A Proposed Framework for Designing MOOCs Based on the Learning Sciences and the First Principles of Instruction

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Introduction

Since the advent of the new technology trend, Massive Open Online Courses (MOOCs), speculation and interest in MOOCs in higher education has been quite high. Whether educators are for MOOCs or against them, this new trend is on the rise. Numerous universities and professors are eager to start a MOOC. According to Shah (2013), "the number of courses offered has grown from about 100 MOOCs in 2012 to almost 700 starting in 2013, with an average of nearly two new MOOCs starting every day. More than 1200 courses have been announced so far" (para. 4). In early 2011, subjects of the offered MOOCs were primarily Computer Science and Engineering; in 2013, Humanities and more Education courses were also developed (Shah, 2013).

Designing an effective learning environment is the most important, yet most difficult task, for instructors in higher education. Informed by recent research on learning, information delivery approaches to designing large lectures, specifically the instructor delivering content to passive students, are giving way to more experiential and active learning approaches. In the design of a MOOC, one challenge is to resist the information delivery approach to instruction in favor of deliberately designing for more active and experiential learning. Designing effective MOOCs that promote retention and successful completion is not an easy task. Problems of low completion rates and instructional design issues cause concern about the range of MOOCs available (Grover, Franz, Schneider, Roy, & Pea, 2013). The average completion rate for a Massive Open Online Course can be less than 7 percent (Parr, 2013). Some instructors have excellent teaching experience in face-to-face lectures and/or regular online courses; however, most instructors design their MOOCs based on their previous experiences, without taking into consideration that as a new trend MOOCs require a new design framework. Sandy McAuley (in her narrative introduction) explained that, "the social and pedagogical structures that could transform the massive open potential of the Internet to viable learning experiences on a similarly massive scale were lacking" (McAuley, Stewart, Siemens, & Cormier, 2010, p. 27) in many of the MOOCs offered.

This concept paper proposes a framework for designing effective MOOCs through the lens of Learning Sciences principles (Sawyer, 2006) and the First Principles of Instruction (Merrill, 2002). The paper starts with a review of the literature, and then focuses on discussing the proposed framework. The need for further research will be established throughout the paper.

A Review of the Literature

In this section of the paper, the literature review helps to define what a MOOC is and why it is attracting attention of higher education. Next, the review examines the factors that contribute to successful MOOCs, and identifies the need for a framework for designing MOOCs. This literature review also examines the Learning Sciences principles and the First Principles of Instruction for designing MOOC learning environments.

What is a MOOC and why is it Getting Attention?

Massive Open Online Courses, or MOOCs, are defined as: "An online phenomenon gathering momentum over the past two years or so, a MOOC integrates the connectivity of social networking, the facilitation of an acknowledged expert in a field of study, and a collection of freely accessible online resources. Perhaps most

importantly, however, a MOOC builds on the active engagement of several hundred to several thousand "students" who self-organize their participation according to learning goals, prior knowledge and skills, and common interests" (McAuley, et al., 2010, p. 4). Another MOOC definition is " an online course with the option of free and open registration, a publicly- shared curriculum, and open-ended outcomes. MOOCs integrate social networking, accessible online resources, and are facilitated by leading practitioners in the field of study" (McAuley, et al., 2010, p. 10).

In part, MOOCs are getting the attention of educators in higher education for the unique learning experience, open resources, and social network offered. MOOC enrolment is also fascinating to higher education leaders and educators, as it can reach as high as 154,763 students, such as edX's and MIT's first MOOC, "Circuits and Electronics", in 2012 (Breslow, Pritchard, DeBoer, Stump, Ho & Seaton 2013). Another high enrollment MOOC was offered by Duke University, "Bioelectricity", in the fall of 2012; the number of students who registered reached 12,175 students (Yang, Sinha, Adamson, & Rose, 2013). The numbers also indicate how students are attracted to free and open MOOCs. A persistent trend, however, is the high attrition rate that plagues most MOOCs, which will be discussed in a subsequent section. The factors that contribute to a successful MOOC are discussed in the next section.

