# From Seminar to Lecture to MOOC: Scripting and Orchestration at Scale

by

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Curriculum, Teaching and Learning
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## Abstract

This dissertation investigates the design of large online courses from the pedagogical perspective of knowledge communities. Much of the learning sciences literature has concerned itself with groups of up to 20-30 students, but in universities, courses of several hundred to more than a thousand students are common. At the same time, new models for life-long and informal learning, such as Massive Open Online Courses, are emerging. Amidst this growing enthusiasm for innovation around technology and design in teaching, there is a need for theoretically grounded innovations and rigorous research around practical models that support new approaches to learning.

One recent model, known as Knowledge Community and Inquiry (KCI), engages students in the co-construction of a community knowledge base, with a commonly held understanding of the collective nature of their learning, and then provides a sequence of scaffolded inquiry activities where students make use of the knowledge base as a resource. Inspired by this approach to designing courses, the research began with a redesign of an in-service teacher education course, which increased in size from 25 to 75 students. This redesign was carefully analyzed, and design principles extracted.

The second step was the design of a Massive Open Online Course for several thousand in-service teachers on technology and inquiry, in collaboration with an affiliated secondary school. A number of innovative design ideas were necessary to accommodate the large number of users, the much larger diversity in terms of background, interest, and engagement among MOOC learners, and the opportunities provided by the platform. The resulting design encompasses a 6-week long curriculum script, and a number of overlapping micro-scripts supported by a custom-written platform that integrated with the EdX platform in a seamless manner.

This thesis presents the course structure, including connection to disciplinary principles, its affordances for community and collaboration and its support of individual differentiated learning and collective epistemology. It offers design principles for scripting and orchestrating collective inquiry designs for MOOCS and higher education courses.

# Table of Contents

# List of Figures

# List of Appendices

# Chapter 1. Introduction

This dissertation describes a research study that investigated the design of large online courses from the pedagogical perspective of knowledge communities. The primary topic of interest is the design of large courses, and specifically how their design can leverage the large numbers of participants in such a way that they are supported in making contributions to one another's learning and inquiry. Another important topic is the role of technology in supporting large scale patterns of interaction and exchange, where various technological elements combine to help the instructor orchestrate a complex pedagogical design.

Guided by a theoretical model called Knowledge Community and Inquiry (KCI - Slotta, 2014), the research began with a redesign of a pre-service teacher education course, which increased in size from 25 to 75 students. Because the course was tripling in size, it provided an opportunity to examine how the large numbers could be seen as a feature or benefit (i.e., rather than an obstacle to overcome or endure).

The redesign was guided by KCI, and allowed an exploration of some fundamental technology patterns. A second major component of the study was the application of these principles in further extending the course design to a new context of in-service teaching, a new scale of thousands of participants, and a new format of a Massive Open Online Course (MOOC).

This chapter begins with a discussion of the broader context of the study, including turbulent changes and new opportunities for university course designs and informal learning on the Internet. It then describes the significance of the study: the need for a principled and theoretically grounded approach to designing large courses, and presents the specific research questions. After introducing the researcher's background, the organization of the dissertation is described.

# 1.1 Research Context

## 1.1.1 Higher Education Context and MOOCs

Much of the research in education and the wider learning sciences has been concerned with conventional K-12 learning, with class sizes of 20-30 students. But in universities, courses of several hundred to more than a thousand students are common. The increasing role of technology, both in classrooms (e.g., using audience response systems or mobile devices) and between classes (e.g., with learning management systems and other asynchronous platforms) has led to a surge of experimentation and research by instructors – many of whom are not grounded in the research methods or theories from learning sciences.

For example, blended and flipped models of instruction are appearing in every domain of higher education. Early demonstrations of the failure of physics lectures to promote deep conceptual understanding (Hestenes, Wells, & Swackhamer, 1992) motivated universities such as MIT and Stanford to adopt new approaches. Such high profile, evidence-based exemplars have inspired a movement of "flipped classrooms" (e.g., Day, & Foley, 2006; Gannod, Burge, & Helmick, 2008) and "blended approaches" that mix online elements meaningfully with in-class activities (Oravec, 2003; Osguthorpe, & Graham, 2003).

Instructors have also been inspired by the widespread availability of online educational resources, including new opportunities introduced by Web 2.0 technologies, to experiment with innovative approaches to teaching in higher education. For example, Wesch (2009) transformed his large-enrolment lecture course into a participatory game, simulating world relations, where students work together to help design a two-hour simulation of the last 500 years of world history. Davidson & Goldberg (2009), whose course on cognition and the brain was already largely turned over to the students, decided that the natural extension would be to crowd-source grading as well.

Outside of formal educational structures, educators and learners have used the new opportunities offered by Web 2.0 platforms to experiment with new ways of organizing learning resources and social learning experiences. Citizens regularly convene, on the Internet, to discuss, co-create, inquire, collaborate and explore a wide variety of topics in forms and modalities that fit well with the ideas of constructivist collaborative learning. Beyond topic-based discussions and incidental learning, there are examples of targeted attempts at supporting community learning. David Wiley was an early experimenter in the field that Couros' (2010) termed "open teaching" — a seminar course taught online using distributed Web 2.0 tools and aggregation, and open to all.

This inspired the Canadian researchers Stephen Downes and George Siemens to launch the first Massive Open Online Courses (MOOC), promoting and implementing their theory of Connectivism (Mackness, Mak & Williams 2010). Several thousand participants in these courses used a variety of tools, self-organizing into communities around shared interests, medium of communication, or language/geographic origin. Fini (2009) termed this approach to using distributed Web 2.0 platforms "loosely-coupled teaching". These early MOOCs were a unique form of connectivist learning, now referred to as "cMOOCS", and are now fading into a broader space of more specialized and directed MOOC formats. Indeed, MOOCS in general are only a small aspect of a larger wave of platforms and communities that can be grouped under the "mass collaboration" moniker, recently explored in an edited volume by Cress, Moskaliuk, & Jeong (2016), and which include both Wikipedia and open source software communities.

More recently, there has been a surge of interest in massive courses by elite universities delivered through platforms such as EdX and Coursera. These platforms and the partnerships between startups, web platforms, and large institutions of higher education — called "xMOOCs" to differentiate them from their predecessors — have opened up a wide range of learning experiences to the broader public, presenting instructors with the unprecedented challenge and opportunity of designing a learning environment for huge numbers (e.g., tens of thousands) of learners within the same course. These new course formats connect learners around the world in every time zone, offering new opportunities to bridge formal and informal communities, and introducing innovative ideas to the instruction of on-campus courses.

While the large number and distributed nature of participants in these MOOCs suggest opportunities for innovative pedagogical designs, the realities so far typically place the learner in an isolated context, with little direct peer interaction or sense of participation in a collective enterprise. However, some instructors are now pushing at the boundaries of technology and pedagogy. Dan Hickey launched a Big Open Online Course (BOOC), building on his research on peer assessment and WikiFolios for collaborative learning (Hickey & Soylu, 2012), where students engaged in small groups to promote and reflect upon the works of their peers (Hickey, Quick & Shen, 2015). A network called FemTechNet created a Distributed Open Collaborative Course (DOCC) on Dialogues in Feminism and Technology where instructors at 15 institutions connected their on-campus courses, and engaged students in acts of online activism, and creating an online archive of feminist work in science (Juhasz & Balsamo, 2012).

The emerging focus on MOOCs within higher education institutions and the broader media has now attracted the attention of learning scientists, with a number of ongoing projects aiming to better understand learners' experiences, applying concepts from the learning sciences to design platforms that enable more powerful learning experiences for a large group of people (Blom, Verma, Li, Skevi & Dillenbourg, 2013; Ahn, Butler, Alam & Webster 2013). A particularly exciting initiative is a group of researchers known as DANCE, which are working with the EdX platform to develop new functionality that specifically supports CSCL research and is based on theories of collaborative learning (Rosé, 2015).

### 1.1.2 Design and Research Around Learning at Scale

Amidst this growing enthusiasm for innovation around technology and design in teaching, there is a need for theoretically grounded innovations and rigorous research around practical models that support new approaches to learning. Current frameworks for instructional design are cast in terms of "cook book" how-to scripts for designers, like Mazur's Peer Instruction (Mazur, 1997), or high-level principles like Laurillard's Conversational Framework (Laurillard, 2012).

Some theorists have offered more fine-grained descriptions of learning models, such as peer tutoring (Roscoe & Chi, 2004), case-based learning (Hutchings, 1993) or self-explanation (Chi & Bassok, 1989). Such "molecules of instruction" reveal some productive patterns, and appear to be well positioned as elements of higher-level designs, yet there remains a need for theoretically guided assembly into broader instructional patterns.

One approach that is consistent with these new forms of user contributed content and aggregation of ideas is that of "knowledge communities," where students are encouraged to consider their learning goals and practices through the lens of a knowledge community, and engage in an array of inquiry practices including knowledge building (Scardamalia & Bereiter, 2006) and scaffolded inquiry (Linn & Eylon, 2006) to advance their collective understanding.

One recent model, known as Knowledge Community and Inquiry (KCI), engages students in the co-construction of a community knowledge base, with a commonly held understanding of the collective nature of their learning progression, and includes a sequence of scaffolded inquiry activities where students make use of the knowledge base as a resource (Slotta, 2014; Slotta & Peters, 2008). As a product of their activities, students develop new interests and avenues for further inquiry, which could not have been be known at the outset. The teacher must therefore be able to adapt (orchestrate) the designed script "on-the-fly," and hence becomes a vital component to both the design and enactment of KCI curriculum.

Pedagogical scripts, and their orchestration, are the subject of growing interest in the CSCL research community (Fischer, Kollar, Stegmann & Wecker, 2012; Tchounikine, 2007; Dillenbourg & Jermann, 2007), with efforts at coming up with theories and formalisms that can help the research community make collective progress. For example, Dillenbourg (2015) has articulated the notion of Orchestration Graphs, which visually describe the progression of learning designs between individual, small group and whole class interactions.

## 1.2 Summary of the Research

The purpose of this study is to investigate the scripting and orchestration of large courses in higher education and MOOCS, specifically inspired by the Knowledge Community and Inquiry model (Slotta, 2014). To this end, the KCI model was used to guide the re-design of a pre-service course for teachers on technology and inquiry. The course, called Technology, Curriculum and Instruction (TCI), began as a knowledge community design for class sizes of approximately 20-25 students, and was taught nearly a dozen times by Dr. Slotta. It was an early success in the design of a higher education course that leveraged collective resources and blended individual, small group and whole class inquiry.

The course addressed the need to integrate technology into lesson designs such that it enabled student learning by helping to make ideas visible, reveal conceptual models, make learning personally relevant, connect students with peers, and allow for formative assessment. Students engaged in active, critical use of technologies during the course, and a culminating inquiry project for small groups in the course was the design of a technology-enhanced inquiry, which also provided a source of organization for the course.

This course had already run for a number of years with a knowledge community design, but faced the challenge of tripling from 25 to 75 students. To begin, we applied a knowledge community approach to inform the design of a whole course script, including student roles, materials and activities, assessments and a clearly specified role for the instructor. We designed a rich technology environment to orchestrate this script, measuring the efficacy of the design in terms of fidelity to the script, as well as learning outcomes (e.g., student artifacts, interactions and assessments).

The re-designed pre-service course ran in Fall, 2013 and Spring, 2014. The final course design (i.e., the script) and its orchestration were analyzed to produce a set of pedagogical and technological design principles. These principles were then applied, in a second major phase of this study, to the design of a Massive Open Online Course for several thousand in-service teachers. This MOOC was a collaborative effort between Ontario Institute for Studies in Education (OISE), with its EncoreLab led by Dr. Slotta, and teachers and administrators at the University of Toronto Schools (UTS). The course targeted globally distributed in-service teachers who want to incorporate more inquiry in their classrooms using innovative technological approaches, was hosted on the EdX platform, and ran for six weeks in the summer of 2015.

A number of innovative design ideas were necessary to accommodate the large number of users, their diversity in terms of background, interest, and engagement, and the range of new opportunities available from emerging technology platforms. The resulting MOOC design encompassed a 6-week long curriculum script, including a number of overlapping micro-scripts (i.e., scripts within the broader script), supported by a customized technology platform that was integrated within the EdX MOOC platform in a seamless manner.

My goal in this work is to study the course script or structure, including connection to disciplinary principles, its affordances for community and collaboration and its support of differentiated learning for individual participants, collaborative opportunities, and an overall collective epistemology (Scardamalia & Bereiter, 2006, 2010). To this end, my goal is to articulate design principles for scripting and orchestrating collective inquiry designs for MOOCS and higher education courses. In addition to the specific research findings, and the specified pedagogical design, my hope is that this research can lead to valuable cross-cutting principles for course design in higher education, including flipped classrooms and MOOCS.

## 1.3 Research Questions

Despite the many critiques that have been leveled towards MOOCs around their high drop-out rates and simplistic pedagogical approaches, Shapiro (2016) identifies the MOOC phenomenon as a watershed event, which demonstrates three things: (1) a massive public demand for expert-led learning of academic ideas; (2) that many academics are eager to experiment with sharing with the public; and (3) that university administrators, capitalists, and the popular press are willing to endorse, sponsor, advertise these experiments. Thus, rather than dismissing the MOOC phenomena as a passing fad, it should be seen as an opportunity for the learning sciences. This work could promote a wealth of innovation and new opportunities for learning and research in the field of technology-enhanced learning, in large informal courses as well as within traditional higher education contexts.

This dissertation applies the KCI model to extend an existing higher education course design, ultimately informing the pedagogical script and technological orchestration of a MOOC for thousands of in-service teachers. Specifically, it seeks to address the following research questions:

1. How can the pedagogical perspective of knowledge communities be applied in the design of scripts for large open learning courses like MOOCs?

    a. What opportunities can be gained for collaboration, interactive media, knowledge pooling (i.e, "wisdom of the crowd")

    b. How can the diversity of participants' background and interests be a productive feature?

    c. How can we enable rich small-group collaboration and orchestration amidst a larger course population of thousands

2. What is the role of technology in the orchestration of large open courses like MOOCs

    a. How does the choice of platform interact with available course activities?

b. What technology features are well suited to supporting a community of learners' approach?

## 1.4 Background of the Researcher

I grew up in a small town in Norway, but had the opportunity to spend my two last years of high school at a United World College in Italy, following the International Baccalaureate curriculum. Not only the international curriculum and style of teaching itself, but also the interaction with students with backgrounds from more than 60 different countries, gave me an enduring interest in different approaches to teaching and learning, and the richness that diverse and multicultural students can bring to a course.

After a year of studying Chinese in a Swedish university, I traveled to China to teach English to classes of 45 undergraduate students. This was followed by a year working in the International Peace Research Institute of Oslo. When I arrived in Toronto to begin my Bachelor in International Development Studies, I was already a "mature student", and able to not only meet the learning objectives of my courses, but also reflect upon the way in which those courses were taught.

I had an early interest in technology and open-source ideas, and became fascinated by the attempts to expand the open-source philosophy from software to other disciplines, such as cultural creations (Creative Commons) and even teaching. In the final year of my Bachelor's degree, I followed an open and disaggregated course offered by David Wiley through blogs and wikis, with the topic of "open education". This course counts as one of my most inspiring educational experiences, and it also provided the idea for my Masters research topic: the production of open courses in Chinese universities.

As I applied to the Ontario Institute for Studies in Education, I knew I was interested in teaching and learning for university students and adults, and I struggled between choosing the Higher Education program, which focused on universities from a social and political science perspective, and the Curriculum, Teaching and Learning department, which focused mostly on teaching and learning in K-12 schools. I ended up choosing the Higher Education department, and focusing on the political initiative to fund the creation of open courses in Chinese universities.

Parallel to my formal studies, I became part of a globally dispersed group of activists who wanted to experiment with the creation of a platform for designing and running open courses. Inspired by the existence of expert and peer-produced open educational resources, such as MIT's OpenCourseware, we wanted to add the social and interactive element. Our community, the Peer2Peer University, become an incredibly rich Community of Practice centered around "peer-to-peer learning." Our discussions about teaching and learning were all the richer because we shared the experience of co-constructing a platform and an approach to supporting learning.

Fascinated by the question of how to better support learning in large online platforms, I chose to pursue my PhD at the University of Toronto, working with Professor Slotta and his group in the Encore Lab. A few years into my study, MOOCs became a global phenomenon, and the University of Toronto signed on to produce courses hosted on both Coursera and EdX. In parallel with my course work and research, I worked part time as an institutional researcher with Open.UToronto, where I supported several post-hoc analyses of MOOC data. I also gained experience as a university Teaching Assistant, often gaining the confidence of instructors and being able to participate in the course design process.

Thus, I was excited by the opportunity to work with Dr. Slotta to redesign his course "Technology, Curriculum and Instruction" based on the Knowledge Community and Inquiry principles, and to apply new technological and pedagogical solutions to the challenge of orchestrating a much larger group of students. This offered a suitable context for my own research, and opened the door to extending the outcomes to the design of a MOOC, where I could design and build a custom technology platform that put our pedagogical principles into practice, allowing the study of how a very large number of people can learn together, building off each other's diversity and insights.

## 1.5 Organization of the Thesis

There are six chapters in this dissertation. In Chapter 2, I review the literature and previous research on this subject. The chapter discusses constructivist and social learning theories, and approaches to structuring learning around these theories, with the Knowledge Community and Inquiry (KCI) framework explored in detail. It then discusses the theoretical origin of scripting theory and orchestration to answer the CSCL challenge of productively structuring collaborative learning, and examples of scripts and scripting research. The chapter then introduces the field of open education and Massive Open Online Courses, and discusses the new field of Learning Analytics, before concluding with the research questions.

In chapter 3, I present the methodological approach, Design-Based Research, and introduce the two main studies that make up this dissertation: two offerings of a pre-service course for teachers with 75+ participants, and one MOOC, with 8,000 registrations and more than 2.000 active learners, targeted towards in-service teachers. The chapter lists data sources and methods of analysis, and considers ethical concerns surrounding the research.

Chapter 4 presents details of the design process and the final design and enactment of the pre-service course, “Technology, Curriculum and Instruction”. The course design was inspired by the KCI framework, and used several Web 2.0 technologies supported by purpose-written scripts to orchestrate multiple levels of collaborative inquiry learning. The course design components are systematically analyzed according to their pedagogical function, and learning analytics and participant observation is used to evaluate the design and the execution, and extract lessons for future designs.

Chapter 5 focuses on the design of the Massive Open Online Course “INQ101x: Inquiry and Technology for Teachers”. It describes in detail the design process, and the technological platform built to support the curriculum. It details the meta-scripts that cover the length of the curriculum, and the smaller embedded scripts that intermix to provide the dynamic exchange between layers of activities, granularity and learning goals. The pedagogical design is analyzed according to the theoretical framework, and the structure that was derived in chapter 4.

In chapter 6, I discuss these outcomes, and discuss how orchestration graphs can be adapted to MOOCs. Principles for supporting orchestration of rich scripts in large learning communities are extracted and named, and venues for future research are explored.

