DIGITAL LEARNING FOR DEVELOPMENT

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MOOCs as an Alternative for Teacher Professional Development

Examining Learner Persistence in One Chinese MOOC

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TABLES AND FIGURES

ACRONYMS

AAOU	Annual Conference of the Asian Association of Open Universities
ARCS	Attention, Relevance, Confidence, Satisfaction
GDP	gross domestic product
MOOCs	Massive Open Online Courses
PIP	picture in picture
TPD	teacher professional development

CONTENTS

PREFACE

The teacher MOOC project in China was initiated by Prof. Wang Qiong of Peking University in 2014. She and her colleagues from 10 universities have worked to provide 20 high-quality MOOCs to over 1 million teachers in China since 2015. This initiative demonstrates how a large country with urban-rural gaps could use digital learning technology to enhance education equity, quality, and efficiency through a large-scale teacher professional development (TPD@Scale) approach. In the past two years, Prof. Wang and her team have been working closely with the Digital Learning for Development (DL4D) program, dedicated to studying MOOCs as an alternative path to TPD.

This report focuses on a particular kind of MOOC learners, defined as persistent teacher-learners by the researchers. Through the analysis of these persistent teacher-learners, this report discusses their distinguishing characteristics, motivations, academic performances, and behavioral patterns. Based on the analysis of the learning-related data in the MOOCs, this report suggests that complex and diverse motivations and individualized self-regulation skills may explain the learners' repetitive learning behaviors. Meanwhile, these learners organize professional learning communities outside the MOOC platform, supplementing their professional development by utilizing both online and offline resources and interactions.

In addition, this study investigates how learners integrate the MOOC learning into their own teaching practice. This TPD@Scale approach based on MOOCs and professional learning communities addresses the issues of the one-shot training approach and may be a more effective approach towards teacher professional development. The key findings of this project will have practical implications for the professional development of teachers.

This study was conducted under the Digital Learning for Development (DL4D) project of the Foundation for Information Technology Education and Development (FIT-ED) of the Philippines. As part of the Information Networks in Asia and Sub-Saharan Africa (INASSA) program of the International Development Research Centre (IDRC) of Canada and the Department for International Development (DFID) of the United Kingdom, DL4D aims to improve educational systems in developing countries in Asia through testing digital learning innovations and scaling proven ones.

Cher Ping Lim
DL4D Network Lead

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ABSTRACT

Massive Open Online Courses (MOOCs) have developed into a significant international movement, showing great promise in addressing equity, quality, and efficiency issues in global education. To date, many MOOCs have been developed specifically for teacher professional development (TPD). In this regard, an important empirical question remains to be addressed: *How and to what extent can MOOCs support equity, quality, and efficiency in teacher professional development?* To help fill this knowledge gap, this study, conducted from 2014 to 2016, focused on *persistent teacher-learners* in a TPD MOOC that was offered for seven consecutive rounds by the X-Learning Center of Peking University. The study found that more than 15% of the 105,383 teachers who enrolled in this MOOC were persistent teacher-learners, defined as learners who enrolled in multiple rounds. Data analysis showed that these persistent teacher-learners had diverse motivations for re-enrollment, including refreshing conceptual understanding, achieving higher scores, earning course certification, and discussing practical problems. The study also found that the persistent teacher-learners developed self-regulated learning skills in the course of multiple rounds of the MOOC and showed significantly higher learning achievement than one-time enrollees. Qualitative and quantitative analysis of both clicklog data and interview data revealed additional insights into the persistent teacher-learners' learning within the MOOC and their real-world teaching practice beyond the MOOC. Overall, this study contributes to an improved understanding of the potential of MOOCs as an alternative TPD delivery mode in developing countries and sheds light on the future design of effective TPD through MOOCs.

Keywords: *MOOC, teacher professional development, persistent teacher-learners, self-regulated learning*

I. INTRODUCTION

Teacher professional development (TPD) is traditionally in the form of workshops that teachers can attend only after being released from their school obligations. For teachers from underserved regions such as rural China, such workshops organized by national, regional, or local authorities remain their sole source of professional development. In contrast, teachers in developed regions are exposed to diverse opportunities for professional development, such as attending online webinars and collaborating with educational researchers. Thus, teachers in developing countries face historical and systematic inequity in access to professional development (Robinson, 2008).

In addition to access, inequity in teacher professional development also manifests in terms of quality. The traditional workshop format typically focuses on delivering information through expert presentations, which may raise teachers' awareness of certain topics but fail to catalyze real-world changes in their classroom practice (Kleiman, Wolf, Frye, & Kleinman, 2013). To accomplish real-world changes, TPD programs need to give teachers opportunities for "hands-on" experiences that are integrated into their daily school life (Fishman, Marx, Best, & Tal, 2003; Garet, Porter, Desimone, Birman, & Yoon, 2001). However, such high-quality professional development is virtually missing, and teachers are left on their own after TPD workshops. There is an urgent need for innovative solutions to ensure equity, quality, and efficiency in delivering TPD in underserved regions in developing countries.

Massive Open Online Courses (MOOCs) have evolved to become a global buzzword across disciplines since its inception only a few years ago (Pappano, 2012), showing disruptive impact in both K–12 and higher education (Hyman, 2012; Skiba, 2012). More recently, MOOCs are also becoming a rich source of TPD (Viswanathan, 2012). Applying online distance education to teacher development is not new (Robinson, 2008). But with MOOCs, educators can learn for free in flexible online environments, and they may have the opportunity to interact and collaborate with colleagues around the world. A growing number of MOOC providers (e.g., Coursera, edX) are partnering with universities to offer TPD courses on a wide range of topics, including student engagement, inquiry-based learning, and classroom research. Such MOOCs have the potential to provide TPD that go beyond "one-shot" training events to promote "collaborative innovation" by teachers with teacher educators, researchers, and their peers on the Internet (Corno & Randi, 1997).

To accomplish real-world changes, TPD programs need to give teachers opportunities for "hands-on" experiences that are integrated into their daily school life.

Given the popularity and potential of using MOOCs to support TPD, an important empirical question that might be asked is: How and to what extent can MOOCs support equity, quality, and efficiency in teacher professional development? A study of learners in TPD MOOCs offered in developing countries is needed to understand the efficacy of these MOOCs in facilitating educational change. Since successful TPD is often characterized as a gradual, highly interactive, and self-reflective process (Borko, 2004; King, 2002), research into teachers' engagement with MOOCs for an extended period of time would be especially valuable. Such research could provide a better picture of teachers' learning intentions, behaviors, and strategies in these MOOCs as well as the MOOCs' impact on their teaching practice, and therefore help determine whether MOOCs could become an innovative tool and a viable solution to bridge current gaps in teacher education in developing countries.

II. OBJECTIVES

The research context was a MOOC series for in-service teachers offered between July 2014 and March 2016 by the X-Learning Center of Peking University. The study focused on a MOOC on *Flipped Classroom Pedagogy* which has been delivered seven times. As teachers could enroll in each round, this MOOC provided a unique context to investigate sustained teacher learning over a long period of time.