Factors for Successful MOOCs

According to Beaven, Hauck, Comas-Quinn, Lewis, and de los Arcos (2014), a successful MOOC promotes students' collaboration, motivation and their self-determination to finish the MOOC. Success in online learning in general, Bouchard (2009) argues, mostly relies on the learners themselves. Bouchard outlines four factors that contribute to a successful learning experience in a MOOC, which are the psychological issues such as motivation, pedagogical issues such as goals and evaluation, and two issues with contextual matters (as cited in Fournier, Kop & Durand, 2014).

Teacher and Learner Roles

One factor that can contribute to a successful MOOC is shifting the teacher and learner roles. Specifically, MOOCs can be designed to enabled peer supported learning. Waite, Mackness, Roberts, and Lovegrove (2012) studied the perception of novices and experienced learners in the MOOC, "First Steps in Learning and Teaching in Higher Education", (FSLT12); this MOOC did not require learners to provide peer reviews of each other's work, nor were they required to build a community, unfortunately, this reflected negatively on novice learners. Data collected from interviews with focus groups indicates, "it was suggested that a core group of experienced volunteers could take responsibility for supporting individual groups within a cohort of novices, moderate back channels and build community at a micro level" (Waite, Mackness, Roberts & Lovegrove, 2012, para. 51); proving that learners play an important role in MOOCs. Learners can build community, support each other (particularly the novice), exchange feedback on their work, and collaborate; thereby, contributing to an overall successful MOOC experience.

Conversely, the study by McAuley, Stewart, Siemens, and Cormier (2010) on the Edfutures MOOC described the importance of the learner's role to build a community and to network in the MOOC, "our premise is that the digital economy is no longer the purview of the information and communications technology (ICT) sector, but rather of web-based collaborations and networks, of which Massive Open Online Courses (MOOCs) are an example" (p. 8).

Bonnie Stewart (in her narrative introduction in McAuley et al., 2010) explained her experience as a student in a MOOC. She was blogging and sharing ideas on the MOOC's wiki, and using different areas of the course's main site to support her learning. She described how she built ties with other people based on collaboration and the exchange of ideas, which leads discussion to the next factor in successful MOOCs - social network integration.

Social Network Integration

One important factor to make MOOCs successful for students is the integration of social media as a way to exchange ideas and build relationships. Yang, Sinha, Adamson, and Rose (2013) studied the social engagement of students and how levels of engagement influenced drop out rates. The researchers used standard social network analytic techniques to analyze the behavior and social positioning in discussion forums. The research showed different paths through the course for cohorts who began at different times. Cohorts that started the MOOC earlier and completed more of the course were less likely to drop out, while cohorts who started the MOOC later tried to catch up with the discussion and material, leaving them less engaged and more likely to drop out (Yang et al., 2013).

The most important finding in Yang's study is that the students who started in the MOOC later than other students had trouble getting into the community discussion, "the analysis was able to reveal that whereas both

information and emotional support are important, emotional support appears to be far more critical to formation of commitment to remain active in the community" (Yang et al., 2013, p. 4). The results of the study indicate that social factors can affect student dropout rates and suggests that earlier social engagement and commitment to support results in fewer dropouts. The authors argue that some MOOCs fail to reach their transformative potential because "they fail to provide the kind of social environment that is conducive to sustained engagement and learning, especially as students arrive in waves to these online learning communities" (Yang et al., 2013, p.1). The study provides valuable information for MOOC designers, and from the previous literature, we can see how important it is to socially engage students in MOOCs and build on each other's knowledge, which is considered a significant factor in successful MOOCs.

Understanding Student Background and Intention

Kizilcec, Piech, and Schneider (2013) studied learner backgrounds, characteristics, and intentions for enrolling in MOOCs, while also measuring their engagement or disengagement during three different MOOCs. Researchers focused on the interaction with course content, and measured and analyzed each student's interaction in the courses. Furthermore, they described how this formative data can benefit MOOC designers and researchers. Knowing who the students are from an early stage in the course can help instructors make adjustments during the course. For example, some students may just watch videos and engage in the discussion, but not do any assessments. Instructors might choose to not send these students reminders of assessment due dates as a strategy to not stress the students. This could discourage them from following an alternative engagement method.