# Chapter 2.
# Literature Review

> Isolated from social interaction, physical artifacts and historical cultures, human brains are poor thinkers and could never have developed into powerful minds.
>
> —Merlin Donald, Origins of the Modern Mind, 1991

## 2.1 Introduction

The goal of this research is to understand how a principled approach to designing large enrolment online courses, grounded in the theoretical perspective of knowledge communities, can support richer and more collaborative learning experiences. This chapter will begin by introducing the foundational literature on social constructivism and the importance of learners engaging with peers, instructors, and the broader community. It will then review some of the specific principled approaches to curriculum and learning design that have come out of this perspective, with an emphasis on the Knowledge Community and Inquiry framework, which has served as the inspiration for our design approach.

To situate the research within a particular domain of inquiry, the review will then address the theoretical notion of scripting and orchestration, which is a topic of emerging significance within the field of Computer-Supported Collaborative Learning. It will then further situate this research project within the context of online learning, reviewing the research on Massive Open Online Courses (MOOCs). This will lead to the specific research questions to be addressed in the present project.

## 2.2 Social Constructivism

In one of the earliest theories of social learning, Vygotsky (1978) suggests that all cognitive functions originate in and develop through social interactions. Extending the notion of the artefact from physical objects to speech objects and concepts, he suggests that all the world's knowledge could be seen as artefacts, first socially constructed, and then internalized individually into what can be termed cognitive artefacts (Stahl & Augustin, 2002).

Vygotsky defines the Zone of Proximal Development (ZPD) as *"*the distance between the actual development level of a child as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers*"* (Vygotsky, 1978, p. 86). In essence, this defines a space within which learners would create their understandings.

Acting within the ZPD, a learner can accomplish a task and reach an understanding otherwise beyond his or her means, through the interaction with a More Knowledgeable Other (MKO). This MKO was originally thought of as being an instructor or older adult, but the theory has been adapted to include peers in collaboration, scaffolds and software affordances, and even computer assisted tutoring systems (Chaiklin, 2003; Järvelä, Häkkinen, Arvaja, & Leinonen, 2004; Murray & Arroyo, 2002; Wood, Bruner, & Ross, 1976).

Vygotsky's theories can be located within the broader framework of social constructivism, which views learning as a process of socially mediated knowledge construction. Learners are not empty vessels to be filled, but active agents constantly attempt to reconcile new information with existing ideas and notions (Linn & Eylon, 2006). Knowledge is not seen as decontextualized and timeless, and the sociocultural context in which learning and teaching occurs is seen as intrinsic to the learning process (Palincsar, 1998).

Students bring their own unique cultural and experiential backgrounds and perspectives to the learning community, and social interaction between learners provide mechanisms for the development of higher-order thinking (Duffy & Cunningham, 1996). Their learning, or co-construction of knowledge artefacts, is mediated by such elements as language, concepts, and graphical representations (Jonassen, 1995). A key question, which has guided much of the research in the field of Learning Sciences, is how this process can best be supported and guided by an instructor or learning designer, as well as by the careful design of the physical and digital learning context and its affordances.

A number of approaches have emerged to help structure learning around social constructivist perspectives. Two early attempts were Anchored Instruction and Reciprocal Teaching. Anchored Instruction aimed to address the poor transferability of conventional learning, and offered interesting and realistic contexts through videodiscs, used to "anchor" subsequent learning and instruction. The anchors were stories, rather than lectures, and were designed to be explored by students and teachers (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990).

Reciprocal Teaching (RT) is an approach where students become teachers or tutors of one another in small group sessions. The teacher and the student take turns assuming the role of the teacher and leading the discussion using four strategies: summarizing, question generating, clarifying, and predicting (Palincsar & Brown, 1984). The purpose is to facilitate a group effort between teacher and students, as well as among students, to help bring meaning to the text. Two levels of ZPD are seen as being in play with RT: the space between the weak readers and the strong readers, and that between the strong readers and the teacher. Weak readers are able to learn expert reading strategies from strong readers, and students learn how to model and support their peers from the teacher's modelling. Support is also scaffolded in a way that is gradually faded as the students become more confident in their skills (Mayer, 1996).

## 2.3 Knowledge Communities

Building on the social constructivist approach, several researchers have defined models where learning occurs within the context of a knowledge community. This section will review three such approaches: Knowledge Building, Fostering Communities of Learners, and Knowledge Community and Inquiry.

### 2.3.1 Knowledge Building

Inspired by the forms of discourse, inquiry and idea refinement that characterize the scientific community, Scardamalia & Bereiter (1996, 2010) have advanced the Knowledge Building (KB) approach to support authentic inquiry in a learning community. Instead of focusing on activities and tasks, the approach centers around the ideas expressed by the students, and how the community can progress together in building on those ideas. A custom-built technology platform called Knowledge Forum offers supportive prompts (scaffolds) when students enter notes, such as "My theory is", and "This doesn't explain…". The organization of notes in Knowledge Forum is a fluid two-dimensional space, which encourages students to work on organizing, reinterpreting and connecting ideas (Scardamalia, 2003).

Rather than offering specific design guidelines and activities, KB is based on 12 principles, that include "Real ideas and authentic problems", "Improvable ideas" and "Idea diversity" (Zhang, Hong, Scardamalia, Teo, & Morley, 2011). For example, in a primary school class using KB, students could be encouraged to generate authentic questions, such as why leaves change colours in the fall.

To investigate such a question, students might start by generating their own theories, then brainstorm ideas, specify their assumptions, and consider how their theories could be improved. This might lead to the students conducting experiments, doing research in existing literature and consulting outside experts. During the entire process, the Knowledge Forum database is kept up to date, and functions as a shared community artefact that supports sense making and guides inquiry (Scardamalia, 2002).

A number of international empirical studies conducted within the Knowledge Building framework (e.g. Lamon, Reeve, & Scardamalia, 2001; Lee, Chan, & Aalst, 2006; Leinonen, Virtanen, Hakkarainen, & Kligyte, 2002; Lossman & So, 2008; Nason & Woodruff, 2003; Zhang, Hong, Teo, Scardamalia, & Morley, 2008; Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007) have described successful KB interventions. However, van Aalst (2009) has raised concerns about the difficulty of integrating a KB project with curriculum goals, the high level of teacher preparation required, and the fact that the principal-based guidance can be very difficult to translate into classroom implementations.

Two other knowledge community approaches—Fostering Communities of Learning (FCL) and Knowledge, Community and Inquiry (KCI)—share many of the same goals as KB, but place more emphasis on structuring learner activities and defining students' learning trajectory to ensure that students reach the appropriate learning and curriculum goals.

### 2.3.2 Fostering Community of Learners

FCL established a central goal of advancing the community's collective knowledge through the integration of epistemic procedures within a sequence of inquiry stages, using shared discourse and a culminating project (A. L. Brown & Campione, 1994). Extending beyond the scope of a single course, FCL introduced the concept of a developmental corridor, where the learning community extends not only horizontally across the classroom, but also vertically across grades (Bielaczyc & Collins, 1999). One example is a 10-week long unit to design the "animal of the future", which was first run in a 2nd grade, then repeated for the next two years, where children made increasingly sophisticated connections between habitats, food chain and predator-prey relationships (A. L. Brown, 1997).

In FCL, guided inquiry consists of a number of scripts during three distinct phases: research, information sharing, and consequential task. During research, students engage in reciprocal teaching (as described above), research seminars, guided viewing, guided writing, consulting experts, and peer/cross-age teaching. During sharing, they use jigsaw, cross-talk, distributed expertise, majoring, help-seeking and exhibitions, and the consequential task sometimes leads to design tasks, publishing or authentic assessments (Collins, Joseph, & Bielaczyc, 2004). Thus A. L. Brown (1997) took the pedagogical “molecule” of Reciprocal Teaching and embedded it within a more comprehensive scope and sequence of roles, goals and activities.

The specific script, or sequence of activities within FCL, focuses on supporting higher level academic and self-regulatory skills, and the enforced uneven distribution of knowledge. For example, a jigsaw design makes students more likely to value their peers’ ideas. The teacher plays an important role as a guide through the whole project, making sure that students stay in their Zone of Proximal Development, modeling higher-level skills in a progression from modeling, to coaching, to scaffolding, all the while gradually providing more autonomy to the students.

### 2.3.3 Knowledge Community and Inquiry

Despite the reported success from the initial research, there has not been much continued research on FCL, other than as an inspiration for other approaches (Shulman & Sherin, 2004). One such approach is Knowledge Community and Inquiry (KCI), a model developed by Slotta and his colleagues (e.g., Slotta, 2012; Slotta & Najafi, 2012; Slotta & Peters, 2008), which builds on FCL, in the sense that it advocates scripting and coordinated grouping to assure comprehensive distribution across a targeted domain, but adds a layer of collective knowledge building, where students engage with Web 2.0 technologies (e.g., wiki, social networks) to develop a shared knowledge base that serves as a resource for their subsequent inquiry.

The emergence of these new Web 2.0 technologies inspired a number of aspects of the KCI framework. From an epistemological perspective, the emergence of user-created media has radically shifted how we access information and learn about the world. We learn by formulating and expressing our ideas and theories in language, posting on discussion forums and tweets. We gain access to deeply personal perspectives of others through personal blogs. We build on each other's knowledge by negotiating the successive editing of Wikipedia articles. And we harness input from thousands of peers through aggregation mechanisms like voting, folksonomic tagging, and even automated classification and suggestion engines.

To support a knowledge community approach, this epistemological shift has to be brought into the classroom, helping students view themselves as part of a group with collective goals and shared resources, where everyone's ideas and experiences are consequential, and where individual learning trajectories are situated within the process of collective advancement. In a typical KCI design (see Figure 1), this is supported not just through the use of supportive technology and a design that encourages structured idea production and exchange, but also through explicit epistemic treatments.

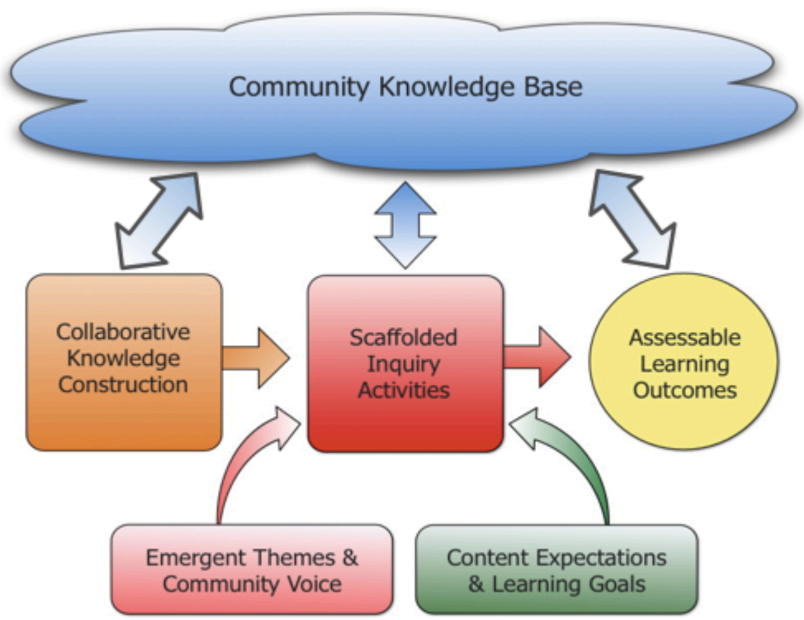



**Figure 1 - KCI model**

Making ideas visible and accessible is at the heart of learning in a KCI design. This requires the use of existing Web 2.0 technologies, sometimes augmented by bespoke technology platforms or supports, as well as a pedagogical designs. Students work individually or in small groups collecting information, brainstorming ideas or solutions, supported by carefully designed prompts and scaffolds. Small group work alternates between cooperative work—divide and conquer—and collaborative—where group members build upon each other's knowledge.

The knowledge base needs to be organized and indexed in a way that it becomes available and useful to the broader community, and the curriculum designed in a way that students are required to rely on the ideas and information gathered by their peers, and know that their peers rely on their own contributions. Some KCI designs might begin with an empty community knowledge base, whereas in other designs, the learners might inherit their knowledge base from a previous effort left behind as the final product of a prior generation of students (i.e., to stand on their shoulders and continue advancing the knowledge). In both cases, the teacher plays an important role in guiding the discourse of the community to ensure that it is progressing, helping students connect their ideas to themes that mature visibly over time (Slotta & Najafi, 2012).

In authentic classroom settings, it is important for the learning designs to provide assessable outcomes linked to learning goals. KCI curricula are designed explicitly to include inquiry activities that lead to the production of artifacts—sometimes personal (e.g., reflections) and sometimes in groups (e.g., designs)—that allow for assessment of learning on a set of pre-specified goals or expectations. Typically, artifacts are evaluated for coherence (presence of mutually conflicting ideas), and completeness (Peters & Slotta, 2010). Many KCI designs feature a group project in which students collaborate throughout the term, with new elements or dimensions added as the students gain access to a larger individual and community knowledge base, and become more conceptually sophisticated (Slotta & Najafi, 2012). Such persistent, revisited projects can function as a means of guiding students' connection of principles throughout the course. Further, given that the projects are indexed to the learning objects of the course, these inquiry projects can support the summative evaluation of student learning.

#### 2.3.3.1 KCI principles

To support the KCI design process, and further research on the KCI model itself, Slotta (2012) has postulated four KCI design principles, each containing pedagogical assertions, technological affordances and epistemic commitments.

#### 2.3.3.1.1 Principle 1

*Students work collectively as a knowledge community, creating a knowledge base that is indexed to a specific content domain.*

The idea of a shared knowledge base is key to a successful knowledge community approach, however it should not be unconstrained, but rather carefully indexed to a specific content domain, for example creating a page structure, scaffolds and prompts.

<u>Epistemic commitments:</u> For students to identify as a community, and understand the knowledge base as their common community resource.

<u>Technological affordances:</u> The basic concept of a knowledge base would be a wiki, where anyone can edit. More sophisticated wikis might have features such as groups, templates, tags and automatic indices. Beyond that, customized and custom-written platforms can support more sophisticated automatic aggregation and different ways of viewing the same information, extending to intelligent agents that perform real-time data-mining.

#### 2.3.3.1.2 Principle 2

*The knowledge base is accessible for use as a resource as well as for editing and improvement by all members*

Building on principle 1, but focusing more on the students' epistemic orientation, this principle states that students must understand that the knowledge base is a primary resource for their inquiry activities. Students' own contributions will be consequential for their peers' learning, and the overall growth of the knowledge base will serve as a collectively constructed and validated resource for the community's overall progress.

<u>Epistemic commitments:</u> To understand the nature of knowledge building processes, notions of improvable ideas, measurable progress in a knowledge base, emergent organization of content, and peer editing. The value of community voice.

<u>Technological affordances:</u> Socially editable media, wikis and notes. Some studies have used specially designed software that run on both student tablets, and on teacher' interactive whiteboards with live sync.

#### 2.3.3.1.3 Principle 3

*Collaborative Inquiry activities are designed to address the targeted domain learning goals, using the knowledge base as a primary resource and producing assessable outcomes*

This principle invokes the principle of inquiry learning, but also serves to constrain the design space for KCI curricula within the broad open space of inquiry projects by focusing on the knowledge base, and need to produce assessable outcomes.

Epistemic commitments: A constructivist approach to learning, where students build on their existing ideas to develop understandings through reflection and application, in a social context.

Technological affordances: Students access Web 2.0 tools through laptops and tablets – collaborative editing, chat, tagging and voting, blogs, etc. Intelligent agents or other orchestrational tools execute pedagogical logic (e.g. grouping of students, redistribution of artifacts, sequencing, etc.).

#### 2.3.3.1.4 Principle 4

*The teacher's role must be clearly specified within the inquiry script, in addition to a general orchestrational responsibility*

Teachers play a crucial role in supporting the community advancement and adjusting the script on the fly based on observation, and possibly real-time learning analytics. The teacher might manually trigger stages of the script, or guide in discussions and inquiry activities to push students to a more sophisticated understanding.

Epistemic commitments: Teacher's role is that of expert collaborator and mentor, as well as orchestrator of the pedagogical flow of activities. Must see his/her own role as that of an important community member, a "mentor at the center".

Technological affordances: Teachers might rely on orchestrational technology to implement, sequence and adapt the pedagogical scripts. Learning analytics can help provide immediate feedback on student progress, social organization and support the teacher in adapting the script.

### 2.3.3.2 KCI designs and research projects

A KCI project typically begins with subdividing the students into small groups, where each group is responsible for populating some portion of the knowledge base, scaffolded by templates and scripts that serve to reinforce connections to the learning domain (e.g., an empty wiki could be created, but with pages that have sub-headers already added that help ensure students will add ideas that are directly relevant to the targeted learning goals). The entire knowledge base is then made available to the whole class to serve as a resource in subsequent inquiry activities, which are carefully designed to target the relevant science learning goals.

In one KCI curriculum, Peters & Slotta (2010) employed wiki templates to support students across 5 sections of a high school biology course to create a community knowledge base about human diseases and body systems. That wiki then provided a resource for subsequent inquiry activities where they created and solved challenging "disease cases." In this way, students were engaged to apprehend material across a wide domain area, specializing in a single body system, but using the wiki from other systems to solve challenge cases.

A second iteration emphasized collaborative processes as students created a detailed wiki about Canada's biodiversity (Peters & Slotta, 2010). In another study, high school science students constructed a wiki about climate change effects in Canada and remediation plans. Using the collective knowledge base, they then drafted proposals of how to remediate climate change issues (Najafi, 2012; Zhao, Najafi, & Slotta, 2011).

In the projects above, students used Internet research to develop their content understanding of a given domain area. Moving forward, a significant research program has developed around the use of digital media embedded within the classroom environment, and other "smart classroom" infrastructure, such as the use of large aggregate displays, or carefully scaffolded movement of students between groups, using personal tablet computers (Slotta, Tissenbaum, & Lui, 2013). For example, Fong (2014) engaged students in investigating a virtual ecosystem "embedded" within their classroom walls, and Lui (2015) immersed students in a virtual Sumatran rainforest. In other projects, students gathered data outside the classroom, and used sophisticated tools to make sense of their observations, such as the images from camera traps (Cober, Acosta, Moher, & Slotta, 2015) or videos referencing physics concepts (Tissenbaum, 2104).

To support the student inquiry, custom software was written that let students collect observations using tablets, which could be aggregated and displayed, and used as an input in the discourse tools. Cober (2013) investigated the role of these aggregate representations in supporting knowledge building. These tools were based on the SAIL framework, a technology platforms built to support the kind of rich learning interaction, and orchestrational needs that KCI scripts require, including support for real-time interactions, aggregate representations, ambient displays of collective inquiry progress, and intelligent agents for mining data (Slotta, Tissenbaum, & Lui, 2013; Tissenbaum, 2014).

The studies above were all carried out with upper-elementary and secondary school students, but KCI has also been applied to the design of several higher education courses. Slotta and Najafi (2012) document an interdisciplinary graduate seminar called “Knowledge, Media and Learning,” offered to doctoral and masters students over a number of years, where the knowledge base was “handed forward” from each successive generation. This led to students feeling part of a more persistent knowledge community that contained not only the current course participants, but all previous students as well.

The culminating project in this graduate course was a small group design project that built on the ideas and insights gathered in the collective knowledge base, and was later documented in detail for future generations. The learning goals of the course, both in terms of content, skills, and epistemic attitudes, match well with the approach to learning, and the tools used. For example, students were expected to not only understand what a wiki is, how it differs from a blog, and how it can be used in a learning/design situation, but also be able to use the knowledge tools in a collaborative situation, and finally to understand deeply the meaning of working collaboratively and creatively in a Web 2.0 situation (Slotta & Najafi, 2012).