The central objective of the study was to examine persistent teacher-learners in TPD MOOCs. In this research, the researchers define *persistent teacher-learners* as learners who enrolled in more than one instance or round of the *Flipped Classroom Pedagogy* MOOC. In other words, the researchers operationalize "persistence" as repeated enrollment in a single MOOC offered multiple times. This focus on persistence is absent from most MOOC research (e.g., Halawa, Greene, & Mitchell, 2013; Whitmer, Schiorring, James, & Miley, 2014) and is therefore much needed in the literature. In this study, the overarching research objective was to provide a rich depiction of persistent teacher-learners, especially those coming from underserved regions, so as to find better ways to support their professional development in the future.

For this purpose, the researchers investigated the following research questions:

1. What does a teacher-learner's enrollment in multiple rounds of the *Flipped Classroom Pedagogy* MOOC look like?
2. What are the demographic characteristics, learning intentions, and learning performance of persistent teacher-learners in this MOOC?
3. What are the persistent teacher-learners' behavioral patterns, if any, over the course of taking multiple rounds of this MOOC?
4. What are the typical scenarios of this MOOC's usefulness for persistent teacher-learners' professional development?

Photo Credit: Dufeng Li

III. REVIEW OF LITERATURE

3.1 MOOCs and Their Development in China

MOOCs have become a buzzword within a few years of its inception, with 2012 named "the year of MOOC" (Pappano, 2012). The emergence of the concept has been traced to an open online course offered by George Siemens and Stephen Downes at the University of Manitoba in 2008 (Daniel, 2012; Liyanagunawardena, Adams, & Williams, 2013). The course *Connectivism and Connective Knowledge* was taken by 25 on-campus students for credit and 2,300 other students from the general public for free. This first MOOC was tagged as a connectivist in the sense that connections among learners and their knowledge artifacts, such as blog posts, were critical to the course itself and the teacher as the sole source of content was deemphasized (Cormier & Siemens, 2010). A later development that brought fame to the MOOC concept, however, was based on a more traditional behaviorist pedagogical model (Bates, 2012). In 2011, Stanford University offered a MOOC on artificial intelligence that enrolled 160,000 students. This "modern" MOOC was designed like a lecture course, using videos of expert lectures to provide content in a scalable manner to a theoretically infinite student population. Today, most MOOCs are of this more modern type and typically involve structured and sequenced teacher-led activities (e.g., videos, readings, virtual labs) coupled with online assessment and a venue for student interaction such as a discussion forum. The two genres of MOOC are distinguished as cMOOCs and xMOOCs, respectively (Siemens, 2013). While there is an ongoing debate over which model works better, the xMOOC is currently dominating the global MOOC discussion and unless specified otherwise, the term MOOC in this study refers to xMOOCs.

One appeal of MOOCs is their potential to democratize access to education. This is especially important for bridging educational gaps in developing countries. In China, the first MOOC partnership was formed in spring 2013 between edX and two top universities—Peking University and Tsinghua University. A few months later, Fudan University and Shanghai Jiaotong University joined Coursera. In May 2014, China's own University MOOC Platform was officially launched, opening up a new wave of MOOC experimentations participated in by a broader range of local universities (Cui, Liu, & Wang, 2015). As of late 2016, there were more than 150 higher education institutions offering MOOCs in mainland China.[1]

3.2 Learner Participation in MOOCs

Research into learner participation in MOOCs has focused mostly on course completion and learner performance. While many MOOCs have "massive" enrollments, the percentage of students actually completing any particular MOOC often falls below 10% (Breslow & Pritchard, 2013; Jordan, 2014). Researchers contend that low completion rates may not be surprising given low barriers to entry and varied intentions of learning among MOOC enrollees. Numerous typologies of MOOC learners have been proposed, but in general, enrolled students can vary from participants who are active in all aspects of the course, to passive viewers of course content, to "samplers" who only wish to engage with particular modules or sections of lessons, and to the merely curious learners who never even access the MOOC after signing up (Ferguson & Clow, 2015; Hill, 2012).

[1] Estimate based on data from the three main MOOC platforms in China – Xuetangx, iCourse163, and CNMOOC.

Some have argued that MOOC retention rates are misleading and that the idea of ‘‘retention’’ itself needs to be re-conceptualized in the MOOC context (DeBoer, Ho, Stump, & Breslow, 2014). Given the variety of learning platforms used in MOOCs, learner participation can be operationalized differently. For example, traditional participation metrics such as attendance can be operationalized by the timing and frequency of login sessions or ‘clicks’ made by a learner, and engagement can be operationalized as viewing and/or the use of different types of tools or materials, including videos, discussion forums, quizzes, wikis, and the like (Breslow & Pritchard, 2013; DeBoer et al., 2014). But no matter which metrics are applied, what is certain is that there is not a single way to depict MOOC participation. In addition, learners have the freedom of working through a MOOC on their own, giving rise to different behavioral trajectories in MOOCs (Chen, Håklev, Harrison, Najafi, & Rolheiser, 2015; DeBoer et al., 2014; Ferguson & Clow, 2015; Woodgate, Macleod, Scott, & Haywood, 2015). These factors make traditional standards for courses incompatible with MOOCs, and they point to the need to distinguish MOOC learner preferences and seek effective ways of supporting personalized learning in MOOCs.

Besides studying participation in a single MOOC, researchers of MOOC participation have also attended to *returning* MOOC learners, or learners who take multiple MOOCs on the same platform. The opportunity of retaking a course (without penalty) is uncommon in higher education. In general, institutional regulations, cost, and student time commitment serve as barriers to retaking courses. However, the openness of MOOCs and their availability at no cost to learners enable retaking of MOOCs. The limited research in this area has found that while it is common for MOOC learners who are unable to complete a MOOC to retake the course, some learners retake MOOCs regardless of success in earlier trials (Woodgate et al., 2015). This preliminary finding has important implications for MOOC practitioners and researchers. While most current MOOC research focuses on MOOC “dropouts” and “failures,” attention also has to be paid to successful learners who keep returning to MOOCs for learning opportunities.

3.3 Self-Regulated Learning in TPD

Teacher professional development (TPD) has traditionally taken the form of one-shot workshops delivered in relatively short periods of time. This format has been criticized for being decontextualized and fragmented (Grossman, Wineburg, & Woolworth, 2001). Teacher education research suggests that the key ingredients for successful teacher professional development include ample opportunities to explore critical issues, being able to situate TPD in practice, and sufficient time for in-depth reflection (Borko, 2004; King, 2002). Key TPD activities include critique and co-construction of innovative ideas, implementation of innovative strategies followed by observation and documentation of the effects of innovation on students’ learning, and reflection on and reconstruction of what it means to teach and learn (Butler, Lauscher, Jarvis-Selinger, & Beckingham, 2004). All of these foster self-regulated learning, which is the ability to take responsibility for one’s own learning and teach autonomously (Zimmerman, 1990).

