The Learning Sciences @ Scale: Current Developments in Open Online Learning

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Abstract: The explosive growth of MOOCs has generated immense interest in online learning in massive courses. However, much of this frenetic activity has emphasized technology and scalability (Reich, 2015), resulting in rudimentary learning experiences (i.e., brief streaming videos followed by quizzes or online discussion forums). This symposium will showcase and discuss four diverse efforts to advance open learning at scale that are directly informed by contemporary theories of learning and educational research methods. This includes research on inquiry-based community learning, computer-mediated discourse analysis, participatory approaches to learning and assessment, and evidence-rich digital-credentials. In each of the four cases, the desire to extend that program of research to learning at scale resulted in significant advances in the more general program of research. In this way the symposium explores efforts to foster learning at scale might advance our theories of learning and our principles and methods for learning design more generally.

Keywords: learning design, online learning, informal learning, learning communities

Introduction

The explosive growth of MOOCs, which have not tended to include complex instructional designs (Reich, 2015), has sparked the interest of researchers in the learning sciences. These innovators see the opportunity for investigating new modes of learning, including new forms of socially mediated materials and activities and new pedagogical affordances for learning at scale (e.g., through learning analytics and educational data mining). This symposium will present a set of papers that describe research of such new opportunities. We recognize the unique aspects of MOOCs where participants arrive with altruistic learning goals, situated within diverse contexts – often from around the world, in all time zones and a wide range of settings – with legitimate interest in engaging with peers and participating in the learning designs. Many of the elements of MOOCS are quite challenging, such as the asynchronous, distributed aspects of participation, the high variation amongst learners in terms of their background and available time, and the lowest common denominator of end user technologies. However, some features have captured our attention, and offered new opportunities for research in our design of pedagogical scripts, collaborative learning environments, and interactive materials. In some cases, this work could potentially return new theoretical insights and methodological capabilities for the wider learning sciences community. We will discuss the implications of our work, the likely trajectories of MOOCS in the coming years, and way that this nascent community within ISLS can help advance

Growing pains and a push for greater interactivity

The earliest MOOCS, known as "cMOOCs" were based on a contemporary view of learning called connectivism (Siemens, 2005) and aimed to support robust peer interaction and networked knowledge construction. However, it has been the subsequent form, known as "xMOOCs" that formed the heart of the rapid expansion of course offerings. Variously attributed to "eXtended" or "eXtension," the online courses at edX, Udacity, Coursera, and others, these courses generally feature streaming videos, online readings, problem sets and quizzes, and peer discussion forums. Once developed, most courses could be offered to new cohorts of learners for very modest costs, and sometimes simply left online for any and all to complete at their own pace. This general model has expanded to many other platforms and sectors and has become quite pervasive, even in smaller more exclusive contexts such as corporate training and for learning towards specialized certifications.

Amidst the "hype and hyperbole" over MOOCs, several certainties emerged by 2012, which the New York Times dubbed "the Year of the MOOC" (Pappano, 2012). In addition to the aforementioned massive expansion of opportunities, other certainties were that MOOCs were generating extensive innovation in online learning more broadly, and that MOOCs were causing many observers to reconsider the design and (particularly) the cost of existing models higher education. Another certainty that emerged around this time is that most MOOCs featured much less interaction than is typical of face-to-face courses. Some observers had already commented on the difficulty of connecting with other learners in the cMOOCs (Mackness, Mak, & Williams, 2010) It turned out that supporting social interaction in the cMOOCs was proving *much* harder. An effort to include more interaction and group projects in a Coursera course on online learning was widely cited for going “laughably awry.” (Oremus, 2013). One study found that engagement in Coursera discussion forums declined significantly over time among completers, and that instructor involvement actually worsened participation; A consensus emerged that most MOOC discussion forums suffered from sharp declines in interaction as courses got underway, and that this was mostly likely due to “information overload” as discussion threads become unnavigable and veered off topic (Brinton, 2013). This relative lack of social interaction was one of the most oft-cited concerns in the “backlash” against MOOCs one year later (Kolowich, 2013).