Another KCI-inspired course was "Curriculum, Technology and Instruction", developed by Dr. Slotta for teacher candidates, with the goal of helping them learn to use technology for inquiry in their future classrooms. This class shared the convergence between approach to learning and technology, and content, skill, and epistemic learning goals. Initially offered to cohorts of 25 teacher candidates, the course used wikis and other Web 2.0 tools to investigate technologies that could be used in inquiry teaching, building on a collective knowledge base handed over from past generations. Again, a persistent project was introduced early in the course, in the form of a lesson design project that was woven through the entire course (Håklev & Slotta, 2014). The course was later redesigned to accommodate more than three times as many students, and this redesign forms a part of the current study (see Chapter 4).

## 2.4 Scripting and Orchestration

### 2.4.1 Theoretical Background

One of the fundamental tenets of Computer Supported Collaborative Learning is the idea that interaction with other learners can improve learning outcomes. Students are forced to externalize their ideas, working with multiple shared representations of knowledge structures, and collaborating to converge on a shared understanding of meaning. (Fischer & Mandl, 2005; Stahl, Koschmann, & Suthers, 2006). However, several studies show that simply asking students to solve a task or discuss a problem is unlikely to engage them in a productive process of collaborative knowledge construction (Cohen, 1994; Mandl, Gruber, & Renkl, 1996).

According to Weinberger, Reiserer, Ertl, Fischer, and Mandl (2005), students are faced with obstacles in two dimensions; (a) a social process dimension and (b) an epistemic process. In the first dimension, social interactions may be suboptimal in regards to learning, with discussions remaining at a superficial level, and students aiming to quickly reach agreement, rather than exploring their different understandings of the problem. In the epistemic dimension, learners might have difficulties understanding the best way of approaching the learning task, perhaps employing superficial pattern recognition and drawing on past experience, rather than applying newly learnt approaches and concepts.

Shank and Abelson (1977) have posited that individuals possess procedural knowledge that guides them to understand and act in specific everyday situations. They define the notion of “scripts”, which are a special form of cognitive schema, gained through the generalization of experience. Many of our ever day actions, such as dining in a restaurant, are guided by such scripts, which also serve to structure our social interactions.

In the epistemically and socially complex situations that arise in collaborative learning contexts, individuals rely on their pre-existing scripts regarding collaborative problem solving, argumentation and other required activities (Kollar, Fischer, & Slotta, 2005, 2007). For some learners, these scripts can be entirely missing, or ill-formed. To help support such learners, Fischer and his colleagues (Kollar, Fischer, & Hesse, 2006; Fischer, Kollar, Stegmann, & Wecker, 2012) proposed a form of scaffold, which they call an “external collaboration script”, that specifies the roles and goals of the participants, allocates material and tasks, and coordinates student grouping and learning activities. This new way of conceptualizing a “script” became a more general means of referring to any designs that helped to guide students and teachers through prescribed forms of learning interaction (Dillenbourg & Jermann, 2007).

Bower, Black, & Turner (1979) systemize an early scripting theory, including the elements of props, roles, scenes, obstacles, errors, and distractions. Tchounikine (2007) and others refine the notions of scripts, including the distinction between micro- and macro-levels. Macro-scripts are sequences of learning activities and tasks that learners must perform individually and in groups, where there is some interdependence between the specific skills, ideas or artefacts encountered in preceding and subsequent activities. These macro-scripts aim to exercise certain higher-order thinking skills and support the relevant curriculum learning goals (Kollar, Fischer, & Hesse, 2006). Micro-scripts address the specific interactions that occur during each task or activity: who initiates the exchange? Does everyone get to speak? Does one student engage with another’s ideas?

Building on such notions, Fischer, Kollar, Stegmann, and Wecker (2012) developed a formalization of a scripting theory of guidance based on a metaphor of “theatrical script” including four levels: play, scene, role and scriptlet. This theory addresses how collaborative learning sequences are shaped by dynamically re-configured internal collaboration scripts of the participating learners, which develop through participation in the learning activities. It goes on to explain how external collaboration scripts can serve to modify student activities, influencing internal collaboration scripts, as well as specifying optimal scaffolding levels and strategies for fading external scripts (Fischer et al., 2012).

Research on scripting within the Computer Supported Collaborative Learning (CSCL) community has taken several different forms. Some have focused on authoring and then carefully researching and documenting specific scripts. For example, in the jigsaw script, students are split into groups, each of which are focused “experts” on one specific aspect of the problem or topic. After the groups have progressed in developing understandings, students are then re-grouped such that each new group includes one member from each of the original expert groups. This ensures that the entire class is exposed to all relevant aspects (Aronson, Blaney, Stephin, Sikes, & Snapp, 1978). Jigsaw is an example of a script that can be modified to fit many different learner groups and subject materials.

Other researchers have focused on creating content-specific scripts, specifying not only the sequence of interactions between students, but also the content discussed, as well as the technology which mediates the activities. In UniverSanté (Berger et al., 2001) students begin by discussing clinical cases in small groups, then connect with another group through an online forum. Next, they explore issues of epidemiology and build strategies to cope with public health problems, using a number of interactive tools and group-formation strategies

Other research has looked at the dangers of over-scripting (Dillenbourg, 2002), how to gradually fade out scripts as students internalize them (Wecker & Fischer, 2007, 2010), and different levels of coercion in scripts (Dillenbourg & Jermann, 2007; Papadopoulos & Demetriadis, 2012).

### 2.4.2 Orchestration: Implementing Scripts and Supporting Teachers

In addition to the theoretical and pedagogical models of scripting, there has also been some research into the design and implementation of scripts. This has included formalisms for specifying, recording and sharing pedagogical scripts, such as UML (Walker, Rummel, & Koedinger, 2009), finite state automata (Haake & Pfister, 2007), Petri nets (Harrer & Malzahn, 2006) and IMS-LD (Hernández-Leo et al., 2005).

Once scripts have been designed (Tchounikine (2008) presents a proposed design approach), they need to be implemented or enacted. Dillenbourg, Nussbaum, Dimitriadis, and Roschelle (2012) call this process "orchestration", defined as "how a teacher manages, in real time, multi-layered activities in a multi-constraints context" (p. 1). The concept of orchestration includes the role of the teacher—what forms of student interaction, classroom discourse, or management of technology environments are required? Orchestration also includes aspects of the constraints of physical space, time, and materials. Teachers, in coordination with physical, material and activity constraints, must orchestrate the script, including adaptations to accommodate the diversity of student ideas and unexpected eventualities.

Recently, Dillenbourg (2015) introduced the concept of orchestration graphs, in the form of timelines with social granularity on the y-axis (ranging from individual work, to small groups, whole class, and the world) and time along the x-axis. This graphical representation serves to specify the activity sequence, as well as group configurations. The book also introduces operators and edges between activities, allowing for descriptions of operations such as grouping students based on their previous work, or redistributing/processing generated artefacts.

Technology also plays an important role in orchestration. While some scripts (e.g., jigsaw groups, also referred to as deBono's hats) could be implemented in a low-tech manner, using only oral instructions, sticky notes and poster paper (Aronson et al., 1978), the logistical demands of such coordination are a heavy load for teachers. Technology environments can support the seamless coordination of grouping, including conditional logic (e.g., student assigned to groups based on previous groups or assessments). Moreover, the technology environments can also scaffold students during activities within the script. A wide range of inquiry activities could include interactive materials like simulations, reflection notes, collaboratively edited Google document, or Google searches. Slotta & Jorde (2010), Dillenbourg and Hong (2008), Dimitriadis, Prieto, and Asensio-Pérez (2013) and others have argued that technology environments can "share some of the load" of orchestration with the teacher.

Many researchers have developed custom technology tools and environments that encompass their theoretical perspective, including features for orchestration as well as activity scaffolds. On such example is the Web-based Inquiry Science Environment (WISE – see Linn & Slotta, 2000), which contains a variety of tools that can be authored into learning objects, resulting in a coherent browser-based inquiry project for students. In WISE, the technology environment serves to orchestrate the curriculum, routing students to different materials and activities, while also scaffolding their engagement by means of inquiry tools for drawing, modeling, experimentation, concept mapping, and many others.

Building on the notion of formal pedagogical scripts, reviewed above, there has been some progress in developing orchestrational frameworks that can support complex, specified designs of collaboration and inquiry. Most such efforts begin by rendering the script into a digital representation, for example with script authoring tools such as Compendium-LD (Conole & Weller, 2008), Learning Designer (Laurillard et al., 2013) or Web Collage (Villasclaras-Fernández, Hernández-Leo, Asensio-Pérez, & Dimitriadis, 2013). The GLUE!-PS system by Prieto et al. (2014) was designed to take such representations and then automatically instantiate a number of different Web 2.0 services, based on the design. These could include setting up different Google documents for each group, creating pages in a wiki or setting up a workflow in Moodle.

Moving beyond the use of off-the-shelf media for collaboration, a number of new possibilities for technology-based scripting and orchestration have recently emerged. For example, the use of "intelligent" software agents can allow for timely provision of prompts and guidance to student groups (Kumar & Rosé, 2011). Intelligent agents can monitor a multitude of signals or events during the curriculum enactment, rerouting information or resources, sending notifications, grouping students according to emergent patterns, or jumping to different steps in the script based on pattern recognition algorithms (Gerardo, 2007).

Artificial intelligence tools can also support automatic clustering of discussion topics, and identify salient posts in large discussions (McLaren, Scheuer, & Miksátko, 2010). Such approaches, which fall under a broader umbrella of "learning analytics" (Duval & Verbert, 2012) allow for the provision of timely feedback to students about how they are progressing. Such feedback could also appear on a Web-based "dashboard" designed to support just-in-time response by the teacher (Rojas & Garcia, 2012), or it could be displayed to the students as an aid in group awareness and self-reflection (Michel, Lavoué, & Pietrac, 2012).

### 2.4.3 Implications for Scripting and Orchestration in Post-Secondary Education

Most of the scripting and orchestration work from the CSCL literature has been of a theoretical nature, and hence agnostic about educational variables like course topic, sequences of lessons, assessments and student background. To the extent that scripting and orchestration research will be relevant to education—including higher education courses and programs—there is a need for stronger connection to the real-world ecology of courses and students. How is a lesson situated within a course context, and the course within a program of studies? How do the epistemic beliefs of the students, their motivation for attending the course, and their choice of learning or coping strategy, affect the individual and group learning processes? And how to the teachers' epistemic beliefs and approaches vary across courses?

In the higher education literature, there is a tradition of considering the educational, social and professional contexts, and their implications for student learning. Biggs (1993) suggests that the most salient contextual variables (i.e. those that influence student learning) are (a) previous knowledge, self confidence, abilities, motives, (b) conceptions of knowledge and learning, (c) approaches to learning and studying, and (d) expectations.

Epistemic beliefs and approaches have been studied at both a micro- and a macro-level. As an example of a macro-level approach, Perry (1999) studied the intellectual journey of Harvard undergrads during four years through repeated open-ended interviews. He found that students in their first year held a commitment to facts (i.e., that were either right or wrong), gradually giving way a more sophisticated belief system, which by the fourth year was characterized by critical relativism, and a commitment to personal values and constructing consistent belief systems.

To explore the development of student epistemologies, Marton & Säljö (2005) used a series of experiments to show how students approached individual learning tasks quite differently, classifying students into either a surface or a deep-learning group. When they measured how students read and understood texts, they found that students in the surface group attempted to remember as many facts as possible, whereas the deep-learning group would attempt to understand the text holistically. An example of the difficulties faced by the surface group is the “principle-example” structure commonly used in academic texts, where surface-group students would often miss the principle by focusing too much on the details in the example (Laurillard, 2012).

Which approach students chose in these studies was found to be related to their level of skill as learners, their psychological ideas of self, strategic choices, and the messages or positioning they may have received from the instruction itself (Marton & Säljö, 2005). An example of the influence of psychological ideas is the concept of self-efficacy, which Bandura (1986) formally defined as personal judgments of one’s capabilities to organize and execute courses of action to attain designated goals. These multi-dimensional measures have been shown to predict students’ academic motivation, persistence and emotional reaction to difficulty (Zimmerman, 2000).

How students perceive the learning task can significantly change their learning attitudes and behaviours. If they see the curriculum as a vast body of knowledge to master, they may perceive learning as a matter of struggle and attainment. However if curriculum is seen by students as more of a process by which they gain knowledge that is important for their success in the world, they may more engaged and excited by learning and see the teacher as a strategic resource

(Palmer & Marra, 2004). For students of the former kind, attending university is often seen as a game to be optimized according to reward structures. For example Miller & Parlett (1974) showed that overworked medical students appraised the system of assessment in a department, and matched their learning styles accordingly.

## 2.5 Open Teaching and Learning, Informal Learning and MOOCs

Life-long learning has been touted as a political aspiration for decades (Aspin & Chapman, 2000), but educational researchers have continued to focus on teacher-organized learning in formal institutions (online and offline). Informal learning has always existed, but with the growth of Web 2.0 and the possibility for anyone with an Internet connection to publish content and interact with peers, new models and approaches have appeared. Focused on interdependent learning in groups and networks using distributed Web 2.0 tools, these movements align well with constructivist and knowledge community-based approaches to learning, and provide an important source of inspiration for imagining learning in the future. In response, a community of researchers has grown to study such learning, who in some cases attempt to create their own theories of learning to better account for these new experiences. The following sections describe the research and experimentation around informal, lifelong learning, including the growth of Massive Open Online Courses (MOOCS) and related research.

### 2.5.1 Early Efforts in Open Online Learning

One early experiment with free online teaching is Bob Dick's e-mail course on action research, which has been running twice a year since 1997 (Zhao, Wight, & Dick, 2012). In this course, students communicate entirely through email, but join discussion and learning groups, and provide feedback to each other on individual projects. Building on such ideas, in 2007, David Wiley launched a Wiki-based course called Introduction to Open Education (Fini et al., 2009). Wiley was an instructor at Utah State University, and his students participated in the course for credit, while outsiders could join for free, without receiving credit. This idea of having a core group of students who take a course for credit, but opening the course to a wider community of non-credit participants became a common method for faculty to get involved with more distributed teaching. Couros (2010) describes a graduate level course at the University of Regina which had 20 for-credit students and 200 non-credit students participating online.

Wiley used a simple wiki for the course syllabus, with students responding to prompts on their own blogs, and using RSS feeds to keep up with their peers. Fini et al. (2009) describes the design of the course, noting how one group of Italian educator who took part decided to join together, and used an existing Italian social network for educators as a “back-channel” during the course. This self-organized group also worked together to construct a final artifact for the course.

### 2.5.2 Experiments With Open Approaches to Learning

Early exemplars like the Wiley Wiki course inspired a number of other individual instructors to experiment with offering open courses. At the same time, a number of collaborative platforms emerged to support course offerings and coordinate study groups. Wikiversity was started in 2006 as a project of the Wikimedia Foundation, which also hosts Wikipedia and other collaborative wiki projects. It struggled with defining its purpose, between curating textbook teaching materials, and actually conducting social learning projects, but nonethless gathered a community of people who were particularly interested in the pedagogical effects of collaborative artefact creation and hypertext (Lawler, 2011; Leinonen, Vadén, & Suoranta, 2009).

Peer2Peer University (P2PU)—directly inspired by Wiley’s example—began as a small volunteer project in 2007 with a platform to run courses that were organized as study groups around existing Open Educational Resources such as MIT OpenCourseWare (Schmidt, 2009). Common to P2PU and many of the individual experiments going on at the same time, was a disavowal of the all-encompassing learning management system (LMS) in favor of Web 2.0 social media and collaborative content creation platforms, as well as an interrogation into the nature of teaching and the role of the teacher or facilitator, in this new media (Stevens, 2012).

Many authors have wrestled with terminology and definitions, given that the word "open" is overloaded to mean many different things. Põldoja and Laanpere (2009), who designed an enhanced RSS feed aggregator specifically designed for a distributed blog course, coined the term “Agora course” for courses meeting the three criteria (a) openly accessible content, (b) open personal learning environment and (c) free and open registration for participants. Couros (2010) defined “open teaching” as “the facilitation of learning experiences that are open, transparent, collaborative, and social” (p. 6). He defined “open teaching methodologies” in reference to educational practice inspired by the open source movement.

Focusing on the distributed technological nature of the courses, Fini (2009) introduced the concept of “multi-tool learning environments”, and describes the teaching in such an environment as “loosely-coupled teaching”. Corneli & Mikroyannidis (2011) suggested the term “P2PLE - peer-to-peer learning environment” for courses where the focus is on learners supporting each other in a democratic fashion, without a strong expert presence. Wild, Mödritscher, & Sigurdarson (2008) talk about the “mash-up PLE” (Personal Learning Environment) as the concept of using a number of existing Web 2.0 tools and plumbing such as APIs (Application Programming Interface) to build one's own integrated learning suite. To theorize the broader ecosystem of peer-to-peer learning and open modifiable tools, Alevizou and Forte (2010) describes an “open participatory learning ecosystem”, and more generally J. S. Brown (2008) conceptualized a “participatory infrastructure”.

### 2.5.3 Theoretical Perspectives From Research on Open Learning

While the social constructivist perspectives of learning discussed at the beginning of this chapter have inspired much of the research on scripting and orchestration, and indeed on learning communities and open learning, there have also been some new theoretical ideas that aim to address learning in the connected age. The most prominent of these is known as connectivism (Downes, 2007; Siemens, 2005), which was itself the topic of the first MOOC (detailed below), which was proposed as a “learning theory for the digital age” (Siemens, 2005). Connectivism posits that learning happens when the learner connects to and feeds information into a learning community, and comes to feel connected to the learning community as a node (varying in size of strength), always part of larger network. This view has received a large amount of attention in the blogosphere, but relatively less in academic circles, however International Review of Research on Distance and Online Learning published a special issue on connectivism in March 2011 (Bell, 2010a).

In the connectivist view, peripheries of knowledge fields are porous, thus learners may traverse networks through multiple knowledge domains. The learning process is defined as the act of recognizing patterns shaped by complex networks, and is both internal, as neural networks, and external, as networks in which we adapt to the world around us (Kop & Hill, 2008; Siemens, 2008). The theory has similarities with other learning theories, such as constructivism, and distributed cognition, but it makes the strong assertion that the neutral structure of a learning and knowing brain is isomorphic to that of a network of learners in the world.

While Connectivism takes the network as its organizing principle, Rhizomatic Learning Theory was inspired by Deleuze & Guattari (1987), using the botanical rhizome as a metaphor for a more open approach to data representation and interpretation, with multiple non-hierarchical entry points. They contrast this to an "arborescent" conception of knowledge (i.e, where a more hierarchical "tree" is the metaphor, with roots, trunk and limbs). Cormier (2008) took these concepts and applied them to digital learning, where curriculum is constructed and negotiated in real time by the participants in the learning process, as opposed to being defined by experts. A rhizome is a kind of a network:

It's just a very messy, unpredictable network that isn't bounded and grows and spreads in strange ways. As a model for knowledge, our computer idea of networks, all tidy dots connected to tidy lines, gives us a false sense of completeness. (Cormier, 2011, para. 8)

In response to the etymology of the word pedagogy in the Greek word *paidagōgia*: "to lead a child", as well as the overwhelming focus on children in the traditional school system in pedagogical research, andragogy has been suggested as a learning theory specifically applying to adults and life long learning. Popularized in North America by Knowles (1975), this field of research focuses on self-directed learners with strong internal motivation and a need for life-relevant skills and knowledge. Inspired by andragogy, but criticizing the fact that is is usually centered around a skilled facilitator, peeragogy (or paralogy) offers a theory of peer-learning and teaching that addresses the challenge of peer-producing a useful and supportive context for self-directed learning.