This study drew on self-regulated learning theory to examine learning behaviors of persistent teacher-learners in MOOCs. Self-regulated learners show awareness of thinking (i.e., being metacognitive), develop and apply learning strategies, and demonstrate sustained motivation (Paris & Winograd, 2003). Educational research suggests that the ability to self-regulate learning is essential for teachers’ professional growth as well as for their ability to promote these processes among students. To succeed in teaching, teachers need to become self-regulated learners (Randi, 2004). Rather than instilling facts and rigid teaching models, contemporary teacher professional development should encourage teachers to find opportunities for learning in their own teaching (Kramarski & Michalsky, 2009). Since teachers face problems and challenges that are genuinely complex, they need to develop self-regulatory skills that enable them to monitor and reflect on their teaching (Butler et al., 2004); including the effectiveness of changes they make to their practice and make adjustments as needed (Kremer-Hayon & Tillema, 1999). Teachers should be supported to self-regulate their learning about teaching (Paris & Winograd, 2003). In the absence of such self-regulation, targeted changes in teaching practice will either not happen or only become dead-ends without real impact on student learning.

In the present study, self-regulation of learners in MOOCs is understood to be twofold. First, during MOOC participation, self-regulated learners are aware of their intentions and learning progress, and they will apply learning strategies to accomplish their goals. Second, teachers who are self-regulated learners would connect what they learn in the MOOC with their real-world teaching practice. Such self-regulation would help sustain their motivation to continually engage with the MOOC in order to support their reflective practice. It is plausible that teacher-learners who are self-regulatory in their teaching are likely to return to MOOCs for additional learning opportunities. Therefore, self-regulated learning theory fits with the investigation of teacher-learners in MOOCs and their attempts to connect MOOC learning with their own teaching practice.

IV. METHODOLOGY

To address the research questions, the researchers applied a case study research design to the investigation of one TPD MOOC and persistent teacher-learners in this MOOC. A case study is a research strategy for understanding the dynamics present within single settings (Eisenhardt, 1989).

The current case study employed an embedded design, involving multiple levels of analysis (Yin, 2011). In particular, the study investigated persistent teacher-learners in the TPD MOOC, with the regions they come from (and potentially other demographic variables related to equity) defining sub-units of the case.

4.1 Context Research Participants

The *Flipped Classroom Pedagogy* MOOC aims to help teachers develop a better understanding of the flipped classroom approach and practice this instructional approach in their own teaching. The seven-week MOOC consists of six modules: an orientation module and five modules on principles and concepts on the flipped classroom approach. The learning materials include video lectures, PDF documents, discussion forums, and quizzes. The assessment and evaluation of learning include tests, homework, and a final exam, which are marked automatically by the system or peer-reviewed. A preliminary report on student demographics has already been published (X-Learning Center, 2015).

To ground the more detailed analyses to follow, Table 1 shows the enrollment and course completion figures for the *Flipped Classroom Pedagogy* MOOC. A total of 126,044 learners enrolled in seven rounds of the MOOC, with 10.35% of them receiving a certificate (CoA) (i.e., achieving a 60% or higher course grade). More than 80% of all MOOC enrollees were teachers from K-12 and higher education settings.

Photo Credit: Zhu Qing

Table 1. MOOC Completion Rates

Rounds	Duration	Enrollees	CoA	CoA%
1	2014/07/01 - 2014/08/10	24,971	5,010	20.06%
2	2014/09/10 - 2014/10/31	29,763	2,425	8.15%
3	2014/12/16 - 2015/01/31	17,924	2,027	11.31%
4	2015/03/18 - 2015/05/07	11,892	1,032	8.68%
5	2014/07/01 - 2014/08/10	24,971	5,010	20.06%
6	2014/09/10 - 2014/10/31	29,763	2,425	8.15%
7	2014/12/16 - 2015/01/31	17,924	2,027	11.31%
	Total	11,892	1,032	8.68%

Note: CoA – Certificate of Accomplishment (i.e., achieving 60% or higher).

By matching enrollment information, it was found that 16,570 people, accounting for 15.73% of the total enrollment, had a record of repeated enrollment and thus fall into the category of persistent teacher-learners.

4.2 Data Sources

To study persistent teacher-learners in the MOOC, the researchers used a wide range of data sources, including entry and exit surveys, MOOC clickstream data, discussion forum data, and semi-structured interviews. Access to MOOC data for this research was coordinated with the Chinese University MOOC Platform following standard research ethics protocols.

MOOC design, quality of learning modules, self-reported MOOC participation, and perceived learning gains. Preliminary analysis of the entry and exit surveys had already been published in an institutional report by the X-Learning Center (X-Learning Center, 2015). For the current study, the entry and exit surveys of identified persistent teacher-learners were analyzed.

By matching enrollment information, it was found that 16,570 people, accounting for 15.73% of the total enrollment, had a record of repeated enrollment and thus fall into the category of persistent teacher-learners.

4.2.1 Entry and exit surveys. At the beginning of each course, learners were invited to complete a survey composed of questions regarding their demographic background (e.g., region, age, and education), reasons for taking the course, and how much effort they planned to put into the course. The survey also contained course-specific questions aimed at gauging the level of knowledge or experience with the course topic. The learners were also asked to complete an exit (end-of-course) survey which included questions on the effectiveness of the

4.2.2 Learning behaviors data. The complete clickstream data for each round of the MOOC consisted of two kinds of events: normal page views and video views. For page views, the user, time, and URL information were used to classify (a) the kind of action (e.g., viewing a post, adding a comment) and (b) the item related to the action (which post, which comment). For video views, the clickstream showed information about which video

was viewed and at what point in the video the user pressed play, pause, etc. Using these data, an individual student's interaction with the course content can be accurately reconstructed.

4.2.3 Learning outcome data. The researchers also had access to learning outcome data, represented by traditional assessment measures based on quiz and assignment results. This course was designed with a number of quizzes or tasks and several summative assignments. The quizzes were embedded inside videos (sometimes multiple quizzes in one short video), or as part of each week's activities. The assignments involved drafting and critiquing plans for implementing the flipped classroom approach. Based on their assessment scores, the researchers identified persistent teacher-learners who received high scores in their first and second enrollment (high-high scores), persistent teacher-learners who received a high score in their first enrollment and a low score in their second enrollment (high-low scores), persistent teacher-learners who received a low score in their first enrollment and a high score in their second enrollment (low-high scores), and persistent teacher-learners who received low scores in their first and second enrollment (low-low scores).

4.2.4 Semi-structured interviews. The researchers conducted an hour-long semi-structured telephone interview with nine persistent teacher-learners who were selected based on their learning outcome data (i.e., those with high-high scores, high-low scores, low-high scores, and low-low scores). The aim of the interview was to construct a rich, qualitative picture of their motivation, access to professional development in their regular professional environments, epistemic beliefs and goals for learning, subjective experiences of taking and retaking the MOOC, and more importantly, their self-regulated efforts to learn about teaching through the MOOC. These qualitative data were triangulated with the student behavior data, allowing us to examine the perceived impact of the MOOC on learners' teaching practice.

