to choose which goal to pursue and how to measure progress and success. There is no autonomy in a course syllabus, which not only defines exactly what will be learned, but also how it will be taught and assessed. The student is given a map to follow rather than being told to make their own. When students are given autonomy, they develop a feeling of control and ownership; they become part of the crew instead of being passengers. Again, students on sports teams or in orchestras are given autonomy about what to practice on their own and how often. A traditional homework assignment is the exact opposite. With Autonomy, students have the freedom to figure out the best to learn a given topic and their own individual learning style.

Purpose is a student's belief that what they are learning matters above and beyond the classroom and the next exam, that it makes a difference in the real world and impacts other people's lives [3]. It's easy to see from the cheer of the crowd or the audience's standing ovation that a sports game or musical performance has a purpose, but trigonometric identities and iambic pentameter are often a harder sell. When students understand the purpose behind a topic, the curriculum comes alive and students realize that it matters. When students see how trigonometric identities are used to measure the positions of satellites that do everything from predict the weather to enable space communication, suddenly the math takes on a deeper meaning. With Purpose, students finally get the answer to the question of "why are we learning this?" besides that it will be on the test.

Taken together Mastery, Autonomy, and Purpose create a framework that fully engages students and gives them the tools to become mapmakers. The M.A.P. Maker pedagogy is about creating learning experiences imbued with Purpose, that give students Autonomy, and that provide regular opportunities to pursue and eventually showcase Mastery. Over the course of the last ten years, we have applied this pedagogy in classrooms around the world through a number of programs, starting with Greengineering and Capstone Projects.

3. Capstone Projects

The [Capstone Projects](#) (CAPS) program was created in 2008 at Newton North High School to solve one of the most pronounced problems in the residential educational system – senior slump. The hypothesis was that the M.A.P. Maker pedagogy could be used to create an advanced research seminar that gives students an independent academic experience outside of the familiar classroom setting with the focus on independent inquiry and intellectual growth that would fully engage students and prevent the traditional second semester senior slump. Through the CAPS program, students pursue a researchable question on a topic of their choosing through traditional quantitative and qualitative research methods along with a substantial field-based inquiry project. For the students, the goal is to develop a topic that inspires them, investigate that toward Mastery, and become a Senior Year Scholar.

In order to make Mastery the expectation for all students, the CAPS curriculum is grounded in Purpose and Autonomy, which is made possible thanks to a suite of digital and online tools, primarily wikispaces and google docs, which were groundbreaking in their application when CAPS first started in 2008. In the context of 2008, these emerging digital tools helped students and faculty organize information in a context of connected transparency. While sharing on Google docs is controlled, the wikispaces (project portfolios) are, by design, made public. Students are tasked with collating secondary and primary data for their own learning and for a public audience. Our pedagogical choices disrupt the tradition of producing work for a single teacher and position our students to enter and contribute to the larger conversation of their chosen research topic - the ultimate goal of academic research. By giving students the opportunity to pick a topic about which they are passionate, there is never a question about the Purpose of what they are learning. Recognizing and clarifying their Purpose is built into the program from day one, beginning with project proposals that specifically asks them to identify the impact they want their project to make on themselves, their peers in the class, their community at large, and the world. Seniors begin the CAPS process by submitting a research proposal. The CAPS curriculum then helps students refine the proposal through a series of deliverables that demand a granularity through both secondary and primary research. This process allows students to find the level of impact that most resonates with them and focus on the details of a topic accordingly, such as recording a concept bluegrass album that transforms a student as a musician, creating an aquaponics system to help a community grow their own food,

or researching cause marketing to inspire a generation across the world. What is even more remarkable is when you combine fifteen to twenty of these students—each one passionate about their individual Purpose and project – into a section and see how they inspire each other.

Once each student has selected their topic and completed the project proposal, the students begin an intensive seventeen week curriculum that teaches them the primary and secondary research skills they need to successfully complete their project. This curriculum is powered by a set of evolving digital content modules that guide students through each step of their project, from initial proposal to final presentation and paper. Students use simple but powerful tools like google apps (sites, slides, docs, spreadsheets, and forms) to document their research, and they create a public wikispaces website, for their learning portfolio, giving students the Autonomy to showcase their learning in ways that suit their individual learning style and project topic. The wikispaces platform enables students to upload unlimited files, photos, and videos about their learning; create unlimited pages to organize different elements of their project; and create a public presence for the project that inspired a higher level of professionalism and sophistication to their work. This broad functionality and flexibility offered students the Autonomy to tailor their learning portfolio to their project, such as embedding the music videos that inspired the bluegrass concept album along with annotations about the lyrics and sound. Furthermore, these digital tools facilitate collaboration by making it easy for students to get feedback from each other and from a series of readers, other faculty in the school that serve a role analogous to a thesis committee. By making it easy to receive meaningful, project-specific, and actionable feedback, students can revise and edit their work more quickly and ultimately demonstrate their Mastery of a given topic, using the comments they receive with each successive iteration as positive feedback.

The culmination of the CAPS program is the final paper and final presentation, where the student is placed in the position of the expert and asked to evaluate and synthesize their experience and learning. These deliverables occur at the end of the seventeen week process, including six weeks where the student withdraws from their traditional classes and does independent inquiry outside of the school, all while meeting weekly with their reader and documenting their daily process on their wiki. Requiring students to document the daily process forces students to organize their learning, providing the structure necessary for the independent learning process to flourish. This combination of unprecedented freedom is made possible by making Mastery the expectation, challenging students to use their presentation and paper as means to demonstrate their learning beyond a reasonable doubt and to celebrate the obstacles they overcame along the way and how those challenges stretched them intellectually and personally. Their final presentation and paper are also uploaded to their wiki, creating a permanent public-facing demonstration of learning together with the details of the learning process and student growth. Ultimately, CAPS provides a learning opportunity unlike anything in the traditional high school experience and one that students say had a tremendous impact:

“I cannot possibly say enough about CAPS. It taught me to manage my time, do independent research, and most importantly it taught me to take pride in my work and take ownership of my education. The research skills CAPS taught me absolutely gave me a leg up in college. But concrete insights aside, CAPS reoriented the way I think about my education. I realized I could drive my own learning — and in college, where most papers and assessments are very open ended, that’s a valuable outlook. I would recommend CAPS to every student. It’s a great feeling to be trusted by your school.” – Jordan A., class of 2010, Yale University class of 2014

Experiences like Jordan’s are typically in the CAPS program, but what is even more amazing is that it is not just top students headed for Ivy League colleges who thrive in this program. In any given year, the CAPS program has an equal balance of AP and Honors Classes students with students who have struggled in a traditional classroom. In the years since the CAPS program has launched, it is grow to attract up to ten percent of the seniors in a graduating class in one school, like Newton North HS and it is identified as a national model by the Ford Foundation and the National Capstone Consortium. This CAPS curriculum has also been adapted to a [freshmen seminar at MIT](#). Moreover, the success of CAPS program proved how powerful the M.A.P. Maker pedagogy could be and in doing so laid the foundation for its future implementation.

4. Greengineering

Inspired by the success of the Capstone program, Greengineering is a new type of class that, first and foremost, was started with a Purpose. Founded in 2009 at Newton North High School, Greengineering started with the audacious mission that students could help prevent climate change and create more sustainable future by learning to process their own biodiesel fuel from the waste vegetable oil used in the cafeteria. Similar to CAPS, we knew that Purpose was integral to Greengineering, but unlike seniors submitting research proposals, we needed to initiate the connection to Purpose to give students an opportunity to solve a real complex problem in their community—reducing waste from the cafeteria—but do so in a way that could have a global impact—reduce fossil fuels by creating a carbon neutral fuel. While this Purpose was first applied to biodiesel, it was broad enough that it enabled Greengineering to grow beyond into sustainable fabrics, aquaponic farming, solar art installations, and more. By having a well defined Purpose, Greengineering engages students in their work in ways not seen in a traditional classroom, and it continuously inspires them to discover new topics and problems to solve.

Greengineering also incorporated Autonomy from the first day of class. Students were not given a syllabus but were asked, “how much fun could we have designing the future?” Students were encouraged to investigate all of the different aspects of biodiesel processing—building the reactor, the chemistry of the reaction, the economics of manufacturing biodiesel, the industrial safety practices, and more. Students then got to pick which topic they were most interested in and were divided into teams based on that choice. Each team was charged with becoming an expert on their topic and presenting their work to the class as a whole,

using online tools like the [Greengineering Wikispace](#) and google presentations. This process centered around what the book *Nudge* calls “choice architecture”, giving the students the freedom to pick from a preselected list, so while the students gets the freedom to choose, all of the choices have a positive educational outcome [5]. As Greengineering grew and the scope expanded, students had the Autonomy to pick projects from topics like biodiesel, sustainable materials, and aquaponics. This Autonomy made the students more engaged because they were genuinely excited about the topic they had to learn.

Without each team of students successfully mastering their topic, the class would not be able to produce biodiesel. Mastery, therefore, was essential in Greengineering, and successfully producing usable biodiesel fuel was the ultimate source of positive feedback. Even before then, putting each team in the position of the experts forced them to operate with the Mastery mentality. The teams had to find and review scientific papers online, email professors and industry experts, and document their findings on the wiki so their peers could learn too. Each team felt positive feedback not only from understanding the key concepts within their topic, but also from seeing their classmates do the same. Furthermore, because biodiesel involves processing chemicals that can be dangerous if improperly handled, students understood that this responsibility meant that the team had to understand all of the elements of the process. All of this came together when in early December, four months into the school year, when as a class they produced the first successful batch of fuel.

The successful production of the first batch of biodiesel proved a turning point in the Greengineering program. That fuel represented the validation of the M.A.P. Maker pedagogy by showing the students that they could in fact achieve their biggest goals. Naturally, that success inspired students to dream even bigger and set new goals, providing the students with more Autonomy and more opportunities for Mastery. In learning how to produce biodiesel, these students transformed into mapmakers. Their success in turn transformed Greengineering; as other students in the school saw their Greengineering peers’ transformation, they were inspired to sign up for the class. Over the course of the next few years, Greengineering grew from one class with seventeen students to a four-year sequence with five different classes, with over two-hundred students (each semester), including a freshman exploratory class and a senior major class that meets twelve hours a week. Greengineering also maintains an enrollment of around 20% IEP and over 50% female students, far greater than the national average for a STEM class. The projects have expanded to cover everything from solar panel installations to playground power to mycelium surfboards to algal lipid cultivation and extraction for fuel research, all of which were first proposed by students who were inspired by an article or video they read online and wanted to learn more. Each of these projects is still grounded in the same Purpose that first inspired the students to pursue biodiesel and become mapmakers.

5. Leveraging Technology

While both Greengineering and Capstone Projects both are made possible by technology, these programs use technology very differently from MOOCs or most experiences. Indeed while the M.A.P. Maker pedagogy would not be possibility without technology, the focus is not on using technology to provide tailored access to information, but to provide students with ways to document their learning using tools like Wikispaces and Google Apps while maintaining Mastery, Autonomy, and Purpose.

Rather than using technology like a traditional MOOC and giving students a platform with all the information they need to learn, the M.A.P. approach challenges students to find the information they need for themselves. The assumption behind this approach is that the kind of problems students will need to solve after school will not have all the information they need in a single place. Instead, students will have to determine for themselves what information they need and what constitutes a reliable source of information, and those two steps are often more difficult than understanding the information. In skipping these crucial steps and using technology to give students all the information they needed, educators not only strip students of the Autonomy they need to feel fully engaged, but they also rob them of the critical opportunity to develop the meta-research skills that will be essential to their future success. In a world where information is expanding at an exponential rate, perhaps the most valuable skill a student can develop is figuring which information is relevant to solving a given problem. The M.A.P. Maker pedagogy is built around this premise and always challenges students to go online and find the information they need for themselves rather than pointing them a pre-selected source.

In addition to giving students the Autonomy to find information for themselves, the M.A.P. maker pedagogy also uses technology to provide students with Autonomy in assessing their learning using the wikispaces platform to share photos, articles, literature reviews and more. Both Greengineering and Capstone projects use technology to document learning in ways that provide a far richer assessment than a unit quiz or final exam ever can. By having students create interactive wikis and multimedia portfolios with photos, videos, annotated literature reviews, and more, technology enables students to document their learning in ways that can capture the depth of their exploration and knowledge far superior to a transcript or letter grade. The next level of digital tools is also developing rapidly through the use of Twitter, Instagram, and Flickr, but once again the Google suite of apps makes documenting and integrating learning almost seamless with photo/video capture apps that save to YouTube channels and shared folders. Furthermore, these online portfolios can help enforce Mastery, challenging students to highlight the “ah-ha” moments where the topic suddenly clicked for them, and making the expectation that they document their learning in a way that demonstrates their expertise on a topic beyond a reasonable doubt. It also gives students the opportunity to document their learning process, encouraging them to create their own project plan, Gantt chart, syllabus, or map in a forum where they will have the accountability that only comes from making a public online commitment. These portfolios also help students improve their communication skills as they have to understand their audience and create a portfolio that is tailored to that demographic.

Lastly, these online portfolios help cement the Purpose of learning about a given topic in a way that a traditional assessment never can. Having students showcase their learning online creates a public record of their learning, something that they can share with their family and friends as well as anyone else online who is curious about the topic. Creating online portfolios makes learning social and gives students the opportunity to share their emerging expertise. Students can get feedback from their peers and recognized experts on the topic, instead of just their teachers. It puts students in the position of the expert and gives them the opportunity to teach their peers around the world. It helps create a worldwide community of learners who celebrate and affirm each other's learning opportunities. Educators already know how magical it feels to help a student understand a topic, and having students create online portfolios that let their work help teach other people is a Purpose so powerful it can inspire a lifetime of learning. This is in direct contrast with a homework assignment that only a teacher ever sees. When a student is told that they must make a website that the general public can see and learn from, the student gets a sense of pride in their work that comes from the powerful combination of Mastery, Autonomy, and Purpose. These online portfolios form the core of how the M.A.P. Maker pedagogy uses technology and helps create a scalable platform to showcase and assess learning, giving students a way to document the whole learning process from linking the videos and articles that inspire them, the resources and experts who helped train them, and the final exhibit they made to document their learning.

7. Conclusion

New technology is already helping to improve access to education outside of the traditional system, but most residential institutions are not using technology in ways that help students achieve their full potential. As long as technology is only used to provide access to information instead of providing students with a Purpose, enabling them to learn with Autonomy, and pursue Mastery, students will never achieve the level of engagement seen in either Greengineering or Capstone Projects. By using technology to enable the M.A.P. maker pedagogy, educators can create learning experiences where students discover they are capable of more and learn to take ownership over their education.

In the years since launching the Greengineering and Capstone programs and validating the power of the M.A.P. maker pedagogy, we have worked to share our findings with educators from around the world, using technology to help scale the impact. We made our curriculum, assessments, and instructional strategies open source because we believe in disseminating best practices and fostering professional relationships. We used the same technologies as the students to share the pedagogical insights that first made CAPS possible. We've also hosted visiting scholars from the U.S. State Department and educators from places like Cairo, Singapore, Hong Kong, and Sydney who wanted to bring these programs to their schools.

Educators looking to create these types of learning experiences for students should start in the school library. Not only do all schools have libraries, but they already serve as the location for research, discovery, and synthesis. Moreover, librarians are the experts in providing both sources of inspiration, curating material and experts on a given topic, and technical support. By offering this support, librarians bring the human element, the Purpose, to the hub of digital learning. For example, students who want to take online classes, like MOOCs, can do so in the library, and the librarian can help connect the students with resources that demonstrate how the MOOC curriculum relates to their daily lives and local communities—adding Purpose to the curriculum. Furthermore, giving students the opportunity to take these courses and have these learning experiences in the library provides the students with enough Autonomy to engage them in the learning process while also providing the right level of support to help students with time management and other meta learning skills. Lastly, by placing students in this learning environment with their peers, they can provide each other with the positive feedback that enables Mastery. In short, the library is perfectly positioned to support technology-enabled learning in ways that are aligned with the M.A.P. Maker pedagogy, giving students a spectrum of blended learning options that expands alongside the scope of the students’ maps.

Right now the students who learn to become mapmakers often do so in spite of their residential education system rather than because of it. The experiences that truly engage them – ones that they will go out of their way to do more of – largely occur outside of the classroom at football or soccer practice, at rehearsal for the musical or orchestra, at their job or community service. These are the institutions where students are thrust into the role of the expert, given a Purpose that inspires and motivates them, trusted with the Autonomy to make decisions, and expected to practice their craft until Mastery. What if these experiences were the core of the educational system instead of the exception? What if every student left school so hungry to learn that they were guaranteed to be lifelong learners. We’ve shown how this transformation is possible by rethinking the role of technology in education and recognizing that learning is not information limited but aspiration limited. Technology has already made opportunities to learn nearly ubiquitous and now the challenge is to do the same for inspiration.

References

- [1] Godin, S., *Linchpin*, Portfolio, New York, 2011.
- [2] Godin, S., *Stop Stealing Dreams*, Self-Published, 2015. Accessed online at <http://sethgodin.typepad.com/files/stopstealingdreams-2015.pdf> on March 5 2016.
- [3] Pink, D., *Drive: The Surprising Truth About What Motivates Us*, Riverhead Books, New York, 2011.
- [4] Sinek, S., *Start With Why*, Portfolio, New York, 2011.
- [5] Thaler, R.H., and Sunstein, C.R., *Nudge: Improving Decisions About Health, Wealth, and Happiness*, Penguin Books, New York, 2009.

On The Integration of Formative Assessment in Personalized Web-based Learning System for Scientific Investigation

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Abstract

Formative assessment is an instructional strategy that educational researchers increasingly reported its positive impact on student learning. To maximize student learning in conceptual science, this study employs the formative assessment strategies as a pedagogical tool to supervise self-directed learning in scientific investigation with a personalized web-based learning system. In this system, we created a set of rules for integrating learning experience and learning style given by each student with the aim to providing the accuracy of individual learning activity. Moreover, the design of embedded formative assessment could function to form students' conceptual knowledge of science concepts and procedural knowledge of scientific investigation. Based on the proposed approach, the formative assessment-embedded personal learning system was implemented with 27 Thai high school students on a physics lesson to investigate impact of this proposed approach, comparing with 29 students who interact with conventional (content-oriented) web-based learning environment. The preliminary result showed that students who learned with the formative assessment-embedded personal learning system had better learning achievement than those who learned in conventional web-based learning environment.

1. Introduction

As technology becomes more prevalent in society, schools are increasingly using technology in science classes [7], [14]. Concurrent with the rapid growth of digital technologies and the integration of Information and Communications Technology (ICT) tools in the practice of science education, several educators and researchers have attempted to develop technology-based instructional materials and approaches for enhancing conceptual learning in science [18], [19]. In recent years, contemporary ICT-based approaches to science learning offer the World Wide Web (WWW) or web-based technology with new possibilities for the delivery of instructional materials, and ample opportunities for students' inquiry-related web-based learning environments to develop scientific conceptual understanding. Moreover, the advancement of web-based technologies has encouraged an increasing number of studies concerning web-based learning environment, in which students are able to learn science-based contents anywhere and anytime. Through the web-based science learning environment, researchers and educators attempt to find the way to stimulate and sustain student motivation, in

order to enhance better learning, through the design of effective interactions in web [17], [21]. Currently, much research has explored students' learning processes and performances in the web-facilitated science-based lesson [8], [9], [13], [22], [23]. However, without employing appropriate theories and instructional strategies in harmony with the unique features of the web-based learning environment, the expectations of higher learning outcomes will not be reached [24]. Therefore, researchers have emphasized the need for well-designed learning support in order to improve the students' learning achievements [9]. Moreover, it is a challenge to develop web-based learning environment that is suitable for the varied needs of individual students such as different learning style.

To maximize student learning, a numerous instructional methods and approaches have been proposed for enhancing the effectiveness of web-based learning system. Formative assessment (FA) is an instructional strategy that many educational researchers recommended to use to inform subsequent learning, and it revealed considerable positive impact on student learning [2], [5]. However, studies on formative assessment strategy and its effects on learning achievement are not nearly as plentiful as they should be. Some of researchers suggested that it is an effective educational intervention for improve student learning [1], [19]. The strategy of formative assessment could be used to supply valuable information for inquiry-based teaching practice in science in order to induce a cognitive process of conceptual formation [19]. In additions, formative assessment via web-based technologies can be used to facilitate students' understanding of course content, teach important concepts and principles, and allow students to engage in problem-solving processes [4], [15]. To explore the effects of formative assessment embedded web-based technology, many researchers focus to study on the integration of formative assessment into web-based learning system. For examples, Buchanan (2000) showed that a web-based formative assessment strategy is able to improve student learning interest and student scores [3]. In additions, Hwang, Chu, Yin, & Lin (2008), and Hwang & Chang (2011) reported an innovative approach for improving student learning in web-based learning environment that the mechanism of formative assessment and feedback not only promotes the students' learning interest and attitude, but also improves their learning achievement [9], [11].

Although web-based environment studies have mentioned that it is an effective teaching method for development of learning achievement as well as formative assessment strategy, and hypothesized it would have beneficial impact on conceptual development in science, only a few studies focused on how to integrate formative assessment and web-based technology to enhance conceptual learning in science. Therefore, an innovative approach of integration of formative assessment into personalized web-based learning system is proposed to elicit student's conceptual learning problem, and integrate learning experience with learning style from each student's characteristics, and formative assessment strategy for improving conceptual learning in science. Moreover, its preliminary result is also presented in this paper.

2. The Personalized Web-based Learning System with Formative Assessment Mechanism

In this study, the personalized web-based learning system with integration of formative assessment strategy is developed for conducting scientific investigation on the conceptual physics of simple electricity in high school level. This system is implemented with MySQL, PHP, and IIS. Although several studies revealed that two important factors (learning style and learning experience) have been usually applied in developing personal web-based learning systems, previous experiences of practical applications have also revealed some importance of matching them together (Srisawasdi et al., 2012). To cope with this issue, in this study, an expert system approach is employed to matching learning style and learning experience of each student to specify scientific investigation-oriented learning activity for individuals, as shown in Figure 1.

In this learning system, the integrated learning styles and scientific investigation-based approach consists of the following three phases:

Phase 1: Learning Style Knowledge Acquisition phase: This phase is invoked to elicit learning style information from individual students. In this phase, each student is asked to provide the answer of the Felder and Silverman's (1988) Index of Learning Styles test [6]. This test contains 44 forced-choice items covered by 4 dimensions (i.e., Active/Reflective, Visual/Verbal, Sensing/Intuitive, and Sequential/Global). Each dimension contains 11 forced-choice items, with each choice (a or b) corresponding to one or another category of the dimension. After the students submit the answer, the system will analyze learning style of each student. For example, a student (S1) could be an Active learner, whereas another student (S2) could be an Intuitive learner. A student will be classified in one of the two options in all four dimensions.

Phase 2: Learning Experience Knowledge Acquisition phase: This phase is invoked to elicit learning experience preferences from individual students. In this phase, Kolb et al.'s (1995) learning experience test is used [15]. This test is covered by four dimensions (i.e., concrete experience, reflective observation, abstract conceptualization, and active experimentation) and contains 9 items. Each student is asked to respond a numeral "4" indicating most like student, a "3" indicating second most like student, a "2" indicating third most like student, and a "1" indicating least like student. After the students submit the answer, the system will analyze learning experience preferences by combining among four dimensions and generate the results such as Accommodator, Diverger, Converger, or Assimilator to each student. For example, a student (S1) could be an Accommodator, whereas another student (S2) could be a Diverger.

Phase 3: Knowledge Integration phase: This phase is used to integrate the information of learning style (LS) and learning experience (LE) from individual students (S_i). In this study, a set of rules is defined to match corresponding personal learning activity (PLA). In the following, part of the rules and the corresponding descriptions are presented.



Figure 1. Illustrative example of an adaptive web-based learning system based a personal learning activity approach

Rule 1:

If $LS(S_i) = \text{“Active”}$ and $LE(S_i) = \text{“Diverger”}$

Then $PLA(S_i) = \text{“Collaborative Hand-on-based Discovery Learning”}$

Rule 1 is used to handle the case that the student is identified the active learner with diverger learning. In this case, the physically hands-on-based material with working together in small groups is adopted as the personal learning activity.