The learning theories and frameworks above have a few similarities. They differ in theoretical depth and explanatory power, but they all aim to explain emerging forms of collaborative learning among self-driven adult learners outside of a formal education system. They have generated enthusiasm and interest within the exigent communities of open learning activists and collaborators, but fairly little interest in traditional academic circles. They focus on different metaphors, and there are substantive epistemological and theoretical differences between them. However, to a large extent they can also be seen as organizing labels for communities, and several have prompted large-scale collaborative approaches, such as the numerous "cMOOCs" that explicitly explore both Connectivism and Rhizomatic learning, and the project to write a Peeragogy handbook (Alexander et al., 2012).

#### 2.5.3.1 cMOOCs

One early example of a MOOC reported by McAuley, Stewart, Siemens and Cormier (2010), was a course with 25 registered students at the University of Manitoba, but that was otherwise open to the wider public. The course topic was the learning theory of Connectivism (described above). The large interest in the topic and a course taught by two foundational thinkers led to a record (at the time) 2,200 learners signing up. Continuing the trend of distributing learning across multiple Web 2.0 platforms, this course put less emphasis on the whole course learning together as a group, and more on self-organization and emergence. Individual communities, linguistic, interest-based, or even tool-centered (Second Life, for example) groups were encouraged, and one of the main roles of the moderators was to help good ideas bubble up and be shared with the whole community.

One community member, Dave Cormier, invented the term Massively Open Online Course (MOOC), to describe the course phenomenon, and a number of these early MOOCs were subsequently run by the original team and other groups (Cormier & Siemens, 2010). This inspired a nascent research program around open and distributed courses, with a theoretical foundation in Connectivism and Communities of Practice (Kop & Hill, 2008) as well as ample citations of the research literature on distance learning.

#### 2.5.3.2 cMOOC research

Those early Connectivist MOOCS came, in short order, to be referred to as “cMOOCS,” in part to distinguish them from subsequent forms of MOOC that were inspired by somewhat different goals or motivations (discussed below). A number of studies performed post-hoc analyses of the cMOOCs, typically employing surveys, participatory ethnography and multi-platform data mining. Presaging the current concern with MOOC completion rates and dropouts, several of these studies focused on the distinction between active participation vs “lurking” (reading but not contributing), as well as an interest in the affordances and challenges of different social platforms employed (personal blogs, discussion forums, wikis, Twitter, etc).

For example, Kop, Fournier, & Mak (2011) studied two different cMOOCs, finding that only a small group of participants actually produced content, and a much larger one lurked, or consumed content. This insight was connected this with the very different levels of social presence and trust enabled by different software platforms (e.g., blogs, forums, Facebook). It was found that some participants were more comfortable in certain places than others, and some had more need for trust than others.

Mackness, Mak, & Williams (2010) studied the low percentage of active participation (approximately 14%) in the initial cMOOC, questioning whether there should be a notion of "free riders" or "novice MOOC behaviors." Observing that sharing requires trust, this study found that many participants chose to organize in small, safe groups, loosing much of the value of the heterogenous network. The study also notes that when the principles of MOOC learning (i.e., autonomy, diversity, openness and connectedness) were more overtly expressed and sustained throughout the course, the concomitant lack of structure and support served to limit participation for many.

However, other researchers have challenged the idea that lurking behaviour constitutes failure on the part of course designers or students. Citing the learning sciences literature, Kop (2011) proposes that four categories were key to social learning: aggregating, relating, creating and sharing. This study found that while most cMOOC participants did not fulfill the requirements of these categories, they still reported satisfaction and learning gains. In fact, participants reported that much of the benefit derived from cMOOCs came from building their personal learning environments and nurturing their networks—actions that would have benefits far beyond the course, but which were mostly invisible to course organizers and other students.

In my own report on a Peer2Peer University course (Håklev, 2011), I also noted how a learner who was not signed up for the course and had followed along without saying a word (i.e., lurking) reported an positive learning experience—one that had made "a significant impact on his life." This outcome would not have been visible to anyone else without a survey that had specifically targeted such peripheral participants. McAuley et al. (2010) also mentioned the benefits gained by cMOOCS from having many lurkers, as well as the potential benefits for lurkers.

### 2.5.3.3 Critiques of cMOOCs

McAuley et al. (2010) criticized the Connectivist perspective, noting that according to the theory, characteristics of "successful learners" include very high levels of autonomy, a willingness and capability to take open positions, and to critique others publicly—all traits, they observed, that are traditionally associated with privilege. Networks have power dynamics, and it is not equal who are listened to. This is also noted by Kop (2010), who cites research by Barabasi on the mathematics of distribution of nodes in a network, and the prevalence of so-called "supernodes", which indicates an absence of democracy, fairness and egalitarian values on the web, and the importance of so-called "information brokers".

Several papers pointed out the difficulties learners had in dealing with the large amounts of information and interaction in cMOOCS, without much preparation or support. These studies (e.g., Mackness et al, 2010; Bell, 2010b) point out that students' common defence mechanism against confusion in large groups and unstructured contexts is to either disengage, or to find a small peer-community that can provide mutual support and structure—drastically reducing the amount of information exchanged. Bell (2010b) warned that this tendency would work against any goal of forming new or emergent connections amongst participant, thus losing much of the initial value of heterogenous networks.

Social interactions, cliques or small group dynamics, politics are all topics that have been recently explored in relation to MOOCs. Mackness & Bell (2015) investigated "the dark side" of a rhizomatic MOOC, where a number of people found the experience "demotivating, demoralizing, disenfranchising, and even disturbing" (p. 34). They also raise important ethical questions around treating students like "lab-rats" in experimental educational settings.

### 2.5.4 xMOOCs

Beginning with a few experimental courses in machine learning and artificial intelligence offered by Stanford professors in 2011, a new kind of MOOC concept emerged, with new, special-purpose platforms such as Coursera (a Silicon Valley startup) and EdX (a non-profit collaboration between MIT and Harvard). These platforms were used to support efforts from established, elite universities, and the course delivery model centered around short videos (inspired by Khan Academy), quizzes, discussion forums, and some peer-review features (Hollands & Tirthali, 2014).

To distinguish these new efforts, whose organizers and the media also referred to as “MOOCs”, from the tradition of connectivist cMOOCs, researchers began calling them “xMOOCs.” Many of these initial courses were massively popular, and the enormous number of learners (in the tens of thousands) as well as the accessibility of all their interaction data led to a large interest from the learning analytics research community, as discussed in the following section.

There have also been some experiments with designing MOOCs that challenge the traditional model, both technologically and pedagogically. This has been somewhat hampered by the fact that MOOCs are typically hosted on large platforms that are outside of the control of the researchers. However, some MOOC platforms are beginning to add rudimentary tools for creating distinct experimental conditions, and a group of researchers known as Discussion Affordances for Natural Collaborative Exchange (DANCE) are working with the EdX platform specifically to integrate CSCL research (Rosé, 2015).

A number of studies have looked at designing better peer-review systems, as well, such as the PeerStudio platform (Kulkarni, Cambre, Kotturi, Bernstein, & Klemmer, 2015). Others have designed highly social platforms that are connected with the traditional MOOC platforms, such as the ProSolo system from the Data, Analytics and Learning MOOC (DALMOOC) (Ferschke, Howley, Tomar, Yang, & Rosé, 2015; Ferschke, Yang, Tomar, & Rosé, 2015).

A course delivered on the Coursera platform called Modern Poetry course attempted to recreate the “seminar feeling” of traditional poetry courses by filming the professor in discussion with teaching assistants, encouraging course participants to meet each other face-to-face in locations around the world, and supporting social network communities outside of the course platform (Audsley, Fernando, Maxson, Robinson, & Varney, 2013). Many newcomers have played with the “MOOC” nomenclature, resulting in an alphabet soup of experiments with SPOCs (Small Private Online Course), DOCCs (Distributed Online Collaborative Courses), and BOOCs (Big Open Online Courses) (Hickey, Kelley, & Shen, 2014).

Much of this research could best be considered as falling within the traditional domain of Scholarship of Teaching and Learning, where instructors experiment with new models based on their own experience in teaching a course, and their own deep understanding of the domain model of their subject. The designs are rarely informed by learning theories or principled approaches to pedagogical design. In addition, the current large MOOC platforms severely limit the design space for course authors, who have the choice between either bolting-on external functionality to existing platforms, or building their own new platforms from scratch—a resource intensive prospect that also loses the advantage of having their course listed on a major platform.

## 2.6 A Role for Learning Analytics

Traditionally, most CSCL studies have had to choose between gathering very high fidelity data on small group interactions in lab settings, or lower fidelity data on students and groups in authentic courses and contexts. Recent advances in learning analytics, and the emergence of large-scale online learning scenarios, offer new opportunities for CSCL research. In particular, the growing interest in large-scale and ubiquitous data (e.g., from MOOCs, described above, or from government databases) has brought together researchers from educational data mining, artificial intelligence in education and learning sciences in the newly minted field of learning analytics (Siemens, 2012; Duval & Verbert, 2012).

### 2.6.1 In the Online Space

Online learning environments are a compelling source of data for learning analytics approaches because of their ability to automatically capture detailed traces of student behaviour. Capturing online discussions through text chat or discussion forums obviate the need for expensive transcriptions, and embedded metadata enable the derivation of sophisticated analytic constructs such as social-network graphs (Laat, Lally, Lipponen, & Simons, 2007; Yoon, 2011), visualizations of semantic growth over time (Chen, 2014; Teplovs, 2010), or sequence-based analysis (Chen & Resendes, 2014).

In the online realm, MOOCs offered by an increasing number of institutions offer researchers access to tens of thousands of learners all going through the same learning experience (Kay, Reimann, Diebold, & Kummerfeld, 2013; Reich, 2015). Such quantities of data have led to advanced in machine learning approaches and data visualizations (Agren, 2014).

Initially, much of the research was based on post-hoc data analysis of existing courses motivated by the sheer amount of data (and hence, the implicit statistical power, see Reich, 2015). These studies often employ machine learning and statistical methods to understand student behavior, or generate predication models (Veletsianos & Shepherdson, 2015). Such quantities of data have led to advances in machine learning approaches and data visualizations (Agren, 2014), however research is hampered by a lack of well-defined methods. There is also a need for standards of significance; given the large number of data points, algorithms could result in patterns and trends that are statistically significant, but might not have much real meaning.

### 2.6.2 In the Physical Space

Recently, there has been some effort to apply learning analytics to the realm of traditional classrooms, given the increasingly widespread availability of personal tracking tools and handheld student applications (e.g., “clicker” systems). Kim, Bae, and Jeon (2009) and Jermann, Mullins, Nüssli, and Dillenbourg (2011) describe the use of eye-tracking approaches to study individual or dyadic engagement. Raca, Tormey, and Dillenbourg (2014) developed a system for tracking gaze and body motion of individual students in a lecture hall, using cameras and computer-vision. They found that determining attention-level based on an individual person’s gaze is difficult, but when the class is studied as a system, there is a measurable lag between the time when attentive students shift their gaze in response to the teacher, and the less attentive students shift their gaze—presumably in response to having noticed their fellow students’ shift. The authors observed that this measure could be a reliable proxy for attention, and could potentially be reported back to the teacher in real-time.

Other approaches have used individual body-worn sensors that were once only accessible to laboratory applications, whereas today’s students often carry sophisticated networked sensors in their phones, watches or other devices, capable of measuring location, pulse, movement and other indicators. Shoukry, Göbel, & Steinmetz (2014) surveyed a number of experiments that integrated physical feedback into learning analytics, such as electroencephalograms (Letourneau, 2013) and emotion sensors (Arroyo et al., 2009).

## 2.7 Research Plan

Despite the many critiques that are perhaps rightfully leveled towards MOOCs concerning their high drop-out rates and simplistic pedagogical approaches, Shapiro (2016) identifies the MOOC phenomenon as a watershed event, as it illustrates three things: (a) a massive public demand for expert-led learning of academic ideas; (b) that many academics are eager to experiment in sharing their ideas and approaches with the public; and (c) that university administrators, capitalists, and the popular press are willing to endorse, sponsor, advertise these experiments.

Thus, rather than dismissing the MOOC phenomena as a passing fad, it should be seen as an opportunity for the learning sciences. Making progress in research on learning at scale can promote a wealth of innovation and powerful new contexts for basic research on the nature of learning, on scripting and orchestration, technology scaffolds and many other topics.

This dissertation applies the KCI framework described above, building on an existing higher education course design (i.e., the pre-service teaching course described above, in the topic of "integrating technology and inquiry into classroom instruction"), to create pedagogical scripts for a new MOOC of the same topic. It also leverages new information and communications technologies as a means of orchestrating that script. Thus, the research will make new contributions to both the scripting and orchestration of large open course designs. Specifically I seek to address the following research questions:

3. How can the pedagogical perspective of knowledge communities be applied in the design of scripts for large open learning courses like MOOCs?
    a. What opportunities can be gained for collaboration, interactive media, knowledge pooling (i.e, "wisdom of the crowd")
    b. How can the diversity of participants' background and interests be a productive feature?
    c. How can we enable rich small-group collaboration and orchestration amidst a larger course population of thousands
4. What is the role of technology in the orchestration of large open courses like MOOCs
    a. How does the choice of platform interact with available course activities?
    b. What technology features are well suited to supporting a community of learners' approach?

To address these questions, I will first scale up and implement the existing pre-service teaching course that has been serving cohorts of 25 to a dramatically new level of 80 students. This effort will then inform the further scaling of the design – including both pedagogical script and technology environment – of an enhanced MOOC serving thousands of in-service teacher participants.

# Chapter 3.
# Methods

## 3.1 Introduction

This chapter presents the methodology that guided this design-based research project. It begins by introducing the theory of Design-Based Research (DBR), which is the central methodological approach employed, including some review of prior design-based studies of KCI. It then presents an overview of two major iterations of this work: one university course for pre-service teachers that applied KCI as a framework for scaling to a size of 75 students, and the second a MOOC that further scaled that design for a community of hundreds of in-service teachers. Each iteration is presented in terms of its research setting, participants, the co-design team, data sources and anticipated methods of analysis. The chapter closes with a discussion of ethics, and my own role as a researcher in this study. Specific methods, including materials and procedures, for each of the two iterations are discussed in detail in chapters 4 and 5, respectively.

## 3.2 Design-Based Research

For the Learning Sciences to go beyond developing theoretical models of human cognition, we must achieve practical designs that can be implemented in authentic "real world" situations (A. L. Brown, 1992). Classroom learning is one such situation, with a large array of uncontrollable variables and constraints, including limited instructional time, curriculum content coverage, interruptions of schedule, the physical organization of the classroom, teacher and student cognition, and many other factors.

To address this, researchers have advanced a design-based research methodology, with reference to fields like aeronautics or artificial intelligence, which make their advances through the reification and testing of conjectures in the form of authentic designs (Collins, 1992; Sandoval, 2004). This approach tends to focus on the application of theoretical principles in authentic designs, rather than the testing of hypotheses in controlled experiment, and includes a strong value of heuristics of practice (Laurillard, 2012). Varyingly referred to as design research (Collins, Joseph, & Bielaczyc, 2004; Kelly, 2004), development research (van den Akker, 1999), or design experiments (Brown, 1992; Cobb, Confrey, Lehrer, & Schauble, 2003), this approach has enjoyed great success in responding to the complexity of learning in authentic situations. Anderson and Shattuck (2012), and McKenney and Reeves (2013), are two reviews that explore the most cited design research articles.

Bereiter (2002) describes design research as "the research that produces innovations and sustains their development" (p. 9). According to Collins et al. (2004) this approach has the following characteristics: (a) it focuses on progressive refinement of an innovation, (b) it attempts to refine both theory and practice through this iterative design, and (c) the evaluation methods are multi-faceted and evolve as the design evolves. Some typical challenges include (a) lack of control of variables, (b) the generation of a huge corpus of data, (c) the need to coordinate the work of many people at once, and (d) the need to consider the interpretive bias of the researcher.

A. L. Brown (1992) introduced the notion of Design Experiments for education, where the researcher embeds his or her ideas within the messy, authentic context of real-world classrooms. In such an environment, it is not easy to control for specific experimental variables, and indeed one must often change multiple variables simultaneously. Hence, theoretical conjectures about learning and instruction are reified through a design process, then enacted in the authentic context of a real-world classroom. The resulting design and enactment provide a wealth of data that can be analyzed to address the core research questions.

This perspective of design experiments differs slightly from the iterative process of design-based research, in that the outcome of the research can be a single case that is evaluated, with iterative implications for the theoretical conjectures, but not necessarily iterating again on the design. The outcome of such analysis could certainly inform revisions or subsequent research questions, but these iterations are not necessary for the work to qualify as a design experiment. Several prominent research programs in the learning sciences have used the design experiment methodology. Notably, Sandoval's (2004) notion of Conjecture Mapping allows for either single or multiple iterations. Cobb (2001) introduces the notion of micro-cycles within a single design iteration, and others have suggested the value of using a single design in multiple contexts (Hmelo-Silver, Liu, Gray, & Jordan, 2015; Puntambekar, Stylianou, & Goldstein, 2007).

The present research includes aspects of single-iteration design experiments, where each of the two courses—the large lecture course for pre-service teachers, and the MOOC for in-service teachers—can be thought of as single designs that make theoretical conjectures real and that can be analyzed in their own right to gain insight into our theoretical conjectures about learning. However, there is also a strong element of iteration, in the sense that the pre-service course was directly informed by its antecedent design (a smaller elective course for pre-service teachers), and in turn informed the design of the much larger MOOC. Hence, the paradigm of Design-Based Research is quite broadly construed and applied within the learning sciences, and this study employs several variations of design-oriented methodology.

In design-based studies of educational innovations, the unit of analysis is often focused on aspects of student learning or engagement, teacher practice, curricular features, or any combinations thereof (D'Amico, 2005). These studies typically focus on some curricular innovation, such as a sequence, a pedagogical approach, a technology-enhanced learning environment, or even the physical classroom environment—anything that can be understood and improved through the application of principles in the design.

In designing an educational innovation, researchers typically engage in a number of stages, beginning with articulating high level goals and principles, brainstorming approaches, asking questions about the teaching and learning of specific constructs, and how these constructs can be assessed and modelled, and articulating measures for the evaluation that will inform theoretical insights and design refinements (Kelly, Lesh, & Baek, 2014).

An initial design is created that captures a set of theoretical principles or conjectures (Sandoval, 2004, 2014). This is then deployed in an authentic learning context, and evaluated in terms of the guiding principles. The design could then be refined based on this analysis or the theoretical principles revisited and refined. This iterative cycle could potentially repeat through many versions, potentially advancing the initial design to the status of a scalable, sustainable innovation. However, most design studies do not progress to this extent, and many are focused on micro-iterations within a single major design cycle (Kelly et al., 2014).