4.3 Data Analysis

In this multi-level case study, the researchers used a mixed methods approach, utilizing both quantitative and qualitative data analysis to address the research questions. Data analysis started from identifying persistent teacher-learners using clickstream data from all rounds of this MOOC — i.e., by detecting learner IDs that appeared in multiple rounds. After identifying persistent teacher-learners, the researchers used the survey data and learning outcome data to draw demographic, intention, and performance sketches of the persistent teacher-learners.

To examine learning behaviors and self-regulation in the MOOC, the researchers mined the clickstream data using advanced clickstream analytics, which employs scalable, distributed computing. A typical clickstream from one course round is up to 3 gigabytes in size, with up to 5 million events. To address the research questions, the team used multiple methods and algorithms, including cluster analysis (e.g., Spectral Clustering) and association rule mining (e.g., Apriori algorithms).

The semi-structured interview data were coded using NVivo to uncover themes with regard to the usefulness of the MOOC for the persistent teacher-learners. The researchers also coded the persistent teacher-learners' self-regulation behaviors beyond the MOOC (such as their daily time management of teaching and learning activities) that they reported during the interviews. The results of this qualitative analysis were triangulated with the learning behavior data in the different MOOC offerings derived from the advanced clickstream analytics, to depict a rich picture of persistent teacher-learners in the *Flipped Classroom Pedagogy* MOOC.

V. KEY RESEARCH FINDINGS

5.1 Basic Description of Persistent Teacher-Learners

From its first round in July 2014 until its seventh round in March 2016, the cumulative course enrollment in the *Flipped Classroom Pedagogy* MOOC was 126,044, with 105,370 unique enrollees (i.e., unique individuals). Of the latter, 16,570 (15.73%) were persistent teacher-learners.

Among the persistent teacher-learners, 13,479 (81.35%) enrolled in the MOOC twice; 2,346 (14.16%) enrolled three times, and 745 (4.50%) enrolled four or more times. Based on the course enrollment data, 75.26% (12,471) of all persistent teacher-learners enrolled for the course in consecutive rounds (e.g., the first and second rounds in a row or the third, fourth, and fifth rounds in a row).

Table 2 shows the gender, age, and professional characteristics of the 16,570 persistent teacher-learners. Female learners accounted for 65.69% of all persistent teacher-learners, and the median age of persistent teacher-learners was 35. Based on the Teacher Career Cycle proposed by Fessler and Christensen (2006), the researchers categorized the age of persistent teacher-learners into six types: pre-career stage[2] (3.47%), career entry (5.41%), stabilization phase (7.60%), experimentation and reassessment (72.57%), and serenity and conservatism (10.95%). The majority of persistent teacher-learners fell into the experimentation and reassessment phase of their teaching career. Teachers in this phase are often more interested in learning new teaching methods and are generally more willing to apply and assess them in their own teaching. It is worth noting that the percentage of persistent teacher-learners in the experimentation and reassessment phase (72.57%) significantly outstrips the percentage of one-time enrollees in the same phase.

It is worth noting that the percentage of persistent teacher-learners in the experimentation and reassessment phase (72.57%) significantly outstrips the percentage of one-time enrollees in the same phase.

[2] The majority of in-service teachers in the Chinese Mainland start their teaching career at an average age of 22 after graduating from an undergraduate program at a teacher's college (also referred to as a normal university/college). Considering also the information about academic qualifications collected from a questionnaire at the start of the course, this study regards the age of 22 as the first year of a teacher's career.

Table 2. Demographic Characteristics of Persistent Teacher-Learners

Variable	Category	Percentage (Persistent Teacher-Learners)	Percentage (One-time Enrollees)
Gender	Male	34.31%	39.00%
	Female	65.69%	61.00%
Affiliation	Kindergarten and Primary School Teachers	15.72%	16.03%
	Junior and Senior High School Teachers	33.70%	29.06%
	University and Vocational College Teachers	31.38%	29.36%
	College Students	6.67%	12.14%
	Others	12.53%	13.41%
Age	≤22 pre-career stage	3.47%	8.94%
	23-25 career entry	5.41%	8.37%
	26-28 stabilization phase	7.60%	8.73%
	29-47 experimentation and reassessment	72.57%	63.23%
	≥48 serenity and conservatism	10.95%	10.73%

In terms of geographic distribution, the enrollees in the *Flipped Classroom Pedagogy* MOOC came from 34 Chinese provinces, autonomous regions, and municipalities. The five regions with the most learners were Heilongjiang, Jiangsu, Shandong, Henan, and Beijing, all of which have a certain percentage of persistent teacher-learners represented in red in Figure 1. Using statistics about per capita GDP published by the National Bureau of Statistics, the researchers divided the provincial-level regions in the Chinese mainland into relatively advanced regions (those exceeding US$10,000; 9 provincial-level regions) and less developed regions (those lower than US$10,000; 22 provincial-level regions). Analysis of the distribution of persistent teacher-learners showed that although more learners come from eastern coastal areas, which are generally more developed, the percentage of persistent teacher-learners in less developed regions (16.59%) was slightly higher than that in advanced regions (14.38%).