MOOC proponents generally responded that the social experience in typical MOOCs was actually quite similar to what many students experience in the large lecture courses that are typical for introductory courses in many college and universities. Indeed, the peer discussion forums available for many MOOCs were similar in ways to the informal study sessions that many students organized themselves into for conventional lecture courses. Furthermore, some discussion forums were moderated by knowledgeable volunteers and even sometimes by paid teaching assistants. Regardless of the reality in 2013, significant effort was already underway among MOOC innovators and researchers to study social learning and more systematically support more and more productive peer interaction. Some of this research was more naturalistic research continuing in the tradition of the cMOOCs. A team at Stanford was developing a MOOC platform (now called NovoEd) which is explicitly based on social learning theory (Ronaghi, Saberi, & Trumbore, 2015). A major program of research at the Open University resulted in the FutureLearn which supports “discussion-in-context” and “community-supported learning” in dozens of free open online courses (Parr, 2013). A particularly promising related strand emerged around scaled up efforts to support peer assessment of extended student work (Kulkarni, Socher, Bernstein, & Klemmer, 2014).

Structure of the session

Other promising efforts to study and support social learning at such a scale have drawn on the insights from the Learning Sciences and Computer Supported Collaborative Learning communities. This symposium features four such efforts from learning science science research groups, organized as a set of four synthesized paper presentations with a panel format for the discussion. Each presenter will (a) address the prior theories and research that is informing their work, (b) show how those theories are instantiated in new learning features, (c) demonstrate the forms of engagement supported by those features, (d) summarize the evidence showing the impact of these features for students, (e) articulate design principles for supporting learning at scale, and (f) highlight current challenges and near-term goals for continued refinement and research. Following the presentations, each of the four presenters will pose one question of another presenter, followed by a wider panel commentary on that question. At the end of each panel discussion, there will an opportunity for audience questioning, moderated by the chair.

Supporting reflection and collaboration in a MOOC for in-service teachers

Hedieh Najafi, James D. Slotta, Stian Håklev, Renato Carvalho, and Rosemary Evans, University of Toronto

“Teaching with technology and inquiry” (INQ101x) was a six-week MOOC designed for in-service teachers interested in learning how to integrate technology and inquiry into their own practice. The course was co-led by a professor and a school principal, and showcased the viewpoints of school administrators and classroom teachers.

INQ101x applied Knowledge Community and Inquiry model (KCI; e.g., Slotta, & Najafi, 2012) to a large-scale context with more than 8000 registered participants. KCI informed our design of a “script” where participants created and applied a collection of annotated resources for teaching with technology and inquiry, and a subset of participants opted to collaboratively design a lesson plan, working in small groups and receiving feedback from the wider community. Two live events in the last week of the course allowed learners to discuss their questions with the course instructors and with master teachers who had contributed to INQ101x. To foster in-depth discussions among learners, we used learners’ professional background to create 10 Special Interest Groups (SIG). Learners chose their SIGs after completing a pre-course survey, a mandatory step to join design groups and SIG specific discussions. Of all registrants, 2008 learners completed the survey, 357 learners joined design groups, and 120 active design groups were formed. More than one thousand annotated resources were submitted to the resource collection.

Given the high number of learners enrolled in INQ101x, providing personal feedback to learners was impractical. Thus, reflection prompts and shared reflective notes were used as a means to promoting deep reflection about course content. Two types of reflection notes were integrated in INQ101x: individual private reflection notes and public reflection notes submitted to course discussion forums and discussed with peers. An example of a public reflection note was: *"Lets talk about the pragmatics of student-contributed content and collective inquiry. When we assign students to create, curate, re-mix and apply ideas and observations, how can we make sure that every student gains the benefits: creating and contributing resources, engaging in productive exchanges with peers, and drawing upon the collective resources?"*

Creating opportunities to foster reflection is integral to teacher education and professional development programs, to help teachers apply new concepts and approaches to their practice, and build new forms of practitioner knowledge (Madeira & Slotta, 2012; Pavlovich, 2007; Spalding, & Wilson, 2002). Reflective notes, shared or private, prompted or non-prompted, are used to encourage teacher reflection (Chitpin, 2006). Lee (2010) argues that sharing reflections with peers can help teachers to improve the depth of their reflections. Blomberg et al. (2014) identify three levels of teacher reflection, with increasing levels of sophistication: description, evaluation, and integration.