Peters and Slotta (2008; 2010b) employed KCI as a theoretical framework to guide the design of a $10^{th}$ grade biology course where students worked collectively to develop a knowledge base about human physiology, and then challenge their peers with inquiry tasks that required them to use the knowledge base as a resource. The researchers worked closely with partner teachers to operationalize the theory into a curriculum that was practically implementable within the learning context, achieved its curriculum goals, and satisfied the theoretical requirements of the research framework.

Peters & Slotta (2010b) describe the script for this study, which began with groups of students creating wiki pages of diseases for specific body systems (respiratory, circulatory, or digestive). 110 students from 5 sections of the biology course were assigned to one of the three body systems, and were scaffolded by a a wiki page template to ensure that all disease pages contained certain required elements (i.e., causes, symptoms, connections to other body systems). After several days creating disease pages, with each class section building on the products of the previous, the community had developed a substantive wiki of more than 25 diseases. As an inquiry project, the students then created disease "challenge cases" from their body system, writing up the symptoms of fictional characters to challenge their peers (from other body system groups) who needed to use the wiki to solve the case.

Peters and Slotta (2010a) analyzed the knowledge building processes (e.g., students' co-editing of the wiki) and the outcomes (e.g., the quality of student wiki pages) as well as learning outcomes for the course (the final exam scores). Process-data was acquired from the wiki revision history, logs of students' online activity, student and teacher interviews, and field-notes. Outcome measure included a content analysis of student inquiry projects, and a comparison of student exam scores against those of previous years (who took the same physiology exam).

The Peters and Slotta (2008) research, as well as subsequent work by Najafi and Slotta (2010) established a standard for design-based research for KCI studies involving three distinct analyses. First, the *design* itself is analyzed in terms of adherence to the model (i.e., the theoretical principles of KCI). Second, the *enactment* of the design is analyzed to determine the level of adherence to the design. In other words, it would be easily conceivable that a quality design could be achieved, but something entirely different enacted when it came time to implement that design. A third analysis is concerned with student learning (Slotta, 2014).

## 3.3 Pre-Service Course

### 3.3.1 Research Context

From 2005 to 2012, a university-level course called "Technology, Curriculum and Instruction" was offered as a "related studies" elective course for pre-service teacher candidates at the

University of Toronto. The course was designed as a seminar-style course for class sizes of approximately 25-30 students, and was taught nearly a dozen times by Dr. Jim Slotta. As he had been working on the KCI principles, Professor Slotta designed the course to instantiate his own theoretical ideas, engaging students as a collective community that created a persistent knowledge base that was passed forward from one semester's cohort to the next. A major inquiry activity of designing a technology-enhanced inquiry lesson was included, which was woven throughout the course, and made use of the knowledge base as a primary resource.

In 2013, the minimum class size was increased to 75, as a result of program changes, presenting an opportunity for the present research to iterate on this design, in alignment with KCI, to triple the scale of the course. As described in Chapter 4, this new scale presented substantial challenges, but the size of the student community also opened up some interesting new possibilities. Technology would also play an important role in helping to orchestrate the design.

The first iteration of this new, larger course was designed in Fall of 2013 and enacted in Spring of 2014 (January-April). Over the summer, we refined the design and improved on the technical tools to prepare for the second iteration, which occurred in Fall of 2014 (September-December). The two iterations were quite similar, overall, with the second benefiting from our improved technologies and slight adjustments to the materials and procedures. For purposes of clarity, this thesis will present the second, final design of the course, and analyze its enactment and fit to KCI in Chapter 4.

The course met for four hours each week in a large computer lab, which had desktop computers on every table, and a partition wall in the middle that could be used to separate the room into two classrooms. Together with another computer lab next door, we were able to fluctuate between having all the students in one large room (served by two mirrored projectors), or split into three groups (two in the divided large lab, and one in the smaller lab).

### 3.3.2 Co-Design Team

The co-design team consisted of the course instructor, Dr. Jim Slotta, who is also my PhD supervisor, and myself. I joined Dr. Slotta as a co-designer, and we met weekly for six months in fall 2013, preceding the launch of the first revised course in January 2014. We focused on a principle-based design process, based on the Knowledge Community Inquiry framework, and also considered both thematically appropriate contents, and technological solutions that would let us continue to implement the valuable aspects of the existing course, with a much larger student population.

While the course ran, I acted as a course teaching assistant, and we continued meeting once or twice weekly to revise the course design, and reflect on how the course was unfolding. Over the summer of 2014, we met regularly to discuss refining the course offering, and we then together offered the course again in September 2014.

During the two course sessions, we regularly invited other graduate students and recent graduates to assist us in the course, and we also discussed and received feedback on the course design and implementation at our weekly lab group meetings.

### 3.3.3 Participants

The students in the course were teacher candidates who followed a one-year Bachelor of Education program, divided into Primary/Junior, Junior/Intermediate and Intermediate/Senior strands. Both the Winter 2014 and Fall 2014 course offerings had 74 students, all of whom were Bachelor of Education (B. Ed.) students. To be accepted to the Bachelor of Education program, the students would have had to first complete a four-year Bachelor program or the equivalent. The B. Ed. program is one-year long, and includes general pedagogical and psychological theory, subject specific methodology, two practicum placements, and a related studies course. Students also have one interest-based elective, for which our course served as an option, for any students who wanted to learn more about the use of technology and inquiry in their teaching practice.

One of the challenges with designing the course was that our students varied in terms of the age level and topics of their teaching interests, ranging from kindergarten to high school, and from arts to science to automotive technologies. The two student cohorts (Spring and Fall) were roughly similar, but one difference was where, in their program, the course occurred. Since the program begins in the Fall, those students who took our initial offering in the Winter term were in their second semester, and thus had completed a number of courses, including lesson design and pedagogical theory, in the previous term, as well as a 5-week practicum experience. Hence, they were closer to the completion of the program, which also carried attendant concerns about finding jobs. Those who took the course in our second offering, in Fall, 2014, were just starting their program, had fresh perspectives but less experience with topics of pedagogy and practice.

The specific design of the course will be presented in Chapter 4, including all materials and activities, and a detailed description of the scripting and orchestration.

## 3.4 MOOC

### 3.4.1 Research Context

EdX is an online learning platform that has grown to be one of the most popular for Massive Open Online Courses. Anyone can sign up to participate in courses, with no pre-requisites for participation. Most courses are free of cost, but some courses (including the one in this study) offer the option of receiving a verified certificate, which essentially confirms that a person has performed the minimum requirements to pass the course. Courses are offered through the EdX website, an instantiation of the open-source OpenEdX software. Once enrolled in a course, the EdX software presents a sequences of activities, typically grouped as weekly themes, with a focus on videos, text and quizzes. There is also a possibility of integrating external tools, which we used in our study to design a more complex sequence of activities, based on a persistent student model.

In 2015, we designed and enacted the MOOC "Teaching With Technology and Inquiry: An Open Course For Teachers" (INQ101x), specifically marketed as a professional development experience for current in-service teachers. The course ran for six weeks in July and August 2015, and also featured several weeks of pre-course activities for early registrations. The course themes and pedagogical design were based on the OISE pre-service course described above, but heavily modified to fit the MOOC format and needs of MOOC learners.

The design and enactment of this course were seen from the outset as part of our design-based research, extending our understanding of how to scale a KCI course. Our strategy was to directly map the design of the pre-service course onto our design of an in-service professional development course. In essence, it would be the same course, but extended to a different context, accommodating in-service teachers instead of pre-service teachers, and responding to the unique affordances of online learning and of MOOCs in particular. The specific design of MOOC activities and materials will be presented and analyzed in Chapter 5.

### 3.4.2 Co-Design Team

This MOOC was a collaboration between Professor Slotta's research group at OISE, and administration and teachers from the University of Toronto Schools (UTS), a high school affiliated with the University of Toronto, led by school Principal, Dr. Rosemary Evans. Drs. Slotta and Evans were billed as co-instructors of the course in our promotional materials, with the aim of establishing a dual perspective of research and practice. A number of graduate students and affiliated researchers contributed to the design of materials, particularly the videos (i.e., writing scripts, recording, and editing), the visual design of the various Web pages, and the advertising elements.

While a dozen or so researchers, teachers, and administrators from OISE and UTS were part of the high-level discussions and framing of the course, the detailed design of the pedagogical scripts, including reflection and discussion prompts, and technological scaffolds were the topic of this study, and hence a continuation of the design-based research in the previous iteration (i.e., the pre-service course described above, and detailed in Chapter 4).

Following the design of the pre-service course, our intent was to add a layer of Special Interest Groups (SIGs) within the MOOC, allowing a reduction in size and increase in focus for any student's cohort (i.e., for online discussions and other inquiry activities). To support the SIGs, we invited various members from our design team and wider community who had expertise within certain disciplines (e.g., arts, history and humanities, math and science) to serve as participant instructors, with the aim of ensuring that each SIG had active instructor who was oriented specifically to that SIG.

The co-design team met regularly for six months before the course began, and several times per week during the running of the course. For the month preceding the launch of the MOOC, and during the MOOC itself, I was living in a small Chinese village, but remained in close contact, and even developed substantive content and functionality from abroad. My living in China was not a factor in my ability to participate in the design or enactment of the MOOC, which is itself a remarkable testimony to the present state of internet technology capabilities, as well as the EdX platform. The technology platform is discussed at some length in Chapter 5.

### 3.4.3 Students

The EdX platform that hosted the course is a highly trafficked website, which actively promotes new courses to a wide community of potential participant based on their previous interests. However, we consciously wanted to reach beyond “habitual MOOC-students” to target specifically in-service teachers, most of whom had probably never taken a MOOC before. We therefore actively marketed the course through social networks and mailing lists that directly target teachers. MOOC students come from around the world, and our MOOC had students register from 169 different countries, with the most frequent countries being the US, Brazil, India and Canada. Students’ median age was 34, and 50% of students had a Masters or PhD.

In total, 7.995 students added the course before the final course deadline, of which 118 paid for the verified certificate option. However, only the students who completed the interactive registration, and accessed some of the interactive components, will be analyzed in this study. By the first course deadline, 1,319 students had registered in the interactive system, ultimately growing to 1,755 students by the final course deadline.

## 3.5 Data Sources

### 3.5.1 Questionnaires

In the pre-service course, students filled out an online questionnaire during the first class session with questions about demographics, teaching interests (subjects and age groups), as well as experience with and beliefs about social media and collaborative learning. All the MOOC students who participated in the interactive activities (i.e., the 1,755 defined in the previous section) completed a questionnaire about their teaching interests (topics and age-groups), and their beliefs and experiences with collaborative learning and social networks. We also asked students to fill out a questionnaire at the end of the course, but this received quite a low response rate and was not analyzed. A copy of the questionnaires can be found in Appendix B for the pre-service course and Appendix H for the MOOC.

### 3.5.2 Artefacts and Learning Traces

In both the pre-service course and the MOOC, students generated digital artefacts, of which some were individual (e.g., the personal reflections), but most were collaborative in nature, such as online discussions, wiki pages, design documents and group presentation plans. All student artefacts were captured, including resources and tags, lesson design iterations, lesson design peer review comments and individual reflections. In addition to student artefacts, we also captured a range of process data, such as when students accessed specific wiki pages, reviewed specific resources, and so on.

The two main technology platforms used in the pre-service course were a wiki system called Confluence and a live collaborative editing system called Etherpad. Confluence wiki pages retain histories of all changes, denoted by which student made the change and the content of their modification. Etherpad also keeps a full document history, but does not keep track of who makes the changes (Etherpad was mostly used in class, often with a single scribe for a group, so specific authorship is not so relevant). The MOOC also used Confluence and Etherpad to support the lesson design project, but the course material was hosted on the EdX platform, and there were a number of custom interactive components developed and served from a separate internet server.

## 3.6 Analysis Approach

KCI offered a theoretical model to guide the design of the two curricula, and was therefore also the framework that informed the analytic design. As described above, a normative approach for analyzing KCI designs involves the analysis of both the design (i.e., in terms of whether the design implements the KCI model) as well as the enactment of that design (i.e., if what was designed was actually enacted with fidelity, or if any deviations actually brought the design closer or further away from the KCI principles). For the analysis of the designs, I captured the various scripts and sub-scripts using graph representations, which were inspired by Dillenbourg's (2015) Orchestration Graphs, introduced above in Chapter 2.

To examine the enactment of the courses, I analyzed student artefacts and learning process traces, examining the success of various design elements. For the pre-service course, I examined the patterns of user contributed content, to see if they were aligned with the principles of KCI, then discussed the general adherence to KCI. For the MOOC, I sought to understand the importance of different orchestrational planes (individual, small group and whole class), as well as the transition between activities using scripting operators and boundary objects. I also examined the orchestrational roles of the instructor, and of the technological environment.

## 3.7 Ethics

Ethical approval for this research project was obtained from the University of Toronto's Office of the Vice President, Research in 2013 (protocol #29492, "Fostering knowledge communities in higher education"). This protocol was renewed in later years, and substantially amended in the summer of 2015, expanding the scope to cover research on the MOOC.

### 3.7.1 Informed Consent

Students in the Pre-Service Course were given an informed consent document, see Appendix A. On the first day of the course, I was given time to briefly introduce the research project and hand out the consent forms to students, while clarifying that participation in the research project was completely voluntary, and that non-participation would not in any way impact the students' learning or grades. To clearly separate the roles and responsibilities of the researcher from that of the course instructor, it was also important to inform students that no data analysis would happen before the final grades were assigned. Students who did not sign and return their consent forms had their data excluded from all subsequent data analysis.

In the case of the MOOC, the students are not enrolled at the University of Toronto for any course credit, and are therefore not considered to be in a power-relationship or dependency with the instructors. All students were asked by EdX to consent as research participants when signing up as an EdX participant, and informed that their anonymized participation data (i.e. not personal information) would be available to EdX and the MOOC organizers for purposes of research. Because the MOOC was offered officially through the University's Office of Online Learning Strategies which extracted the data from EdX (i.e., ensuring that all data was properly anonymized) it was not deemed necessary to ask MOOC students for any further consent.

### 3.7.2 Data Management

Learner artefacts and activity logs from online platforms (i.e., for the pre-service course and any non-EdX MOOC software) was stored on enterprise-level secure servers hosted by the Education Commons at the Ontario Institute for Studies in Education, located at The University of Toronto. All MOOC data was stored at the University of Toronto's Office of Online Learning Strategies. Upon importing and cleaning, all data from Education Commons servers was immediately stripped of identifiers leading back to students' identities, and was assigned unique arbitrary identifiers to allow linking different data sources together.

## 3.8 Role of the Researcher

The design of the pre-service course was the result of a collaborative process between myself and the course instructor, where we met weekly for six months prior to the course. While the course was running, we continued meeting to debrief and adjust the script according to the situation in the class. During the class sessions, I gave occasional plenary announcements about technology and research participation, and also led part of the class during the portions when the class was split in three main groups (detailed in Chapter 4). I also developed and managed all of the custom technology (scripts) to ensure that different Web 2.0 platforms used "talk to each other".

The MOOC was developed in collaboration between Professor Slotta's research group and the University of Toronto Schools, as described above. My role in the team was primarily focused on the interactive and pedagogical scripting aspects of the curriculum, while other team members focused more on the contents and materials (e.g., the videos) for each week. Together with Dr. Slotta, I developed the curriculum script as a primary component of this research, consisting of interlocking micro-scripts, including activities for reflection, inquiry and design (detailed in Chapter 5).

I also had the full responsibility for the technology development and support for the MOOC, consisting of a stand-alone server with numerous interactive interfaces, and a learner model implemented as a database that was integrated seamlessly into the EdX platform. I participated in the MOOC discussion forums, primarily those asking for technical assistance, and also conducted some participant observation in curriculum design groups and SIGs.

# Chapter 4.
# Design Study 1: Pre-Service Course

## 4.1 Introduction

In this chapter, I will present and analyze the design of the pre-service course, called "Curriculum, Technology and Instruction". I will begin by describing the course history and design goals, followed by the design of the course, which comprised a weekly script based on a set of core themes, as well as cross-cutting vertical scripts running through the course. I will describe these elements in detail, as well as the technology that enables them. I will also specify a few experimental scripts we ran to explore orchestration in a scaled up course.

The course, which ran successfully with 75 students in the Fall of 2014, was designed as a set of scripts that were informed by KCI and allowed the class to self-identify and work as a knowledge community. An important product of our design is the identification of key design challenges that helped define important areas of focus. This chapter presents the results of our design study in two main analyses. The first is a design analysis, which presents the overview of our design, and explicates the various scripts that served to coordinate student grouping and activities. The design analysis also identifies the key challenges and presents the scripts by which those challenges were addressed. The second is an analysis of the enactment or orchestration of the course, which examines first whether the scripts were enacted faithfully to their design, and then ultimately whether the enactment led to a successful implementation of KCI for a large lecture course.

## 4.2 Course Design

The objective of the course, titled "Technology, Curriculum and Instruction," is to help students learn more deeply, and help pre-service teacher candidates learn to use technology and inquiry within their instructional designs. Students should gain a deep appreciation for the affordances of various technologies, and how they enable new ways of organizing classes, ultimately helping their own students to learn through inquiry and collaboration, engage with the outside world, express themselves creatively, build, model, and connect their ideas with others.

A key objective is for the learning experience within the course to be constructivist and transferable (i.e., to practice what we preach). Hence, students should engage with inquiry and technology, in order to learn about how they could use it in their own teaching. The true test is not whether students can repeat and analyze theories during a test, but whether they will be able to apply general concepts, and a library of specific technologies and approaches, in their future professional career. To do this, we want to give the students the opportunity to use and experience both technologies and styles of learning, and model the kind of teaching that we wish to teach.

### 4.2.1 The Effects of Large Numbers

The particular form of inquiry-oriented instruction employed in previous versions of this class (e.g., where students were engaged in learning with specific technologies, presenting to their classmates, and designing curriculum lessons), are easier to meet in a small seminar-style class with 15-20 students, than with a large class with 75+ students. Thus, a large part of our design efforts went into overcoming the challenge of letting students experience a "seminar-style" class, despite the large numbers. We carefully designed a consistent weekly experience to minimize confusion and wasted time, consisting of a regular weekly script (i.e., pattern of activities) and a number of cross-cutting scripts that ran throughout the course, connected to each week's theme. We used a hierarchy of groups to subdivide students into manageable units, relevant to their interests, and managed the coordination of these groups and exchange of artefacts through technology-based orchestrations.

While the larger class size was a challenge, it also introduced new opportunities. With a cohort of 75 students, we got a more diverse student body, with a greater range of ideas and perspectives. Moreover, the larger class size enabled us to generate more homogenous small groups, in which students can better translate the abstract course ideas to their individual teaching interests. With the right tool support, we were able to harness the large number of students to brainstorm, sort and process large amounts of information. This tension between the things we could do "even though we are many", and the things we were able to do "because we are many", as well as the opportunities of both greater diversity, and greater homogeneity, will resurface when we design the MOOC.

### 4.2.2 Curriculum Themes and Basic Course Structure

In addition to the general design goals, the course was required to address specific curriculum concepts and learning goals. Building on a previous course design (described in Chapter 3), we settled on a set of 6 core themes, that mapped onto the learning goals set for the course: (a) Inquiry and Mind Tools, (b) Collaboration and Peer Exchange, (c) Mobile and Handheld Devices, (d) Tangible and Embodied Learning, (e) Online Teacher Communities, and (e) Ethics and Teaching in the Internet Age, including Equity and Diversity in the Classroom. Students encountered the latter two components after completing a practicum, which gave them a space to reflect on the experiences and challenges they met in their schools.