The three courses studied by the researchers were: "Computer Science 101", covering high school level content (HS-level); "Algorithms: Design and Analysis", covering undergraduate level content (UG-level); and "Probabilistic Graphical Models", a graduate level course (GS-level). The results of the study show that the HS-level courses had the highest number of participants, the most female participants, and the highest number of participants who actually completed the course, in part because of the wide accessibility of the entry-level content. The study also indicated that the main reason for enrolling was because the course was fun yet challenging, and the second reason was to enhance their resumes. Furthermore, the majority of the participants for the courses, overall, were well-educated males from the US; perhaps, because of the technical nature of the courses. Also, high enrollments may be related to the broadband access required. For example, potential participants from countries with low or medium- HDI may have slow bandwidth, restricting their engagement with the videos in the MOOC (Kizilcec, Piech and Schneider, 2013).

Betsy Williams focuses on the importance of making good use of MOOCs' big data, understanding student background, and how increasing student knowledge would be useful for business and planning, instruction, and research (AIED Workshops Proceedings, 2013). Williams stated, "unfortunately, MOOCs are not making the most out of their big data because they are not collecting enough data on students' backgrounds" (Williams, 2013, p. 11). Williams emphasizes the importance of collecting core demographic information, including year of birth, gender, and race/ethnicity. MOOC providers could also ask users for their current city or place of residence to provide more accurate location results than the IP address. Questions about place of origin and native language can also provide a sense of student history and culture (Williams, 2013). This information can be valuable data for researchers and operators of course platforms. It could also help provide specific course recommendations to students based on why they are taking the course. Furthermore, knowledge about students can help instructors build on their existing knowledge and tackle any issues or potential errors; this is part of Pedagogical Content (Williams, 2013).

The Need for Further Research

Online learning in all forms, like MOOCs, will become more prevalent in higher education for many years to come. According to Hill (2012), "online technology and its associated delivery models, like MOOCs, will continue to evolve at an accelerated pace, at least compared with the experience of the past decade" (p. 96). Online courses will also play an important role in institutions that have avoided them previously and will help create new institutions (Hill, 2012). In Fall 2011, there were 572,000 more online students in the United States than in 2010 with an increase of 9.3 percent in the number of students taking online courses than the previous year (Allen and Seaman, 2013). According to Bujack, Paul, and Sandulli (2012), more research is needed to guide the development and implementation of MOOCs, and to demonstrate and evaluate the educational benefits. In addition, Parry (2010) states that MOOC providers don't yet know the best way to implement successful MOOCs, even though there is evidence that many factors can contribute to that success. McAuley et al. (2010) stated that the new educational forms are pedagogically and technically different, and these differences create a need for new learning methodologies and frameworks.

From a review of recent research, one can discern many factors that make the experience in MOOCs successful. There is a need for a framework to design MOOCs and help address the massive number of students, their different backgrounds, and intentions within the design. It is our position that educational technology researchers need to bring together principles from the Learning Sciences with an effective instructional design framework in the design of MOOCs in order to promote student engagement and active learning in a successful learning experience. We propose that by drawing upon the foundations and research of the Learning Sciences to guide the implementation of activities based on the First Principles of Instruction framework, that designers can create learning environments that support student learning and engagement and enhance retention. The new framework will emphasize how designers can improve their existing MOOCs.