Rule 2:

If $LS(S_i) = \text{“Visual”}$ and $LE(S_i) = \text{“Assimilator”}$

Then $PLA(S_i) = \text{“Individual Simulation-based Discovery Learning”}$

Rule 2 is used to handle the case that the student is identified the visual learner with assimilator learning. In this case, the physically simulation-based material with working individually is adopted as the personal learning activity.

Rule 3:

If $LS(S_i) = \text{“Sensing”}$ and $LE(S_i) = \text{“Diverger”}$

Then $PLA(S_i) = \text{“Collaborative Hybrid-based Discovery Learning”}$

Rule 3 is used to handle the case that the student is identified the sensing learner with diverger learning. In this case, both physically and virtually, with hand-on and simulation-based materials with working together in small groups is adopted as the personal learning activity.

In order to maximize the better personalized learning with web-based technology, the mechanism of formative assessment was included in this learning system. The formative assessment can be the compass to guide students towards learning and academic achievement [9]. With the characteristics of formative assessment, it allows the students to repeatedly participate in the process of practicing and observing more, gaining feedback immediately, reflecting and revising their answers in response. In this learning system, the mechanism of formative assessment is designed to situate individual students in an instruction of scientific investigation. Moreover, the learning system provides personal supports or guidance for each procedure during the scientific investigation. During the web-based learning process, the learning system guides the students to interact with necessary components of scientific investigation based on the formative assessment mechanism from beginning to the end. Figure 2 represents the formative assessment-oriented guiding mechanism of the personalized web-based learning system.

4. Experimental Design

To examine the effectiveness of the proposed approach on students' learning achievement, this study was conducted on simple electricity unit of a secondary school Physics course. Before the experiment, the students took a pretest to evaluate their prior knowledge of the simple electricity. The learning activities lasted 150 minutes that was an approximately time utilized by all students. After the learning activity, a posttest was conducted.

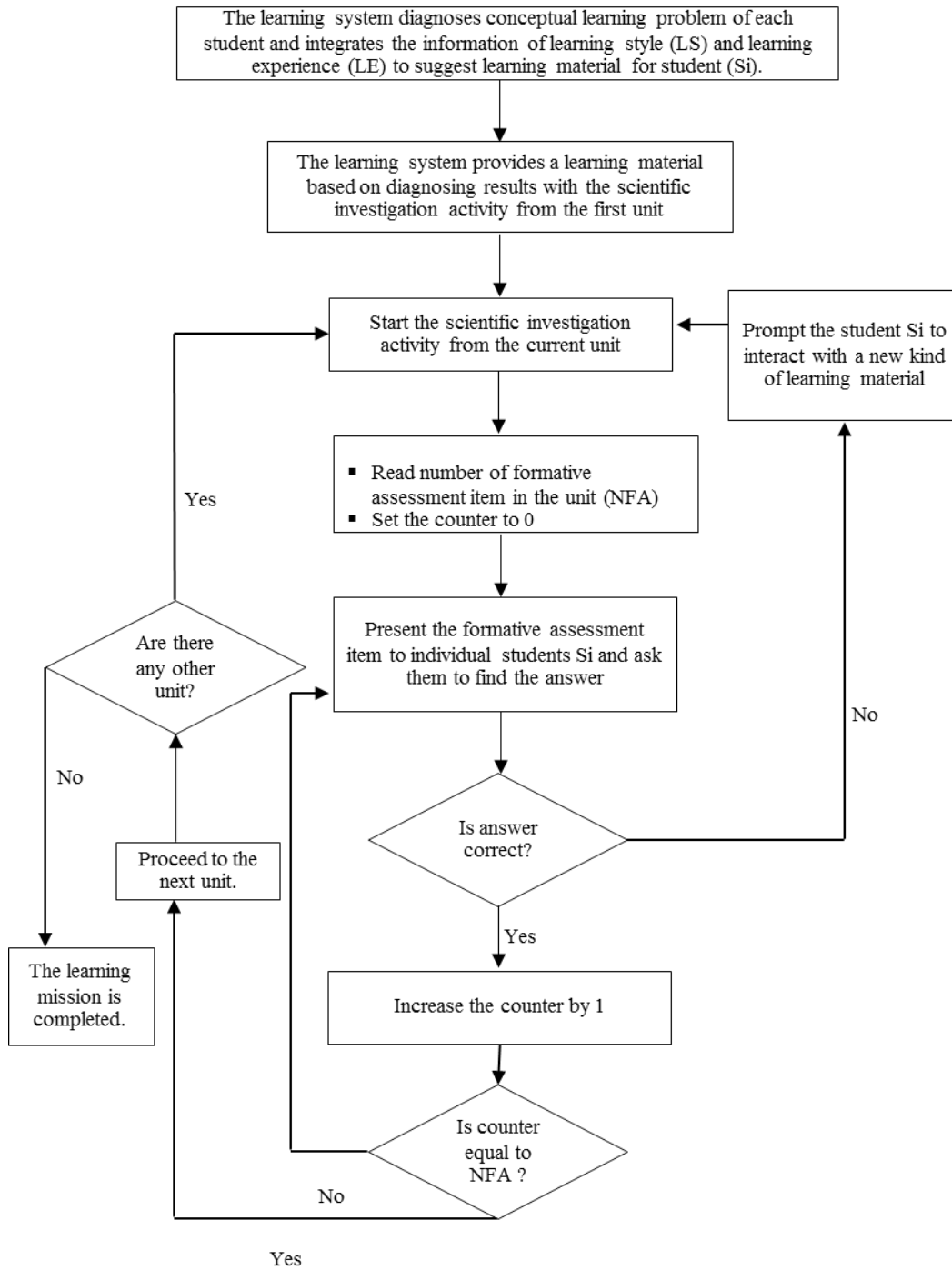


Figure 2. The mechanism of formative assessment in the personalized web-based learning system

4.1 Participants

The participants of this experiment were two classes of 11th grade students in northeast

Thailand. A total of 56 students were recruited in this study. The two classes were randomly divided into two groups (i.e., experimental group and control group). The experimental group included 27 students, while the control group had 29 students. In this study, the same teachers facilitated the students in the two classes in order to avoid the influence of different experienced teachers on the experimental results. The students in experimental group participated in the lesson provided by the developed system, while those in the control group learned with the same lesson in conventional web-based learning environment.

4.2 Researcher Tools

In this study, a pretest and a posttest were implemented as the research tools. Both the pretest and the posttest were designed by three teachers experienced in teaching the Physics course. Each test consisted of 12 two-tier multiple-choice items, with one point awarded for each correct answer; therefore, the total score of each test was 12. The pretest aimed to evaluate the students' prior knowledge of the simple electricity content, while the posttest aimed to evaluate the learning achievement of the students after participating in the developed system. The KR-20 value of the pretest and posttest was 0.83 and 0.84, respectively, showing acceptable reliability in internal consistency.

5. Experimental Results

In the following discussions, the results of pretest and posttest are presented. To ensure that they had equal prior knowledge in the topic, the *t*-test was used. It was found that the mean \pm standard deviation of pretest of the experimental group was 4.93 ± 1.83 , and of control group was 4.86 ± 1.73 . There was, that means, no significant difference between the mean score of pretest of the control and the experimental groups ($t = 1.34$, $p = 0.447$), indicating that the students in both the groups had similar level of physics knowledge about simple electricity before participating this study. After finishing the learning activity, the two groups took a posttest to examine how the learning achievement was affected by the treatments. In this study, the pretest scores was used as covariate. The posttest scores of both control and experimental groups were analyzed with ANCOVA, as shown in Table 1.

Table 1. ANCOVA results of the posttest

Groups	N	Mean \pm SD	Adjusted mean	SE.	$F_{(1,54)}$	η^2
Control	29	7.72 ± 2.15	7.730	0.332	9.656	0.154
Experimental	27	9.22 ± 1.34	9.215	0.344		

* $p < 0.05$

The result in Table 1 shows that there is significant difference of the posttest scores between the experimental group and the control group ($F_{(1,54)} = 9.656, p < 0.05$). In other words, the mean score of posttest for the experimental group was significantly higher than that for the control group, suggesting that the developed personalized web-based learning system integrated formative assessment system could help the students in improving their learning achievement in the topic.

6. Discussion and Conclusion

This paper presents an innovative approach for integrating formative assessment into a personalized web-based learning system, which utilizes the learning style and learning experience for customizing individual lesson for students. Based on the proposed approach, the personalized web-based learning system with integration of formative assessment was implemented. The learning system can adaptively provide personal scientific investigation activity to individual students based on their own learning style and experience. It also can be used to predict the scientific investigation-based learning activity of students for an in-class science course.

To evaluate the performance of this innovative approach, an experiment on conceptual physics of simple electricity in high school physics course was conducted in regular class. There were 56 of 11th grade students recruited in this study in order to compare the conceptual learning performance of the conventional (content-oriented) web-based learning environment and our innovative approach. As personalized web-based learning system, based on learning style or pedagogical aspect/learning experience, with integration of formative assessment has been proven to be helpful to students in improving their conceptual learning efficacy. This finding consistent with several researchers, who found that student with different learning performance need accurate learning suggestions and appropriate learning material for their learning, and then they can learn better based on their learning style and have increased learning achievement [10], [16]. Moreover, the embedding of formative assessment into personalized web-based learning system could enhance students' conceptual learning in science. This confirms the findings from the study of researchers who reported that the more diverse formative assessment strategies are embedded in the e-learning environment, the greater the learning effect obtained by the students [21], [23]. The findings of this study have important implications for web-learning design of high school science courses, as well as for research and development into the benefits of personalized or adaptive web-based learning system. Therefore, the success of this study, by integrating the mechanism of formative assessment into personalized web-based learning system, could play an important role in developing the adaptive web-based learning environment for concept-based teaching and learning in school science.

Acknowledgement

This research project is supported by Mahidol University under Grant Numbers 67/2557 and 103/2558.

References

- [1] Black, P. & Wiliam, D (1998), "Assessment and Classroom Learning", *Assessment in Education*, 5(1), 7-71.
- [2] Black, P. et al. (2002), *Working inside the Black Box: Assessment for Learning in the Classroom*, Department of Education and Professional Studies, King's College, London.
- [3] Buchanan T, (2000), "The efficacy of a World-Wide Web mediated formative assessment", *Journal of Computer Assisted Learning*, 16, 193–200.
- [4] Carmichael, P. & Tscholl, M, (2013), "Cases, Simulacra and Semantic Technology", *Journal of Computer Assisted Learning*, 29(1), 31-42.
- [5] Falk, A, (2011), "Teachers learning from professional development in elementary science: Reciprocal relations between formative assessment and pedagogical content knowledge", *Science Education*, 96(2), 265-290.
- [6] Felder, R. M., & Silverman, L. K, (1988), "Learning and teaching styles in engineering education", *Journal of Engineering Education*, 78(7), 674–681.
- [7] Guzey, S., & Roehrig, G, (2009), "Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge", *Contemporary Issues in Technology and Teacher Education*, 9(1), 25–45.
- [8] Henly, D. C, (2003), "Use of Web-based formative assessment to support student learning in a metabolism/nutrition unit", *European Journal of Dental Education*, 7, 116–122.
- [9] Hwang, G. J., & Chang, H. F, (2011), "A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students", *Computers & Education*, 56(4), 1023-1031.
- [10] Hwang, G. J., Panjaburee, P., Shih, B. Y., Triampo, W, (2013), "A group decision approach to developing concept effect models for diagnosing student learning problems", *British Journal of Educational Technology*, 44(3), 453–468.
- [11] Hwang, G. J., Chu, H. C., Yin, P. Y., & Lin, J. Y, (2008), "An innovative parallel test-sheet composition approach to meet multiple assessment criteria for national tests", *Computers & Education*, 51(3), 1058-1072.
- [12] Kolb, D. A., Osland, J. S., & Rubin, I. M. (1995), *Organization Behaviour* (6th ed.). New Jersey: Prince-Hall.
- [13] Li, L.M, Li, B., & Luo, Y, (2015), "Using a dual safeguard web-based interactive teaching approach in an introductory physics class" *Physical Review Special Topics - Physics Education Research*, 11(1), 010106.
- [14] Niess, M, (2009), "Preparing teachers to teach science and mathematics with technology", *Teaching and Teacher Education*, 21,509–523.
- [15] Oh, S., & Jonassen, D. H. (2007), "Scaffolding online argumentation during problem-solving", *Journal of Computer-Assisted Learning*, 23, 95-110.
- [16] Panjaburee, P., Hwang, G. J., Triampo W., & Shih, B. Y, (2010), "A multi-expert approach for developing testing and diagnostic systems based on the concept-effect model", *Computers & Education*, 55(2), 527–540.
- [17] Reeves, T. C., & Reeves, P. M, (1997), The effective dimensions of interactive learning on the WWW. In B. H. Khan, (Ed.), *Web-based instruction* (pp. 59-66). Englewood Cliffs, NJ: Educational Technology.
- [18] Srisawasdi, N., & Kroothkeaw, S, (2014), "Supporting students' conceptual learning and retention of light refraction concepts by simulation-based inquiry with dual-situated learning model", *Journal of Computers in Education*, 1(1), 49-79.
- [19] Srisawasdi, N. & Panjaburee, P, (2015), "Exploring effectiveness of simulation-based inquiry learning in science with integration of formative assessment", *Journal of Computers in Education*, 2(3), 323-352.

- [20] Srisawasdi, N., Srikasee, S., & Panjaburee, P, (2012), “Development of a Constructivist Web-based Learning System with Student Personalized Conceptual Profile” Proceeding from the 20th International Conference on Computers in Education. Asia-Pacific Society for Computers in Education, Singapore.
- [21] Wang, S-K, & Reeves, T. C, (2006), “The effects of a Web-based learning environment on student motivation in a high school earth science course”, *Educational Technology Research and Development*, 54(6), 597-621.
- [22] Wang, K.H., Wang, T.H., Wang, W. L. and Huang, S. C, (2006), “Learning styles and formative assessment strategy: enhancing student achievement in Web-based learning”, *Journal of Computer Assisted Learning*, 22: 207–217.
- [23] Wang, T. H, (2010), “Web-based dynamic assessment: taking assessment as teaching and learning strategy for improving students’ e-Learning effectiveness”, *Computers & Education*, 54(4), 1157–1166.
- [24] Windschitl, M, (1998), “The WWW and classroom research: What path should we take?”, *Educational Researcher*, 27(1), 28–33.

Effects of Instructional Games on the Handwriting Performance of Physically Challenged Primary School Pupils in Lagos, Nigeria

by

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Abstract

This study investigated the effects of instructional games on the physically challenged pupils' performance in handwriting. Also, the influence of ability on the performance of pupils in handwriting was investigated. The subjects for the study were 48 primary four pupils of Atunda – Olu school for the physically handicapped, Surulere, Lagos. The research was quasi-experimental involving 4x3 factorial design. The findings of the study showed that students exposed to the three instructional games (MRG, DGG and MRDG) performed better than those exposed to the conventional classroom teaching. However, the performance of pupils exposed to MRDG and MRG were not significantly different. Generally, ability levels had significant influence on the pupils' performance scores in handwriting, but the mean gain scores of pupils with high, medium and low levels of ability exposed to DG were not significantly different from one another.

1. Introduction

Primary Education is the beginning of formal education in Nigeria. It is thus regarded as the entrance into the rest of the educational system [1]. The National Policy on Education [9] perceives primary education as the foundation on which other levels of education are built. So it describes it as the key to the success or failure of the whole system. This perception is appropriate because acquisition of the basic skills of literacy in letters and figure has its beginning at the primary school. It is the base of educational pyramid. To this end, every single subject recommended is relevant and pertinent to his wholesome development [35]. One of the subjects in the primary school timetable is Handwriting.

Today, the teaching of handwriting is comparatively neglected. This is reflected both in the failure of many colleges of education to show students how to teach writing and in the absence of research into writing problems of non-handicapped and handicapped children alike. Yet, as many practicing teachers and psychologists will testify, schools contain a sizeable number of pupils experiencing server difficulties with handwriting. The implications of such difficulties are highlighted by the studies of Briggs (1970 & 1980), which show that the quality of handwriting may make the difference between passing and failing of major examination even when the quality of the content remains similar.

Physically challenged pupils fall into such category of candidates. These are people whose primary distinguishing characteristics are physical problem. A physical disability is a condition that interferes with the child's ability to use his or her body (i.e. inability to take part in routine school or home activities).

A pupil with poor hand control may be frustrated and unhappy with his handwriting, which in turn can result in a lowering of self-esteem, [26] has suggested that our goals for education should be to help people become enthusiastic, to assist them in learning how to learn, and to provide them the resources, aids and motivation which are necessary to further their opportunities to learn. Games are a great deal of use in the furtherance of these aims. Games consist of groups of players (i.e. decision-makers) placed in a prescribed setting, with constraints within this setting represented by rule system and method of procedure [33], [10], [12]. However, [2] states that game may be best suited to that section of the age group that has not succeeded in the school system. This larger group of under-achievers might be expected to include all those children who are under-motivated, learning disabled and physically challenged. [13] challenging this view, says games appear to have been useful with both gifted and slow learners at the same time [34], [28], [31] believe that games can be used with any ability group.

This researcher, however, has not found much in government reports, advice to teachers, and official curriculum guides upon the teaching of handwriting. It has truly been the most neglected of the three Rs [17] Furthermore, there has been no consistent policy on the teaching of handwriting in Nigeria. Neither the National Policy on Education nor the report of the National Workshop on Primary Education had anything to say on the subject [19], [24]. Practice has varied from authority to authority and from school to school.

This researcher has not found any method developed for the Nigerian physically challenged students in the teaching of handwriting. Even the Federal College of Education (Special) Oyo that trains teachers for the disabled and other related institutions in Nigeria lag behind in providing facilities for writing. An appreciation of the problems faced by pupils with poor hand control has led the present researcher to appreciate the need to introduce the use of games to improve the handwriting of physically challenged pupils.

2. Research hypotheses

Based on the research questions raised the following hypotheses are generated and tested at .05 level of significance.

- a. There is no significant difference in the handwriting performance scores of pupils exposed to instructional games and their counterparts exposed to conventional classroom teaching.
- b. Ability level has no significant effect on handwriting performance of pupils exposed to MRG, DG, MRDG and CCT
- c. No significant difference exists in the handwriting performances scores of high, average and low academic ability pupils exposed to Drawing game.

3. Methodology

3.1. Research instruments

The following instruments were designed for the study

- a. Instructional Materials. Two games (MRG and DG) originated from [29] were adapted for the study. In the original format of MRG, doorbell was used to audibly reinforce the child when he approached the figure ground boundary, whereas in the adapted format 6 volt bulb was used as a means of reinforcement. If the bulb lights, it means that child has approached the guardrails and hence the game passes to another child's turn. In the metal road game (MRG) the activity of propelling a car along fine motor skills, which are prerequisite to controlling a pencil. The sequence of turns the car make in order to progress from one end of the road to the other aids the child in developing fine motor co-ordination that follows a predetermined visual sequence. The second game called Drawing Game is also an enjoyable means of providing practice in developing motor control with a pencil. As long as the child stays within the boundaries of the stencil design, and as long as the pen touches the foil surface of the stencil, the light will remain on. If the child goes out of the defined area, the battery circuit is interrupted and the light will go off. Any design can be created for use in the frame and each design can be adapted to the child's level of development.
- b. The handwriting performance test (Appendix A) design by the researcher consists of Nigerian National Anthem printed in large, bold print at the top of the unlined papers. The passage contains materials appropriate in the content and vocabulary of ages nine and ten year old Nigerian children. Furthermore, the passage was chosen as likely to have meaning for the overwhelming majority of Nigerian pupils. There were 40 words in which every letter of the alphabet, except j, k, q, x and z, was used at least once.
- c. Test of academic ability is a modified 100 – item test constructed by [23]. The test consists of (a) Mathematics – 25 questions (01-25); (b) English – 25 questions (26-50); and General paper – 50 questions (51-100). Questions number 54,57,61,73,95 and 97 of the original test item were modified to suit the ability of the pupils used in the study.
- d. The perceptual-motor test [36] was used for this study. The test is designed to assess a wide range of motor function including both gross and fine motor skills. Since the focus of this study is on fine movement only ten fine motor sub-test appropriate for nine and ten year olds was adapted and administered following the standard procedure for administration. The import of this test is to find out what the child has already learned and understands and to show what skills have been mastered or otherwise. The reliability of the test of academic ability, handwriting performance test and perceptual-motor test were established with the split-half method. The correlation coefficients of 0.82, 0.86 and 0.97 were obtained respectively.

3.2. Sample and Sampling Techniques

The target population of this study was all physically challenged the data gathering location in this study because it is among the states that pioneered the teaching of physically challenged person in Nigeria.

Pupils of the Atunda-Olu school for the physically handicapped, Surulere, Lagos were purposively sampled for the study. Four arms of primary four (intact classes) were selected and randomly assigned to treatments using a table of random numbers. The subjects were further subdivided into high, average and low academic ability levels based on performance in academic ability test comprising Mathematics, English and general paper.

3.3. Data analysis

The perceptual-Motor test [58] was administered and scored according to the instructions in the manual. Test of Academic Ability was also administered and scored. For the handwriting test, the sample was assessed on a scale containing the following five criteria: (i) uniformity of letter size; (ii) spacing of words; (iii) pressure on the writing paper (iv) formation of individual letter; (v) alignment of words.

Three independent judges comprising a teacher, a psychologist and a fine artist scored all 48 samples. The judges marked each of the five criteria independently and separately. All samples was scored for uniformity of letter size, then shuffled and scored for spacing of words then shuffled and scored for pressure on the writing paper, and so on. This procedure was adopted to minimise basing effects of scores of one criterion on another.

For each criterion a seven-point scale was used (1) representing very poor performance (2) indicating poor performance (3) indicating low average performance (4) representing average performance, (5) indicating High average; (6) indicating good performance, and (7) representing very good performance.

The range was 5 to 35, five being very poor performance, 35 being excellent performance. The total marks of each group were determined by adding up the scores. Inferential statistics that is ANCOVA (analysis of covariance) was used to answer all the three research hypotheses.

4. Results

This section contains the results of the research. These results are displayed in tables for easy interpretation. The four groups of pupils exposed to instructional treatments comprised of 12 pupils exposed to MRG (experimental Group I), 12 pupils exposed to DG (Experimental Group II), 12 pupils exposed to MRG/DG (Experimental Group III), and 12 pupils exposed conventional classroom teaching (Control group). The students' scores were analysed through Analysis of Covariance techniques, which statistically controlled the initial difference that existed between the four groups a level of 0.05 probability was adopted for all analyses as the criterion for significance.

H₀₁: There is no significant difference in the handwriting performance scores of pupils exposed to instructional games and their counterparts exposed to conventional classroom teaching. To determine the effects of four instructional treatments (MRG, DG, MRDG and CCT), the students' scores were analyzed as indicated in Table 2.

Table 1: Analysis of covariance of means scores of the treatment groups (MRG, DG, MRDG and CCT).

Source of	Sum of	Experimental Method				
		Df	Mean	F	Significant of F	P< .05
Post covariates PRE	214.082	1	214.082	32.549	000	
Main Effects TRTM	337.944	1	337.944	51.381	000	*
Model	552.027	2	276.013	41.965	000	
Residual	295.973	45	6.577			
Total	848.000	47	18.043			

* = *Significant*

An examination of table 1 indicates that treatment was found to have contributed significantly to the variations in the subject performance score ($f(1, 45) = 51.381, P < .05$). When the pre-performance test score was used as a covariate of the Post-test score, there was significant difference among the group means.

The null hypothesis that there is no significant difference in the handwriting performance scores of pupils exposed to games and those exposed to conventional classroom teaching therefore rejected.

To further test for the contribution of each treatment group to the significant difference from the control group, a post-hoc analysis was carried out to determine any significant differences among the groups. If a significant difference exists, which of the groups was better than the other? This was determined by the multiple range test of one-way Scheffe. It should be state that Scheffe could only be applied if there was significant difference.

Table 2: ANOVA Multiple range test of post-test score by one-way

Source	Df	Sum of square	Mean	F-ratio	P < .05
Between Groups	1	256.000	256.000	19.892	000*
Within Groups	46	592.000	12.870		
Total	47	848.00			

Table 3: Summaries of the Scheffe multiple range Comparison of Post-test Mean Scores of the Treatment Groups.