Designing a 12-week course is different from designing a short and targeted learning intervention, including the need to pursue a number of different goals and projects simultaneously. Our design effort was guided by the previous version of the course, which had itself been designed with specific connections to the learning goals, and also had aimed to achieve some elements of KCI (e.g., a course community, using a wiki for a knowledge base). Hence, we had some foundation, but needed to do a complete re-design given the tripling of scale. As well, this design effort was recognized as being part of the present dissertation. We would be asking students in the course to complete research participant agreements, in accordance with an approved ethics protocol, and we had specific research objectives, as described above. This was a departure from the previous version, which had aimed simply to create a certain pedagogical emphasis (i.e., of collective inquiry), but did not aim to formally achieve or evaluate the KCI model.

Figure 2 presents the basic course design, where each week addressed a particular theme, and was organized according to a recurring pattern or script. The overarching script sought to capture KCI principles, engage students with peers in various small group configurations and activities, and make knowledge accessible from one part of the community to another, and from one stage of the script to the next. Each week began with a homework assignment that set the stage with relevant readings, and individual reflections contributed in the class wiki. Class sessions were 4 hours, with a short break near the mid point, and were structured according to a specific sequence, as detailed below.

Cutting across all weeks of the course were several progressive scripts, including a lesson design activity that was informed and refined according to each week's themes. There was also a collective effort to identify and evaluate technology resources, resulting in a growing wiki that became a resource for designs. These cross cutting, progressive activities can be seen as "macro scripts", and are shown in the figure as vertical ribbons cutting across the weeks.

Hence, the course design can be analyzed in terms of the weekly activity patterns (horizontally, in Figure 2) as well as the more global progressive scripts (vertically, in Figure 2). From an instructional design perspective, this can also be interpreted as a sort of spiral interaction through a recurring pattern of activities, where students and groups increase in their sophistication, with access to a growing personal and community knowledge space.

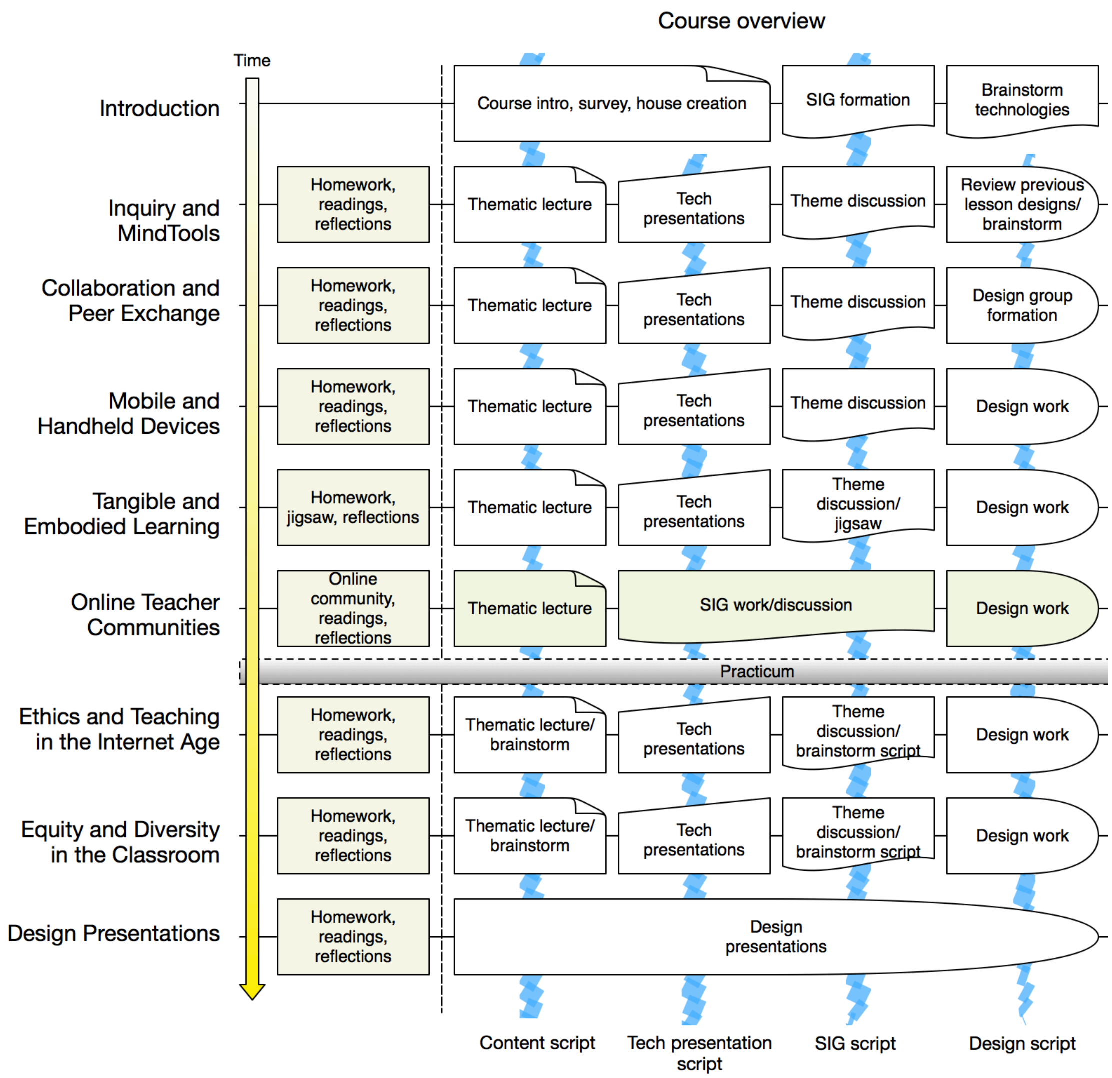



**Figure 2 - Course script overview**

The recurring pattern of each week also served to provide a source of consistency for students in the face of a somewhat unfamiliar way of learning, and to minimize disruption and time spent organizing and grouping students.

### 4.2.3 Setting the Epistemic Context: Week 1

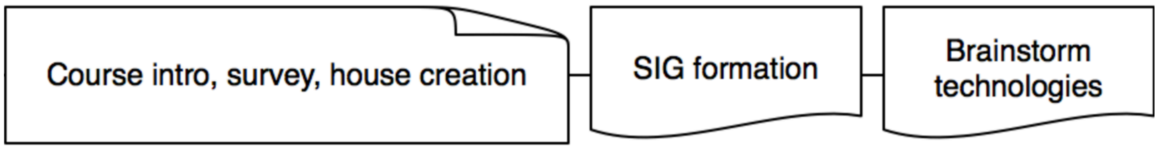



**Figure 3 - First week script**

During the initial class section, we began with an explicit epistemic treatment. While introducing the topic of the class, the instructor emphasized that the class would be living what it was learning, and that we would actively experiment with and gain an understanding of technical tools and approaches that support collaboration and inquiry learning. We would benefit from everyone's experience and ideas, and an important part of the course would be for students to collaborate on building up a community knowledge base, that they would rely on in activities and projects. The class is also one generation in a series, and will benefit from ideas and work that past students have done—and will generate artefacts that will be passed on to future generations.

After the epistemic treatment, and the logistics, the research project was introduced and discussed, and students were asked to sign informed consent documents. Another important aspect of the first day of the course was the group formation (described below).

## 4.2.4 Weekly Script

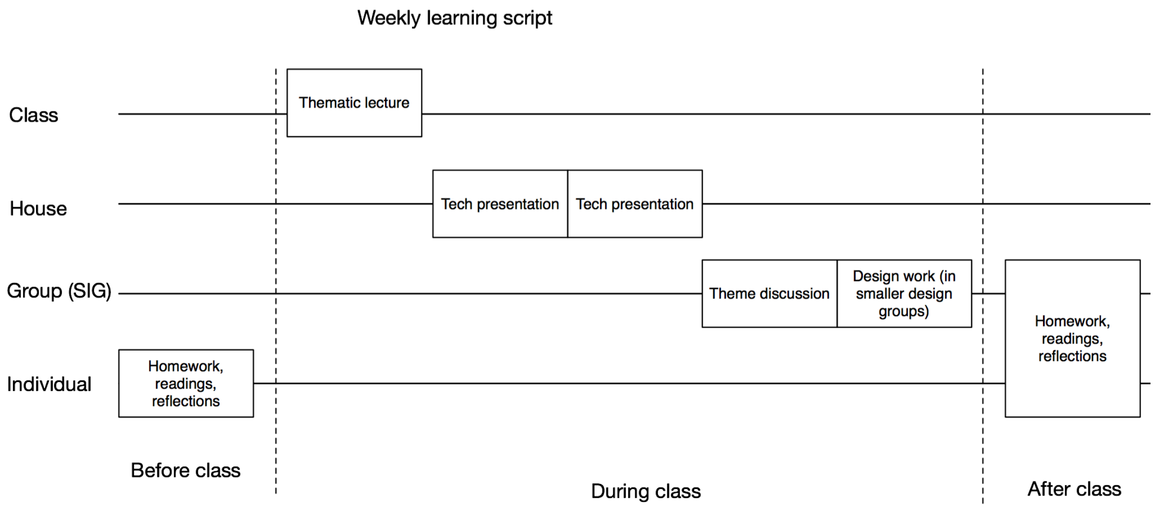



**Figure 4 - Weekly learning script**

The course began in a plenary format, with all the students gathered in the large computer lab. The instructor delivered an introduction to the topic, often providing examples from his own and his colleagues' research, and sometimes engaging the whole class in experimentation or exercises. This lecture was held in an amphitheatre-shaped computer lab with approximately 100 seats, and the instructor was adept at engaging the students with questions, resulting in discursive threads of rebuttal and follow-up.

After the plenary session, the class was separated into three thematic "houses:" (1) secondary math and science; (2) primary grades; and (3) secondary arts, history and humanities. Two houses remained in the main computer lab, with a motorized separating wall engaged to divide the space into two distinct rooms. A third of the class left for a separate computer lab next door.

Thus separated into houses, students engaged in several distinct activities. First, teams of two or three students delivered prepared presentations of particular technologies they had found, with an emphasis on their applicability in inquiry-learning, and the disciplines and age-groups targeted by that house. Where possible, the students were encouraged to include a significant hands-on component, where all the students in the house were involved trying out the technology, using it to fulfill certain tasks, culminating in a concluding discussion (i.e., as opposed to just watching a presentation). At the end of each presentation, students in the house were asked to provide a short online peer review of the presentation. Typically, two such presentations were scheduled for each class session, with a few exceptions (i.e., of either one or three groups). Appendix F presents the full list of all technologies presented, organized according to house.

After the technology presentations, students in each house were further divided into Special Interest Groups (SIGs), organized according to their disciplinary and grade-level emphases (e.g., “middle school science”, “art and music”). Once they had re-seated themselves in SIG groups, students engaged in a guided discussion about the concepts from the weekly theme, and the new technologies presented, with a focus on their own special area of interest. These discussions were guided by a technology environment called Etherpad, a collaborative editing environment that allows multiple participants to co-edit a document. We carefully designed discussion prompts that appeared on the Etherpads. The SIG groups had ongoing access to these discussions, as potential resources within the wider community. Appendix E presents the list of Etherpad discussion prompts, organized by weekly theme.

The final activity conducted in each week was to collaborate in even smaller groups of 2 or 3 members (from within a SIG) to design a technology-enhanced inquiry lesson. Although students were expected to spend significant time outside of class collaborating on the lesson designs, this presented a fixed time when all group members were guaranteed to be physically co-located, and hence supported improved communication and coordination. It also allowed the instructors to provide occasional feedback and guidance, and allowed a number of peer-review and feedback activities, where lesson design teams presented their design-in-progress to other SIG members.

Figure 4 shows a graph of the idealized weekly script in terms of Dillenbourg’s orchestrational planes. While there were a number of weeks that deviated slightly, for various reasons, this script provided a strong underlying structure for the course lessons. Below I will show how these elements form horizontal scripts that run through the course.

### 4.2.5 Integrating the Themes and Supporting Progress as a Community

Each of the activities during a given week can be seen as portions of larger scripts that run throughout the length of the course. In other words, the table in Figure 2 can be read both horizontally and vertically. Horizontally, each week's activities build upon and explore a given topic in increasing depth, supporting students in applying abstract principles to their own teaching topics and age groups, providing opportunities to connect theoretical ideas to pre-existing notions and experience, and moving up Bloom's (1956) taxonomy from information acquisition, through critical consideration and comparison with other previous concepts acquired, to creativity and application. Vertically, several scripts were contrived to help the community progress from one week to the next, weaving in the themes, where possible, and building on the steadily increasing maturity of the knowledge community.

#### 4.2.5.1 Technology presentation script: Building a repertoire of tools

One recurring activity that constituted a vertical progression through the weeks was the creation of a wiki space that gathered, organized and discussed technology resources for the course community. Students were instructed that they would be finding, presenting, and writing about interesting technology resources that would be suitable for inquiry oriented instruction. This included everything from presentation tools (e.g., PowToons) to quizzing and polling environments (e.g., Socrative, Poll Everywhere, or Kahoot), to repositories and collections (e.g., Kahn Academy).

Students were asked to organize themselves into small teams (n = 2 or 3) within houses, and to find technologies that they wanted to present to the other students in the house. It was emphasized that presentations should focus on pedagogical affordances of the tools presented, as well as hands-on opportunities for other students to experience how the tool could be used in learning scenarios. To the extent possible, design presentations were scheduled according to the appropriate weekly themes, and were expected to include some reflection on the connection between the tools and the current theme.

To model the kind of presentations that the instructional team hoped to see, the instructor and teaching assistant gave a model technology presentation during the second week of class. To further support their presentations, and encourage more in-depth consideration of the affordances and design principles of a tool, students were asked to fill out a wiki page for their technology contribution, for which they were provided a template that included a set of prompts. When completed, this page also contained links to the artefacts (such as handouts and slides) generated by the design team, and became part of the public knowledge base. In this way, the students in the class developed a sense of progress as they watched the scope and volume of the wiki gradually increase from one week to the next. Moreover, they were able to go to this wiki as an important resource for their design of a lesson plan (another progressive script, described in a lower section).

#### 4.2.5.2 SIG script: Supporting Special Interest Groups

To enable students to better connect ideas from the course with their own experiences and teaching interests, students were asked to organize themselves (using an Google Spreadsheet to quickly brainstorm ideas and gauge interest) into Special Interest Groups (SIGs) consisting of members who share a common teaching interest (i.e., topic and age level of instruction). These groups were formed during the first class session, after the class had been divided into houses, and were given time to meet during each class session, a place on the wiki to gradually build up a community knowledge base, and inquiry tasks that were to be performed at home between classes.

When SIG groups met during class time, they went to their regular SIG space on the wiki, knowing that it would contain a link to the day's Etherpad document. These documents were automatically generated for each SIG, pre-populated with reflection prompts asking them to connect the weekly theme, and the technology presentations, with their own teaching practices and subject area. After the class, the text from the Etherpads was automatically inserted into the SIG wiki page for that week, allowing a sense of persistence and growth of their SIG wiki space. Other activities conducted within SIGs included occasional continuation of inquiry projects begun in class, as well as lesson design projects, described in the next section.

#### 4.2.5.3 Lesson design script: Developing lesson design plans

The Lesson design assignment served as a major inquiry project and helped to ground the principles and themes of the course, helping students to develop their theoretical and conceptual understandings while also building a repertoire of technologies and approaches to teaching. Students began by reviewing lesson designs by students in past courses, and brainstorming design ideas, with prompts such as "What are topics you know are difficult to teach in your subject area?".

The lesson design teams comprised a subset of SIG members (i.e., there were typically 2 or 3 lesson design groups drawn from any given SIG), and followed a structured process that included new prompts each week that were tied to that week’s theme. These prompts gradually became more complex, reflecting a growing student understanding of epistemological ideas, beginning with surface-level questions about student demographic, topic and approach, becoming more specific with a detailed activity plan and learning goals, and going deeper into questions about pedagogical approach, ethical and equity questions, and finally considering the approach to assessment.

Throughout the course, there were multiple opportunities for feedback and peer review within the lesson design process, occurring both in-class and at home, and including both unstructured discussion and more structured (i.e., scaffolded) written feedback assignments (which were one of the graded elements of the course, see the syllabus in Appendix C), formal graded feedback from instructor at the mid-point, final presentation to the class, and final summative feedback and grade from the instructor.

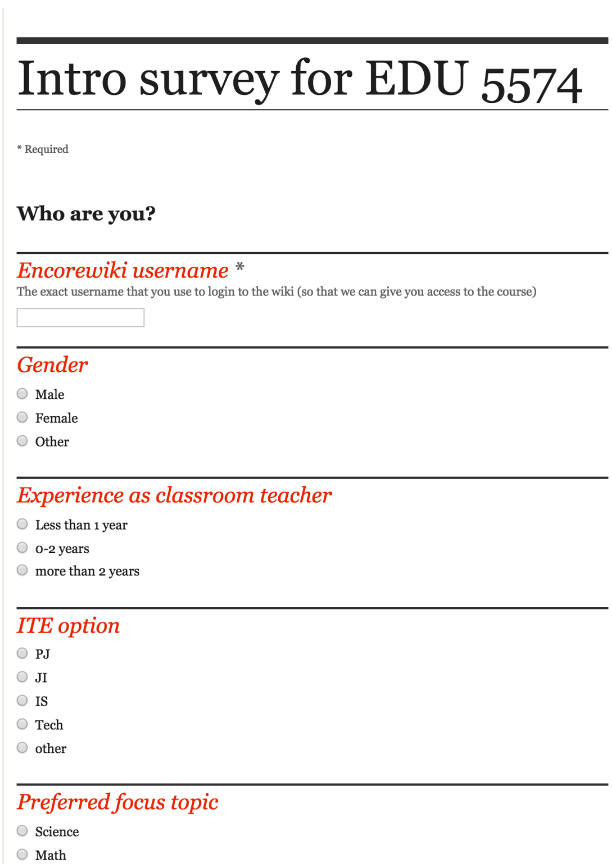
### 4.2.6 Key Design Challenges

A fundamental interest or value of KCI is to support complex inquiry scripts where students are moved seamlessly into various groups, producing and consuming artifacts in concert with other groups. With such an overarching commitment to establishing an nurturing a community oriented pedagogy, we were confronted with several key challenges, which constitute a valuable outcome of the design analysis. These challenges would likely appear as a recurring feature of any course design effort, including our own efforts to scale the KCI scripts of this course to a larger MOOC context (described in Chapter 5). In large measure, these challenges were concerned with the specification and the orchestration of group membership and content creation and re-use, as well as the challenge of facilitating rich collaborative learning in an online environment. These challenges are fundamental to overcoming the challenge of large numbers, and to realizing the benefits of large numbers, as discussed above.

In a course with four hours of physical class time each week, much of the orchestration was done by the instructor during class, asking students to move into groups, or progress to the next activity. Still, we recognized that technological supports would be imperative for smooth coordination of these tasks, including a wiki to coordinate all student contributions, and the integrated use of scaffolding technologies for discussions and group work. Hence, our solutions to challenges below comprised both pedagogical and technological designs.