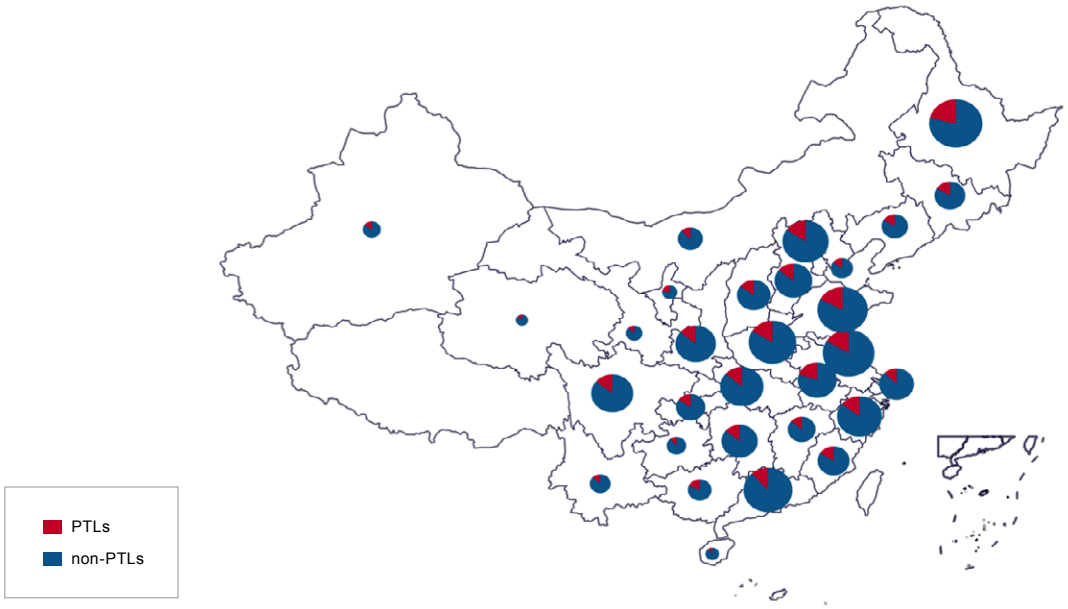


Figure 1. Geographic Distribution of MOOC Learners

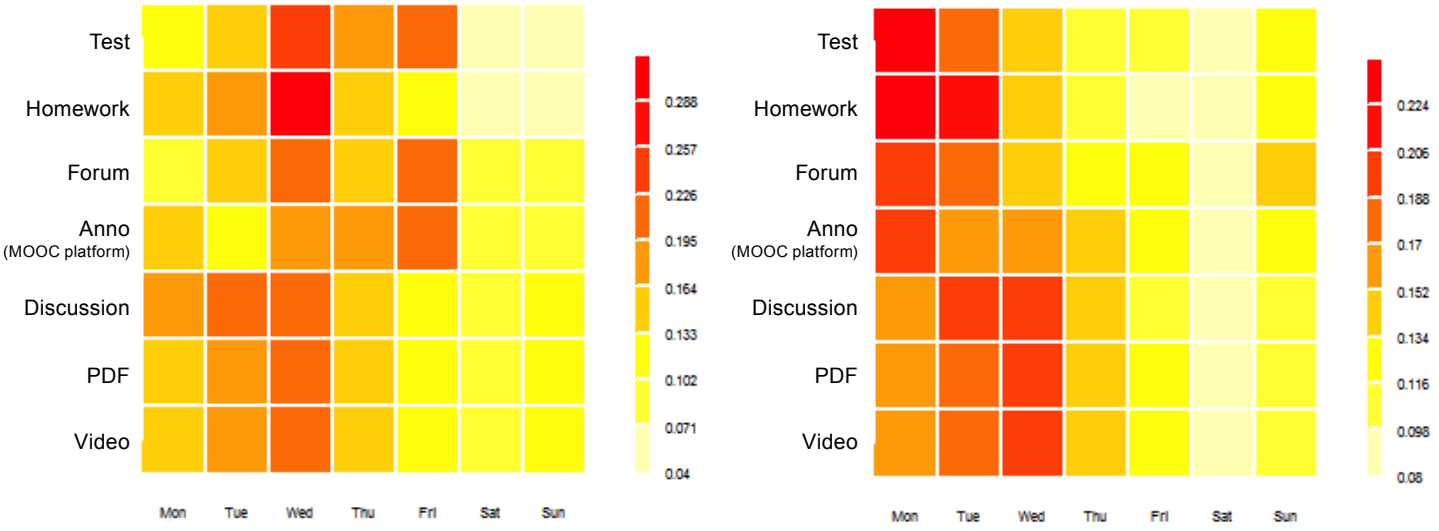
5.2 Advanced Learning Strategies and Better Performance

Based on their learning behaviors and feedback from the interviews, the researchers found that persistent teacher-learners generally demonstrated more advanced strategies and better performance than one-time enrollees. They collected the frequencies over a one-week period (from Monday to Sunday) of seven types of learning behavior of one-time enrollees and persistent teacher-learners, namely, viewing videos (*video*), downloading files (*pdf*), posting in the *forum* (compulsory posting in relation to course content), discussion (*discuss*; general discussion about issues other than course content, including posting and reading), viewing announcements on the login page of the MOOC platform (*anno*), taking the module test (*test*), and submission of the unit homework (*hw*).

Figure 2 is a thermodynamic diagram of the MOOC in the fourth semester which shows that following the update of the course content every Wednesday, persistent teacher-learners showed more concentrated learning behaviors within that day, whereas the learning behaviors of one-time enrollees were more scattered. With regard to the submission of the module test and homework, in contrast to one-time enrollees who mostly rushed to complete the task before the deadline on Wednesday, the majority of the persistent teacher-learners would have already completed the test and homework by Monday or Tuesday.

The feedback of one respondent, Teacher K, during the interview, validated these observations:

> *I found this MOOC was a perfect match for my teaching. It's much better than the other training projects I have ever attended. [...] So I was really looking forward to learn the new materials once the course was updated every Wednesday morning. [...] I even woke up at 4 am to check the new content sometimes, in case I can't find time during the daytime.*



One-time enrollees

Persistent teacher-learners at their first enrollment

Figure 2. Frequencies of Learning Behaviors of One-Time Enrollees and Persistent Teacher-Learners

Analysis of the behavioral characteristics of persistent teacher-learners showed more advanced learning strategies even during the first enrollment (when it was not known whether they would re-enroll in the course). These better strategies would account for the significantly better overall academic performance of the persistent teacher-learners (even on their first attempt) than that of the one-time enrollees in the course. Due to the non-normal distribution of the academic performance of the MOOC, the researchers applied a Wilcoxon rank sum test to validate the difference in academic performance of the two learner groups. The results of the analysis show that at significance level $P<0.000$ ($W=1e+07$), the scores of persistent teacher-learners ($M=72.35$) are significantly higher than those of one-time enrollees ($M=30.11$).

5.3 Diversified Motivations for Re-enrollment

The better academic performance of persistent teacher-learners even during the first enrollment could be potentially linked to stronger motivations. One hypothesis in this regard is persistent teacher-learners enroll in the same MOOC more than once primarily because they believe that the course is worth learning, and they would like to earn a certificate of course completion.

To test this hypothesis, the researchers examined the change of scores of persistent teacher-learners across different rounds. The results showed that 44.76% of persistent teacher-learners did not attain any score from all attempts; 24.27% of them did not attain scores above the passing level, and 9.87% did not enroll in the course again after having obtained the certificate after multiple trials. However, 21.10% of them enrolled in the course again after attaining a passing grade, including a notable 13.34% who re-enrolled after attaining an excellent grade (i.e., greater than 80%).

Figure 3 demonstrates the scores of two-time enrollees in their first and second enrollments, which are represented by the X-axis and Y-axis, respectively. The figure shows a relatively low score for a large number of enrollees (represented in purple) in either the first and second enrollment, which is probably due to the failure to complete the whole course or the low importance they attached to scores and the certificate. Some enrollees (represented in blue) attained relatively low scores during their first time but achieved higher scores and scores above 60 the second time. Other enrollees (represented in green) attained scores above 60 during their first time, which makes their scores during their second time less important for them. The fourth group of enrollees (represented in red) attained relatively high scores during both their first and second enrollment, with some scoring more than 80 and even up to 90.

Figure 3. Scatter Chart for the Scores of Two-Time Enrollees

These results suggest that the motivations of persistent teacher-learners to enroll in a course more than once were diverse. Some enrollees wished to complete the course; others wished to attain scores above the passing level, and others were striving for higher grades regardless of a passing grade. In the interviews with the persistent teacher-learners, the following motivations for enrolling in the course again even after getting relatively high scores and the certificate were mentioned: reviewing or updating knowledge, solving practical problems, having exchanges with like-minded people, or simply keeping connected to the course updates and learning opportunities. For example, one persistent teacher learner said:

For the second time, I really don't care about the scores. I only want to find some support from those teachers who also use flipped classroom in their own teaching. Their experiences are very valuable to me [...] and the sense or the feeling of belonging is important to me, so that I won't feel lonely in my teaching. Because in my school, there is no other teacher who would like to try this kind of new teaching method.