Mean Scores	Groups	Group IV (CCT)	Group III (MRDG)	Group II (DG)	Group I (DG)
25.5000	Group IV (CCT)				
31.0833	Group III (MRDG)	*			
31.8333	Group II (DG)	*			
29.5833	Group 1(MRG)				

It could be observed from table 3 that there are significant difference between Group 4 (CCT) and Group 3 (MRDG); Group 4 (CCT) and Group 2 (DG);

H0₂: ability level has no significant effect on handwriting performance of pupils exposed to DG, MRG, MRDG and CCT.

Table 4: ANCOVA on the post-tests performance score of subjects according to ability.

Source of variation	SS	df	MS	F	Sig
Covariates	214.082	1	214.082	39.122	.000
Main effects ABL	40.049	2	20.025	3.659	.036*
Model	656.474	12	15.706	9.997	.000
Residual	191.526	35	5.472		
Total	848.000	47	18.043		

* = Significant at $P < 0.05$

By looking at table 4 one can observe that ability had a significant main effect on the performance scores of the subject ($F(2, 47) = 3.65, P < 0.05$). Therefore, the null hypothesis (H0₂) is rejected. This shows that ability in this study constitutes a very important moderating variable.

H0₃: No significant difference exists in the handwriting performance scores of high average and low academic ability pupils exposed to DG.

Table 5: Analysis of covariance of mean scores of DG

Source of Variation	Experimental Method					
	SS	df	MS	F	Sig of F	P<.05
POSTDG Covariates PREDG	13.652	1	13.652	2.098	.186	NS
Main Effects ABLDG	23.962	2	11.981	1.841	.224	
Model	37.614	3	12.538	1.927	.204	
Residual	52.053	8	6.507			
total	89.667	11	8.152			

NS = Not Significant

Table 5 indicates that there was no significant difference in the posttest performance mean scores of high average and low ability level pupils who were exposed to Drawing Game in handwriting ($F(2.11) = 1.841, P < .05$) therefore, the null hypothesis is not rejected.

5. Discussion of results

The main focus of this study was to determine the effect of instructional game strategies on handwriting performance among the physically challenged pupils in primary schools. The study also examined the interactive effect (if any) of treatment and pupil ability on performance in handwriting.

The discussion of the results of this study is closely guided by the hypotheses that were raised in the study. The findings, which have emerged as a result of this study, are placed within the framework of previous studies.

5.1. The effects of instructional games on performance

The analysis of covariance was computed to test the hypothesis involving treatment and performance. The findings from the study (Table 1) show that there was significant difference among the four groups when pre-performance test was used as a covariate of the post-performance test.

This suggests that the method of instruction which students are exposed to would have a significant effect on their performance. Therefore, it can be concluded that DG, MRG and MRDG are superior to conventional methods in terms of effectiveness. In addition, drawing game provides better instructional strategy than metal read game and MRDG. This was revealed in the mean gain scores, the Scheffe multiple range comparison test and the graphical comparison of all the four groups.

It also suggests that poor handwriting performance of physically challenged pupils may be due to the conventional methods presently in use in most schools which have been found to be less effective. This has also been proved from past studies, that is, handwriting performance depends on the methods of teaching employed in schools [25], [27]. These results may have been due to many reasons. One of which is that primary school pupils are used to playing games and they enjoy playing games, therefore, using the games in the classroom setting now make handwriting task a lot of fun [2], [3], [4], [7].

The drawing game's group better performance than the metal road game group could be attributed to the nature of the drawing game, which is similar to handwriting activities. The writing material – brass-tipped-pen – is similar to pencil and the stencils provided are designed along alphabets, Arabic figure and geometric shapes. With these characteristics of drawing game, there is bound to be a better performance than those who belonged to the metal road game. Pupils who were exposed to the conventional classroom teaching group had the least performance. What must have been responsible for these was that they were not using games so they were passive for most periods of lesson.

The findings that the subjects exposed to games showed more achievement than the conventional group is supported by [2], [3], [4], [5], [20], and [30]; [21], [22]. However [18], [8], [32], and [11] among others showed a result contrary to the researcher's findings. Summarily, from the findings, it is evident that both drawing and metal road games are capable of facilitating the learning of handwriting, better than conventional methods.

5.2. Effect of ability on performance in handwriting

The result of ANCOVA as in table 4 shows vividly that significant differences exist in performance among the pupils of different abilities hypothesis H_0 is therefore rejected. This goes on to support earlier research findings that showed that ability have influence on performances [1], [4], [15], [19], [35]. This result is due to the fact that, the ability of a pupil determines to what extent he can learn. Therefore, one expects pupils of high ability to perform best and those of low ability to perform least. This implies that the ability level of pupils will have varying effect on handwriting performance. This goes on to support other researches too, that the type of strategies or instructional materials used to teach could determine how well pupils of varying abilities (especially of low ability) would be able to learn and improve on their performance [17] and [37]. However, the researcher goes further to examine if a

particular method facilitates better performance for each of the ability level groups. The results in table 8 revealed that there was no significant difference in the posttest performance gains between subjects in the high, average and low ability level groups who were exposed to drawing game. This implies that the high ability level subjects exposed to DG did not perform significantly better than average and low ability levels. This is an indication that those that are termed to be below average in their academic performance could improve and learn better through gaming [18], [14], & [17], [6].

6. Conclusions

Findings showed that significant existed between the four groups compared. The DG group produced the best results in pupils' performance to handwriting followed by MRDG group. The purpose of the study was principally to know which medium performed better. It was also to give the researcher opportunity to make meaningful contributions to knowledge. Of particular interest was the utilization of instructional games for improving the handwriting skills of physically challenged primary school pupils. However, the findings can be generalised for three other situations that have variables similar to the ones that this study had.

First, although, this research was conducted, using handwriting skills, the results can be generalized for other subjects such as Geometry in Arithmetic and Drawing in Fine Arts. Second, the findings may be generally applicable to conventional primary schools where handwriting is also taught as a subject.

Lastly, the findings may be generalized for other categories of special students. For instance, the results of the physically challenged pupils can be generalized for mentally retarded, learning disabled and hearing impaired pupils.

In conclusion, though the games in this study led to significant improvement they did not lead to perfect performance as some pupils still performed poorly. Therefore, it must be noted that there might likely be no perfect method/strategy or instructional material for the teaching of handwriting. Rather, it must be realized that these games, like any other game should be incorporated into the handwriting teaching as one of the many teaching strategies.

7. Recommendations

On the basis of the findings of this study the following recommendations are made: Special teachers should give prominent position to handwriting on the school timetable like other subjects. Instructional games should be designed, validated and evaluated for the teaching of handwriting in special primary schools.

Special school administrator should carry an awareness drive to generate awareness in the general populace (especially parents of disabled pupils) of the usefulness and effectiveness of instructional games even to pre-school handicapped children. In addition to printed materials in the libraries, special schools should stock instructional games that could be used to teach difficult concepts and living skills.

References

1. Abimbade, A. *Effects of the use of electronic calculator on outcomes of mathematical instruction*, unpublished Ph.D. Thesis, University of Ibadan, Ibadan 1987.
2. Adelakun, S.A. Gaming in Integrated Science Class. Paper 38. *Science Teachers Association of Nigeria (STAN), 1997 Annual Conference Proceedings*. 1997. Pp.209-11.
3. Adeniran, S.A. The use of developed games for teaching Mathematical concepts. A motivation and retention strategy. *Education Today* 7 (2), 1994. 55-57.
4. Aremu, A. *Effects of card and geoboard gamebased instructional strategies on primary school pupils' achievement in practical geometry*. Unpublished Ph.D. Thesis. University of Ibadan. 1998.
5. Blum, H.T. & Yocom, D.J. A fun alternative: using instructional games to foster student learning. *Teaching Exceptional Children*. 29. (2), 1996. 60-63.
6. Chiang, Y. T., Lin, S.S. J., Cheng, C.Y., & Liu, E.Z.F. Exploring online game players' flow experiences and positive affect. *Turkish Online Journal of Educational Technology*, 10(1), 2011. 106-114.
7. Clark, R.E. Reconsidering research on learning from media *Review of Educational Research*, 53 (4), 1985. 445 – 460.
8. Duchastel, P. Knowledge-based instructional gaming: GEO. *Journal of Educational Technology Systems*. 17, (3), 1989. 189-203.
9. Egenfeldt-Nielsen, S. Review of the research on educational usage of games. Retrieved on November 25, 2015 from <http://www.it-c.uk/people/sen/papers>. Reviewing %20literature %20on%20simulations %20games%20for%20learning_v0.5.doc. 2003.
10. Federal Republic of Nigeria. *National policy on education* (3rd ed.) Lagos: NERDC Press 2004.
11. Gee, J.P. *What Video games can teach us about literacy and learning*. New York: Palgrave- McMillan. 2003.
12. Glifford, K.E. Lecture to a conference at Edge Hill College of Education. 2000.
13. Griffiths, M.D. Aloma: Revista de Psicologia (Computer game playing and social skills: A pilot study). *Ciencias de l'Educacio I de l'Esport*, 27, 2010. 301-310.
14. Hannum, W. The physics of the Roller Coaster: leaving physics through simulation. *Education Technology* Jan – Feb. 201, 2001. 25-35.
15. Hewitt, Games in instruction leading to environmentally responsible behaviour. *Journal of Environmental Education* 28, (3), 1997. 35-37.
16. Inal, Y. & Cagiltay, K. Flow experiences of children in an interactive social game environment. *British Journal of Educational technology*, 38(3), 2007. 455-464.
17. Jenkinna, P.K., *The importance of 3R in national development*. Lagos: Pink publishers. 2013.
18. Klaus, W.H. *The use of microcomputer for mathematics instruction in Grades. (1 - 4)*. Washington, D.C. National Science Foundation. 1982.
19. Klein, D. J. & Freitag, E. Effect of using an instructional game on motivation and performance. *Journal of Educational Research*, 84, 1991. 821 – 824.
20. Lawal,12 R.A. Types and uses of tests. In I.O. Abimbola (ed.), *Fundamental principles and practice of institution*. Ilorin: Belodan I(Nig) Enterprises, 2001. pp. 333-353.
21. Lawler, R.W. and Usmani, S. Teaching Indian children English vocabulary with computer- based simulations. In Lawler, R.W.k & Yazdani, P. (eds). *Artificial Intelligence and Education* Vol. II. Ablex Norwood N.J; Sindex Press, 1997. 51-59.
22. Lee, C.Y., & Chen, P.M. A computer game as a context for non-routine mathematical problem solving: The effects of type of question prompt and level of prior knowledge. *Computers & Education*, 52(3), 2009. 530-542.

23. Macauley, S.I. A re-appraisal of primary school curriculum in Nigeria. *National School Curriculum Review Conference Proceeding 2nd – 6th September*. Federal Ministry of Education, Lagos. 1991. (pp. 279-291).
24. Ministry of Education. *Primary school learning certificate examination* Osogbo: Osun state. 1996.
25. Mwoltu, P.P. A re-appraisal of primary school curriculum in Nigeria. *National School Curriculum Review Conference Proceedings 2nd – 6th September*, Federal Ministry of Education, Lagos. 1991. Pp. 292-300.
26. NERDC, *National Workshop on Primary Education*. 1973.
27. Odewale, O.J. *Differences between the conceptual pencil drawing of specific objects by children with moderate learning difficulties and low vision*. Unpublished M.Ed dissertation University of Birmingham. 1993.
28. Oduolowu, E.A. *The relative effectiveness of open classroom and conventional strategies on pupils' acquisition of the basic literacy and numeracy skills*. Unpublished Ph.D. Thesis. University of Ibadan. 1998.
29. Reason, R. & Boote, R. *Learning difficulties in reading and writing: A teacher's manual*. New York: Nfer-Nelson. 1996.
30. Rieber, L.P., Smith, L. & Noah, D. The value of serious play. *Educational Technology*. Nov – Dec., 1998. 1998, 29-35.
31. Schloss, P.T. & Milliren, A.P. *Learning aids*: Springfield, Illinois: Charles Thomas Publishers. 1975.
32. Shaffer, D.W. *How computer games help children learn*. New York: Palgrave Macmillan. 2007.
33. Spires, H., Turner, K. Lester, J. & McQuiggan, S. *Engagement, academic dispositions, and success in game-based learning environments*. In L. Annetta, (Chair). *Motivation, Affect and Engagement in Game-Based Learning Environments*. Paper to be presented as part of a symposium at the 2008 meeting of the American Education Research Association. New York, NY. 2008, March.
34. Steinkuehler, C.A. Learning in massively multiplayer online games. *Paper presented at the 6th International Conference of the Learning Sciences, Mahwah, NJ*. 2004.
35. Taiwo, S.A. *Application of technology to aid the investigation and remediation of the learning retarded children*. A paper presented at the International Conference on Special Education. Held at Federal College of Education (Sp) Oyo. 1998, 27 – 30.
36. Taylor, J.L. & Walford, R. *Learning and the simulation game*. Milton Keynes: The Open University Press. 1978.
37. Thomas, S. Pervasive learning games: Explorations of hybrid educational gamescapes. *Simulation Gaming*, 37 (1), 2006. 41-55.

Producing Lightboard Videos for an Introductory Mechanics Residential Class and MOOC

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Abstract

We are working on producing a Massive Open Online Course (MOOC) while at the same time improving our own on-campus teaching. In this paper, we focus on the the video component. After a brief discussion of some of our principles of video production, we present our insights into making lightboard videos, and end by examining the uses of videos that we have throughout our class.

1. Introduction

It can be challenging and very time-consuming to make effective videos for teaching a subject; creating content for a Massive Open Online Class (MOOC) based on our residential introductory mechanics class was no exception.

Our class is an introductory calculus-based physics class aimed for mainly non-majors. In the on-campus class, we use various active learning techniques, such as clickers and in-class group problems, and the class itself is heavily problem-focused. We slowly build the students' problem-solving ability, starting with simple questions to test recall or simple applications, and building up to more complex problems that involve understanding and applying multiple concepts. Teaching concepts at just the right time and providing feedback are crucial to this teaching method. We plan to structure our online class in a similar way to the on-campus class with an increasing difficulty of problems, short lecture clips to introduce concepts inserted at the right time, and ample feedback.

In addition to producing the MOOC, we also use many of the online resources in our on-campus class, including online assignments, answer-checking, slides from all past classes, and supplementary videos. Therefore, our on-campus class benefited from our production of videos for the MOOC. In the fall of 2015 when we began this endeavor, we did not have a good method to record our lectures. We produced some animation videos, but the lightboard (described below) soon became the major focus of video development. This paper describes how we thought about the videos we produced, the lessons and tricks to lightboard video production, and the uses for videos that we

have found in our course.

2. Philosophy of videos

Videos are an important part of the efforts to produce the MOOC and to improve the on-campus class. While video is often criticized for being passive, our goal is to make short and directed videos that will introduce concepts, give hints, and fill other functions, with enough practice around the videos to make students pay attention. We intend the videos to be useful learning tools for the students. The videos will be surrounded by concept questions that will quickly allow students to assess if they have learned the content, and the videos are short enough that students can watch them again if necessary. We also document the main points of each video above the video itself so it is easy to determine if it contains what the student wants to learn or review. We stay away from long lectures because we want the students to choose to watch only when they are ready and receptive to learning.

While making our videos, we consider a few factors. First, we tried to keep the videos short. In our active learning class, we try to follow the principle of not talking for more than 15 minutes [4], and we aim for the videos to be even shorter [5]. When making animations in particular, we also use Mayer's multimedia principles; the videos do not have many distracting movements or images, and we try to sync the visuals with the auditory cues [6]. We also try to make the visual cues and information consistent with what students are learning, in the style of [1]. In general, while making our videos, we try to balance the time it will take to produce of the videos with their educational value. Reference [3] provides a nice discussion of different types of videos and emphasizes that video should preferentially be used in certain contexts, such as building a rapport, providing motivation, visualizations, and demonstrations. In addition to this list, we believe video is essential for showing behavior that we want students to mimic, such as how to set up a diagram. They also emphasize that, while sound quality is important, video quality does not have to be the same as a professional video for students to learn well from it. They warn that good teachers do not necessarily make good videos, and we have found this to be good advice. From other video producers, such as Dianna Cowern (Physics Girl), we also learned to pay attention to factors such as enthusiasm – in order to sound dynamic and engaging in a video, the speaker has to sound even more enthusiastic than normal while shooting [2].

3. Lightboard lessons

The lightboard is a technology originally developed by Michael Peshkinn at Northwestern University. It consists of a glass panel supported by a strong metal frame attached to both the floor and the ceiling. To see a picture of our setup, see Figure . The presenter stands behind the panel of glass and writes using a dry erase marker at the board. The image is then flipped so the viewer can see the writing in the correct direction. As the teacher works on the board, he or she can see what the viewer will see on a screen placed right behind the camera. This screen allows the presenter to get instantaneous feedback on the appearance of the final video.

This experience feels somewhat natural to teachers. Instead of pivoting to look at a class, the teacher simply needs to look up at a camera. The flow of talking and writing feels very much like lecturing to a class. Teachers who would pause to observe the students now stop to look into the camera, giving a connection to the viewer and natural breaks in the content. Teachers who are good at using space on a board will very quickly adapt to filling out the available space efficiently.

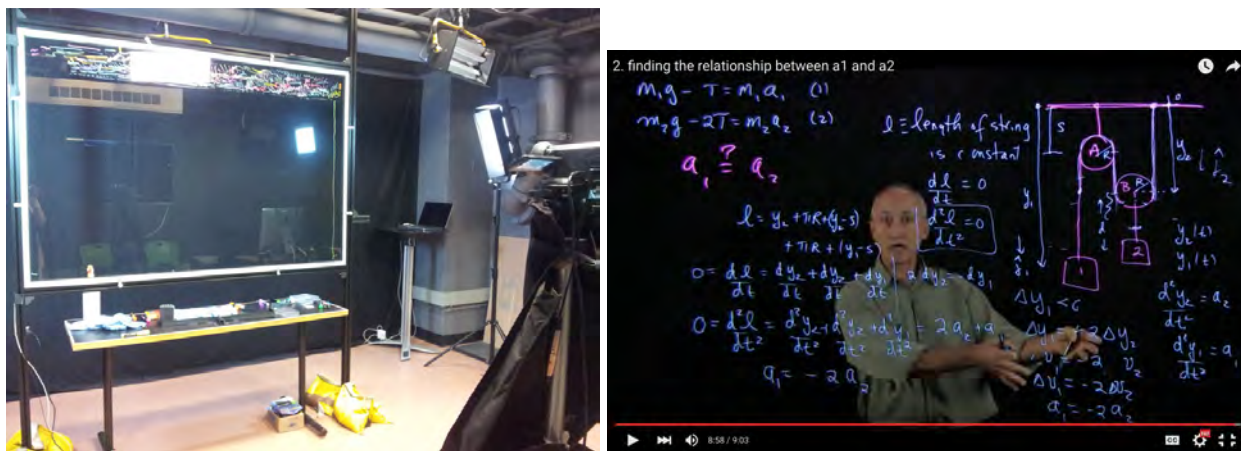


FIG. 1. Left: The room that contains the lightboard. The large glass plate is the board on which dry erase markers are used. The camera is on the right side of this picture and of the lights we use to illuminate the presenter can be seen. Right: Lightboard capture video still frame – showing the idea of the teacher finding a "hole" in the text while discussing a point.

While the lightboard is very natural, there are many tricks that we have learned to make videos even better. The placement of the teacher's head relative to the writing is not as important while writing, but once the teacher pauses to discuss what is written, it is important for the head to be fully visible. Some instructors have discovered that leaving a few little "holes" in the writing at various points in the board at head-level can solve this. They can talk naturally as they write and then find the "hole" for their head when looking at the camera for a discussion. To see an example, see the right image in Figure .

Because of the size of the board, learning to pace a lecture to exactly utilize the space of our one board has a learning curve. This has the surprising advantage of limiting the length of our videos to an appropriate duration. Sometimes, when an example or discussion takes more than one board, we are forced to selectively erase, so the important part can be retained while simplifying the material that is currently visible.

After watching some of the videos we produced, the teachers also learned to quickly draw something on the board to provide something interactive and engaging right at the beginning of the video. This is often an important diagram or equation which helps the students to focus on something that will provide context and prepare them for the subject of the rest of the video. Instead of only listening to the audio, the visual part of the brain can start engaging with the material as well.

One interesting problem arises due to the way the video is filmed. In order to see the writing in the correct direction, the camera image is mirror-imaged. The right hand rule is used frequently in physics to determine the direction of different vectors in relation to each other. When viewing a lightboard video, the right hand appears to be the left hand and the left hand appears to be the right hand. Therefore, teachers must practice the "left-hand rule" instead as well as switching which direction they call "into the board" and "out of the board". These are minor points that teachers quickly learn, but is an interesting example of an unforeseen issue that arises from the use of this new technology. For a discussion of this, see <https://youtu.be/5oPI0C30R2g>.

Once all of these tricks have been learned, teachers feel very natural in front of the lightboard.

It also becomes incredibly efficient – we can produce a video in about 2-5 times the length of the final video. Because of the natural feel of the lightboard, we find that there are other advantages. The eye contact from the presenter can help direct the students' attention to the appropriate part of the board. Body language can also be used to convey meaning.

In general, we have found that the lightboard is useful when we want students to mimic what we do; for example, how to draw diagrams, set up equations, identify variables, etc. Animation, on the other hand, is helpful when movement or visualization is fundamental to student understanding. We have found that the lightboard is very powerful and efficient, but sometimes we would benefit from a short visual of motion, and in these cases we can create animations that are quickly inserted into lightboard videos. For an example of this, see <https://youtu.be/HyjhwQFg3I>.

4. Uses of videos

There are four main categories of videos that we have made: concept videos, math derivations, worked examples, and teacher training. We present a brief description of each below along with Table I which gives more detail about some of the videos produced. In the last column of the table, we list the percentage of students in the class who viewed each individual video listed. These videos were produced at the same time as the on-campus class was running and some videos were better advertised than others, but comparing categories can still give some insight into their relative popularity.

Concept videos introduce topics or concepts to students. It is important that these videos are concise and have few distractions, so that students can easily review and understand what we are trying to present. The style of these videos ranges from fully animated to fully lightboard. There is some degree of scripting that generally takes place before these videos are shot, although in the case of our more experienced teacher, scripting is obviated by his years of experience teaching. Some of these concept videos present a big picture, such as how different subfields of mechanics relate to each other; other concept videos discuss more narrow ideas, such as a definition of one particular useful concept.

Mathematical derivations are often useful to see one time in physics but do not represent the major skill that is being taught. Therefore, these are topics that we often consider too detailed to discuss in detail during class. Not all students find these topics helpful in understanding the material and going through long derivations in class costs time that could be better used for group work. However, there is a significant proportion of the population who is very interested in these types of arguments, and who would benefit from the ability to view them multiple times or at the right time in their learning. While these videos had only a small number of views (see Table I), we have heard from students directly that they were a useful complement to in-class lectures.

Worked examples are a very popular type of video (see Table I). These videos tend to be longer (often 3-15 minutes) because we take the time to carefully go through all of the problem-solving procedures and work through the solution. Although we did not track the timing, we suspect that people used these problems while working on the homework to see how a similar problem was solved. When a student is invested in the outcome like this, we suspect the length of the video is not as important of a concern. In these videos particularly, we try to instill good habits in the students. We are careful to set up our diagrams in exactly the way we want the student to imitate. Equations are only introduced after discussion of what physically happens and what concepts we are using, so as to discourage “equation hunting,” which is so detrimental to learning physics; at the end of solving a problem, we consider the answer to make sure it makes physical sense, both

TABLE I. List of selected videos produced

video type	video title	length (min:sec)	popularity (%)
Concept	Vector Decomposition	1:34	37
Concept	Torque	2:01	23
Concept	Internal and External Forces	3:41	19
Concept	Rocket Equation	16:23	8
Concept	Position and velocity in circular motion	5:53	6
Concept	Center of mass	6:21	6
Concept	inertial and non-inertial reference frames	8:11	5
Concept	Rotational motion from the CM reference frame	5:38	3
Concept	Position vector	2:18	2
Concept	Kinetic energy of rotation	5:33	2
Derivation	Position in different reference frames	4:12	10
Derivation	If $p=0$, L independent of origin	6:06	6
Derivation	Net force is derivative of total momentum	7:02	4
Derivation	Moment of inertia of a sphere	5:24	3
Derivation	external force is total mass \times CM acceleration	6:09	3
Derivation	Derive torque = $I \times \alpha$	5:25	2
Derivation	Derive parallel axis theorem	10:20	2
Worked ex.	Set up pulley problem	6:14	37
Worked ex.	Find a relation between a_1 and a_2	9:04	33
Worked ex.	Moment of Inertia of Bead on a Ring	3:54	14
Worked ex.	Kinematics example	6:58	11
Worked ex.	collision of a point mass and pivoted ring	8:05	4

by thinking about the size of the value as well as the units.