The Proposed Framework for Designing MOOCs

The Learning Sciences is an interdisciplinary field of study that draws on multiple theoretical perspectives and research paradigms to advance knowledge and the application of knowledge about human learning and ways in which learning may be sponsored in intentionally designed environments. One element of the Learning Sciences is an openness to multiple perspectives on learning, including theories and approaches from other disciplines, particularly those that focus on and understand learning as a collective endeavor and not just the property of an individual (Hoadley & Van Haneghan, 2011). Openness is necessary because it takes multiple perspectives to understand the complex ecologies in which learning is situated. A second element of the learning sciences is a commitment to building solutions to problems in teaching and learning in formal and informal learning contexts. Learning scientists want to have an impact on learning and that means taking on the real world and its complexities. A third element is that knowledge of learning and instruction that is generalizable and meaningful can be acquired by studying the design in context and is not just the province of experimental and correlational research undertaken in laboratory settings (Hoadley & Van Haneghan, 2011). A fourth element of the learning sciences is studying learning in formal, informal and non-traditional contexts. The fifth element is that learning scientists look to how emerging technologies can be used to inform and transform how we teach and learn. Learning Scientists focus on studying learning in authentic contexts, and focus both on the individual as learner and also knowledge building and learning in community (Bereiter and Scardamalia, 2006). "The goal of the learning sciences is to better understand the cognitive and social processes that result in the most effective learning, and to use this knowledge to redesign classrooms and other learning environments so that people learn more deeply and more effectively" (Sawyer, 2006, p. xi). The learning sciences draw upon different disciplinary approaches and learning theories, such as constructivism, cognitive science, educational technology, and socio-cultural approaches to studying learning (Sawyer, 2006).

The Learning Sciences emphasize the importance of learners' quality of life, preparing citizens for the 21st century's technical and scientific needs and increasing social interconnection between diverse groups (Roschelle, Bakia, Toyama, & Patton, 2011). Sawyer (2006) identified key features of the learning environment that apply research from the learning sciences. He stressed the importance of building on the learner's prior knowledge to develop new ideas and understandings so learners go beyond simply memorizing information to pass the test. Those who design learning environments need to focus on developing deeper conceptual understandings and usable knowledge, and then modify learning designs based on the contexts in which new ideas are taught. Students can reach deep conceptual understanding by engaging in their own learning; however, it is difficult to achieve deep learning through lecture alone. .Students learn better when they have opportunities to express their developing knowledge through conversations with peers or by writing a reflection paper or collaboratively applying ideas to solve authentic problems. Students acquire deeper knowledge when they engage in academic activities related to the everyday practices of professionals who work in the discipline. For example, students can do historical inquiry rather than simply memorizing events and dates (Sawyer, 2006).

The First Principles of Instruction Framework

"The science of instructional design involves both theory and research. Theory is about describing phenomena and predicting (hypotheses) consequences from given conditions. Research is applying appropriate methodology to test these predictions" (Merrill, 2007, p. 5). Instructional design theory emerges from the attempt to understand the best conditions for learners in order to acquire specific knowledge and skills, instructional goals and learning outcomes while the use of the research is to have method for empirically testing and verifying these predictions (Merrill, 2007). There are a number of instructional design models that are well developed and effective for design, such as the ADDIE model (Branch, 2009), layers of design (Gibbons and Rogers in Reigeluth (2009)), and First Principles of Instruction (Merrill, 2009). The First Principles of Instruction (Merrill, 2009) is defined as a

relationship that is true under appropriate conditions. According to Merrill (2002), the First Principles of Instruction are:

- Task centered principle: learners are involved in solving real-world problems.
- Activation principle: learners recall, describe, or demonstrate related prior knowledge.
- Demonstration principle: instruction demonstrates the three types of generalizable skills - how to, what-happens, and kind-of.
- Application principle: learners engage in application of the new knowledge.
- Integration principle: learners demonstrate their new skill or reflect on it.

Merrill (2009) explains that the principles are not meant to be used individually, nor are they a method or model for instruction; rather, the principles should be used together, and with the principles, models or methods can be implemented. The effectiveness of instruction is determined by the degree to which the principles are implemented.

Gardner (2011) tested the use of First Principles of Instruction as a framework for organizing multiple strategies of active learning in an online biology course for undergraduate students. The course consisted of two modules, "the First Principles Module" and "the Traditional Module". Students chose one module to participate in during the course. The traditional module consisted of a conventional online approach, providing information and explanation of the subject with a few examples. Study results showed that the learning gain from pretest to posttest at the remember level was significant for the traditional group and was also significant for the First Principles group. In addition, the pretest to posttest gain at problem solving for the First Principles group was significant. Finally, when students rated their confidence in solving future problems, those in the First Principles group were significantly more likely to predict future success (Gardner, 2011, p. 1).