5.4 Learner Clusters and Typical Behavioral Patterns

Different motivations lead to varied learning behaviors, and understanding the behavioral patterns of persistent teacher-learners is useful for determining how to better facilitate teacher professional development in MOOCs.

In this study, four types of learning behaviors were identified based on first-time learners' use of the main learning materials, which included course videos, documents, discussion, tests, and homework. First-time learning behaviors consisted of: video viewing (54.33%), reading (20.25%), discussion, including posting and replying to posts at forums, (14.72%), and tests and homework (10.69%).

Based on the above classification, the researchers conducted a cluster analysis of the learning behaviors of persistent teacher-learners during their second enrollment and identified four clusters of learners with distinct traits (see Figure 5), described in the next page.

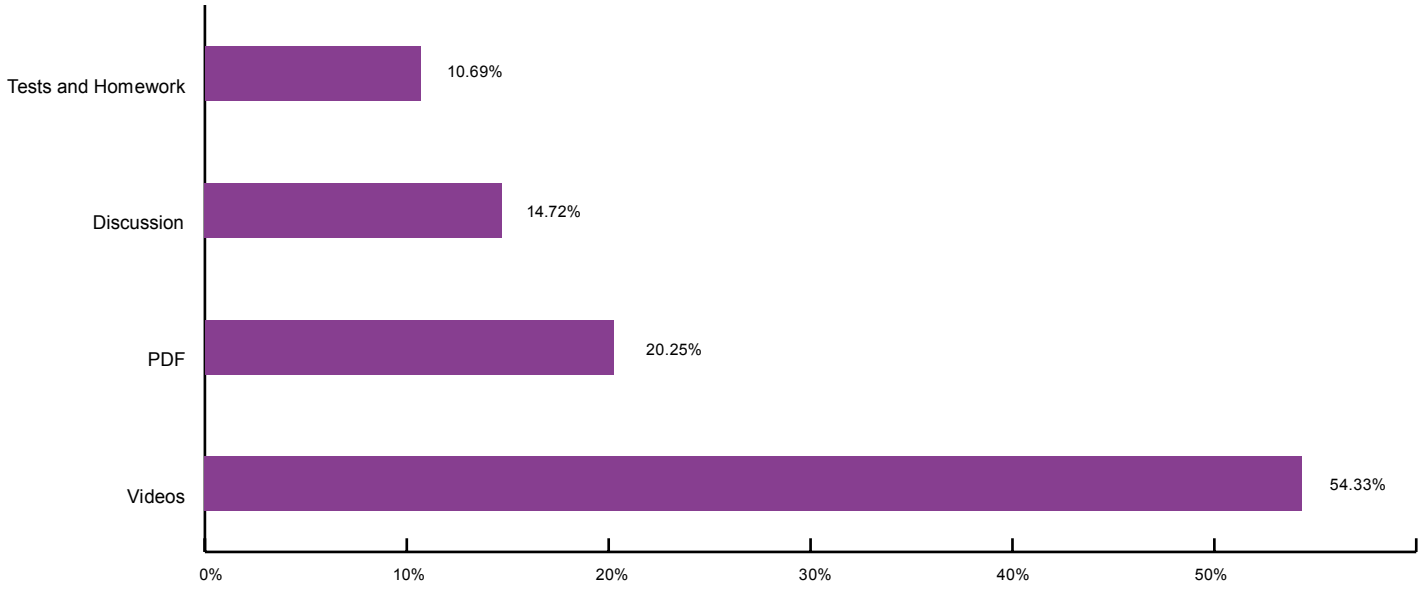


Figure 4. Percentage of Four Types of First-Time Learning Behaviors

Regular learners (73.94%): The majority of these learners failed to complete the course the first time they enrolled, and they demonstrated a similar behavioral pattern (with reference to the four types of learning behaviors) as the first-time learners.

Video viewers (8.92%): Video viewing accounted for 74.27% of the learning behaviors of persistent teacher-learners during their second enrollment, while other types of learning behaviors occured at a significantly smaller percentage (in particular, the average percentage of discussion participation is only 7.43%). It seems that video viewing is a strong motivation of persistent teacher-learners during their second enrollment.

Document collectors (6.09%): Although video viewing accounted for 52.12% of the learning behaviors of these learners, they demonstrated a stronger tendency to download course documents. Most of the documents were transcripts of videos. From the interviews, the researchers found that the motivation to collect documents and to review the course content by reading documents existed among these persistent teacher-learners.

Score seekers (11.05%): Test taking and doing the homework accounted for 25.13% of the behaviors of learners in this cluster, which was significantly higher than the 10.69% average among first-time learners and slightly higher than the 19.21%

average among regular learners. This behavior indicates a strong motivation to seek higher scores. From the interviews, the researchers found that this score-seeking behavior is due to a desire to collect feedback; for example, submitting the unit homework once again in order to peek into the homework submitted by peer learners through peer review, or to collect comments on one's own homework from other learners. Figure 5 shows the results of the above clustering of learning behaviors.