### 4.2.6.1 Orchestration of group assignment

Due to the large number of students, and the diversity of teachable subjects and target age groups, it was important to split the students into various groups for purposes of the scripts described above (lesson design, technology presentations, etc). The challenge here was to design a meaningful group hierarchy that reinforce students' specific learning goals or that reinforce community and promote learning, and orchestrate the assignment of students to groups in a timely manner. We began with the core organizational construct of three "houses", which were partly a response to the physical limitations of the space (one large classroom that could be subdivided into two, and a second smaller classroom), and available personnel (the two regular instructors, and a visiting assistant). They also served to reduce the class to smaller, more manageable “chunks” that were closer in size to the prior version of the course. This responded to our concern that the intensive pedagogical methods (collaboration, inquiry, discussion and design) would be untenable with a large audience.



Intro survey for EDU 5574

* Required

**Who are you?**

*Encorewiki username* *
The exact username that you use to login to the wiki (so that we can give you access to the course)

*Gender*
- Male
- Female
- Other

*Experience as classroom teacher*
- Less than 1 year
- 0-2 years
- more than 2 years

*ITE option*
- PJ
- JI
- IS
- Tech
- other

*Preferred focus topic*
- Science
- Math

**Figure 5 - Survey for incoming LTI students**

In order to coordinate the grouping assignments, we began in the first class with a survey (Figure 5) that allowed us to gather an immediate (i.e., real-time) sense of the student distribution, and inform our division of the class into three houses with roughly equal amounts of students. Given the distribution key, we were able to use computer scripts to automatically assign students to the correct groups with the correct permissions, based on their survey answers.

Within houses, students self-organized into Special Interest Groups (SIGs) of 3-6 people that shared a common teaching interest (i.e., topic and age level). These groups persisted throughout the term, and each had their own wiki space. Part of the SIG groups' purpose was to allow members to apply the concepts and theoretical perspectives of the course themes to their own specific teaching interests and practices. The SIGs were given time each week for discussions, maintained their own wiki knowledge bank, and participated in knowledge gathering and organizational tasks.

A final group that required definition and orchestration was that of the lesson design teams. These were pairs (or occasionally triads) of students who worked together throughout the course to conceptualize, design and refine a specific lesson targeting technology and inquiry. This hierarchy of groups can be visualized as a nested membership: design teams fall with SIGs, which fall within houses the ultimately belong to the course as a whole — representing an increasing granularity from just a few houses into many groups of decreasing size and increasingly specific applications. See Figure 6 for a visualization.

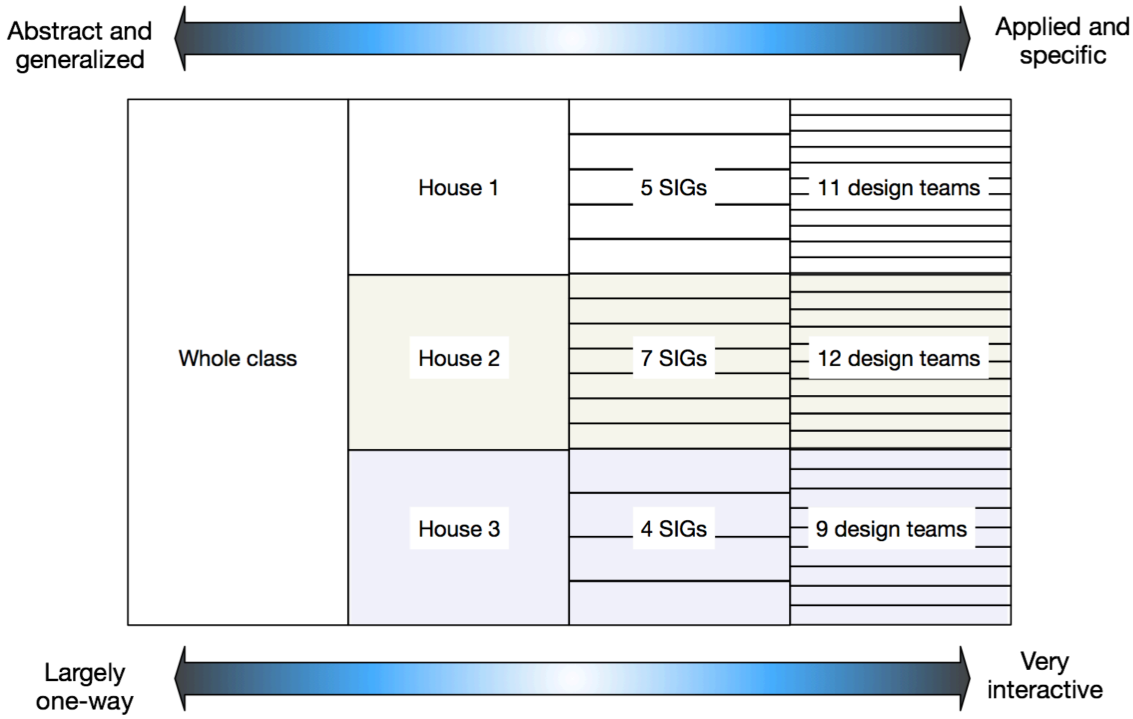



**Figure 6 – Increasing granularity and specificity of groups**

#### 4.2.6.2 Supporting bi-directional assumption of content

Another key challenge was that of ensuring that course content generated by students (i.e., technology resources, SIG discussions, etc.) would become an important resource to be cycled back into the wider community's knowledge base. Traditional course designs include primarily downward flow of content, as provided by the instructor (or sometimes the students), and consumed by students in the form of readings, videos, activities or other materials.

In KCI, there is an emphasis on knowledge construction, with a commitment to the development of a knowledge base that is both a product of, and subsequently a resource to inquiry activities. This presented a key challenge for a large course, to ensure that the content developed and contributed by students was viewed as (and indeed, was truly) a resource for subsequent activities. Our response to this challenge was through scripting, where we developed activities that assured such dependencies.

Figure 7 shows the bi-directional production and consumption of knowledge and resources, where SIGs produce relevant materials (e.g., the technology resources) for design teams, whose products are then made visible and accessible to wider groups like SIGs and house. Sections below outline the specific scripts through which our design was able to respond to this challenge.

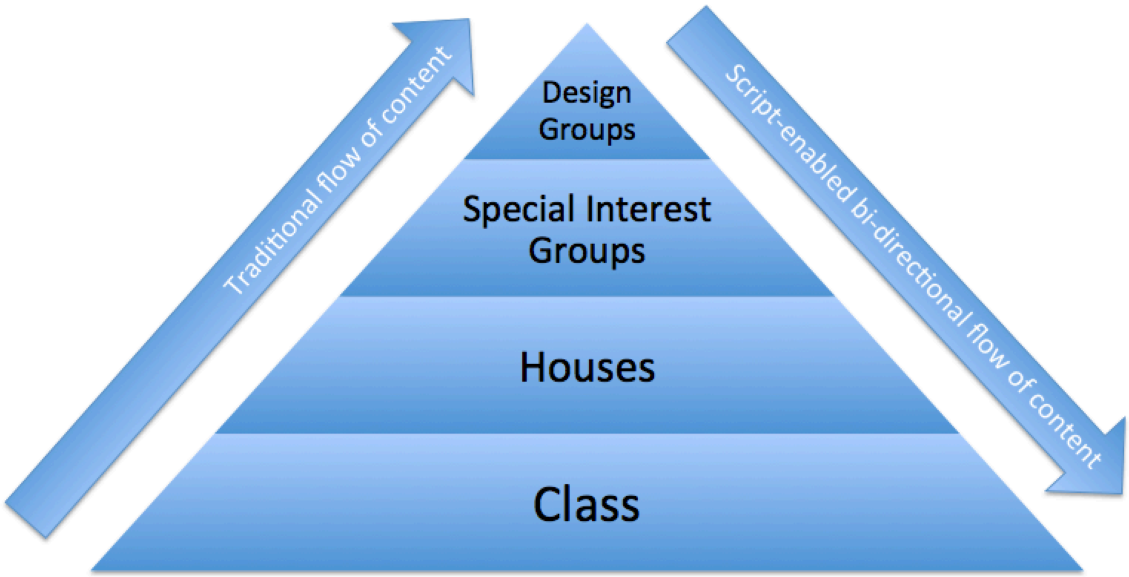



**Figure 7 - Moving across the granularity triangle**

This nested granularity approach enabled meaningful re-use and transfer of knowledge within the community. Despite the large numbers of learners, organized into diverse groups according to teaching interests, we needed to ensure that the products of these groups became accessible and indeed relevant to all others, where possible. For example, a computer technology SIG might have very different needs and approaches from a group of primary school history teachers, but one of those groups might come up with an interesting way of using blogs, or FitBits that could provide insight and inspiration to the other group.

While all the student artifacts and records of discussion captured in the online system were technically available to all other students, and indeed students did frequently access other groups' pages out of interest, we wanted to think about scripts that would better enable the cross-dissemination of ideas and insights.

Below, I present two specific scripts that served to promote such exchanges. The first was designed to support active input into the whole-class lecture and then feed into SIG-specific discussions, and the other adapted the jigsaw script to reorganize students into cross-course expert groups, and then share their expertise within their SIGs.

#### 4.2.6.2.1 Brainstorm script

After the students returned from their 5-week practicum placements, we wanted to provide them with an opportunity to discuss and reflect upon problems or issues that they encountered during those placements, specifically those related to the various weekly topics. We ran this script twice, first asking about ethics issues they had encountered during their practicum placements, and a second time asking about equity/diversity issues they had encountered.

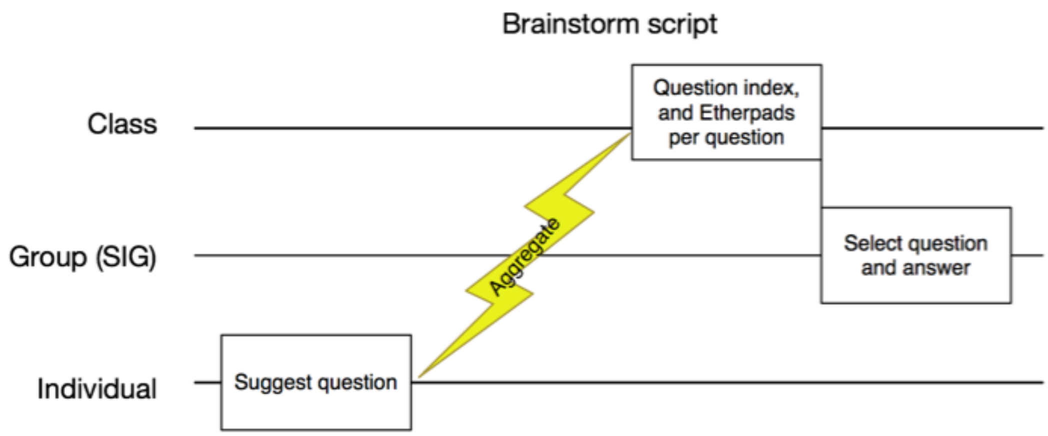



**Figure** 8 **- Brainstorm script**

The script (visualized in Figure **8**) began during the plenary lecture with a discussion about the weekly topic. *First,* students were provided with a short link to a Google Form, where they were asked to choose a title, specify the grade level, and describe the issue they encountered. Students did this individually or in pairs on computers.

*Second,* as each new issue was added to the Google Spreadsheet, it was then extracted and used as the topic for a newly generated Etherpad, with space for other students to respond with ideas on how to resolve or respond to the issue. All the Etherpads were then linked from a central page on the wiki, which was provided to the students. The students were given some time to add issues individually or in pairs during the plenary lecture. *Third,* when students came together in their SIG groups, they were asked to choose one or two issues to discuss in depth using the Etherpads. All resulting discussion pages remained available to the whole class for later consultation. Screenshots of the script components are shown in Figure 9.

By beginning the brainstorming during the plenary, we were able to gather ideas from all students (i.e., across houses and SIGs). The in-depth work done on the Etherpads during the SIG meetings ensured that students were able to contextualize the issues in terms of their own SIG focus area.

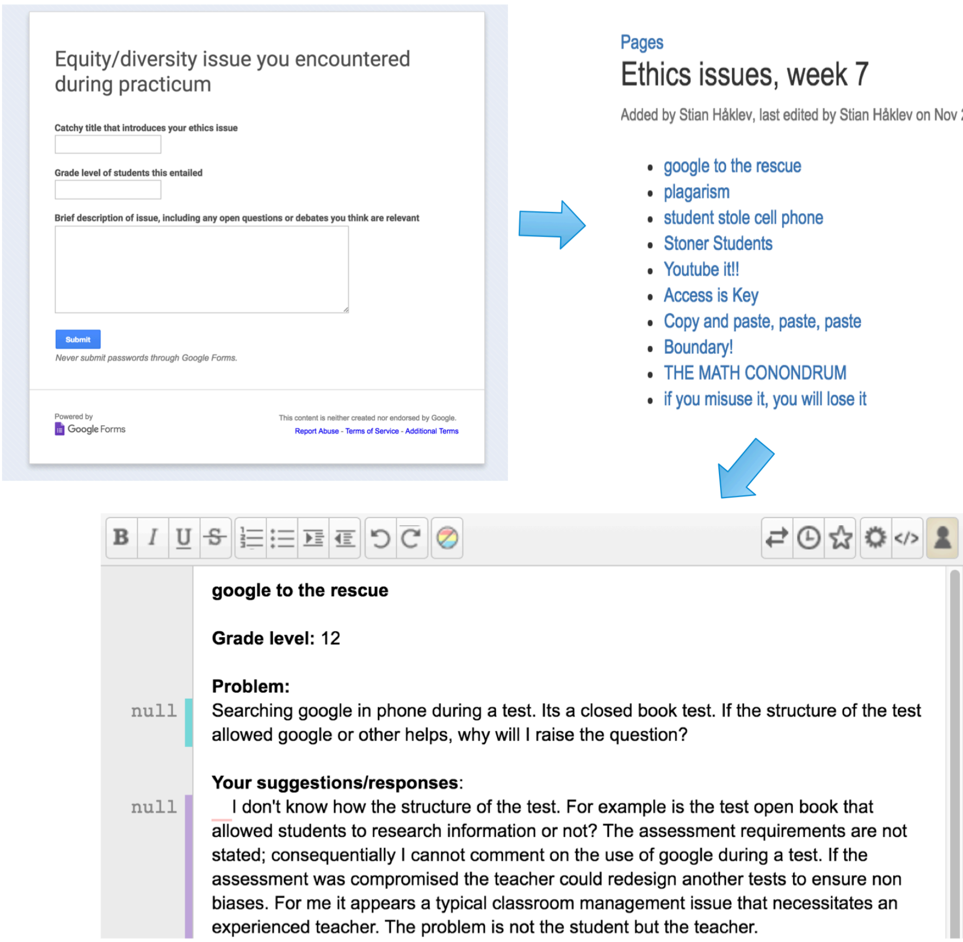



**Figure 9 - Screenshots of Brainstorm script**

#### 4.2.6.2.2 Jigsaw script

In the jigsaw script, students were assigned to specialist groups where they developed a focused level of expertise or insight. They were then re-assigned to new groups with members from all specialist groups, combining their expertise in an inquiry task. The script has a long tradition in CSCL as a way of encouraging epistemic interdependence, and bringing diverse perspectives from the whole class into the small group discussion (see for example Pozzi, 2010).

We designed a script based on the jigsaw pattern that took advantage of the time students spend at home preparing for class, and used software scripts to automate the distribution and aggregation across all the students. The script (illustrated in Figure 10) was planned for week 5, which had "Tangible and embodied learning" as a topic. We anticipated that most of the students would not have heard much about these concepts, and would have difficulties applying them to their own teaching.

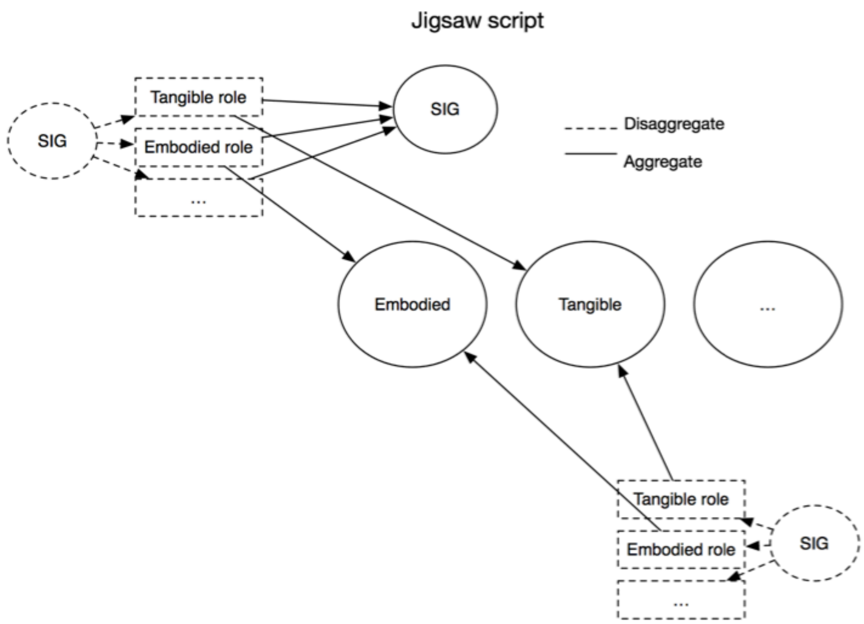
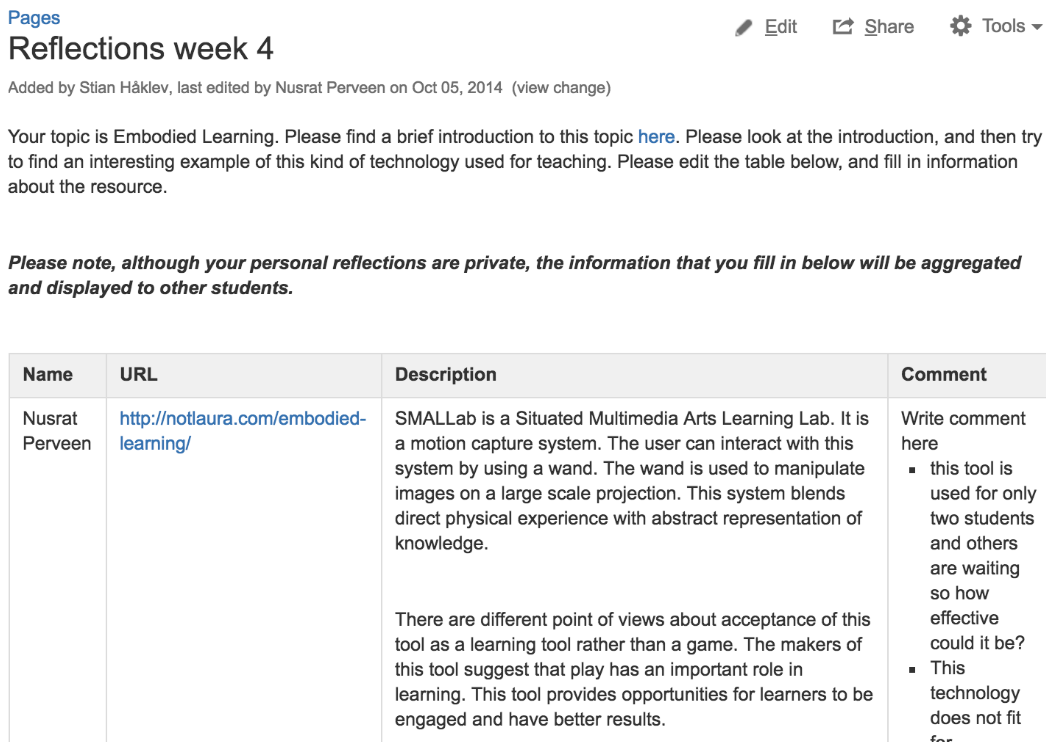



**Figure 10 - Jigsaw script**

We created four expert topics, each with a corresponding topic page on the wiki: (a) Augmented and Virtual Reality; (b) Making and Tangible Computing; (c) The Quantified Self; and (d) Embodied Learning. For each page, Dr. Slotta wrote a short introduction, and provided a few links or examples to get the students started. *First*, the students in each SIG were automatically sorted into topics, with SIG groups with more than four students having some topics covered by two students.