The use of the First Principles of Instruction in designing learning environments, as with most multi-step models, has advantages and disadvantages. According to Clark, one of the advantages in the Activation Principle is that instructors can help students become actively engaged in a course and stay engaged by helping students connect their own goals and interests to course goals. By discussing the usefulness of course goals and the consequences of not achieving these goals, instructors can help students sustain their confidence in achieving the course goals by demonstrating previous experiences that successfully applied those same goals (as cited in Merrill, 2002). Furthermore, the First Principles of Instruction is a flexible framework that can be applied to different learning environments. It's easy for designers to apply the First Principles of Instruction in their practice, because it starts from a designer's point of view. The First Principles of Instruction is not as complicated as other multi-step models. Finally, since the principles are problem-based, the learning is more practical for the user (Merrill, 2007).

One of the disadvantages of using the First Principles of Instruction is that it does not take the learner's perspective into consideration when designing the learning environment. The designer needs to be careful and think about learner reaction when using this model. Sometimes the steps are not clear enough to distinguish, making the design process bulky. If the problem that needs instruction is very difficult, it could impact the instruction itself (Merrill, 2007).

The First Principles of Instruction is an established approach for designing a learning environment. It is appreciated for taking into consideration the designer's point of view at each step. Since the First Principles of Instruction is not a stand-alone model or method of instruction, designers can integrate principles in any method or model that suits their situation. The First Principles of Instruction is also supported by research and each principle included is based on an instructional design theory. Also, the principles are general and can be applied to all teaching and learning situations under any educational philosophy or theory (Merrill, 2009). In a study conducted by Cropper, Bentley, and Schroder (2009) to evaluate and measure the reliability and validity of Merrill's First Principles with award-winning online courses the researchers agreed the principles were valid for evaluating the quality of online courses. The researchers stated, "From the results to date we believe that Merrill's first principles should be included in the myriad of criteria for determining online course quality" (Cropper, Bentley & Schroder, 2009, p. 139), which is strong validation.

The authors have decided to use the First Principles of Instruction in this framework as the foundation, or outline, to design the learning environment, and to integrate Learning Sciences principles at each step of the design process to make the MOOC design more flexible and conducive to active learning and student engagement according to the contemporary research on learning in education. The next section provides a description of each part of the new framework.

The Task-Centered Principle

The task-centered principle means that learning is acquired when instruction is based on a progression of

whole real-world problems or tasks (Gardner, 2011). According to the proposed framework, students will be taught progressively more complex knowledge, so learning tasks should move from less difficult to more difficult tasks (Merrill, 2002). Building on the learner's prior knowledge before introducing new knowledge is a concept from cognitivism and an important principle in the Learning Sciences. .It is also considered to be part of the First Principles of Instruction (Sawyer, 2006; Merrill, 2002). For these reasons, the concept of building on the students' prior knowledge will be the first step in the MOOC.

Activation Principle

In the activation principle, students will be required to recall and build upon their previous knowledge. To activate their learning, students who register for the course will be sent a quick online survey during registration week to measure their familiarity with the course subjects and their professional level. Simple questions will be included in the survey, such as what is your educational background? Are you familiar with the course's topics? These kinds of questions will help instructors to make adjustments to the course based on the registered student population. Also, the survey will ask about the students' intention of enrolling into the MOOC. It is align with the recommendation in the activation principle that learning is promoted when learning goals are consistent with the learners' goals (Merrill, 2002).

Demonstration Principle

In the demonstration principle, the instructor demonstrates the new knowledge based on the concept of "how to", or "what-happened", or "kind-of". The First Principles of Instruction works particularly well with MOOCs that are problem or task-centered where students are involved in solving real world problems (Merrill, 2002). The demonstration principle supports enhanced student learning by guiding them to relate their new knowledge to specific examples and by observing a demonstration or application of knowledge consistent with the content taught. The proposed framework will adopt these concepts into the design of the MOOC by preparing videos for learners and posting them in the MOOC. Peer-demonstration and peer-discussion will be implemented into the design to enhance student learning, as learners will be asked to respond to each other's questions. Students will interact with one another and exchange and build upon each other's ideas to construct collective knowledge through the use of social media, discussion threads, and blogs in the MOOC. The use of the social media can be very helpful in MOOCs as it is beneficial in building learning communities. This concept of participatory learning and learning communities is consistent with learning sciences principles (Merrill, 2009; Sawyer, 2006).