A new use for worked examples that we have found is a subcategory of “hint” videos. Throughout the semester we spend a lot of in-class time on group-paced problem solving. While we do have a lot of teaching staff engaging with students, there are some points in time where students get stuck and can not progress until they receive help. To solve this problem, we produced a few “hint” videos and we found that some students would watch these hint videos instead of waiting for help. We only had a very small sample of these types of videos, so we have not collected adequate data to comment on their usefulness, but we plan to expand these videos in a future semester.

Finally, we enjoyed success with a completely unexpected use for video. Our introductory physics class has several sections each taught by a different professor. All the students are given the same homework with the same deadlines and they come together to take common midterms and a final. Therefore standardization across the different sections is crucial. One way to get better standardization is to present the different faculty with a short video quickly explaining the major concepts covered in a particular day. This was reported to be useful, especially by the less-experienced faculty. In particular, this helped standardize notation and clarify the emphasis of a

particular class. We also did not produce or use these videos in large quantities, but we would like to experiment more with them in future semesters.

5. Conclusion

In this paper, we reviewed some of the principles of good video production and use of videos in a course. Making lightboard videos only takes a little practice to learn how to properly use the space, move your body to be visible, look at the camera, and to consider special challenges like the right-hand rule. The four uses of video that we have focused on so far are concept videos describing basic ideas, mathematical derivations of various physics relations, worked examples, and teacher training videos.

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- [1] Zhongzhou Chen and Gary Gladding. How to make a good animation: A grounded condition model of how visual representation disjoin affects the construction of abstract physics knowledge. *Physical Review Special Topics - PER*, 10:010111, 2014.
 - [2] Dianna Cowern. Talks at google: Dianna cowern, aka physics girl.
 - [3] Anna Hansch, Christopher Newman, Lisa Hillers, Tomas Schildhauer, Katherine McConchie, and Philipp Schmidt. Video and online learning: Critical reflections and findings from the field. *HIIG Discussion Paper Series*, 02:1–31, 2015.
 - [4] J. hartley and I. Davies. *Programmed Learning and Education Technology*, 15:207, 1978.
 - [5] Juho Kim, Philip J. Guo, Daniel T. Seaton, Piotr Mitros, Krzysztof Z. Gajos, and Robert C. Miller. Understanding in-video dropouts and interaction peaks inonline lecture videos. In *Proceedings of the First ACM Conference on Learning @ Scale Conference, L@S '14*, pages 31–40, New York, NY, USA, 2014. ACM.
 - [6] Richard Mayer. *Multimedia Learning*. Cambridge University Press, 2001.

The Educational Impact of Whiteboard Animations: An Experiment Using Popular Social Science Lessons

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Abstract

Whiteboard animations are increasingly used in education despite little evidence of their efficacy. In this study, we measured the impact of whiteboard animations and other common instructional formats on learning outcomes, experience, and motivation. We recruited participants from Amazon's Mechanical Turk (N=568; 326 females). Participants were randomly assigned to view online lessons about popular topics in social science from well-established scholars in one of five common instructional formats: whiteboard animation, electronic slideshow, stage lecture, audio, and text. Results showed a benefit of whiteboard animations in terms of learning and subjective experiences of enjoyment and engagement.

Introduction

Video has become the most common medium to deliver online education. The popularity of video lectures, however, does not always match with its value as the right medium to accomplish instructional goals (Hansch, McConachie, Schmidt, Hillers, & Newman, 2015). In their recent review, Hansch et al. (2015) outlined eighteen different video styles and highlighted the importance of considering which video style to choose for a given course. This consideration is not only important to achieve pedagogical goals; video production is the most expensive part of online course production (Hollands & Tirthali, 2015). Schacter & Szpunar, (2015) draws attention to the lack of systematic research on how to enhance learning from instructional videos. For instance, such widespread use of online lecture materials requires innovative pedagogies and practices to engage students with the inherently passive media format. One type of video format emerged in the last couple of years is whiteboard animations.

“Whiteboard animation” depicts the process of drawing a finished picture, usually on a whiteboard or something resembling a whiteboard. Unlike traditional animations, whiteboard animations can dynamically represent concepts (and misconceptions) without focusing on narrative action. Whiteboard animations place viewers in the animator/narrator role as the images are constructed, presumably with the goal of helping viewers mentally construct the concepts. The animator builds audience expectations with step-by-step drawings and finalizes the main point with the completed drawing; new points are then commenced with a blank board and a new drawing. These animations use somewhat amusing line drawings that can be considered as emotional design in multimedia instruction (Mayer&Estrella, 2014; Plass, Heidig, Hayward, Homer, & Um, 2014). According to emotional design, learners learn better from multimedia

materials if they use attractive and amusing looking aesthetics design that invoke emotional responses compared to traditional design.

Whiteboard animations are increasingly used in a variety of contexts, including higher education, online learning, and the public communication of academic scholarship (e.g., Thon, Kitterman, & Italiano Jr., 2013; RSA videos); some claim that they may be more educationally effective than traditional presentations (Lee, Kazi, & Smith, 2013). Despite such claims and popularity, there is little to no compelling experimental evidence that they are more effective in terms of learning, motivation, or persuasion than other formats. This causes for some concern: whiteboard animations are both expensive and time-consuming to produce; moreover, unlike more traditional instructional formats, they must generally be outsourced to specialized third parties.

Similar to whiteboard animations is Khan-style tablet drawings. Guo, Kim and Rubin (2014) found that Khan-style tablet drawing tutorials are more engaging than slides or code screencasts. However, the data in this study came from four courses in science fields. Thus, it may not be possible to make generalizations to other domains. Similarly, in a previous experiment (Türkyay, 2016), using a set of short (1-2 minute) physics lessons, we found evidence that whiteboard animations are advantageous for both affective experiences and recall compared to text only, audio only, and videos. The current study extends the previous whiteboard animation study. In this study, we investigated similar effects for social science lessons of a more common length and deployed better measures of learning (i.e., comprehension of content).

Multimedia Learning and Animations

Multimedia learning theories mainly focus on the cognitive processing involved in learning (e.g., Mayer 2005). Fundamental principle behind multimedia learning is that people learn better from words and pictures than from words alone (Mayer, 2005). Using both words, including written and spoken text, and pictures, including static images and video, lets the brain process more information in working memory (Sweller, 2005).

In recent years, several researchers emphasized the possible role of motivation in multimedia learning. Moreno and Mayer (2007, p.310) highlight that emotional and motivational factors mediate learning by affecting cognitive engagement. Moreno (2005) proposed the cognitive affective theory of learning with media (CATLM) to better incorporate the role of motivational and metacognitive factors in multimedia learning and to extend cognitive theory of multimedia learning (CTML, Mayer, 2009). Mayer (2014) concluded, “Motivational features can improve student learning by fostering generative processing as long as the learner is not continually overloaded by extraneous processing or overly distracted from essential processing.”

Animations are a form of multimedia learning materials. They can be characterized by their interactive nature and extensive use of pictorial representation of information (Plass et al., 2009). Instructional animations present events changing over time (e.g., motion, procedures) and help learners to develop dynamic mental models (Boucheix & Guignard, 2005), and they are most commonly used to show scientific phenomena.

Animations can have multiple functions: cosmetic, decorative, attention gaining, motivating, presentation, or clarification (Rieber 1989, quoted in Plass et al., 2009). In all levels of

education, animations have gained increasing importance for the representation and communication of complex ideas (Plass, Homer, & Hayward, 2009), yet, the absolute effect of animations on learning is not clear.

Several design features can reduce unnecessary processing and increasing knowledge construction when learning with animation (see Plass et al., 2009). Höffler and Leutner (2007) state that animations can be effective when they use cueing technique. Cueing principle is about adding elements to direct learners' attention to important aspects of the learning material (de Koning, Tabbers, Rikers, & Paas, 2009). Cueing facilitates overt attentional allocation to direct learners' attention to important content, making educationally important aspects salient. It can help reduce searching demands in the animation and support search strategies (Keller et al., 2006). Moreover, de Konning et al. (2007) found that cueing can increase student learning of both cued and uncued content in an animation. Lowe (2003) stated that dynamically represented content is more salient and can serve as cues to improve learning of the animated content.

While animations have a long history in the realm of education, and there is a plethora of research on instructional animations, attempts to measure their impact on educational outcomes have been inconclusive and often contradictory (Betrancourt, 2005). For example, Hoffler and Leutner's (2007) meta-analysis concluded that there is a significant difference between using animations and using static images, whereas Tversky, Morrison, and Betrancourt (2002) found no significant impact of animations on learning. For practical applications, however, the relevant question is not *whether* animations affect learning, but rather "*when and how* animation affects learning" (Mayer & Moreno, 2002).

For the current study, we selected voice-over slides, stage lecture videos, audio/podcast and text as common forms of instructional materials to compare with whiteboard animation. These are among the most common formats for instructional materials formats.

Based on the background information we presented earlier, we hypothesize:

Hypothesis 1: Participants who receive whiteboard animations will perform better on a retention test than students who receive the same lesson in other formats.

Hypothesis 2: Participants who receive whiteboard animations will report more positive subjective experiences of enjoyment, engagement, attention and challenge compared to others who receive the lesson in other formats.

Hypothesis 3: Participants who receive whiteboard animations will have lower attrition rates compared to those in other groups.

Methods

Design

We used a between-subjects design with participants assigned randomly to one of five instructional conditions: whiteboard animation, electronic slideshow (i.e., sequential images with narration), stage lecture (i.e., video of a presenter and electronic slideshow), audio (i.e.,

narration) only, and text only. Participants were randomly placed in one of the conditions automatically using *Qualtrics*.

Participants

Participants were recruited from Amazon's Mechanical Turk (N=568; 326 females). Anomalous patterns in the data were identified and cleaned. Such patterns included participants with the same IP addresses and irrelevant answers to open-ended questions. The final number of participants whose data we analyzed was 532 (307 females). The average age was 36.3 ($SD=11.3$). The majority of participants were native English speakers (91.4%) and non-students (87.8%). On average, participants reported watching instructional videos for 2.6 ($SD=4.3$) hours per week, listening to instructional podcasts for 1.5 ($SD=3.6$) hours per week, and reading instructional texts for 3.8 ($SD=7.2$) hours per week.

The full experiment consisted of three sections, each lasting 15-20 minutes. Participants could earn up to \$2.25 for completing all sections, but only the first was required. Participants were compensated \$1.00 for the first section, \$0.75 for the second, and \$0.50 for the last.

Stimuli

Instructional videos were selected from the *Royal Society for the encouragement of Arts, Manufactures and Commerce's* (RSA) Animate series. We selected three presentations from their popular public YouTube channel: one on dishonesty by Dan Ariely, one on empathy by Roman Krznaric, and one on the purpose of language by Steven Pinker. Each presentation was originally available in two formats: whiteboard animations and stage lecture. We used these videos to create each additional format. To create the text-only condition, we transcribed the presentation. To create the audio-only condition, we stripped the video to leave only the audio narration. To create the electronic slideshow condition, we screen captured completed drawings and edited over the original audio. For the audiovisual formats (i.e., all but the text-only one), the lengths of the presentations were identical.

Procedure

Participants completed the study online through *Qualtrics*. After consenting, they answered a short demographic survey and completed up to three sections of the experiment (see Figures 1 and 2). Each section consisted of one 10-minute-long lesson followed by a questionnaire, distractor task, and comprehension test, with the order of the lessons randomized across participants. In order to control for time on task for the audiovisual formats, participants were not allowed to pause the lesson.

In the questionnaire, we asked participants to rate each lesson in terms of enjoyment ("How much did you enjoy the lesson?"), engagement ("How much do you want to continue?"), attention ("How much did you pay attention to the lesson?"), and challenge ("How much did you feel challenged by the lesson?") using a 5-level Likert scale, from "not at all" to "extremely." Each comprehension test consisted of ten multiple-choice questions (e.g., "Which one of the following may help to become a more empathetic society?", from empathy lecture), created by the research team, and an open-response question, in which participants were asked to summarize the lesson. These summaries were coded by two independent coders for main ideas and standardized before averaging.

After participants completed the first section, they were given the option to complete an additional section (for less compensation) and a final section (for even less compensation). Participants' choices to stop or continue with successively smaller rewards provided us with an objective behavioral measure of their motivation to learn with their assigned presentation format.

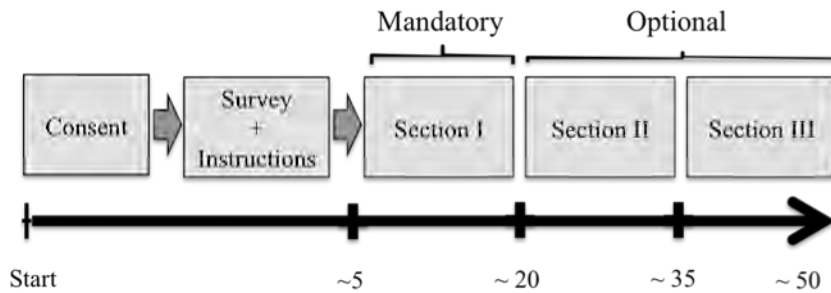


Figure 1. General procedure

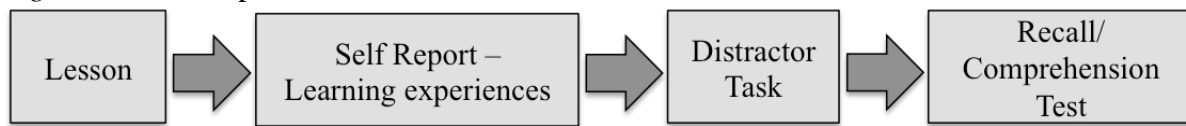


Figure 2. Procedure within a section

Results

Because data from the second and third sections violated the assumption of statistical independence and due to attrition, our analyses of subjective experience and comprehension include data only from the first experimental section.

Subjective experiences

To examine how instructional format affects subjective experience, we conducted a series of one-way ANOVAs with Lesson Format as the between-subjects factor. There was a significant effect of Lesson Format on enjoyment, $F(4,526)=7.3, p=.00001, \eta^2=.06$; attention, $F(4,526)=4.1, p=.003, \eta^2=.03$; and engagement, $F(4,527)=4.2, p=.002, \eta^2=.04$; but no significant effect on challenge, $F(4,526)=1.5, p=.190$.

We conducted a planned contrast to compare the whiteboard animation group with rest of the participants on affective outcome variables. Results showed that the whiteboard animation group reported enjoying the lesson more than other groups did, $t(526)=4.42, p=.0001$; paying more attention, $t(526)=2.67, p=.008$; being more engaged, $t(527)=2.93, p=.004$; and being more challenged, $t(526)=1.93, p=.054$, when compared to the other groups.

Table 1. Means and Standard Deviation of Affective Outcomes in Section 1

	Enjoyment		Attention		Engagement		Challenge	
	M	M	M	SD	M	SD	M	SD
Continuous								
Animation (n=107)	4.07	4.38	4.38	.95	4.00	.95	3.64	1.03
Slides (n=105)	3.67	4.32	4.32	1.08	3.72	1.08	3.50	1.01
Audio (n=109)	3.83	4.23	4.23	1.01	3.90	1.01	3.52	1.02
Lecture (n=99)	3.57	4.11	4.11	1.07	3.49	1.07	3.33	.98
Text (n=112)	3.46	4.07	4.07	.91	3.61	.91	3.40	.95

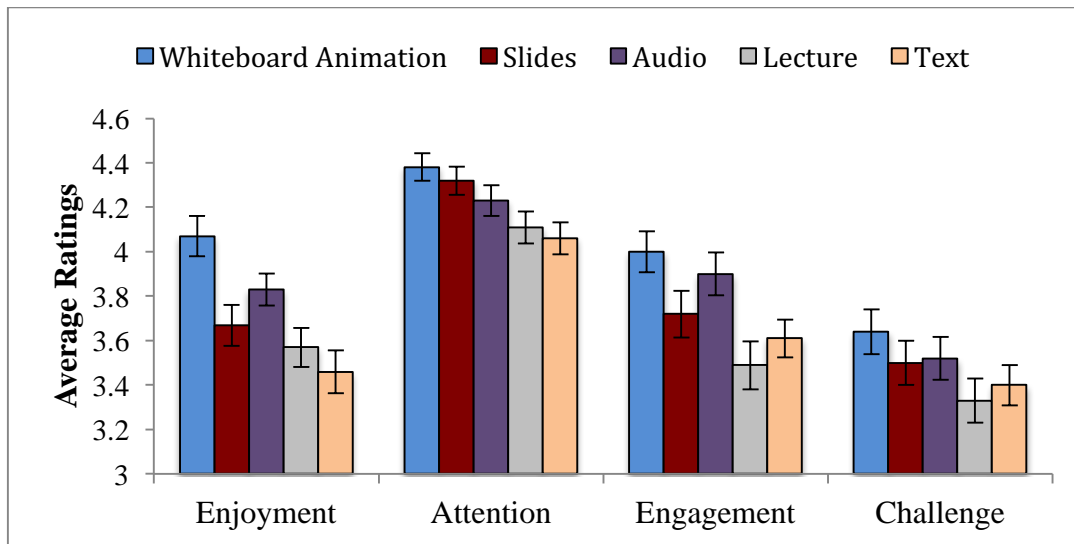


Figure 3. Average scores on participants' subjective experiences at the end of the Section I

Learning

To examine how instructional format affects learning, we conducted a series of one-way ANOVAs with Lesson Format as the between-subjects factor. There was a small but significant effect of presentation mode on participants' multiple-choice test scores, $F(4,527)=2.5, p=.05, \eta^2=.02$. There was a marginally significant effect of Lesson Format on the number of main ideas in participants' free-response summaries, $F(4,527)=2.1, p=.08, \eta^2=.02$.

Planned contrasts revealed that participants in the whiteboard animation group performed significantly better than other participants on the multiple choice test, $t(527)=2.2, p=.03$, and summarized significantly more main ideas than other participants, $t(527)=2.0, p=.04$.

Table 2. Average Comprehension Scores Measured per Group in Section I.

	Whiteboard animation (n=107)		Slides (n=105)		Audio (n=109)		Lecture (n=99)		Text (n=112)	
	M	SD	M	SD	M	SD	M	SD	M	SD
Section I	.62	.22	.54	.22	.57	.22	.55	.23	.60	.22

Behavioral Engagement/Attrition

A chi-square test revealed marginally significant association between participants' decisions to continue and lesson format for continuing onto the second section, $\chi^2(531)=9.1, p=.058$, but not onto the third section, $\chi^2(377)=6.83, p=.145$. Examination of the cell frequencies showed that 79.7% of the participants in the text group chose to continue to Section II, while the percentage of participants who chose to continue in the Lecture group was 63.3%. The percentages for other groups were between 65% and 75% (see Table 3). Fisher's LSD tests showed that a higher percentage of people from the text group continued onto the second section than those who were in slides ($p=.025$) and lecture groups ($p=.01$); and a higher percentage of people from the

whiteboard animation group continued onto the third section compared to the slides group ($p=.017$).

A follow-up one-way ANOVA showed that there is a statistically significant difference between groups in how much time they spent on the lesson page, $F(4,521)=12.03$, $p=2.32$. Tukey's HSD post hoc test revealed that the text group spent significantly less time ($M=7.13$ minutes) compared to other groups ($M=10.49$ minutes) on the lesson ($ps<.001$). This may be one of the reasons that the text group was willing to continue to the second section.

Table 3. Percentages of Participants Choosing to Continue after Section I and II per Group

	Whiteboard animation	Slides	Audio	Lecture	Text
Section I to II	71.0% ($n=76$)	65.7% ($n=69$)	75.2% ($n=82$)	63.3% ($n=62$)	79.7% ($n=89$)
Section II to III	60.5% ($n=46$)	40.6% ($n=28$)	45.1% ($n=37$)	46.8% ($n=29$)	45.5% ($n=40$)

Conclusion

In this paper, we investigated the impact of instructional format—and whiteboard animations in particular—on learning and experience for a set of social science lessons from a popular YouTube channel, RSA. Although the views on YouTube for these different formats indicates the popularity of whiteboard animations (e.g., as of today there were 779,974 views for animated version of Roman Krznaric's lecture compared to 142,693 for the original lecture type video), this study empirically showed how different video formats impacts the participants' cognitive and affective experiences. Lesson format had a significant impact on participants' subjective experiences, with participants responding most favorably to the whiteboard animations. One explanation for this benefit is that whiteboard animations provide learners with a first-person experience of involvement that models and encourages either knowledge construction or a sense of interactivity that promote engagement (Pedra, Mayer, & Albertin, 2015). Another explanation is novelty; the whiteboard animation group may have paid attention to lessons because this format is still fairly new. Further research is needed to distinguish between this sort of explanation—based on robust, intrinsic benefits of a particular multimedia format—and a short-lived novelty effect.

Although multimedia-learning principles are well established and scientifically grounded, the rapid evolution of online learning is generating novel situations where they may need to be refined or extended to be directly applicable (e.g., Yue et al., 2013). Given the substantial investments necessary for creating and producing online learning materials, it is surprising that very few recent innovations have been tested for efficacy and impact on learning outcomes. Our preliminary analyses indicate that whiteboard animations may be worth the cost: as shown in our study, they promote both learning and engagement.

References

Betrancourt, M. (2005). The animation and interactivity principles in multimedia learning. *The Cambridge Handbook of Multimedia Learning*, 287–296.

- Boucheix, J.-M., & Guignard, H. (2005). What animated illustrations conditions can improve technical document comprehension in young students? Format, signaling and control of the presentation. *European Journal of Psychology of Education*, 20(4), 369–388.
- Guo, P. J., Kim, J., & Rubin, R. (2014). How video production affects student engagement: an empirical study of MOOC videos (pp. 41–50). ACM Press. <http://doi.org/10.1145/2556325.2566239>
- Hansch, A., McConachie, K., Schmidt, P., Hillers, L., & Newman, C. (2015). *The role of video in online learning: Findings from the field and critical reflections*. Retrieved from http://www.hiig.de/wp-content/uploads/2015/02/TopMOOC_Final-Paper.pdf
- Hollands, F.M., & Tirthali, D. (2015). *MOOCs in higher education: Institutional goals and paths forward*. Palgrave Macmillan.
- Höffler, T. N., & Leutner, D. (2007). Instructional animation versus static pictures: A metaanalysis. *Learning and Instruction*, 17(6), 722–738. doi:10.1016/j.learninstruc.2007.09.013
- de Koning, B. B., Tabbers, H. K., Rikers, R. M. J. P., & Paas, F. (2009). Towards a Framework for Attention Cueing in Instructional Animations: Guidelines for Research and Design. *Educational Psychology Review*, 21(2), 113–140. <http://doi.org/10.1007/s10648-009-9098-7>
- Lee, B., Kazi R. H., & Smith, G. (2013). *SketchStory: Telling more engaging stories with data through freeform sketching*. IEEE TVCG (InfoVis '13) 19, 12, 2416–2425.
- Mayer, R. E. (2005). *Multimedia Learning*. Cambridge University Press.
- Mayer, R. E. (2014). Incorporating motivation into multimedia learning. *Learning and Instruction*, 29, 171–173. <http://doi.org/10.1016/j.learninstruc.2013.04.003>
- Mayer, R. E., & Estrella, G. (2014). Benefits of emotional design in multimedia instruction. *Learning and Instruction*, 33, 12–18.
- Mayer, R. E., Hegarty, M., Mayer, S., & Campbell, J. (2005). When Static Media Promote Active Learning: Annotated Illustrations Versus Narrated Animations in Multimedia Instruction. *Journal of Experimental Psychology: Applied*, 11(4), 256–265. doi:10.1037/1076-898X.11.4.256
- Mayer, R. E., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review*, 14(1), 87–99.
- Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, 38(1), 43–52.
- Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning: The role of modality and contiguity. *Journal of Educational Psychology*, 91(2), 358–368.
- Pedra, A., Mayer, R. E., & Albertin, A. L. (2015). Role of interactivity in learning from engineering animations: Learning from animations. *Applied Cognitive Psychology*, 29(4), 614–620.
- Plass, J. L., Homer, B. D., & Hayward, E. O. (2009). Design factors for educationally effective animations and simulations. *Journal of Computing in Higher Education*, 21(1), 31–61.
- Plass, J. L., Heidig, S., Hayward, E. O., Homer, B. D., & Um, E. (2014). Emotional design in multimedia learning: Effects of shape and color on affect and learning. *Learning and Instruction*, 29, 128–140. <http://doi.org/10.1016/j.learninstruc.2013.02.006>
- RSA - Animate, <http://thersa.org/events/rsaanimate>.
- Schacter, D. L., & Szpunar, K. K. (2015). Enhancing attention and memory during video-recorded lectures. *Scholarship of Teaching and Learning in Psychology*, 1, 60.