We examine the impact of participation in such reflections on INQ101x learners' knowledge of teaching with technology and inquiry. We address the following research questions: (1) How do personal reflection notes evolve over the six weeks of the course? and (2) How does peer feedback received through public reflection notes contribute to progress in teacher understandings over the six weeks of the course? We adapted an existing rubric for assessing the quality of personal and public reflection notes in INQ101x (Hatton, & Smith, 1995; Moon, 2013) as: non-reflective, descriptive reflection, dialogic reflection, and critical reflection. Reflection notes of science and math teachers were included in the data set. We apply our findings to create a set of principles that can guide the design of effective reflection and discussion prompts for large online courses.

Envisioning support of social learning in MOOCs

Carolyn P. Rosé, Carnegie Mellon University

Data from Massive Open Online Courses (MOOCs) offer evidence of the association between types of conversational interactions and retention (Wen et al., 2014a; Wen et al., 2014b; Wen et al., 2015), team project quality (Yang et al., 2015), and learning (Wang et al., 2015) in the environment. These insights inform design of interventions to support improved outcomes (Howley et al., 2015; Ferschke et al., 2015a; Ferschke et al., 2015b). This work represents a series of investigations related to the broad vision of designing and building out affordances for collaborative learning in MOOCs through DANCE[1].

If we can leverage the rich potential source of support in the plentiful student population in MOOCs, we may be able to substantially reduce attrition and meet instructional goals better at the same time. The area of automatic collaborative process analysis has focused on discussion processes associated with knowledge integration. Frameworks for analysis of group knowledge building are plentiful and include examples such as Transactivity (Berkowitz & Gibbs, 1983; Teasley, 1997; Weinberger & Fischer 2006), Inter-subjective Meaning Making (Suthers, 2006), and Productive Agency (Schwartz, 1998). These discussion processes are theorized to occur when students adopt an orientation towards one another in which they are most likely to experience cognitive conflict and learning (de Lisi & Golbeck, 1999). Automated analysis technology (Rosé et al., 2008) enables triggering support for these types of interactions in an automated way (Adamson et al., 2014).

MOOCs are not unique in their pattern of exponential attrition over time. Instead, the same pattern is evident in all forms of online communities. Social support exchanged through discussion forums is known to be associated with increases in commitment and corresponding reductions in attrition in online communities (Wang, Kraut, & Levine, 2012). Findings from our own MOOC deployment in Fall 2014 provides evidence that the experience of a synchronous collaborative chat in the midst of MOOC participation reduces attrition at the time point of the experience by more than a factor of two (Ferschke et al., 2015b).

Our early intervention was designed for short, periodic collaborative exchanges. More recently we have been working towards more persistent social interaction throughout a course in the form of team based projects. Our analysis of data from two team based MOOCs suggests that the success of teams in state-of-the-art team based MOOCs is low (Wen et al., 2015; Yang et al., 2015). While the behavior of team leaders, and to a lesser extent that of other team members, predict team outcomes, the evidence points to the conclusion that the problem starts even before the teams begin to function in that capacity. In particular, the team formation process itself must be improved in order to produce teams that are positioned for success at the start. We propose a deliberation-based team formation procedure to improve the selection and initiation process leveraging the same discussion processes associated with enhanced learning. What that means is that a pretask is assigned to students to do individually and then post to a public discussion forum for feedback from other students in the class. Students are required to select a small number of students to provide feedback to in this context. An automated process analysis tool is then used to make an assessment about the number of transactive contributions exchanged between each pair of students in this context. A constraint satisfaction algorithm is then used to assign students to teams in such a way that the average pairwise observed exchange of transactivity from the discussion forum activity between students assigned to the same team is maximized across the student population. Results from pilot investigation in MTurk suggest strong effects both of deliberation pretask with feedback from fellow-students and team selection based on automatically detected transactivity in during this pretask discussion.