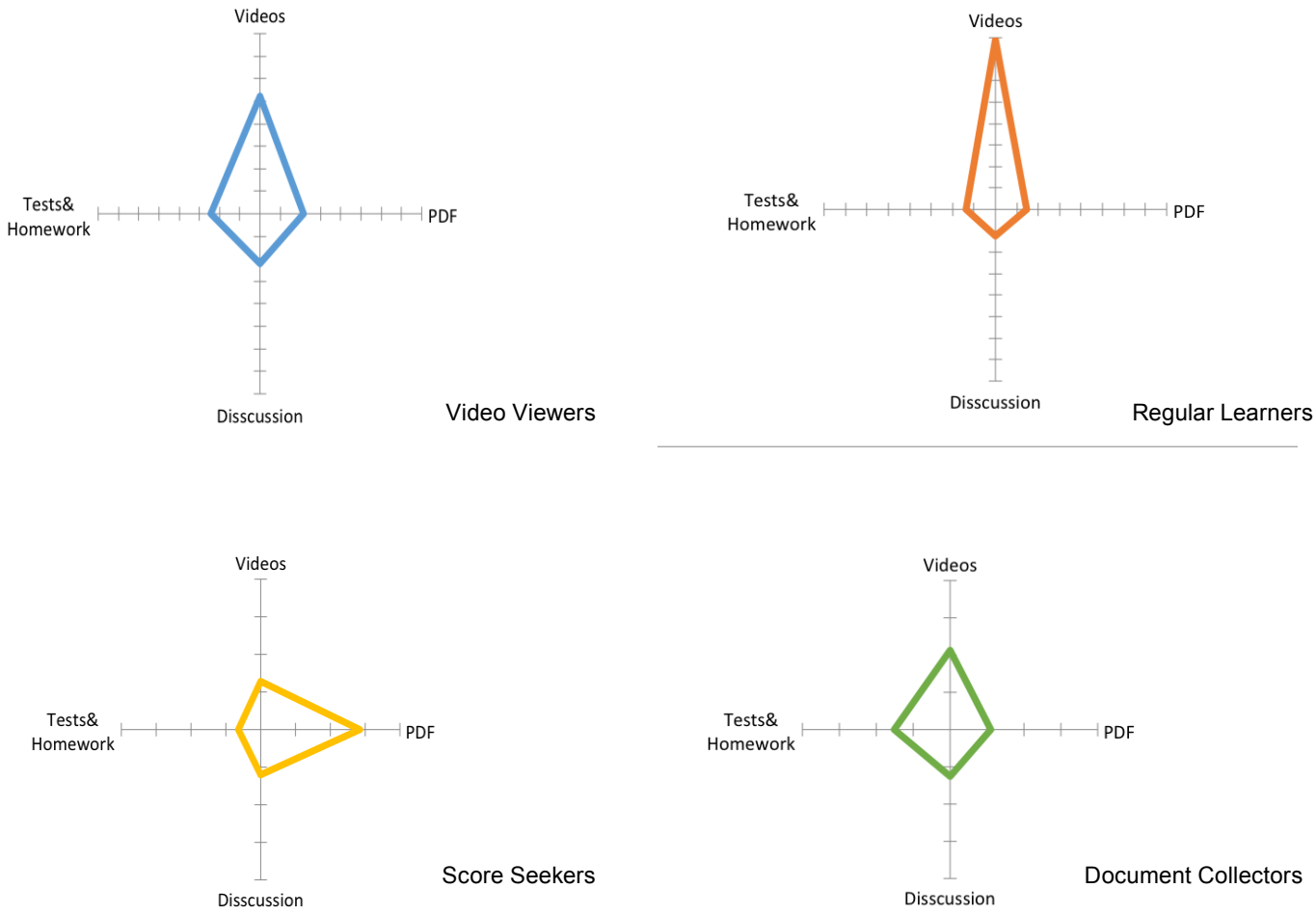


Figure 5. Cluster Analysis of Persistent Teacher-Learners' Learning Behaviors During the Second Enrollment

5.5 Learning With a Focus on Specific Modules

Following the cluster analysis of their learning behaviors, the researchers further explored the types of course materials or features that were accessed by the persistent teacher-learners. For instance, with regard to the video-viewer cluster, the team looked into the following: What kind of videos did they watch? Which set of videos were watched most frequently? Why did they prefer these videos?

From the interviews, the researchers found that the teachers reflected on the problems or confusions they encountered while teaching in relation to the content of the MOOC, and this would prompt them to return to the course and review certain videos. This is shown in the story of Teacher Z:

Last year, I went to a very famous high school in our province to observe one class taught by an experienced teacher. She made her instructional design with a very detailed plan for every minute in one class. [...] After class, some teachers who observed this class brought up a strong opposite opinion about whether it's necessary to be that strict about time in teaching. I was really confused at that moment! [...] I thought about this, and I remembered our MOOC mentioned this in Unit 4, so I went back to this module to watch this video again.

As validated by data analysis, this behavioral pattern is predominantly evident in theory and operating instructions, which suggests that theory, is valuable for persistent teacher-learners in their return to MOOC courses. Certain videos covering core theory are key to dispelling their confusions; hence the strategy of selected viewing of theory videos observed among persistent teacher-learners. In this study, based on data mining (keyword length 12) of the second time learning of persistent teacher-learners through association rule mining (using Apriori algorithm); the researchers found the maximal frequent itemsets (Support Level 0.23) of two categories of videos (see Table 3).

Table 3. Two Maximal Frequent Itemsets

Maximal frequent itemset-1	Maximal frequent itemset-2
How to promote student's self-reflection?	How to promote student's self-reflection?
Mastery Learning Theory	Mastery Learning Theory
Definition of Flipped Classroom	Bloom's taxonomy
ARCS Model	Scaffold of instructional objectives
Why are my students being silent?	Bloom's taxonomy on attitude and emotion
Case from X school: instructional design of flipped classroom	Bloom's taxonomy on Psychomotor
Idea sharing: from tasks to works	How to match the objectives and strategies?
Class demonstration-students as teachers	Exploring: Can students learn by themselves?
Diversified teaching video styles	How to install Camtasia Studio (Screenshot software)?
How to designate the video style and modality?	How to designate the video style and modality?
How to transcribe PIP (picture in picture) video with PPT?	How to transcribe PIP (picture in picture) video with PPT?
How to insert titles and how to export videos?	How to insert titles and how to export videos?

This behavioral pattern points to the need for TPD courses to provide a bridge between course learning and pedagogical practice.

These results show that the sets of videos that were reviewed most frequently by persistent teacher-learners were those on theories related to Flipped Classroom, including Mastery Learning Theory, Bloom's taxonomy and the ARCS model, as well as specific techniques for the application of Flipped Classroom pedagogy, such as the use of screen recording software and video style and prologue/epilogue.

It is evident that when reviewing the course, the persistent teacher-learners were practice-oriented, probably with the aim of resolving confusion and technical obstacles they encountered in their teaching. This behavioral pattern points to the need for TPD courses to provide a bridge between course learning and pedagogical practice. With regard to the design and development of TPD MOOCs, this behavioral pattern shows the importance of thoroughly explaining key theories and operating instructions so that they are firmly linked to the teacher-learners' pedagogical practice.

VI. IMPLICATIONS AND RECOMMENDATIONS

The findings of this study of persistent teacher-learners in one TPD MOOC have practical implications for the instructional design of MOOCs, the application of MOOCs in teacher training in less developed regions, and the development of other MOOCs.

First, based on the course completion and repeated enrollment data, different instructional design frameworks are required for learners with different levels of capabilities and information literacy. This point is not reflected in the design of most MOOCs, leading to difficulty in completing the course for many learners. At the same time, to better serve persistent teacher-learners who complete the MOOC the first time they enroll, MOOC developers could also consider updating the course content and expanding on key and difficult learning points. The teaching content that is in greater demand and which poses more difficulties for understanding needs to be further improved. The latter is a powerful use of the learner data generated in MOOCs to improve course design.

Second, the study's findings underscore the value of MOOCs in teacher training. Especially in less developed regions where training resources are lacking and tend to be of an inferior quality, MOOCs can and should be an important approach to teacher professional development. The *Flipped Classroom Pedagogy* MOOC has been recognized by in-service teachers, principals, and institutions of higher learning, and many provincial and municipal administrations in the Chinese mainland have formally recommended the course to all of the in-service teachers within their jurisdictions. In addition, multiple higher education institutions have recommended the course to faculty members or pre-service teacher candidates. Unlike MOOCs for the general public, uptake of MOOCs for teachers depends to a large extent on administrations and schools. It is therefore important to explore synergies with educational administrators to further unleash the power of MOOCs in teacher professional development.