- Thon, J. N., Kitterman, A. C., & Italiano Jr., J. E. (2013). Animating platelet production adds physiological context. *Trends in Molecular Medicine*, *19*(10), 583–585.
- Türkay, S. (2016). The effects of whiteboard animations on retention and subjective experiences when learning advanced physics topics. *Computers & Education*, *98*(1), 102-114.
- Tversky, B., Morrison, J. B., & Betrancourt, M. (2002). Animation: can it facilitate? *International Journal of Human-Computer Studies*, *57*(4), 247–262.
doi:10.1006/ijhc.2002.1017
- Um, E. “Rachel,” Plass, J. L., Hayward, E. O., & Homer, B. D. (2012). Emotional design in multimedia learning. *Journal of Educational Psychology*, *104*(2), 485–498.
<http://doi.org/10.1037/a0026609>

STEM at Senior Secondary Level: Status of some Schools in Jammu Region of J&K State

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Abstract

India recognizes that there is a great need to attract students to science courses, and motivate them to take up challenging research problems to make India a knowledge economy and take advantage of its demographic dividend. To attract students to become tomorrow's innovators by pursuing STEM education, Government of India has made a number of interventions with a major programme launched in 2008 called INSPIRE (Innovation in Science Pursuit for Inspired Research). The main aim of this programme is to increase the R&D base in the country. It, perhaps, is the largest such programme anywhere in the world. We have also been part of this programme in implementing INSPIRE Internship in the State of Jammu and Kashmir (J&K). This sub-component falls under Scheme for Early Attraction of Talent (SEATS), which aims to attract talented youth to study of science by arranging science camps for about 50,000 science students of Class XI with global leaders in science to experience and reveal the joy of innovation on an annual basis nationally. We have organized nine camps so far which have been attended by 3235 students of our State. The paper discusses the broad methodology adopted in organizing these camps and the feedback received from the attendees and some of the mentors. We shall also discuss the findings of a STEM survey conducted recently in the region, to try and highlight the effectiveness of STEM teaching, learning and the experiences of the students in Jammu region of J&K State.

Key Words: STEM, NMEICT, MeLT, Scientific temper, INSPIRE

1. Introduction

India became one amongst 135 nations to make education a fundamental right in 2009 by passing the Right of Children to Free and Compulsory Education Act under the Article 21A of the Indian Constitution [1] for children between 6 and 14 years of age[2]. The literacy rate in the

age group of 7+ years stood at 64.8% (2001) and rose to 73% in the year 2011 (census) [3]. The total enrolment in primary stood at 13,24,28,440 in the year 2013-14 [4]. The total population of the State of Jammu and Kashmir as per 2011 census stood at 1.25 Cr with a literacy rate of 67.2%. Total enrolment at primary level was 12,23,462 in the year 2013-14. There were 23,234 schools (owned + aided by government) in 2013-14 in the State, having a total of 86,828 teachers. In J&K, 60% teachers in the government schools were professionally trained as against 80% at the national level in 2013-14 [5]. In 2009 Rashtriya Madhyamik Shiksha Abhiyan (RMSA), a Government of India scheme targeting secondary and senior secondary schools was launched. It envisaged achieving an enrolment rate of 75% from 52.26% in 2005-06 at secondary stage [6].

Sustainable development and research in basic and applied sciences go hand in hand. It is therefore, most essential for nations to attract large chunks of their young school going population to the study of science. Different countries have evolved various approaches to ensure participation of youth in science education. India recognizes that educating students in STEM subjects is the need of the hour and has thus, been making efforts in this direction. Reforming the way teachers teach, particularly in STEM subjects, has been and is a big challenge. Several authors have suggested that conventional methods of teaching only result in creating pseudo-experts. In most of the cases such students are not employment ready and often lack required skills [7]. It has been established that unless students are taught in a manner which encourages and enables them to apply, use, put into practice, what they have learnt in the classroom by additionally involving their own imagination to its fullest potential they cannot become productive. Cooperative or peer learning can be a rewarding experience for the children as it leads to sharing of ideas towards completion of an academic task or assignment [8]. Thus, one has to ensure that teachers of STEM subjects are able to impart the required skills to instill creative and problem solving capability in children. At the same time one has to devise strategies to attract and retain students in STEM areas. India has initiated several measures in this direction which have come from both government backed initiatives as well as through non-governmental interventions. Science popularization and development of scientific temper has been at the core of most of these interventions. Recent advances in information and communication technologies have given a new flip to these initiatives as more and more youth are able to access internet not only on computers but more importantly through mobile devices.

There have been many interventions both at national and local level and this paper shall discuss a few of them:

2. Interventions in Science and Technology (National perspective)

Inculcation of scientific temper, attraction and retention of talent in Science has been a constant challenge. India, aspiring to be a knowledge economy, has been making sustained efforts in this regard. A series of policy interventions have been made by successive governments to attract highly motivated students for pursuing basic science courses and a research career in science. Some of these are:

2.1 Science Olympiads

Department of Atomic Energy (DAE) based, National Board of Higher Mathematics (NBHM) was instrumental in initiating and organizing activities which lead to India's participation in the International Mathematics Olympiad (IMO) from 1989. Homi Bhabha Centre for Science Education (HBCSE), a national centre of TIFR, Mumbai and the Indian Association of Physics Teachers (IAPT) started the Physics Olympiad programme in the country from 1997. In 1999, HBCSE extended the programme to chemistry and biology. These efforts received good support from Government, and India finally sent its first team to International Physics Olympiad (IPhO) in 1998, International Chemistry Olympiad (IChO) in 1999 and International Biology Olympiad (IBO) in 2000 [9]. Indian students have done very well at international level in these Olympiads and have won a number of medals.

2.2 Kishore Vaigyanik Protsahan Yojana (KVPY)

In 1999, Kishore Vaigyanik Protsahan Yojana (KVPY), a national program of fellowship [10] in the area of basic sciences was initiated by Government of India and coordinated by Indian Institute of Science, Bangalore. Through this programme students with talent and aptitude for research are identified, and are extended help to pursue research careers in science. Till 2013, a total of 3875 fellows have benefitted from this programme in science, engineering and medicine streams.

2.3 Innovation in Science Pursuit for Inspired Research (INSPIRE)

As part of vision 2020, Innovation in Science Pursuit for Inspired Research [11] (perhaps the biggest such programme anywhere on the globe) meant for attracting and retaining talent in science was initiated in 2009-10. The scheme envisages giving India a leading edge and pegging it as an emerging knowledge economy. It comprises of three main components namely (i) Scheme for Early Attraction of Talent (SEATS) (ii) Scholarship for Higher Education (SHE) and (iii) Assured Opportunity for Research Careers (AORC).

SEATS encourages study of science by providing INSPIRE Award to one million young students in the age group 10-15 years so as to give them an opportunity to experience the joy of innovations. Additionally, one week science internship mentoring camps for about 50,000 senior secondary level students are held annually, throughout India for interaction with gifted teachers and global leaders in science. As a part of SHE, annually, 10,000 scholarships (Rs.80,000/- each) are provided for undertaking Bachelor and Masters level education in the natural and basic sciences. AORC aims at attracting, attaching, retaining and nourishing talented young scientific human resource so as to expand the country's R&D base. This scheme is extended in both basic and applied sciences (including engineering and medicine). The component also provides assured opportunities for post-doctoral fellowships by providing contractual and tenure track positions for five years in both basic and applied sciences.

INSPIRE has so far touched 10 lakh students in the age group of 10-15 years under its awards component. More than 230 innovations by young students are pending provisional patenting. Over 2.10 lakh students in the age group of 16-17 years have participated in internship camps during the last four years. More than 29,000 students among the top 1% performers in school

boards are now studying UG courses in sciences. 3,300 INSPIRE fellowships have been provided for pursuing research degrees to students who are first rank holders at Master's level in Universities. More than 370 post doctoral scholars have been provided INSPIRE faculty awards under AORC component of INSPIRE scheme. More than 30% of the scholars receiving INSPIRE faculty awards have returned from various countries to work in, and for India, thus reversing the brain drain through brain gain.

3. Our Interventions

Inculcation of scientific temper, attraction and retention of talent in Science has been a constant challenge. As India wants to be a knowledge economy it has been making sustained efforts in this regard. A series of policy interventions have been there from time to time by the government to attract highly motivated students for pursuing basic science courses and a research career in science. Some of these are:

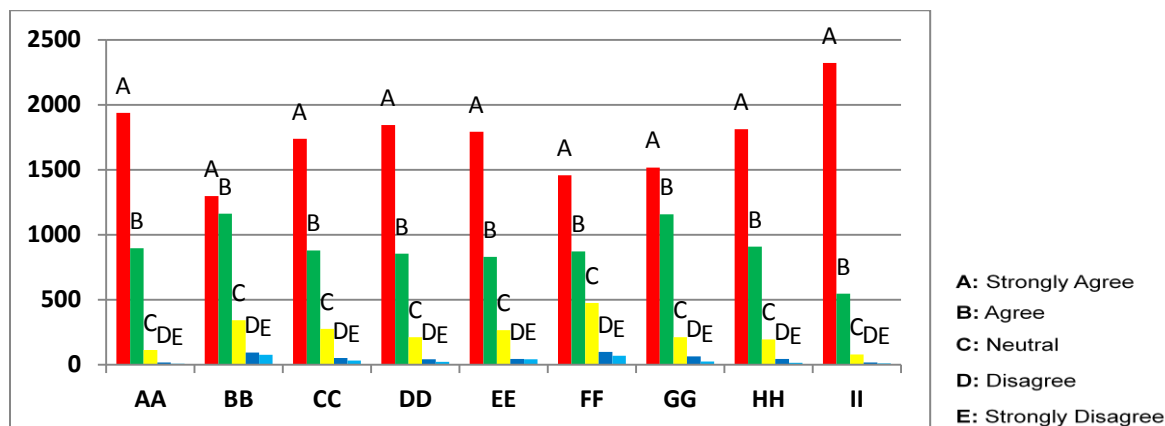
3.1 MeLT in J&K

Under National Mission on Education through Information and Communication Technology (NMEICT), we deployed VSAT enabled mobile e-learning terminals as part of a nationally coordinated project (V-MeLT). Prior to the deployment, a need assessment survey was conducted in a limited geographical area in Jammu & Kashmir, India in 2009 [12]. It confirmed that there are many children without access to ICT enabled education in the region. Limited ICT infrastructure is available, that too only in centrally funded institutions which are very few in number. To take the ICT infrastructure to these un-served institutions, we joined hands with IIT Roorkee to plan and deploy V-SAT Enabled Mobile e-Learning Terminals (MeLTs). An impact assessment survey (third party) was conducted, results of which were also presented in LINC 2013 [13]. It demonstrated the success of the pilot implementation of MeLTs in India.

3.2 Our Intervention in INSPIRE in J&K for STEM Promotion

We conducted our first INSPIRE camp in April 2010 in the University with participation of students from all over the state of J&K. We have organized nine camps during April 2010 - September 2015. Two camps are proposed to be held during this year. A total of 3140 students and 120 mentors have participated in the camps held so far. Mentors include national and international awardees, Fellows of National and International Science Academies. In July 2015, during the 8th camp with the participation of 620 students, we achieved the distinction of organizing the largest such camp anywhere in the country. These camps have brought students from Jammu and Kashmir regions on one platform [14]. However, it was not possible to get students from the Ladakh region of the state which is over 700 kms away from us. Therefore, we organized an INSPIRE camp in June 2014 in Leh in collaboration with the local unit of Army and district administration. The most recent Camp was organized in September, 2015. Students were exposed to hands on demonstration sessions, tours to NHPC, DIHAR, Khardungla Pass, Air Force Station, Leh etc to broaden their horizon. Our initiative has been the

largest such initiative by any University in the State of J&K. Feedback received from the participants is given below:



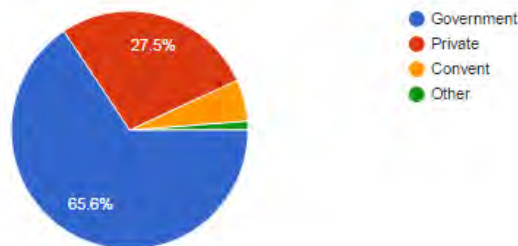
- AA:** The INSPIRE camp administration was appropriate and informative
- BB:** The INSPIRE camp was scheduled at a suitable time
- CC:** The camp facilities and location were appropriate and satisfactory
- DD:** Lectures & interactions with the Mentors were of high standards
- EE:** Quality of Meal was good (Breakfast, lunch, tea-breaks & dinner)
- FF:** The lab sessions & tour were highly interesting & informative
- GG:** The Mentors responded to questions in an informative, appropriate and satisfactory manner
- HH:** All the lecture venues had excellent audio visual & projection facilities
- II:** Overall, the camp was informative, valuable & inspiring

It was very encouraging to note that the maximum number of participants strongly agreed that these camps were ‘informative, valuable and inspiring’ as indicated above in the plot. In successive camps, we find the students getting fascinated by the demonstrations and hands on sessions. The beauty of observing science in action, and in some cases themselves translating theory into tangible results through experimentation awakens them to joyful learning. It removes the disconnect children usually feel between science and the real world. We are often asked why these simple interventions are not a part of their regular curriculum. Interactions with mentors, is helpful to students to experience the joy of innovations, and fills them with confidence that they can also be part of the innovation landscape of the country. On the last day of each camp students would not want to leave the camp and most of them request us to extend the duration.

4. STEM Survey

The INSPIRE scheme is meant to serve the meritorious students (top 1%). To understand the overall status of the children, including those not having access to best schools, we decided to undertake a survey among children of senior secondary schools or those who have just passed out from that level. This survey was aimed at understanding the status of STEM education in the Jammu

Which type of school did you study in/ are studying in? (160 responses)

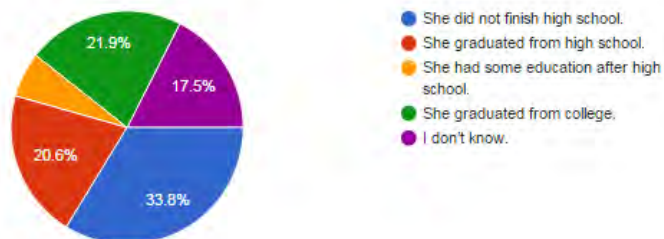


region of J&K State. The questionnaire was designed on the pattern similar to that of National Centre for Educational Statistics (<https://nces.ed.gov/>). We used Google forms to collect the responses from the respondents who had access to internet. Prints of the form were used to collect the responses from those who did not have access to internet/ good quality internet. A total of 160 respondents in the age group of 17-19 years took part. The survey results are discussed here:

Majority of the respondents (65.6%) were studying in government schools, 27.5% in private schools, and the remaining in convent schools or others.

Interestingly, although 79.4% studied mathematics as one of the subjects at senior secondary level and 32.5% studied biology as one of the subjects, only 15% studied both together. The perceived career opportunities rather than an actual interest seem to be the reason for the mathematics tilt. Biology is perceived to be a research driven career path, where as mathematics along with physics and chemistry leads majority to professional/ technical degrees and employment avenues immediately after graduation.

How far in school did your mother go? (160 responses)



How far in school did your father go? (160 responses)



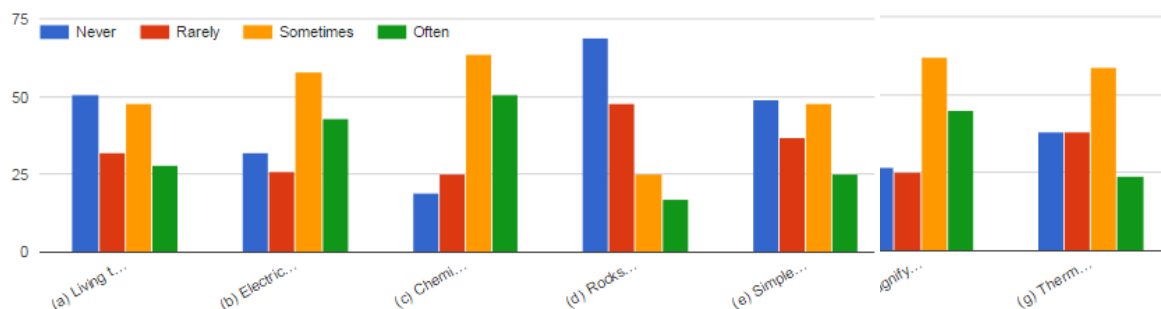
Fathers of 26.9% and mothers of 33.8% respondents did not finish high school. Fathers of 18.1% and mothers of 20.6% respondents had completed high school. Fathers of 27.5% and mothers of 21.9% respondents have graduated from college. 42.5% respondents said that people at their home hardly talk to each other in english, and 27.5% responded that english is never spoken at their homes.

Majority of the respondents (67.5%) said that they have separate bedroom at home, while 45.6% respondents said that they have more than one bathroom at their home. 67.1% had either a car or a bike or both at home.

We observe that 51.2% respondents had a computer/ laptop at their home for use however, 55.6% had access to internet at home. Access to internet has been made easier and affordable by the use of smartphone, 58.1% respondents owned one, and 61.9% were active on facebook. We observed, that although close to 50% respondents have a computer or laptop at home, the school does not make them use it for doing homework even though majority of the respondents said that they could do these or similar activities using computers. It was interesting to learn that majority of them use internet to compare products. At the same time school or their curriculum does not

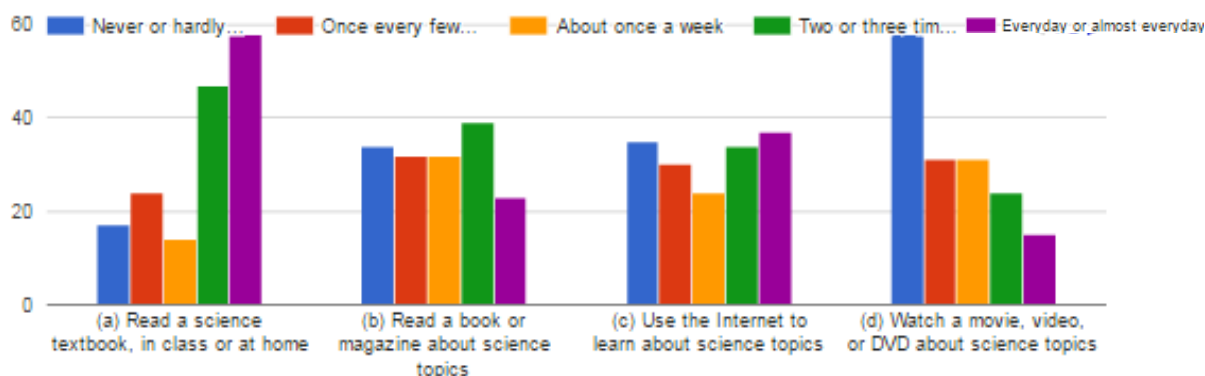
encourage them to discuss inventions that change the way people live; choices people make that affect the environment; conditions that influence the use or availability of machines or devices; and the way people work together to solve problems in their community or world. Majority of the respondents rarely or only sometimes discussed such issues.

Most of the schools do not have adequate laboratory infrastructure to demonstrate experiments and promote hands on learning. In science class this year, a sizable number of respondents had either never, or only rarely, done hands-on activities or projects with (a) living things (52.5%) (b)



electricity (36.3%) (c) chemicals (27.5%) (d) rocks or minerals (73.8%) (e) simple machines (53.8%) (f) magnifying glass or microscope (32.5%) (g) thermometer or barometer (47.5%). What is clearly visible is that experimentation/ hands-on is not a regular feature of the school activity thereby depriving the children from learning to reason.

This can be alleviated to quite an extent by integrating recorded digital content from online open sources with traditional classroom teaching. Blended learning would enable the students to

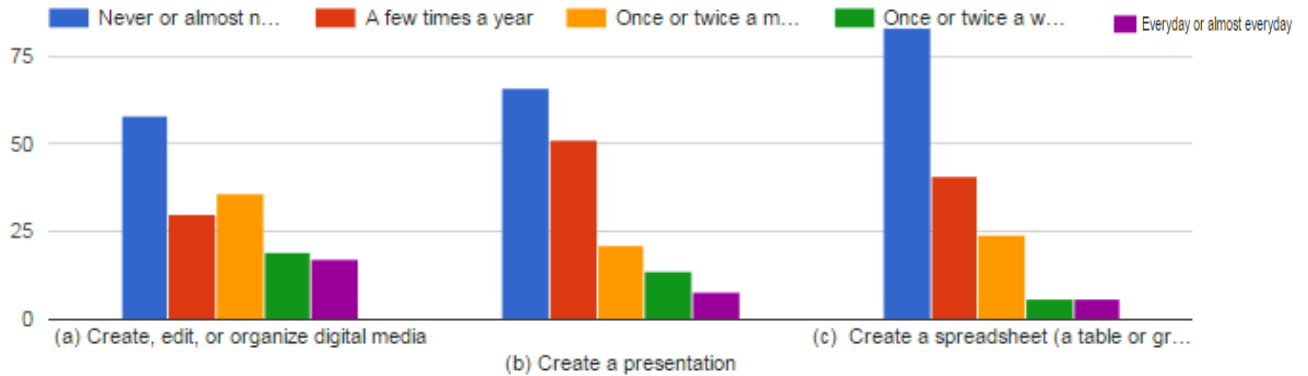
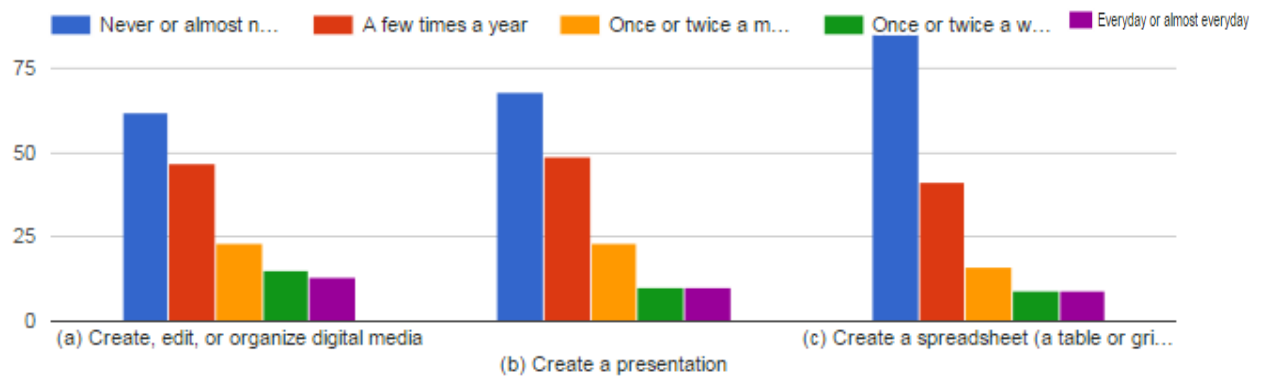


understand, appreciate, and in time develop a scientific temper and spirit of inquiry. However, the teachers have themselves been educated in a traditional setup where technology enabled learning was not there; hence they are unable to integrate technology in their teaching concepts.

65.7% respondents read a science textbook in class or at home either every day or at least two to three times a week. 55.7 % have never/ sporadically watched e-content such as movies, videos,

or DVDs about science topics. Almost half of the respondents have not used internet to learn about science topics.