Scaling up participatory approaches to learning and assessment in open courses

Daniel T. Hickey, Suraj Uttamchandani, and Joshua Quick, Indiana University

This paper argues for a gradual iterative response to pressures to scale up learning, so that technology can respond to rather than constrain theoretical advance. This research embraces situated and participatory perspectives on learning (Greeno et al., 1998) and assessment (e.g., Moss, et al., 2008, Hickey, 2015). A prior program of design-based research resulted in a core set of design principles, local theories, and specific practices for fostering broad learning outcomes and measuring those outcomes in technology-supported learning environments. By aligning informal, semi-formal, and formal assessment, these efforts have delivered very high levels of socio-technological engagement with disciplinary knowledge (as in Engle & Conant, 2002), while leaving behind dramatically enhanced understanding and significantly enhanced achievement (Hickey & Zuiker, 2012)

The data for the most recent cycle of research comes from an online graduate course on Educational Assessment. A conventional version of the course in both Sakai and Google Sites was refined over several years in order to overcome the constraints of these platforms on participatory learning (Hickey & Rehak, 2013). With the support of a grant from Google, the resulting design principles were further refined in three annual "big open online courses" ("BOOCs") using in an extensively customized version of Google Coursebuilder. The first course started with hundreds of learners, including a subset of students taking the course for credit. Each cycle has further automated key features, including personally contextualized registration and participation, assignment to networking groups, personalized "wikifolio" open assignments, anchored peer commenting, contextualized analytics and feedback, peer endorsement and promotion, and open digital badges for completion, leadership, and advanced work.

This research has led to further refinement of the course design principles, which are now as follows: (1) Use public contexts to give meaning to knowledge tools; (2) publically recognize and reward productive forms of disciplinary engagement; (3) assess student generated artifacts through local reflections, (4) help learners self-assess their understanding privately, and (5) measure aggregated achievement discreetly.

Analyses from the most recently completed Assessment BOOC revealed levels of persistence comparable to others MOOCs: 11% of the 179 registrants and 29% of those who completed the first assignment completed the course. But this analysis revealed dramatically higher levels of individual and social engagement than most MOOCs support. Weekly wikifolios averaged 2,820 words for credential students and 1,377 words for open completers; credential students averaged 4.2 comments per week and 337 words per comment while open students averaged 3.7 comments per week and 302 words per comment. Coding of the comments revealed that around 90% of the comments were disciplinary (because they referenced the topic of the assignment), while 25% were contextualized (because they referenced a specific practice context). We also obtained satisfactory levels of achievement on a timed exam consisting of challenging multiple-choice items (averaging 80% for credential students around 78% for open students).

This research is significant because it has resulted in streamlined features to support participatory learning at scale. With modest additional work, these features can be shared broadly as open source modules that can be easily integrated into other platforms via Learning Technologies Interoperability (LTI) standards.

Orchestration graphs: How to scale up rich pedagogical scenarios

Pierre Dillenbourg, EPFL, Switzerland

The goal of orchestration graphs is to describe how rich learning activities, often designed for small classes, can be scaled up to thousands of participants, as in MOOCs (Dillenbourg, 2015). A sequence of learning activities is modeled as a graph with specific properties. The vertices or nodes of the graph are the learning activities. Learners perform some of these activities individually, some in teams and other ones with the whole class. The graph has a geometric nature, time being represented horizontally and the social organization (individual, teams, class) vertically. These activities can be inspired by heterogeneous learning theories: a graph models the integration of heterogeneous activities into a coherent pedagogical scenario.

The edges of the graph serve to connect activities, representing the two-fold relationship between activities: how they relate to each other from a pedagogical and from an operational viewpoint. From the operational viewpoint, edges are associated with operators that transform the data structures produced during a learning activity into the data structures needed to run the next activity. From the pedagogical viewpoint, an edge describes why an activity is necessary for the next activity: it can, for instance, be a cognitive pre-requisite, a motivational trick, an advanced organizer or an organizational constraint.

The extent to which one activity is necessary for the next one is encompassed in the weight of an edge. The transition between two activities is stored as a matrix: the cell (m,n) of a transition matrix stores the probability that a learner in cognitive state m will evolve to state n in the next activity. This transition matrix can be summarized in the form of a parameter that constitutes the edge weight: an edge between two activities has a heavy weight if the learner performance in an activity is very predictive of his success of the connected activity. The graph also constitutes a probabilistic network that allows predicting the future state of a learner. An orchestration graph describes how the scenario can be modified, stretched, cut, extended.

This presentation will begin with a review of the orchestration graph approach, illustrating the application of such an approach in several activity designs. Following, the sequence of activities from one recent MOOC will be presented in terms of orchestration graph, revealing transitions between "orchestrational layers" and suggesting new opportunities for learning analytics.

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