Application Principle

The application principle promotes the application of the knowledge acquired by using it to solve problems. Students will apply their new knowledge to solve problems or to make collaborative decisions or to complete an assignment. To enhance peer-collaboration, students will work on the assignment in groups and provide constructive feedback to the other groups after posting their own work online. Students will also receive instructor feedback on their work that focuses on continual improvement. According to Merrill, "learning is promoted when learners are guided in their problem solving by appropriate feedback and coaching, including error detection and correction" (Merrill, 2002, p. 49). Student collaboration and peer feedback / formative assessment are fundamental principles in the Learning Sciences. Learning scientists, like Bereiter and Scardamalia, have used the terms knowledge building to describe this collaboration that focuses on building knowledge in community. The concept behind the knowledge building is that knowledge advances through continual idea improvement in community rather than as an individual act. The learners' role also changes when building knowledge in community and each learner is treated as a contributing member of the community. Knowledge building should become a consistent effort to introduce students into a knowledge creating culture according to Scardamalia & Bereiter (2006).

It should be noted, however, that while the theories from the Learning Sciences on sponsoring learning in designed environments is meant to motivate students and cognitively engage them through collaborative assignments and active learning while using the technology, sometimes the actual application of the theory is much harder. The characteristics of this learning environment can actually decrease student engagement, even for those who were originally engaged at the beginning of the course, because students may not be accustomed to the new rules, norms, and procedures like the openness of MOOCs, the deeper engagement in knowledge building and the demands of collaborative learning. Students need to be committed to collaborating and be self-regulated to ensure their ability to construct their learning and knowledge. Students will need to adjust to their work, idea, and artifacts being critiqued through course activities in order to thrive. Students will also need to get used to the instructor acting as a facilitator to learning rather than as a primary source of information (Sawyer, 2006).

Integration principle

The last principle is the integration principle. In this part of the MOOC design, learners will integrate what they have learned into their everyday world by reflecting on, discussing, presenting, or defending their new knowledge (Gardner, 2011). In order for learners to work in groups and collaborate successfully, the MOOC instructor needs to consider the learners' backgrounds and intentions in the division of groups' assignment for example. Learners have to have similar interests to the subjects and motivation to succeed. According to Oliveira, Tinoca and Pereira (2011), in this sense in order for the collaboration to take place there must be a motive and space for negotiation; collaboration in a community is characterized by participants who share a common goal, are at a similar level and can perform the same actions while working together.

MOOC designers should conclude the course with wrap-ups where all information and course material are summarized and aligned with the course goals. We argue if the course is designed with this framework in mind, it will be very active, it will engage students, and be learner-centered. Based on the proposed framework designers should be selective when choosing the best practice, activities, and resources for their learning environment. Designers need to consider student values, motivation, and readiness for a subjective approach to learning. The design of the MOOCs, if based on the Learning Sciences principles and the First Principles of Instruction should be successful if all of the principles and concepts are integrated and applied to the MOOC design (Sawyer, 2006).

The First Principles of Instruction	The Learning Sciences Principles
The task-centered principle	• Building on the student's prior knowledge
Activation principle	• Students recall their previous knowledge
Demonstration principle	• Building continues communities • The use of the social media
Application principle	• Peer feed-back • knowledge building
Integration principle	• The learners' background and intentions

Figure 1. A Framework for Designing MOOCs Based on the Learning Sciences and the First Principles of Instruction

Conclusion

This concept paper proposed a framework for designing MOOCs, based on Learning Sciences principles of Knowledge Building and Active Learning, and the First Principles of Instruction. It provided a literature review and discussed the need for a new framework. The use of a contemporary instructional design model, the First Principles of Instruction, provides the designed learning environment with a strong base and core for the design. In addition, the Learning Sciences principles provide the openness and the move towards contemporary methods, approaches and concepts for sponsoring learning. The research of learning sciences demonstrates that the use of its concepts and principles will help students achieve their learning goals and acquire the necessary knowledge that MOOCs are designed to provide.

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