As part of their school work majority of the respondents do not use a computer or other digital technology for creating, editing or organizing digital media, they do not create any presentations or spreadsheets, and if at all they do so they do it only a few times a year. This is despite the fact that 51.2% respondents had a computer/ laptop at their home which they use, while 55.6% had access to internet at home. The story is no different when it comes to homework as shown in the figure on the next page:



5. Future Directions

These efforts, governmental/ non-governmental initiatives, to encourage STEM education at senior secondary level and beyond would be more fruitful if the children inculcate the scientific temper and spirit of inquiry from the earlier classes. The benefits of blended learning have been demonstrated time and again in micro environments; however their translation into everyday teaching in the schools seems to be possible only by first priming and training the trainers and making them an integral part of the process along with strengthening of digital infrastructure. BLOSSOMS [15] is an excellent example how this can be achieved using the teaching duet pedagogy.

6. References:

- [1] "Provisions of the Constitution of India having a bearing on Education". Department of Higher Education. (<http://education.nic.in/constitutional.asp>)
- [2] "India joins list of 135 countries in making education a right". The Hindu News. 2 April 2010 <http://www.thehindu.com/news/national/article365232.ece>
- [3] http://mhrd.gov.in/sites/upload_files/mhrd/files/statistics/EAG2014.pdf
- [4] The Right of Children to Free and Compulsory Education Act, 2009 (http://ssa.nic.in/rte-docs/Final_RTE_4th_Year.pdf).
- [5] <http://ssa.nic.in/>
- [6] http://mhrd.gov.in/rmsa_status
- [7] Robert J. Sternberg, "What Is an "Expert Student?" Educational Researcher, Vol. 32, No. 8, pp. 5-9.
- [8] Effandi Zakaria and Zanaton Iksan, "Promoting Cooperative Learning in Science and Mathematics Education: A Malaysian Perspective" Eurasia Journal of Mathematics, Science & Technology Education, 2007, 3(1), 35-39.
- [9] <http://www.iisc.ernet.in/insa/ch5.pdf>
- [10] <http://kvpvpy.iisc.ernet.in/>
- [11] <http://www.inspire-dst.gov.in/>
- [12] S K Wanchoo, A Kaul, S Vaishnavi, H Sinvhal, H K Verma, "MeLTs; A new approach to delivery of e-learning in remote and un-served rural areas in India"; Proceedings of LINC-2010 international Conference held at Massachusetts Institute of Technology, Cambridge USA during May 23-26, 2010.
- [13] S. K. Wanchoo, Ajay Kaul, S. Vaishnavi, H. Sinvhal, H. K. Verma "Educational Technology and its acceptance level among the students and teachers in some rural area" Proceedings of LINC-2013 international Conference held at Massachusetts Institute of Technology, Cambridge USA during June 16-19, 2013.
- [14] www.inspire.smvdu.ac.in
- [15] <https://blossoms.mit.edu/>

Mobile Apps for Recording Climate Change: A Case Study of Mobile Learning through Citizen Science in Four Urban Secondary Schools in India

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Abstract: *The Government of India has launched several ambitious initiatives to revolutionize the way India embraces technology in every sphere of its operations. In education in particular, e-learning as a tool is still not very widespread and there are presently few e-tools available to promote environmental education in schools. Mobile Apps for Climate Change, launched in 2014, was designed to help meet this need through developing and utilizing three mobile apps (iButterflies, iTrees, iNaturewatch Birds) to assist through citizen science documenting urban biodiversity. In an effort to introduce the apps and develop awareness of urban biodiversity, the apps were launched through a special challenge to students in classes from 6 to 8 in four metropolitan areas: Mumbai, New Delhi, Kolkatta and Hyderabad. Altogether 1599 students and 48 teachers from 32 schools from the four cities took up the Urban iNaturewatch Challenge beginning in January 2015 and concluding in April 2015. During this span, students collected 2227 records on 47 species of trees, 48 species of birds, and 50 species of butterflies. For correlation, tree phenology and flight periods of butterflies and birds were compared with temperatures at each location. In addition to encouraging scientific analysis, the iNaturewatch Mobile apps also were analyzed for pedagogical principles as place-based data collection tools, often considered to be most common type of app in science education. They are also classified as technology-based scaffolding and include conceptual scaffolds with visual and audio representations. This paper reports on issues related to usage of the iNaturewatch Mobile apps for climate change studies, engaging students outdoors for environmental studies, and the potential of students as citizen scientists in urban settings.*

1. Introduction

India today is enthusiastically embracing ICT. In order to transform the public services through the use of information technology, the Government of India has launched the Digital India programme with the vision to transform India into a digitally empowered society and

knowledge economy (Digital India Website)[2]. The progress of any nation depends on the system of education adopted by it to groom the next generation. With the proliferation of mobile technologies in all walks of life, there is a need for India to remodel and upgrade the current education delivery system. Several initiatives have been taken by the Government of India to promote e-learning. One of the most prominent among them is the “National Program on Technology Enhanced Learning (NPTEL)” by the Ministry of Human Resources Development. The mission of NPTEL is to enhance the quality of engineering education in India by providing free online courseware. NPTEL’s mission is coincident with the introduction of m-learning (the use of mobile devices to deliver education anytime anywhere) into India’s education sector, especially in the field of adult learning in rural areas. Mobile devices can be especially helpful in the quick conceptualisation of smart education systems. This is especially important in India, which has the second largest mobile phone user subscription base in the world, with over 900 million mobile phone users (Raman, 2015)[6]. However, as observed in Saudi Arabia by (Alrasheedi *et al*, 2015) [1], in India too, infusion of mobile technology into education, especially environmental education, is inhibited as most educational institutions have a ‘no mobile’ policy in place.

This paper discusses a pilot project, Mobile Apps for Climate Change, which introduced m-education in participating Indian schools. The aim of the project was to develop three Android mobile apps as Eguides for 50 commonly found indicator species of birds, butterflies & trees. The project also included a student citizen science programme in urban schools to collect data on the impact of climate change on urban biodiversity using mobile apps. Three mobile apps were developed to facilitate the project: iButterflies, iTrees, iNaturewatch Birds, collectively known as iNaturewatch Mobile Apps. These apps were used to collect data on urban biodiversity in four metropolitan areas: Mumbai, New Delhi, Kolkatta and Hyderabad. This was the first time in Indian schools where students used their mobile phones to complete a school project. As defined by Shih & Mills (2007) [8] and Traxler (2008)[10], iNaturewatch mobile apps fits the definition of m-Learning, which means anytime, anywhere learning capacity using multiple media functions like pictures, videos, text, and voice within the learner’s comfort of space and time, spontaneity, interactivity, informality, and ownership of learning. This paper also discusses the pedagogical principles used in implementation of the project.

2. Project Issues: The *Mobile Apps for Climate Change* project addressed two main issues:

2.1 Cities are often very rich in biodiversity as they are located in very rich and fertile areas. As natural geographic areas, they typically have very high diversity of plants and animals. However, cities as human made environments need to learn how to co-exist with that biodiversity. With rich biodiversity, cities have enormous potential to mitigate climate change (Elmqvist, 2015)[3]. When this is considered in light of estimates that by 2050 the global urban population will double to 6.3 billion, population growth will affect urban ecosystems adversely, if not managed (CBD, 2012)[7].

In order to conserve urban biodiversity, documentation is important and currently is not done systematically. Post Conference of Parties (COP) 10, the Ministry of Environment of Forests and Climate Change (MoEFCC) of India initiated the People’s Biodiversity Register (PBR) to address this deficit, however the work is progressing at a snail’s pace. Therefore, involving common citizens in monitoring of flora and fauna will be helpful to bridge this gap and generate data that provides insights about climate change through observations of seasonal behavioral changes in urban biodiversity. Because birds, butterflies and trees are indicators of a

healthy urban environment, they were chosen as the research subjects for the project. Additionally, most of the necessary descriptive knowledge is readily available in field guides or scientific institutions but few e-learning tools are freely available. Having mobile apps to help in ready identification of common species of urban biodiversity was a first step in addressing this issue. However, like any citizen science project, the accuracy of the data collected needed to be validated. For the *Urban iNaturewatch Challenge*, team members served to evaluate the data and redundancies and obvious inaccuracies were removed. The use of these mobile apps in documenting urban biodiversity led to formulating four research questions that are presented with responses in the discussion section at the end of this paper.

2.2 It is claimed that many children are suffering from nature deficiency syndrome and that while children are increasingly comfortable with their gadgets indoors, they tend to avoid being outdoors (Louv, 2015)[4]. The authors sought to find ways of engaging children in a meaningful way to use the very same gadget to take them outdoors thereby reversing the process. Additionally, environmental studies have tended not to interest students in India because it is not a graded subject area. Students tend to spend their time on graded subjects and ignore ungraded subjects. Another drawback is that the curriculum is largely based on environmental problems rather than depicting positive aesthetic and ecological values of biodiversity. In this context, use of technology such as mobile apps could provide a novel and effective way of engaging students. In addition to learning to identify species, the students could be given more responsible tasks collecting data that could reflect on the impact of climate change on their immediate environment. While recognizing that the project served to motivate and engage middle level students in getting outdoors to collect species data and to increase environmental awareness rather than to serve as a scientifically valid database, project leaders hope that the apps may ultimately be employed in collecting and posting scientifically valid data. In this case, the student citizen science programme wherein students used iNaturewatch mobile apps to record their findings and feed to the master database on the project website became an interesting yet challenging school project.

1. Methods

1.1 Content for apps & website: The mobile apps were inspired by the Audubon eguides and their framework was similar to these apps. The species selection was done on the basis of the most common species found in any urban area. A total of 50 species of birds, trees and butterflies were selected for inclusion in the apps with 447 photographs for species description. The pictures included male/female birds and butterflies, early stages of butterflies, and tree leaves, flowers, fruits, and barks. Birdcalls also were included the bird app.

As the project included a citizen science component wherein the users could report their sightings, a project website was developed for collecting and presenting the data. As the mobile apps were offline the data entry section was incorporated into the website. The website included guidelines of the study along with datasheets that could be downloaded if a school decided to use datasheets rather than the mobile phone. The online datasheet had preloaded information about the individual species.

1.2 Development of mobile apps and website: The authors engaged a digital advertising company, LycodonFx Pvt. Ltd. for development of the mobile apps and website. A dedicated

developer could take responsibility for maintaining the mobile apps and website beyond the project period. Ladybird Environmental Consulting (LEC) provided the designs and the apps were branded as iNaturewatch based on an LEC citizen science initiative. A iNaturewatch logo was designed and the website domain (www.inaturewatch.org) was created. The apps were individually named as iTrees, iButterflies, iNaturewatch Birds (see **Figure 1** for snapshots).



Figure 1. Snapshots of Mobile Apps

In addition to the mobile apps and website, an instructional video on usage of the apps and data entry on the website was developed to instruct teachers and students in how to use them. The video is available on Youtube (<https://www.youtube.com/watch?v=6u5xvtBfgZE>). A tutorial section was also embedded in the app along with the video link (see **Figure 2**)



Figure 2: Tutorial

1.3 Identifying schools for the citizen science programme: The team collaborated with environmental NGOs who had existing school programmes. In Mumbai, Greenline of Donbosco Development Society was chosen as they already had 50 city schools enrolled in their programme. For other cities, WWF-India was selected as they run nature clubs among schools across the country

One of the challenges faced by the project partners was school’s policy of not allowing students to use mobiles in schools and many schools declined to participate for this reason. The approach was therefore changed for such schools. Instead of students, the teachers were asked to use their own mobiles for the project work. We also provided individual tablets to each partner so that their staff could demonstrate the mobile apps for schools or use it while conducting sessions for students in the field.

2. Results

2.1 Publishing and Launching of Mobile Apps: The mobile apps and website were published on 12 December 2014 and are available for free download on Google Play Store. The launch events were planned throughout December 2014 at respective locations. During the project, downloads of each app ranged between 1000-5000 with ratings between 4.3- 4.6 out of 5. The project apps were downloaded from 11 countries around the world indicating that their usefulness was not confined to the project.

2.2 Urban iNaturewatch Challenge: To encourage student participation in the citizen science initiative, the Urban iNaturewatch Challenge was introduced during the launch. Due to the introduction of a competitive element that might encourage inflated reporting, the challenge meant that the emphasis of this initial project was less on reliable documentation and more on generating enthusiasm for and awareness of urban biodiversity. However, project leaders anticipate the apps may be employed in other more scientifically verifiable activities. Under this challenge the highest number of sightings recorded by a particular school would “win” the competition. Participating schools agreed to consider the challenge as a student project ensuring that participating students received marks for carrying out the project. Classes 6-8 were selected and divided so that Class 6 studied trees, Class 7 Butterflies, and Class 8 birds. Each class had a group of 25-30 students. For school communication a circular and registration form was developed for all schools. A poster was developed and circulated among the schools and social media to promote the Urban iNaturewatch Challenge,. Altogether 1599 students and 48 teachers from 32 schools from four cities had taken up the Urban iNaturewatch Challenge(see **Table 1**).

Table 1. Total Participating Schools and Students

City	No. of Schools	No. of Students
Mumbai	9	192
Hyderabad	7	603
New Delhi	6	96
Kolkatta	10	708
Total	32	1599

The project partners conducted orientation sessions for the teachers and students to understand the registration process. Both the LEC video and a slide-based presentation were provided. The orientation included briefing project participants on Climate Change, biodiversity, project objectives, the role of student scientists, and methods for collecting and filling the biodiversity datasheet. Additional outdoor visits also were conducted to provide experience using the apps and observation methods in the field.

2.3 Data Collection by Student Citizen Scientists: Data collection began in January 2015 and concluded in April 2015. The data was collected through eco clubs and nature walks organized by participating teachers. Students also collected data from nearby parks and gardens. Some students collected the data daily others reported sightings once per week. Students often found it easier to identify trees as compared to birds and butterflies. Many schools also lacked a proper green cover and thus had to choose a nearby park to complete the project. Some students also collected data from around their houses. The teachers also had to supervise the days when the students were allowed to bring their mobile phones for using the apps so that the device was not misused. Some schools identified one leader in each group who was given permission to bring their mobile phone on identified days. Some schools also allowed students to upload their data so the teachers did not have to take further time out from their normal duties.

Owing to the competitive spirit of the challenge the authors anticipated duplicate/incorrect entries. Thus, multiple entries from one user for a set of species on same date from same school and inaccurate data pertaining to a species from a particular city were removed. Due to the short duration of the project, valid scientific screening of data could not be completed. Project leaders plan to add this element in future project iterations.

(i) **Species Diversity:** Students recorded 47 species of trees, 48 species of birds and 50 species of butterflies from all four metros. Hyderabad recorded highest numbers of species, 41,45,41 respectively, followed by New Delhi (36, 29,15), Kolkatta (21, 30, 24) and Mumbai (34, 9,10). The diversity was primarily related to the participants’ efforts in uploading the data and secondarily to the cities’ urban biodiversity (see **Figure. 3**).

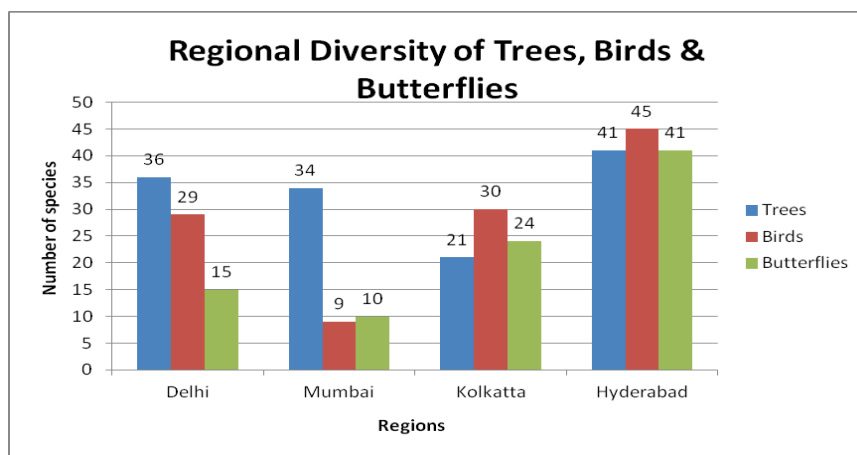


Figure 3. Diversity by Region

(ii) **Tree Phenology:** Students collected information on tree phenology including leaf fall, new leaves, flowering, fruiting and seed dispersal, important parameters to check for climate change impact on trees (Stirnemann *et al*, 2010)[9]. Any change in weather also affects tree phenology, thus helping identify climate change impact. Among the weather parameters, temperature was the most important parameter as it triggers natural cycles within trees. As seen in **Figure 4**, Hyderabad showed the highest records of leaf fall (n=61) at temperature 34° C, while highest flowering and fruiting (n= 147, n= 107) at lowest temperature of 34° C. Highest new leaves records (n=81) were observed for Mumbai at temperature of 36° C..

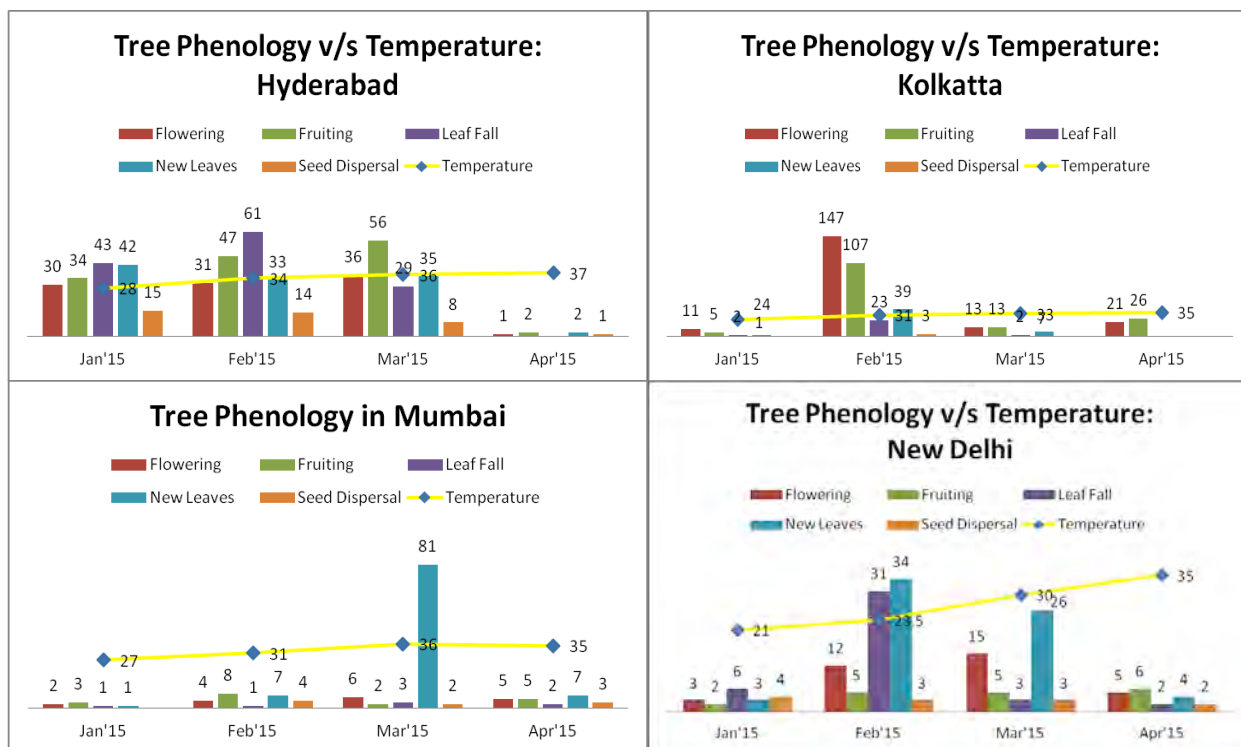


Figure 4. Correlation of Tree Phenology and Temperature.

(iii) **Flight Period of Butterflies & Birds**

Flight periods in butterflies and birds are affected by change in temperatures (Polgar *et al*, 2013)[5], (Wormworth & Mallon, 2006)[11]. Similar to the tree phenology data, the students collected data on flight period of butterflies and birds (**Figure 5**) and the highest butterfly and bird sightings were recorded in Kolkata (n=234, n= 367) in February 2015 at temperature of 31° C, followed by Hyderabad (n=81, n= 231) at slightly higher temperature of 34° C. As discussed, results like these are primarily due to the efforts made by the students rather than an indication of higher diversity in a particular city.

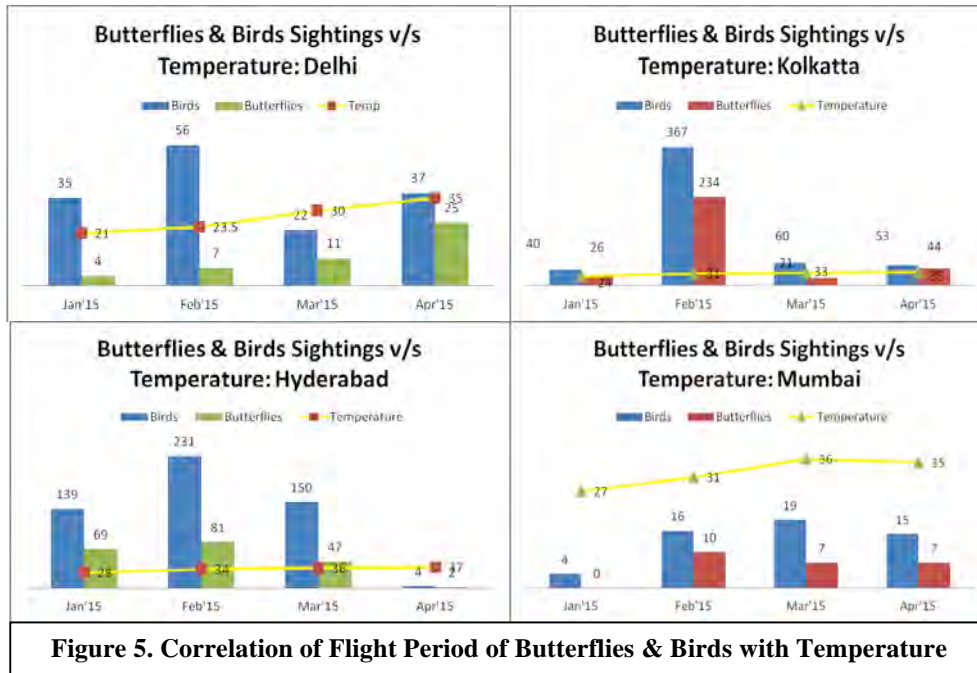


Figure 5. Correlation of Flight Period of Butterflies & Birds with Temperature

3. **Project Conclusion:** The Urban iNaturewatch Challenge concluded in April 2015 with a total 2227 records uploaded to the project website. To conclude the challenge a valedictory function was organized for all participating schools. The student teams were asked to make presentations of their data and winners were declared and celebrated in each project site. The project generated excellent media support due to its innovation in combining environment and education through technology and successfully attracted media coverage in most of the cities national and regional newspapers as well as TV channels. Numerous press reports released the following day certainly helped in creating much needed public attention. These press releases also acted as an incentive for the schools that participated in this initiative and in getting more schools to take an interest in it.

4. **Student and teacher feedback on the project:** A summary of feedback from project participants is provided below.

A majority of the teachers found the apps useful referring to them as the best way they had experienced in applying modern technology to a good use. The teachers reported that these apps enhanced student observation and listening skills and developed the attitude of appreciation. Teachers also stated that because of the apps students were now observing more things around them in detail. The teachers reported finding the apps to be very student friendly and enhanced their knowledge of birds and nature. The overall rating given by majority of the teachers was 8 out of 10.

The students found the project very useful as it imparted information on birds, trees and butterflies little known to them earlier. The students liked the fun section included in the app that allowed the users to test his/her knowledge on trees, birds and butterflies. Overall, students

reported that it had been a fun and exciting experience and helped them learn many new things. Students claimed that learning about trees; birds and butterflies through this app increased their interest in the conservation of wild life. Students rated the app 9/10 and were very keen to participate in similar programmes for nature conservation and environmental education. Students reported that the best part of the App was that one could browse the trees with the help of bark pattern and leaf shape.