Finally, if MOOCs are introduced as a viable solution to teacher education, a series of high-quality MOOCs are necessary. In Mainland China, there is an ongoing effort to organize well-known universities to develop a series of MOOCs catering specifically to in-service teachers' needs. These MOOCs can enrich the resources available to promote Chinese teachers' professional development, provide learning materials tailored to teachers with different needs, and help with their individual professional development. The systematic development of MOOCs for teachers is worthy of the support and assistance of governments, institutions of higher learning, and foundations. In particular, there is an urgent need to conduct research on evaluating the effectiveness of MOOC learning and exploring the principles for MOOC design which, together with the development of MOOCs, could help tens of millions of in-service teachers improve their professional capabilities and thus pave the way for an education system that is more equitable and of a higher quality.

The Flipped Classroom Pedagogy MOOC has been recognized by in-service teachers, principals, and institutions of higher learning and many provincial and municipal administrations in the Chinese mainland have formally recommended the course to all of the in-service teachers within their jurisdictions.

VII. CONCLUSION

In this study, the researchers have described a special MOOC learner subgroup, namely, persistent teacher-learners, in a teacher professional development MOOC. They analyzed persistent teacher-learner motivations, learning strategies, and other traits and found that the majority of persistent teacher-learners were at the stage of experimentation and reassessment in their teaching career, with relatively richer experience in teaching practice. Their motivations for enrolling in MOOCs were diverse, with some striving for certificates or higher grades and others revisiting the MOOC to refresh their knowledge of content or to engage in practical problem-solving. Generally speaking, the persistent teacher-learners demonstrated stronger goal-setting and self-regulation in learning.

In view of the finding that these persistent teacher-learners comprised a significant percentage of the learners in the *Flipped Classroom Pedagogy* MOOC, on the one hand, and the capacity of MOOCs to provide free, open, and multiple access to learning opportunities, on the other hand, the researchers believe that MOOCs represent a promising new pathway for teacher professional development.

In terms of equity in education, MOOCs allow teachers from less developed regions with very little access to quality training to take courses from top universities in China online. As mentioned, the data showed that over 60% of the learners in the *Flipped Classroom Pedagogy* MOOC came from the less developed regions of China, and the percentage of persistent teacher-learners from the less developed regions was higher than the percentage of persistent teacher-learners from the developed regions. These findings point to the MOOC's potential for promoting equity in teacher professional development. Prior research also shows that MOOCs can play a role in promoting participation of all teachers in professional training, providing, in particular, a precious opportunity for teachers from less developed areas (Ambadkar, 2014). With MOOCs, teachers who in the past were too busy with their work to participate in systematic teacher training can use their limited spare time to polish their teaching skills. Thus, MOOCs can provide open and fair access to training for all faculty members within an institution.

With regard to quality of education, the core objective of teacher training is to improve teachers' knowledge and skills to enable them to address challenges and enable more effective learning for all (Manning, Morrison, & McIlroy, 2014). Unfortunately, traditional teacher training tends to be too academic and disconnected from real-world practices, and thus teachers still find it difficult to apply the new knowledge they acquire in training courses to actual teaching practice. MOOCs can be designed to pay particular attention to the relevance of topics discussed to real-world practice and problem-solving by providing multiple and continuous access to a variety of resources for pedagogical practice, such as pedagogical designs and templates, case studies, texts and worksheets for learners, and the like. Based on the interviews and analysis of the behavioral patterns of the persistent teacher-learners in the *Flipped Classroom Pedagogy* MOOC, the researchers have developed an understanding of how the MOOC helps teachers solve specific problems and "flip" their classrooms using an array of teaching and learning resources. And based on the course evaluation undertaken by the X-learning Center of Peking University (Liu, 2016), 96.02% of the learners agreed that this MOOC is very valuable to their career and well worth studying; 94.53% of the learners said they obtained "new knowledge"; and more than 90% of the learners said they improved their understanding about flipped classroom through this MOOC.

[W]e believe that MOOCs represent a promising new pathway for teacher professional development.

With regard to efficiency, the use of MOOCs in teacher training has a very minimal marginal cost. Since a MOOC is offered at a fixed cost and based on an iterative framework, having both new and persistent teacher-learners contributes to lower cost and higher efficiency (Kellogg & Edelmann, 2015). The improved efficiency is manifested in the cost of teacher training.

Problem solving by teachers can also become more efficient as the MOOC provides a communication platform for like-minded teachers to form a community of practice.

The research findings likewise call attention to some areas for further study. For example, it was observed that the persistent teacher-learners tend to solve problems with the help of instant messaging tools (such as WeChat and QQ) rather than through the discussion forums in the course, which raises important questions for the MOOC's instructional designers, such as how to sustain communities of practice among persistent teacher-learners using external tools. Another area for further study, particularly with regard to the theoretical aspect of self-regulated learning, is to identify and pinpoint individual learning goals and the specific goal orientation of MOOC enrollees (and especially persistent teacher-learners), which is a precondition for understanding their learning behaviors and strategies. Equally important is understanding how to track and analyze changes in learning goals and goal orientation of persistent teacher-learners in the course of their enrollment in different offerings of the course. With respect to data collection and analytics, an area for further study is determining self-regulated learning behaviors and learning strategies from the MOOC's "big data" (in current research on self-regulated learning, the usual method is through interviews). These questions are critical to the application of self-regulated learning theory to MOOC research.

Photo Credit: Dufeng Li

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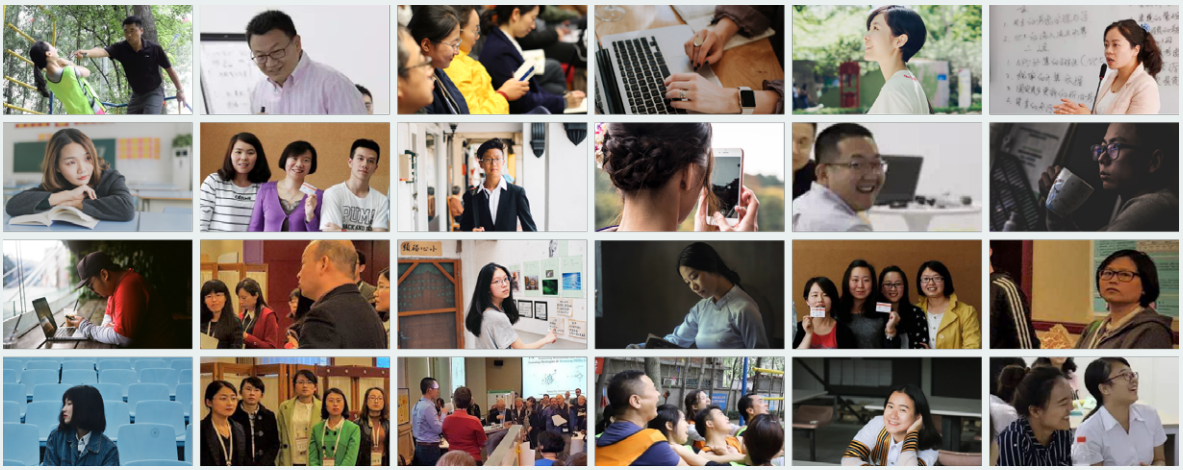

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