5. Pedagogical analysis of iNaturewatch mobile apps and citizen science programme

Based on the theoretical framework for higher secondary education by Alrasheedi *et al.*, (2015)[1], the project work fulfilled five characteristics of innovation: Complexity, Trialability, Observability, Compatibility, and Relative advantage (see **Table 2**).

Table 2. Analysis of theoretical framework

Complexity	Having multiple photographs of a single species such as bark, leaf, fruit, flowers for trees, male and female adults along with calls for birds, and male and female butterflies along with caterpillars and egg pictures
	Creating simple identification filters for ease of identification such as leaf shape, bark texture in case of trees, colours in case of birds and butterflies
	Providing tutorial and instructional video on how to use the app
	Providing a link to “record the sighting” for every species
	Datasheet with objective type and preloaded information about the species requiring minimal effort from the students
	Offline mobile app removes the internet barrier and cost
Trialability	The project adapted to existing student project works, thus not adding to the burden of students and teachers
	The project NGO partners were already working with the students, therefore facilitating the integration of the project activity with other ongoing activities
Observability	The mobile apps were specially designed for urban schools therefore a citizen science component was added to demonstrate the results of using the app
	The Urban iNaturewatch Challenge served to help students believe that they could participate in and contribute to scientific research.
Compatibility	The mobile app was an innovation as it proved to be first app that helped students with their environmental projects.
	Teachers found the app helpful in providing finger tip ready reference
Relative advantage	The mobile app replaced the usual way of field data collection by providing easier species identification and ready data entry if Internet was available

The iNaturewatch Mobile Apps fulfilled five of the six General Characteristics of Mobile Apps cited by Zydny & Warner (2015)[12]. Due to space limitations two characteristics, the technology-based scaffolding characteristics and the student outcome measures are reported here. The mobile apps comprise **technology-based scaffolding** as the information is provided in

tiers to avoid overwhelming students. For example, if a student wants to know if the tree he/she sighted is present in the mobile app, he/she will first open the 'Explore Trees' section with further tiers of identification filters for Bark and Leaf type. When they selected one category such as Leaf type, different types of leaves were listed. If they press the correct option based on the shape, it will open further into a collection of trees having similar leaves. Here if the tree in question is present in the app, it will show up in the list and pressing the right option will then open a page that has detailed information about the tree. The mobile apps are further classified into **Conceptual Scaffolds** as all relevant support information is provided within the app. If the student does not find the tree in question in the app, they could send pictures to an expert to seek guidance on identification. They could also send queries to participating experts online/offline.

The apps also fall under **Procedural scaffolds** as an instructional video was provided on how to collect and feed the data into the preloaded datasheets on the website. The website also included a list of instructions for schools to follow such as how frequently data need to be collected, why it is important to record repeat sighting, and why maintaining a standard time gap between two sightings was important for monitoring biodiversity.

Student outcomes measures demonstrated that the iNaturewatch Mobile apps provided cognitive outcomes in all three areas of lower-level (knowledge and comprehension); higher-level (analysis, synthesis, and evaluation); and cognitive load (factors that affect cognition).

- i. Low levels of cognitive outcomes were measured by the understanding about the urban birds, trees and butterflies among the students.
- ii. High level of cognitive outcomes were measured by the presentations done by the students on their project work wherein they analyzed the data collected by their teams and presented it the audience
- iii. Cognitive load was measured in reports that the students became capable of remembering species names and were comfortable in speaking about their observations related to particular species.

Skill-based outcomes were also observed as the participating students became citizen scientists and learned methods of data collection in the field.

6. Discussion

This section provides discussion of research questions generated by the project.

(i) *Can mobile apps be used for documenting climate change impact on urban biodiversity?*

As demonstrated in Figures 5 and 6, the students were successful in collecting urban biodiversity data which could be correlated with weather parameters such as temperature, humidity and precipitation to ascertain tree phenology and flight periods of birds and butterflies at a given location. Owing to the short duration of the Urban Citizen Science Challenge, the data may not corroborate to indicate climate change impact. However, the data suggests that if data collection is planned in a systematic manner, the iNaturewatch mobile apps could be used for climate change studies. In that case, experts would need to validate the data before it is published.

Project experience suggests the following changes might make such studies more user-friendly:

- Converting the apps to Internet based operation so that the data entry could be directly made from the app rather than first on the app and then onto the website.
- Weather data could be directly gathered by the app rather than fed manually by the users.
- Providing offline storing of the records within the app and then synchronizing when

Internet service is available.

(ii) *Can environment as a subject be taught among secondary schools using iNaturewatch Mobile Apps?*

The results strongly suggest that the iNaturewatch Mobile Apps have been successful in helping the students to complete their science projects. As the iNaturewatch Mobile Apps provided ready reference for urban biodiversity, teachers became more confident in dealing with the subject. Additionally, evaluation of the project results suggests the following changes might make the apps more effective:

- Increasing the species count from 50 to 100 to include more species across the country;
- Developing the apps for iOS and Windows platforms;
- As described by Zydney & Warner (2015)[12], adding a digital sharing feature allowing users to share their data on social media or among their teams
- Developing apps for other life forms such as amphibians, reptiles, mammals, wildflowers and Fungi could be additional indicator species helpful in mapping climate change impact.

(iii) *Could mobile apps make outdoor learning more engaging for school students?*

The iNaturewatch mobile apps were most useful when the users were outdoors. This was reported to be the first time that the Indian students found a mobile app for school project work. Collecting data was real and not a copy-paste job, often the case in school projects. For their periodic data collection sessions, the students ventured out in groups in and around their schools and homes to collect data. Several candidly confessed that whenever their parents scolded them for spending time on the mobile phones during the project they had a valid answer in saying that they were studying and not idling their time - even though it may have been a cover up at times.

(iv) *Is it possible to develop student citizen scientists for environmental studies?*

That the data results presented in the results section are solely the efforts of 1599 students and their teachers demonstrates that if the right resources are provided and properly guided, students have enormous potential to contribute environmental data and education as citizen scientists. Having an incentive such as competition and extra marks for project work also was observed to motivate students. This was first time that Indian students were involved in a biodiversity study through citizen science approach. As mentioned earlier, like any citizen science project, the data collected by citizen scientists needs validation from experts.

10. Conclusion

The Mobile Apps for Climate Change project was the first of its kind in using mobile technology for environmental studies in secondary schools in India. Data from the initial implementation demonstrated that the project created a pioneering opportunity for teachers to develop student projects with the iNaturewatch Mobile Apps while reducing the teacher's burden and developing scientific acumen among the students. Like any citizens science projects, the collected data needs to be authenticated by experts before it is used for scientific analysis. Long-term studies of this nature may result in documenting climate change impacts within cities and fostering the use of mobile apps as tools for urban citizen scientists.

11. Acknowledgements

We are deeply thankful to U.S. State Department's Bureau of Educational and Cultural Affairs International Exchange Alumni for funding the project through the Alumni Engagement Innovation Fund (AEIF) and the team at U.S. Consulate General, New Delhi & Mumbai for providing assistance to the project team. We are immensely thankful for the support extended by Fr. Savio and his Team at Greenline, Mumbai and Ms. Farida Tampal, Dr. Mita Nangia and Dr. Saswati Sen and their teams at WWF-India (Hyderabad, New Delhi & Kolkata) for implementation of the citizen science programme among the schools. We are thankful to the creative team of LycodonFX Pvt. Ltd for giving shape to the project idea by designing and developing the mobile apps, website and infographic video tutorial. We specially like to thank staff of LEC; Prasad Kambli, Priti Choghale and Prabha Vannier for painstaking data analysis.

12. References

- [1] Alrasheedi, Muasaad, Luiz Fernando Capretz, Arif Raza (2015). A systematic Review of the Critical Factors for Success of Mobile Learning in Higher Education (University Students' Perspective). *Journal of Educational Computing Research* 2015, Vo. 52(2), 257-276.
- [2] Digital India Website: <http://www.digitalindia.gov.in/content/about-programme> (28.02.2016)
- [3] Elmqvist, Thomas (Jan 2015). Cities and Biodiversity Stockholm Resilience Centre Retrieved www.stockholmresilience.org/21/research/research-news/6-8-2012-the-biodiverse-city.html (29.02.2016).
- [4] Louv, Richard. (2005) *Last child in the woods: saving our children from nature-deficit disorder* Chapel Hill, NC : Algonquin Books of Chapel Hill.
- [5] Polgar, Caroline. A., Richard B. Primack, Ernest H. Williams, Sharon Stichter, Colleen Hitchcock (2013). Climate effects on the flight period of Lycaenid butterflies in Massachusetts. *Biological Conservation*, 2013; 160: 25
- [6] Raman, Anupama (May, 2015). *Mobile learning: Smart education system for India*. <http://forbesindia.com/blog/business-strategy/mobile-learning-smart-education-system-for-india/#ixzz41TpctgVM> (28.02.2016).
- [7] Secretariat of the Convention on Biological Diversity (2012) *Cities and Biodiversity Outlook*. Montreal. 64 pages
- [8] Shih, Y. E., & Mills, D. (2007). Setting the new standard with mobile computing in online learning. *The International Review of Research in Open and Distance Learning*, 8(2):1–16.
- [9] Stirnemann, R. , Pletsers, A. , Proctor, H. , Cooney, T., Caffarra, A. , O'Halloran, J. , Jones, M. and Donnelly, A.(2010). Climate change impacts on phenology: implications for terrestrial ecosystems. Phenology 2010 Conference, Trinity College, Ireland. <https://www.tcd.ie/Botany/phenology/assets/docs/climatechangeposter.pdf> (05.03.2016)
- [10] Traxler, J. (2008). Podcasting in context. In G. Salmon & P. Edirisingha (Eds.), *Podcasting for learning in universities* (pp. 12–19). New York, NY: McGraw-Hill International.
- [11] Wormworth, Jannice, Karl Mallon (2006). *Bird Species and Climate Change*. pp 75. www.climate.org/topics/climate-change/migratory-birds-climate-change.html (05/03/2016)
- [12] Zydney, Janet Mannheimer, Zachary Warner (2015). Mobile apps for science learning: Review of research. *Computers & Education* 94 (2016), 1-17.

Quest for Elearning Knowledge Quality and its Influence on Online Students' Learning Outcomes

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Abstract

This study presents the indicators of eLearning knowledge quality and its influence on students' satisfaction, which further relates to their learning outcomes. The limited attention given towards knowledge quality (KQ) and its role in students' performance is taken into account. Data was collected from 348 undergraduate and postgraduate students using quantitative approach. Confirmatory factor analysis confirmed the second-order factor perceived eLearning KQ construct – comprising five dimensions. Further, the reflective model was tested using structural equation modeling which demonstrated a significant relationship between KQ – satisfaction, satisfaction – academic performance and learning effectiveness. The study provides a reliable tool to investigate intrinsic, contextual, representational, accessible, and actionable KQ and provides the suggestions to improve online students' performance and learning in the eLearning context.
Keywords: eLearning knowledge quality, satisfaction, academic performance, learning effectiveness

1. Introduction

Educational reform is fed by technology that provides a multitude of learning opportunities to students without time and place constraints. Facilitation is served through the eLearning gateway, where institutions have invested substantially in electronic resources [1] and are increasingly shifting towards the online learning paradigm for course delivery and training [2]. To catch the eLearning wave in this competitive environment, managing the quality of knowledge is critical to maintaining a competitive image in the market. Electronic resources (content in the eLearning environment) are used to build individuals' knowledge repositories, and a high level of knowledge quality (KQ) contributes to improved performance and efficiency.

As students are more concerned about content quality [3] that is one of the component of knowledge construction that contributes towards meaningful learning, it is essential to investigate the relationship between quality factors and their subsequent outcomes.

It is noted that studies have reported on the implementation of blended learning [4], students' satisfaction with online courses [5], and the outcomes of eLearning adoption [3, 6, 7]. However, the quality of knowledge gained from online content and its subsequent influence on students' behavioural and learning outcomes is rarely discussed.

To address the highlighted issues, this study is conducted and guided by the following research question:

- Is there any significant relationship between perceived knowledge quality and student satisfaction and subsequent influence of satisfaction on students' learning outcomes (perceived academic performance and perceived learning effectiveness) in the eLearning context?

2. Research framework

2.1. Elearning Knowledge quality

Based on the prior conceptualization of data and information quality [8] and recent studies on KQ [9], this study presents KQ as a second-order factor construct.

Intrinsic KQ. Intrinsic KQ is defined as the extent to which the content has quality in its own right to help in quality knowledge gain. Quality is assessed via its reliability (fulfilling intended function with required accuracy), usefulness (frequent usage of knowledge source), consistency among knowledge items in the repository, and good reputation. Regular renewal of the knowledge source (content) is essential for its quality [9]. Although knowledge is based on prior experience and beliefs [10, 11], it should contain the fundamental aspects to meet quality requirements.

Contextual KQ. Assessment of knowledge quality varies according to different contexts, thus, knowledge must have a relevant context to determine its quality, otherwise, it is useless for further use [12]. The same knowledge resource might have different meanings in different contexts (Management, technology). Therefore, it is necessary to monitor knowledge relevancy according to context [13]. Meeting the required learning need in the desired context [14] and its timely availability makes it valuable. The complete, detailed, current, timely, relevant, and value addedness of the available knowledge resource determines contextual knowledge quality.

Representational KQ. Representational KQ includes aspects related to content presentation i.e. format. Individuals get knowledge from different databases, information systems or online repositories. In order to meet the representational quality criteria, some aspects are essential. A well-presented, concise, well formatted, and compact knowledge resource with ease of interpretability (clarity in symbols, language, and definitions) demonstrates good representational quality [15]. Consistency in presenting the different knowledge resources increases the chances of understandability and improves the quality of knowledge gained.

Accessible KQ. The accessibility of the required knowledge resource is equally important for KQ [16]. The quick and easy retrieval of relevant resources from the referred database helps in providing quality knowledge. Freedom and ease of access [15] to different resources from subscribed scholarly databases within or outside the institution produce quality knowledge. Restriction or limited access forces students to look for alternative resources on the internet, which might not be reliable and will not provide quality knowledge.

Actionable KQ. Actionable KQ is related to aspects that include actionable nature. Knowledge is about action; it means to apply the retrieved information in real life to get its benefits [17]. The content, which is adaptable and applicable in different domains and also can be expanded for future use, has good quality knowledge features. A student reads about some major concepts while still studying, and later in practical life adapts and applies these concepts in a job. The previous concepts and their practical use help in expanding the knowledge of the student/individual. The adaptability, applicability, and expandability of the knowledge resource mark its usefulness [9].

2.2. Hypothesis development – Linking knowledge quality, and behavioural and learning outcomes

This study identifies a five-dimensional knowledge quality relationship with students' satisfaction and its subsequent influence on learning outcomes in an eLearning context.

eLearning KQ - Satisfaction

KQ is considered an important determinant of user satisfaction [16, 18, 19]. In the eLearning environment the process of learning is independent of other people as the learning comes from different devices and places, thus, good quality knowledge helps in improving user satisfaction [20]. It is expected that knowledge quality of content in an eLearning environment may affect student satisfaction:

Hypothesis 1: knowledge quality positively influences student satisfaction with eLearning content.

Perceived academic performance

Academic performance is referred to as the degree to which the targeted educational goals or tasks are achieved by student, teacher or academic institution [21]. Islam [6] used the students’ perception about anticipated grades to measure perceived academic performance. Individual performance fulfillment is used as a reference to judge satisfaction when comparing the outcomes or results [22]. Islam [6] argued that if the students are provided with better learning assistance in-terms of learning content and effective discussions, they become satisfied with the content and overall learning environment, which leads to improved academic performance. Thus, current study postulates that:

Hypothesis 2A: Students’ satisfaction with knowledge quality positively influences their perceived academic performance.

Perceived learning effectiveness

Students’ perception about their learning has been used to measure learning effectiveness [23, 24]. Learning effectiveness is explained as how well individuals have achieved their goals in terms of the knowledge gained from a particular course. The current study uses the perception-based approach – and uses the students’ self-evaluation to assess their own knowledge gain or learning effectiveness in relation to a particular subject.

There is a high correlation between satisfaction and learning effectiveness [25, 26], and effective outcomes can be achieved from a satisfied person. Thus, this study hypothesizes that, to achieve effective learning, students should be satisfied with the quality of the knowledge gained.

Hypothesis 2B: Students’ satisfaction with knowledge quality positively influences their perceived learning effectiveness.

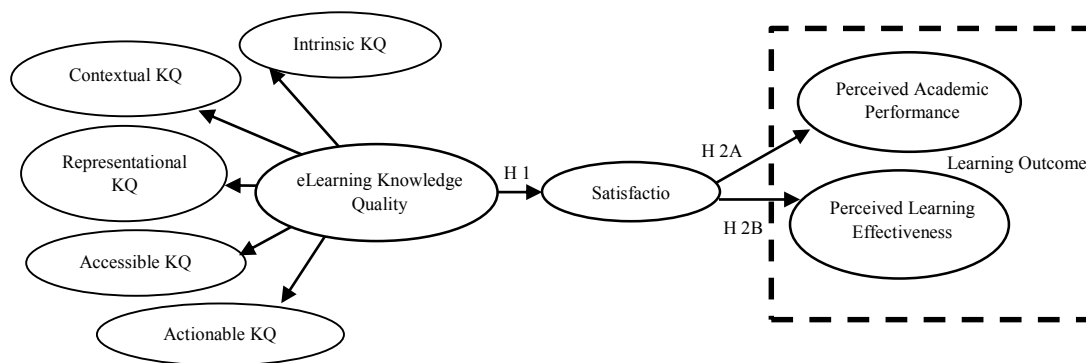


Figure 1. Proposed Structural Framework and Literature Map

Figure 1 depicts the key indicators of KQ and the detail literature map of the structural framework with proposed hypothesize relationships.

3. Research methods

The quantitative research approach was employed to test the proposed research model. The study followed two stages.

This study has utilized the SPECTRUM (Student Powered e-Collaboration Transforming UM) (See Figure 2) which is a Learning Management System (LMS) implemented in University of Malaya (UM), Kuala Lumpur, Malaysia – built on MOODLE (Modular Object-Oriented Dynamic Learning Environment). The system is secure and is available for all registered students of via assigned login and password and it is compulsory for them to use SPECTRUM. It provides access to lecture material, online quizzes, discussion forums and assignments submission etc.

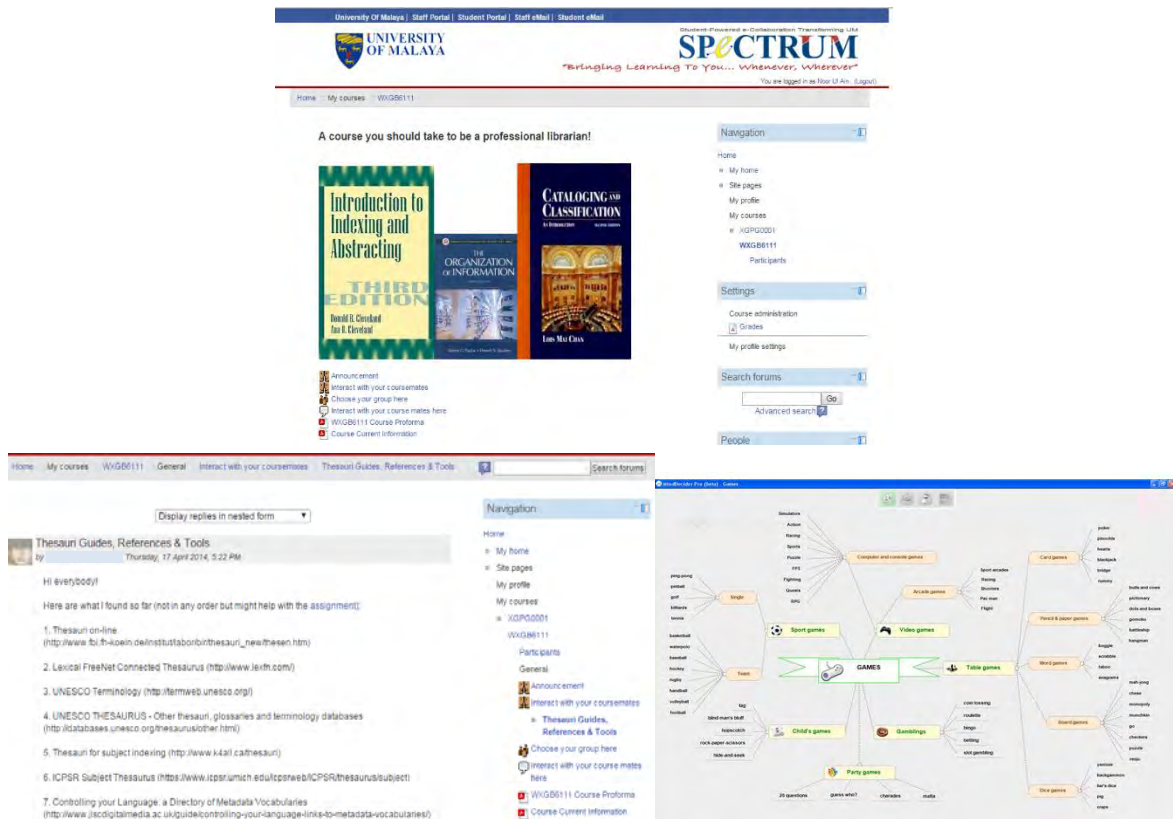


Figure 2. Overview of SPECTRUM

Undergraduate and postgraduate online students who use SPECTRUM were selected as the targeted population. As per 2014 University of Malaya students' statistics, there were total 10,005 students from 8 faculties were using SPECTRUM. Figure 3 shows the detailed statistics of courses available in SPECTRUM and the respective total number of students in each faculty. Proportional stratified sampling was used with an estimated sample of N=370 for the quantitative survey.

Students' satisfaction was measured using 4- items adapted from Lee, Wong [27] and Kulkarni, Ravindran [19], 3-items for academic performance adapted from McGill and Klobas [7], and 4-items were adapted from Lee, Wong [27] and Wan, Wang [25] to evaluate perception based learning effectiveness. Items were measured at 5-point Likert scale items (SA=1 to SDA=5) (See Appendix).

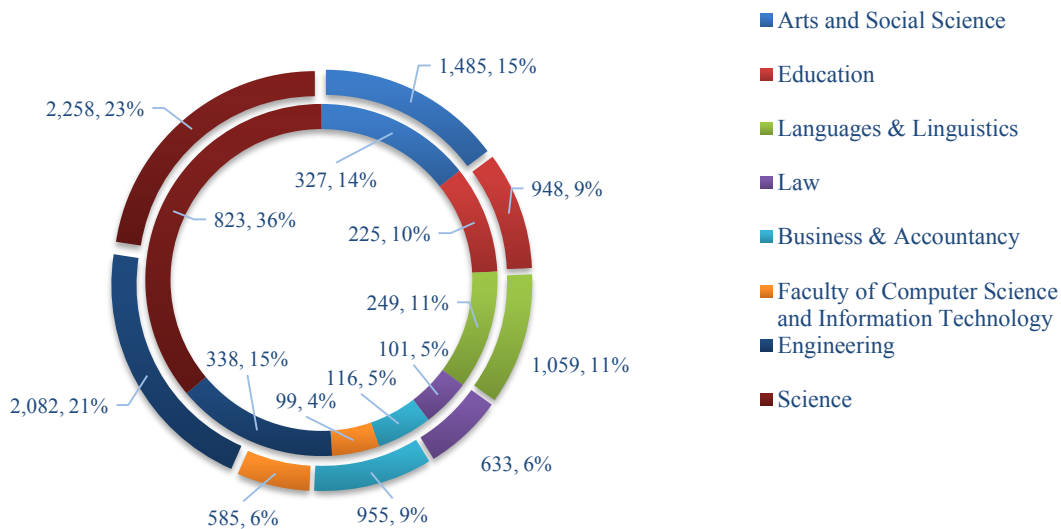


Figure 3. Statistics of SPECTRUM's courses and total students in each faculty

Inner Circle: Courses available in SPECTRUM in each faculty
Outer Circle: Total students in each faculty

4. Results

4.1. Descriptive Analysis

The analysis of 348 useable questionnaires showed an equal number of male (178, 51.1%) and female (170, 48.9%) respondents, of whom most were enrolled in second (70, 20.10%), third (74, 21.30%), and fourth (70, 20.10%) semester. A number of respondents reported ≥ 13 years of computer experience (170, 48.9%). However, 1st year (150, 43.1%) and 2nd year (108, 31.0%) students had greater eLearning system use experience.

4.2. Results for the second order factor model of perceived eLearning KQ

At this point, the second order factor perceived eLearning KQ model was subjected to a confirmatory factor analysis using SPSS AMOS 17.0 and was evaluated based on the goodness-of-fit criteria.

The reliability of the five dimensional (34-items) perceived eLearning KQ scale was tested using Cronbach's alpha values (α). The α values were higher than the suggested benchmark value of .70 [28] for all variables (See Table 1). In the process of CFA, some items were eliminated after assessing the parameter estimates and modification indices (leaving 30-items) for required model fit as per suggested goodness-of-fit- criteria ($\chi^2/df < 2$, GFI 0.9, CFI > 0.9 , TLI > 0.9 , AGFI > 0.9 , RMSEA < 0.05 [29]).

The average variance extracted (AVE) values (0.500 to 0.583) were all above the suggested benchmark, i.e. > 0.5 , providing evidence of convergent validity. Further, the composite reliability (CR) for all the variables exceeded the suggested 0.70 threshold [30]. Additionally, the AVE square root values, that were higher than the correlation between any pair of constructs, confirmed the discriminant validity (see Table 1).

Table 1: Composite reliability, Cronbach's alpha, Convergent and Discriminant Validity

Constructs	α	AVE	CR	Intrinsic KQ	Contextual KQ	Representational KQ	Accessible KQ	Actionable KQ
Intrinsic KQ	0.898	0.514	0.931	.718				
Contextual KQ	0.869	0.500	0.898	.247**	.707			
Representational KQ	0.803	0.513	0.835	.337**	.324**	.716		
Accessible KQ	0.754	0.519	0.762	.298**	.395**	.556**	.720	
Actionable KQ	0.764	0.583	0.802	.297**	.137*	.207**	.148**	.764

Further, keeping in mind the goodness-of-fit criteria, second-order factor model showed a good fit values ($\chi^2/df = 1.625$, GFI = .911, CFI = .941, TLI = .934, AGFI = .92, RMSEA = .042). Additionally, the standardized factor loadings for the second-order factor model show significant values [(Intrinsic KQ $\beta=0.60$, $R^2= 0.667$), (Representational KQ $\beta=0.98$, $R^2= 0.638$), (Contextual KQ $\beta=0.58$, $R^2= 0.545$), (Accessible KQ $\beta=0.72$, $R^2= 0.761$), (Actionable KQ $\beta=0.62$, $R^2= 0.577$)]. Thus, the five latent factors indicated the good construct validity of eLearning KQ.

4.3. Results of reflective structural model

The structural model constructs were loading significantly on their respective latent variables. The related values for composite reliability, average variance extracted, Cronbach's Alpha were higher than the suggested benchmark value i.e. > 0.70 (CR), $>.05$ (AVE) [30], > 0.60 (α) [28] respectively (see Table 2).

Table 2: Structural model's construct reliabilities and validities

	Cronbach's Alpha (α)	AVE	CR	R ²	St. Factor Loading
Satisfaction	0.772	0.627	0.823		
S1				0.842	0.918
S2				0.837	0.915
S3				0.502	0.45
Perceived academic performance	0.701	0.505	0.751		
AP1				0.554	0.604
AP2				0.577	0.714
AP3				0.575	0.80
Perceived learning effectiveness	0.745	0.516	0.809		
LE1				0.593	0.641
LE2				0.547	0.7
LE3				0.523	0.723
LE4				0.553	0.8

The fit values of the overall model presented a good fit based on the goodness-of-fit criteria [29]. The fit values were $\chi^2/df = 1.523$ ($< 2, 3$), CFI = .922 (> 0.9), TLI = .917 (> 0.9), RMSEA = .039 (< 0.05), which supported the proposed structural model. The results of the proposed structural model, which confirms significant relationships for all proposed hypotheses are presented in Figure 4. KQ – satisfaction ($\beta = 0.939$, $P = 0.000$), students' satisfaction - perceived academic performance ($\beta = 0.279$, $P = 0.000$) and perceived learning effectiveness ($\beta = 0.214$, $P = 0.001$).

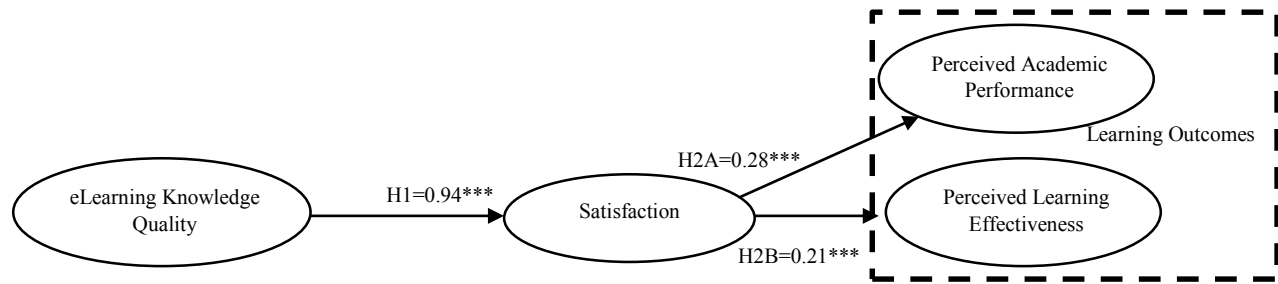


Figure 4. Results of Proposed Structural Model (*)Significant at the .001 level)**

5. Discussion

Based on analysis of the literature, this study explains the essence of knowledge quality, and how it can be measured using a large-scale survey of students involved in eLearning activities. The results confirm the relative importance of Representational KQ, Intrinsic KQ, Contextual KQ, Accessible KQ, and Actionable KQ for perceived eLearning KQ. Representational KQ is considered more important because online students initially interact with the eLearning interface and the content that resides in the environment. Secondly, students look for intrinsic KQ and require new and accurate knowledge [13]. Contextual KQ has received importance at the third highest level, which shows that context is important to fully understand the knowledge related to the task in hand [11, 17], and contextual KQ is dependent on users' context. Contextually relevant content with adequate and timely details is regarded as an important indicator. Similarly, Accessible KQ is considered equally important – where ease of access to required resources is believed to be an important aspect from the students' perspective [31]. The quality of accessibility is the gateway to the online content having more truthiness and provides quality knowledge gain from the eLearning environment. Putting the required knowledge into action demonstrates actionable KQ [17] and it is viewed as being essential by students. This shows that knowledge has quality if it is appropriate, relevant to the context and actionable.

The provision of quality knowledge leads to satisfaction, which results in better performance and learning from the environment. A significant relationship between KQ – satisfaction supports H1. It shows that the quality of the intrinsic, contextual, representational, accessible, and actionable aspects of eLearning content leads to students' satisfaction with the quality of knowledge gained. Similar findings have been reported in the literature [16, 19] in the context of knowledge management systems. Further, a significant relationship between students' satisfaction – perceived academic performance and perceived learning effectiveness is proved – supporting H 2A and H 2B respectively. This asserts that students are satisfied with the quality of knowledge gained from the eLearning content and, based on the knowledge acquired, they perceived they would get good grades and that they had effectively learned the concepts. Similar results were reported in previous studies, where satisfaction is an important antecedent of perceived academic performance [32, 33] and perceived learning effectiveness [26]. Islam [6] claimed that satisfaction with the environment and content has a high positive correlation with students' perceived academic performance.

6. Conclusion

Knowledge is an intangible resource for organizations and educational institutions which help them to gain a competitive advantage [14]. The quality of knowledge leads to better performance and growth [9]. Studies have investigated its influence in the context of system success [16, 18],

however, this study takes a step forward and theoretically contributes by presenting a five dimensional eLearning KQ scale. Further, as a pioneer in investigating KQ outcomes in the eLearning context, this study asserts that satisfaction is a global assessment that follows the evaluation of knowledge quality. Students' satisfaction with the quality of knowledge gained helps in improving their performance and learning from the environment.

The implications are for educational institutions, where a distinct eLearning KQ instrument can be used for evaluating the online content, which is the source of knowledge. The assessment not only improves performance and learning but also builds a positive relationship between students and the eLearning environment. Management should focus on the provision of intrinsically correct, contextually relevant, well-represented, easily accessible, and actionable content to provide quality knowledge. This study explains that how students can obtain high-quality knowledge which will improve their learning effectiveness. Additionally, the students' actual grades (GPA) should be taken into account for comparison with anticipated grades.

Although the study contributes significantly, but the study had a few limitations. Assessment is only based on coded content in an eLearning environment, provided through lecture materials, discussion forums etc. – other eLearning factors may change the effect on instrument development. A number of interesting avenues and directions for research are recommended that may address some of the study's limitations. As the eLearning environment is built from different components, and each one has its own impact, integration of other factors (services, management and technological) needs to be investigated in order to judge students' performance. It is recommended that cultural factors be considered, as learning takes on different forms and performs different functions in different regions of the world [34]. Knowledge has its roots in quality, and the measurement of knowledge quality may fuel an interest in institutions to take a stand for quality and produce effective academic outcomes.

References

1. Chen, Y.-H. and I. Chengalur-Smith, *Factors influencing students' use of a library Web portal: Applying course-integrated information literacy instruction as an intervention*. The Internet and Higher Education, 2015.
2. Masoumi, D. and B. Lindström, *Quality in e-learning: a framework for promoting and assuring quality in virtual institutions*. Journal of Computer Assisted Learning, 2012. **28**(1): p. 27-41.
3. Rodríguez-Ardura, I. and A. Meseguer-Artola, *What leads people to keep on e-learning? An empirical analysis of users' experiences and their effects on continuance intention*. Interactive Learning Environments, 2014(ahead of print June 12): p. 1-24.
4. Graham, C.R., W. Woodfield, and J.B. Harrison, *A framework for institutional adoption and implementation of blended learning in higher education*. The Internet and Higher Education, 2013. **18**: p. 4-14.
5. Kuo, Y.-C., et al., *Interaction, Internet self-efficacy, and self-regulated learning as predictors of student satisfaction in online education courses*. The Internet and Higher Education, 2014. **20**(0): p. 35-50.
6. Islam, A., *Investigating e-learning system usage outcomes in the university context*. Computers & Education, 2013. **69**: p. 387-399.
7. McGill, T.J. and J.E. Klobas, *A task-technology fit view of learning management system impact*. Computers & Education, 2009. **52**(2): p. 496-508.
8. Waheed, M. and K. Kaur, *Knowledge quality: A review and a revised conceptual model*. Information Development, 2014.
9. Yoo, D.K., M.A. Vonderembse, and T. Ragu-Nathan, *Knowledge quality: antecedents and consequence in project teams*. Journal of Knowledge Management, 2011. **15**(2): p. 329-343.

10. Davenport, T.H. and L. Prusak, *Working knowledge: How organizations manage what they know*. 2nd ed. 2000, Boston: Harvard Business Press.
11. Nonaka, I., *A dynamic theory of organizational knowledge creation*. Organization Science, 1994. **5**(1): p. 14-37.
12. Lee, S., *The impact of knowledge management practices in improving student learning outcomes*. 2009, Durham University.
13. Rao, L. and K.-M. Osei-Bryson, *Towards defining dimensions of knowledge systems quality*. Expert Systems with Applications, 2007. **33**(2): p. 368-378.
14. Chiu, C.-M., M.-H. Hsu, and E.T. Wang, *Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories*. Decision Support Systems, 2006. **42**(3): p. 1872-1888.
15. Alkhattabi, M., D. Neagu, and A. Cullen, *Assessing information quality of e-learning systems: a web mining approach*. Computers in Human Behavior, 2011. **27**(2): p. 862-873.
16. Halawi, L.A., R.V. McCarthy, and J.E. Aronson, *An empirical investigation of knowledge management system' success*. Journal of Computer Information Systems, 2008. **48**(2): p. 121-135.
17. Nonaka, I. and H. Takeuchi, *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation*. 1995, New York: Oxford University Press.
18. Jennex, M.E. and L. Olfman, *A model of knowledge management success*. International Journal of Knowledge Management (IJKM), 2006. **2**(3): p. 51-68.
19. Kulkarni, U.R., S. Ravindran, and R. Freeze, *A knowledge management success model: theoretical development and empirical validation*. Journal of Management Information Systems, 2007. **23**(3): p. 309-347.
20. Chen, H.-J., *Linking employees' e-learning system use to their overall job outcomes: An empirical study based on the IS success model*. Computers & Education, 2010. **55**(4): p. 1628-1639.
21. Ward, A., H.W. Stoker, and M. Murray-Ward, *Educational Measurement: Theories and applications*. Vol. 2. 1996: University Press of America.
22. Oliver, R.L. and J.E. Swan, *Consumer perceptions of interpersonal equity and satisfaction in transactions: A field survey approach*. Journal of Marketing, 1989. **53**(2): p. 21-35.
23. Alavi, M., *Computer-mediated collaborative learning: An empirical evaluation*. MIS quarterly, 1994. **18**(2): p. 159-174.
24. Waheed, M., et al., *Perceived learning outcomes from Moodle: An empirical study of intrinsic and extrinsic motivating factors*. Information Development, 2015.
25. Wan, Z., Y. Wang, and N. Haggerty, *Why people benefit from e-learning differently: The effects of psychological processes on e-learning outcomes*. Information & Management, 2008. **45**(8): p. 513-521.
26. Liaw, S.-S., *Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: A case study of the Blackboard system*. Computers & Education, 2008. **51**(2): p. 864-873.
27. Lee, E.A.-L., K.W. Wong, and C.C. Fung, *How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach*. Computers & Education, 2010. **55**(4): p. 1424-1442.
28. Churchill, J. and A. Gilbert, *A paradigm for developing better measures of marketing constructs*. Journal of Marketing Research, 1979. **16**(1): p. 64-73.
29. Byrne, B.M., *Structural equation modeling with AMOS: Basic concepts, applications, and programming*. 2nd ed. 2013, New York: Routledge. 416.
30. Fornell, C. and D.F. Larcker, *Evaluating structural equation models with unobservable variables and measurement error*. Journal of Marketing Research, 1981. **18**(1): p. 39-50.
31. Wang, R.Y. and D.M. Strong, *Beyond accuracy: What data quality means to data consumers*. Journal of Management Information Systems, 1996. **12**(4): p. 5-33.
32. Hsieh, P.-A.J. and V. Cho, *Comparing e-Learning tools' success: The case of instructor-student interactive vs. self-paced tools*. Computers & Education, 2011. **57**(3): p. 2025-2038.
33. Lee, J.-K. and W.-K. Lee, *The relationship of e-Learner's self-regulatory efficacy and perception of e-Learning environmental quality*. Computers in Human Behavior, 2008. **24**(1): p. 32-47.

34. Olaniran, B.A. and M.F. Agnello, *Globalization, educational hegemony, and higher education*. Multicultural Education & Technology Journal, 2008. 2(2): p. 68-86.

Appendix. Measures

Perceived eLearning KQ

Intrinsic KQ

The content available in the spectrum...

- Is correct and adequately fulfills my learning requirements.
- Is interlinked and not giving contradictory and redundant details
- Is new, original and I didn't study before
- Covers all topics instead of focusing on only one in the subject I am studying/registered
- Is consistent with the other published or online source for the topic I am searching
- Is easily available on google top 10 indexing or search results
- Is used to make my presentation, assignments, and notes
- Is not too long in length to be studied completely
- I know about the content available on the spectrum and I believe it
- Is trustworthy
- Is taken from authentic source and its references are available

Contextual KQ

- Is of sufficient quantity to fulfill my tasks.
- Is giving adequate detail of each topic on the subject I am registered.
- Is recently uploaded in the subject I am registered for this semester.
- Provides enough detail of the topic to understand and I can use it in my quizzes and discussions.
- Is related to the subject I am studying/registered.
- Is uploaded by lecturer in-time that helps in understanding the lecture.
- Improves my current understanding of the topic from its use
- Is convenient to find

Representational KQ

- Is presented in a compact and comprehensive format under its required topic.
- Uses the same style, structure, and format for the same type of articles/presentations
- Clearly explain the meaning of the topic I am studying
- Is presented in standard format which is easy to read and understand
- Is easy to find because of fewer changes in the design/interface of spectrum

Accessible KQ

- Is easily accessible outside or within the organization using my registered login details (e.g. Like articles, lectures and referred links).
- Is sometimes not accessible due to server maintenance or broken links
- Having large file size needs strong internet connection to download

Actionable KQ

- Is modifiable for different class discussions, projects, presentations according to topic/context.
- Can be applied to my class assignments, activities, and projects.
- Can be expanded for my future assignments and projects.

Satisfaction

- I am satisfied with the knowledge obtained from content in SPECTRUM.
- The available knowledge satisfied my learning needs.
- I am satisfied with the overall learning experience from SPECTRUM.

Perceived Academic performance

- Using content from SPECTRUM...
 - I obtained good grades
 - Enables me to improve my grades compared to the course without online learning material
 - Will increase my grade point (CGPA)

Perceived Learning effectiveness

- I learned a lot of factual information from content in SPECTRUM
- I gained a good understanding of the basic concepts of the relevant online content in SPECTRUM
- I learned to identify the main and important issues of the relevant topic
- I developed the ability to communicate clearly about the subject

ElectrizArte: Using Arts and Engineering to Improve Learning

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Abstract

ElectrizArte is a extracurricular activity where students pursue art-based engineering projects under supervision of college professors. In addition to the design, implementation and testing of their projects, students travel to rural public high schools to show their projects, and network with high school students to foster interest in engineering majors and attending college.

1. Learning in College

College professors usually make too many assumptions of their students' interests. They assume that the students have enough reasons to choose their majors and that they are (and should) be very interested in any course they are taking. That's a partial picture: most students, while are interested in the main areas of their major, either are not interested in several particular subtopics or have another large set of interests outside their major.

Everyone has a set of interests and abilities. Some abilities are fully developed because the person had the initial interest, and some possess a particular ability and is not particularly interested in using it. This is the case of students that are highly capable, but generally uninterested during a class: everything is easy for them, and can pass effortlessly. These are the students whose teaching usually label them as “very smart”, “with a lot of potential”, but “lazy” and “unfocused”.

Another kind of student is the one that has lots of interest in a particular topic but struggles with it. Their abilities are not fully developed and bad grades might motivation might be lost.

1.1 Arts and Engineering

One way to improve college learning is to use existing interests outside engineering, and bring them into college projects. One of the most popular interests is arts, music, for example: you don't need to be a musician to appreciate and enjoy music. Our project is named: ElectrizArte (mix of electricity and arts in Spanish), and it is an extracurricular activity in our Electrical Engineering major at the Universidad de Costa Rica.

1.2 Goals and objectives of ElectrizArte

We use engineering to magnify the perception of the arts: it is more impressive see bright lights everytime a drum is played, for instance. Conversely, we use arts to attract interest in engineering: if you touch a laser beam and a musical note is played, you would want to see why it happens, how it happens, producing questions in your mind that opens it up to learn engineering and science principles. We consider that the main objectives are to increase motivation to learn engineering and develop

technical and non-technical engineering skills, as a complement of their formal engineering education.

1.3. Methodology: project based learning

Our project works with electrical engineering students from freshmen to senior level, where instructors guide them to design, implement, test engineering projects related to arts. Students work either individually or in teams, based on an idea given by the instructor or conceived by the students.

Students in this scenario, not only acquire technical knowledge, but also develop graduate attributes that are not normally addressed in ordinary courses, such as leadership skills, teamwork, oral expression [1]. These attributes are as valuable in industry as the technical ones, and are increasingly being required by accreditation bodies [2].



Figure 1. Students working in ElectrizaArte in their free time.

One of the earliest projects is a software implementation of a laser harp:



Figure 2. Software based laser harp

This musical interface detects which laser beam is being touched and produces a musical tone. It involves hardware (webcams, lasers and power supplies), and software (computer vision algorithms,

MIDI interfaces). None of these topics is specifically seen in a particular course in their major, so students had to learn by themselves under the guidance of an instructor, and successfully design, implement and test this musical interface in under 3 months.

This kind of projects involve the creation of a whole new kind of musical instrument (or interface), producing the need of a new kind of musical interpreter. Another kind of project involves the modification or addition to an existing musical instrument to magnify its effect. We can see in Figure 2, a LED-enabled bongo drum:



Figure 3: LED-enabled Bongo drum

This is a hardware project that involved analog circuit design, perfect for a junior engineering student to apply his/her engineering knowledge in analog electronics to a practical and enjoyable project. Even engineering professors are amazed and delighted to test the drums (and circuit). The effect in high school students is almost the same as seeing a magic trick. We take advantage of this effect in our tours, described below.

2. Attract attention in high school students

The other big part of this project is to actually use this mixture of arts and engineering to effectively attract attention to engineering. This is achieved by touring public rural high schools with the artistic projects and the students that built them. The students achieve a very important stage in their learning process that is usually overlooked or ignored in college: the phase where they indeed show their work and explain all the internal workings of their projects. This is because the learning process is especially fruitful when the learner is consciously involved in the design and implementation of a project that can be exhibited, tested, discussed, examined or admired [3][4].

We pinpoint rural high schools because these students are the most overlooked students in our educational system: they are far from the big cities, receive bad education, less attention from universities, have fewer resources (human and material) and are more disconnected from the latest technological advances.

2.1 Our approach to students

Our presentations involve 3 acts: oral presentation regarding goals and methodology of our project, musical or artistic presentation, and full interaction between college and high school students. The most important part is the last one, the first two acts can even be seen as an excuse to produce the full interaction. This is achieved gradually: first using the musical act, and inviting students (and some teachers) to stage and start playing with us, using the engineering projects (as the laser harp describe above). Finally, we invite all students to come and play all instruments and ask any questions they like to the college students.

We show some of our visits to high schools in the figures 4, 5 and 6 below.



Figure 4. Orosi High School



Figure 5. San Carlos High School



Figure 6. Tronadora High School

Once the student see the engineering projects producing art, we hope they achieve the most important thing we need: they open their minds, and start producing lots of questions. And in that stage, learning is not only possible but is accelerated: they learn how electrical circuits detect and amplify signals, how computers process images, and how sound is produced, for instance. We aim to produce the maximum number of these events in our projects.

The effect on our own college students is also greatly beneficial: they tour the country (Figure 7), seeing other realities that are different from their (mostly) urban ones, and get the feeling and the experience that their knowledge and their experiences might motivate high school students to eventually apply to college, knowing that all high schools we visit have a very low college admission rates. We firmly believe that these interactions do achieve that (Figure 8).



Figure 7. ElectrizarArte students on tour.



Figure 8. College and high school students' interaction.

3. Performance evaluation

In order to measure the students' performance and views, they complete a self-assessment tests. The results are shown in Table 1:

	Evaluation		
	Improvement		
Objective	None	Slight	Significant
Motivation	2	9	5
Technical skills	0	6	10
Non-technical skills	0	11	5

Table 1. Self Assesment test results

Even though these results are obtained by self assessment, they show promising results for the project objectives. Although it is true that all students that participate in the project already must possess certain level of self motivation, the regular public performances, the sight of students working in artistic and engineering projects indeed lower the threshold for other students to try to enter the project. Once part of the project, we can see that they improve (in some amount) their technical and non-technical skills.

4. Conclusions

Learning engineering does not have to happen inside a course, or inside a classroom. It should involve all kinds of interests to develop other kinds of abilities too. Our project successfully involves arts in engineering projects that foster more engineering learning, provides new experiences with

professors and even with high school students (and rural realities) when we tour the country.

This project demonstrates that an extracurricular activity, with no credits, or tests, and with instructor guidance, can motivate students to take control of their own education, broaden their social conscience and produce a better engineer that our country needs.

References

- [1] Edward Crawley, Johan Malmqvist, Sören Östlund, Doris Brodeur. Rethinking Engineering Education: The CDIO Approach. New York NY:Springer, 2010.
- [2] Canadian Engineering Accreditation Board. Accreditation criteria and procedures 2010. Ottawa, ON. Engineers Canada 2010.
- [3] Seymour Papert, Michael Resnick. Constructionism: A New Opportunity for Elementary Science Education. Proposal to the National Science Foundation. Cambridge, MA.
- [4] Erwin Roberts, Adam B. Smith. Education and Teaching. New York, NY: McGraw Hill, 2010.