When logging into their personal space, students found detailed personalized instructions, asking them to visit a given topic page and learn more about the topic they had been assigned to. They were then asked to find at least one interesting resource relevant to the topic, and their teaching interest, and to fill in a templated form (see Figure 11) before mid-week with ideas about how this resource could be used for teaching.

*Second*, at mid-week we manually triggered a computer script that took the forms filled out by all the students, and aggregated them in two ways. First, it put all of the resources submitted by a specific SIG into the SIG page (see Figure 12). Then, it put all of the forms submitted by a certain topic, regardless of SIG or house, and combined them on the topic pages (see Figure 13).



Pages

Reflections week 4

Edit Share Tools

Added by Stian Håklev, last edited by Nusrat Perveen on Oct 05, 2014 (view change)

Your topic is Embodied Learning. Please find a brief introduction to this topic here. Please look at the introduction, and then try to find an interesting example of this kind of technology used for teaching. Please edit the table below, and fill in information about the resource.

***Please note, although your personal reflections are private, the information that you fill in below will be aggregated and displayed to other students.***

| Name | URL | Description | Comment |
|---|---|---|---|
| Nusrat Perveen | http://notlaura.com/embodied-learning/ | SMALLab is a Situated Multimedia Arts Learning Lab. It is a motion capture system. The user can interact with this system by using a wand. The wand is used to manipulate images on a large scale projection. This system blends direct physical experience with abstract representation of knowledge.<br><br>There are different point of views about acceptance of this tool as a learning tool rather than a game. The makers of this tool suggest that play has an important role in learning. This tool provides opportunities for learners to be engaged and have better results. | Write comment here<br>▪ this tool is used for only two students and others are waiting so how effective could it be?<br>▪ This technology does not fit for |

**Figure 11 - Screenshot of student reflection page**

The students were then asked to visit the relevant topic pages they had been assigned to, and vote on the best topic-related resources. These pages were initially only available to the students assigned to a given topic. *Third,* at the SIG meeting there was final inquiry discussion, where each student could draw on their own research, and that of the whole topic group wiki for expertise, we made the topic pages with all the assembled resources and pedagogical ideas available to all students in the course.

Pages / ... / House 3 SIG 1 2014

Edit Share Tools

# Week 5 (3-1-2014)

Added by Stian Håklev, last edited by Stian Håklev on Oct 08, 2014 (view change)

SIG discussion pad

We distributed your SIG members to try to get equal representation of all the categories of tangible and embodied learning. For those with only 2 or 3 members, we chose the categories that we thought would be relevant. When you come together in the next class, we will ask you to discuss the prospects of tangible and embodied learning for your SIG, and you can refer to these ideas.

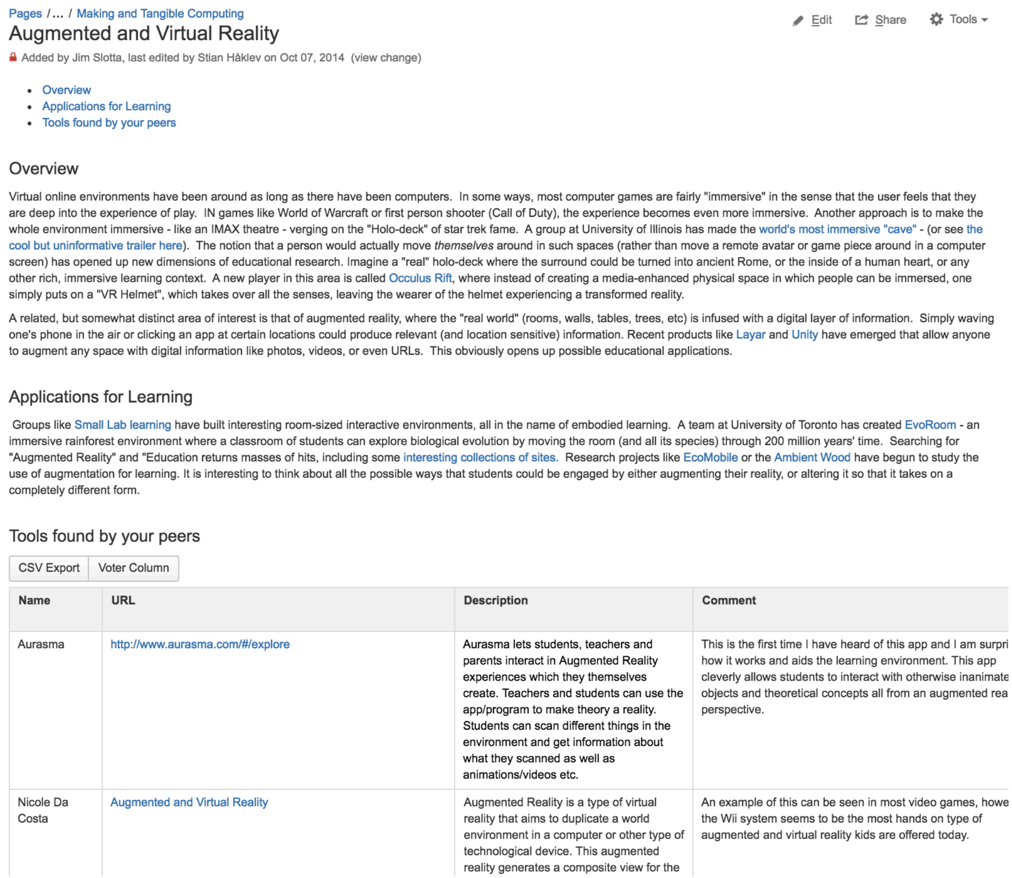
## Making and Tangible Computing

| | | | |
|---|---|---|---|
| Geogebra | http://www.geogebra.org/ | A software that allows the study of geometry and algebra in a new visual, interactive way. | SMART board allows the usage of this software in the classroom and eases the explanation of mathematics. |
| This could help us if we choose to create a math lesson. We can incorporate the use of this technology in explaining equations and showing an instant image of such equations. | | | |

## Embodied Learning

| | | | |
|---|---|---|---|
| Nusrat Perveen | http://notlaura.com/embodied-learning/ | SMALLab is a Situated Multimedia Arts Learning Lab. It is a motion capture system. The user can interact with this system by using a wand. The wand is used to manipulate images on a large scale projection. This system blends direct physical experience with abstract representation of knowledge.<br><br>There are different point of views about acceptance of this tool as a learning tool rather than a game. The makers of this tool suggest that play has an important role in learning. This tool provides opportunities for learners to be engaged and have better results. | Write comment here<br>▪ this tool is used for only two students and others are waiting so how effective could it be?<br>▪ This technology does not fit for |

**Figure 12 - Screenshot of SIG page**



Pages / ... / Making and Tangible Computing

Augmented and Virtual Reality

Edit Share Tools

Added by Jim Slotta, last edited by Stian Håklev on Oct 07, 2014 (view change)

- Overview
- Applications for Learning
- Tools found by your peers

Overview

Virtual online environments have been around as long as there have been computers. In some ways, most computer games are fairly "immersive" in the sense that the user feels that they are deep into the experience of play. IN games like World of Warcraft or first person shooter (Call of Duty), the experience becomes even more immersive. Another approach is to make the whole environment immersive - like an IMAX theatre - verging on the "Holo-deck" of star trek fame. A group at University of Illinois has made the world's most immersive "cave" - (or see the cool but uninformative trailer here). The notion that a person would actually move *themselves* around in such spaces (rather than move a remote avatar or game piece around in a computer screen) has opened up new dimensions of educational research. Imagine a "real" holo-deck where the surround could be turned into ancient Rome, or the inside of a human heart, or any other rich, immersive learning context. A new player in this area is called Occulus Rift, where instead of creating a media-enhanced physical space in which people can be immersed, one simply puts on a "VR Helmet", which takes over all the senses, leaving the wearer of the helmet experiencing a transformed reality.

A related, but somewhat distinct area of interest is that of augmented reality, where the "real world" (rooms, walls, tables, trees, etc) is infused with a digital layer of information. Simply waving one's phone in the air or clicking an app at certain locations could produce relevant (and location sensitive) information. Recent products like Layar and Unity have emerged that allow anyone to augment any space with digital information like photos, videos, or even URLs. This obviously opens up possible educational applications.

Applications for Learning

Groups like Small Lab learning have built interesting room-sized interactive environments, all in the name of embodied learning. A team at University of Toronto has created EvoRoom - an immersive rainforest environment where a classroom of students can explore biological evolution by moving the room (and all its species) through 200 million years' time. Searching for "Augmented Reality" and "Education returns masses of hits, including some interesting collections of sites. Research projects like EcoMobile or the Ambient Wood have begun to study the use of augmentation for learning. It is interesting to think about all the possible ways that students could be engaged by either augmenting their reality, or altering it so that it takes on a completely different form.

Tools found by your peers

CSV Export | Voter Column

| Name | URL | Description | Comment |
|---|---|---|---|
| Aurasma | http://www.aurasma.com/#/explore | Aurasma lets students, teachers and parents interact in Augmented Reality experiences which they themselves create. Teachers and students can use the app/program to make theory a reality. Students can scan different things in the environment and get information about what they scanned as well as animations/videos etc. | This is the first time I have heard of this app and I am surpri how it works and aids the learning environment. This app cleverly allows students to interact with otherwise inanimate objects and theoretical concepts all from an augmented rea perspective. |
| Nicole Da Costa | Augmented and Virtual Reality | Augmented Reality is a type of virtual reality that aims to duplicate a world environment in a computer or other type of technological device. This augmented reality generates a composite view for the | An example of this can be seen in most video games, howe the Wii system seems to be the most hands on type of augmented and virtual reality kids are offered today. |

**Figure 13 - Screenshot of theme page**

### 4.2.6.3 Enabling online collaborative inquiry

For the week whose theme was "Online teacher communities", we decided to conduct the class fully online, in order to give students an experience with synchronous online tools, and to further our own understandings of how to script and orchestrate online activities. We developed a collaborative inquiry script that aimed to help students' experience be less isolated or individualistic, with major activities as follows.

*First,* we used CommentPress, a WordPress plugin that enables collaborative paragraph-level commenting of shared documents, so that students could read and comment collectively on an article about online teacher communities. *Second*, for a live (i.e., synchronous) portion of the class, we used Google Hangout On Air, a videoconferencing tool for small groups, with the additional feature that you can stream the video of the hangout to an unlimited number of people. The students were thus able to observe the instructor and the teaching assistant as they conducted a Google Hangout (corresponding to the plenary lecture phase of the weekly script), and to ask questions through the commenting functionality. We also used PollEverywhere (an audience response tool) to better engage students.

*Third,* eschewing the technology presentations, we moved directly into houses, where we employed Google Spreadsheets to coordinate students' concurrent contributions of their prior experiences with online learning communities. *Fourth,* we supported students to work in their SIGs, using the built-in chat functionality of Etherpads, which also let the instructors virtually visit different SIGs and follow their discussions. *Finally,* we encouraged students to engage in self-organized continuing work in their design groups.

### 4.2.7 Technology Environment

Collaborative scripts in small groups could be carried out using simple, non-technological tools, such as post-it notes and large sheets of paper, with the teacher manually assigning students to groups. However, in a larger class, with more complex scripts, it becomes unfeasible to orchestrate the class without the support of technology. In addition to enabling the orchestration of complex patterns of grouping and interchange of ideas and materials, collaborative technologies have specific affordances for learning which will be discussed in Chapter 6. In addition, the topic of the class was how to use technologies to support inquiry learning, and thus the hands-on experience with these same technologies was very important for student experiential learning. Below, I will briefly present the technologies which played a key role in this course.

#### 4.2.7.1 Wiki platform

The digital content of the course was organized largely through the use of a wiki platform called Confluence, which has several affordances that support our learning design goals. Many traditional wikis use a special form of markup to edit pages, which presents a hurdle for beginners. Confluence wiki has a WYSIWYG interface (What You See is What You Get), which makes it much easier for students to begin editing pages. The pages are rich media documents which can contain different fonts and colours, tables (very useful for coordinating multiple responses), as well as embedded pictures, videos, and even other custom rich elements.

The wiki is organized into spaces, and each user automatically gets their own personal space, which is by default only visible to themselves, and the wiki administrator (in this case, the instructors). This space was used for weekly reflections, and to distribute personalized links and instructions as part of the pedagogical scripts. The whole class had a single large space (differentiating it from other courses or communities), but within that space, we could assign students to groups with different access rights.

There are a number of features that support organizing pages and exploring content. Students can view a list of all pages in a certain space, or use the search functionality to look for specific content. Pages can also have tags and categories to promote discovery, and within a given page, an automatic table of contents can be generated based on headers, for easier internal navigation.

#### 4.2.7.2 Concurrent editing

A major weakness of wiki platforms for collaborative work is that they only allow a single user to edit a given page at a given time. There is no real-time collaboration option, and when students edit the same page concurrently, they run the risk of overwriting each other's versions, and loosing information. Thus we chose several other tools for supporting live collaboration during class time. Initially, we used Google Documents (both the text editor, and the spreadsheet), and later we transitioned to Etherpad, which is an open-source tool that we ran from our own servers. It presents an interface that is much more simple than Confluence wiki, or Google Docs, with no differentiation of fonts, embedding of rich media etc. Instead, it is focuses on coordinating collaboration, with text coloured differently depending on who typed it, an online presence indicator, and an embedded chat tool.

#### 4.2.7.3 Other tools

Given the technology-related focus of the course, we frequently introduced and employed other web-based tools, either as part of demonstrations relating to the specific weekly themes, or for specific pedagogical purposes. For example, we used Google Forms to conduct quick surveys, and also to quickly collect and populate tables during class. We also experimented with audience feedback tools, collaborative drawing/collage tools, Smartboards and other technologies.

#### 4.2.7.4 Integrating tools through APIs and scripts

Most of the tools we employed were not designed specifically for teaching and learning, and even those that were (e.g., the audience response systems like Poll Everywhere), were not designed to be integrated with other tools within a broader workflow of activities. However, many of these tools offer an Application Programming Interface (API) which provides a connection point through which two programs or tools can communicate directly. Using custom scripts written in the Python language, we were able to obtain a degree of control over these tools through these APIs, allowing them to be integrated with other tools and environments and thereby embody our pedagogical script in the technology environment.

For example, we were able to automatically create user accounts for various tools (i.e., generating the accounts automatically) using the personal information (name and email) they had entered through the initial survey during the first class. Further, students could be automatically grouped into special interest groups with appropriate access permissions based on their teachables. Each week, scripts were used to automatically create templated Etherpad documents with discussion prompts for each discussion group. After the in-class discussion, the content was automatically moved from the Etherpads, and inserted into the group wiki space, for historical reference.

Each week, we inserted reflection prompts into students' personal wiki spaces. Then, once students had written their reflections in response to these prompts, the resulting data were extracted and collated in a Google Spreadsheet, where the instructor could easily read several weeks' worth of reflections from each student, and leave appropriate comments, which were in turn automatically posted to their personal spaces.

## 4.3 Enactment

In this section, I present the enactment of our course. It is important for any design-oriented research to present and evaluate not only the design (i.e., whether it embodies the targeted theoretical perspective, etc.), but also the enactment of that design—whether it was even possible to implement what was designed, and to what extent the implementation adhered to the intended vision.

It is also through the enactment that we may gain insights into the design itself, prompting revisions and informing take-away findings about the overall success, as well as possible generalizations and design principles. Hence, this section first introduces some basic measures of success, to confirm that indeed students engaged with our course, completed the required activities, and enjoyed an overall positive experience.

A short discussion of the orchestration of the activities, which was distributed between the instructor and the technology environment, is also provided.

### 4.3.1 Demographics

The course had 74 students, 45 female and 29 male. Most had less than one year of experience teaching, but there was a minority with several years of experience, as shown in Figure 14.

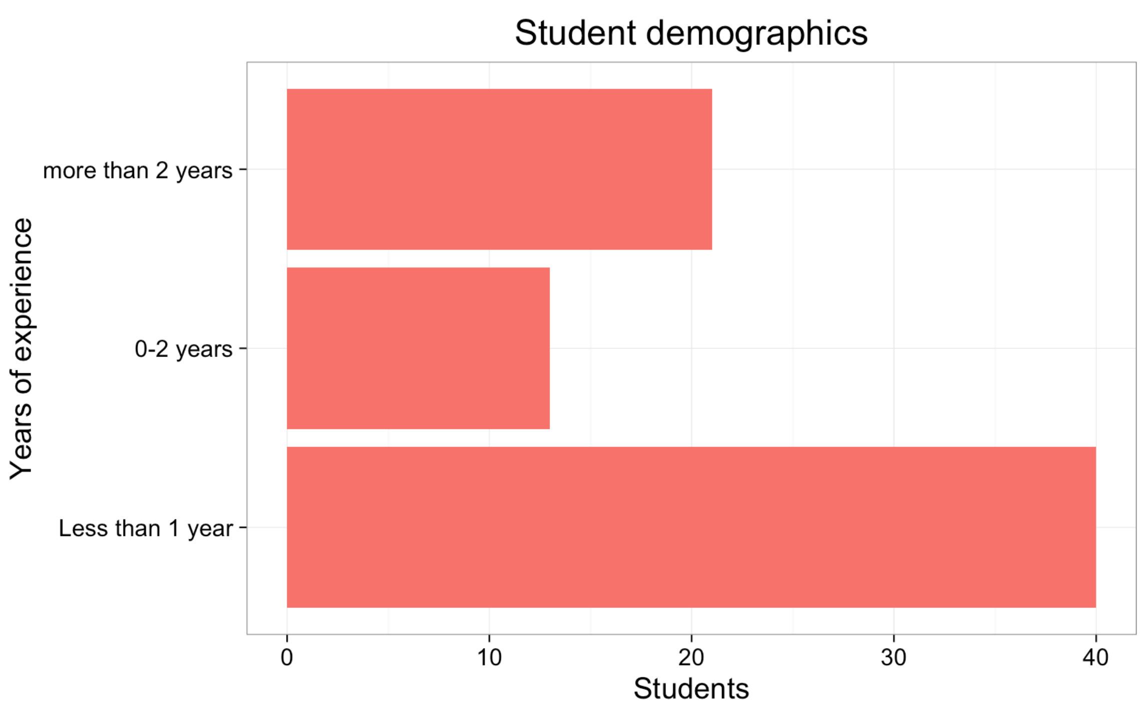



**Figure 14 - Student demographics**

The students were part of the either Primary-Junior (PJ), Junior-Intermediate (JI), Intermediate-Senior (IS) or the Technology stream, and had a wide range of teachables, Figure 15.

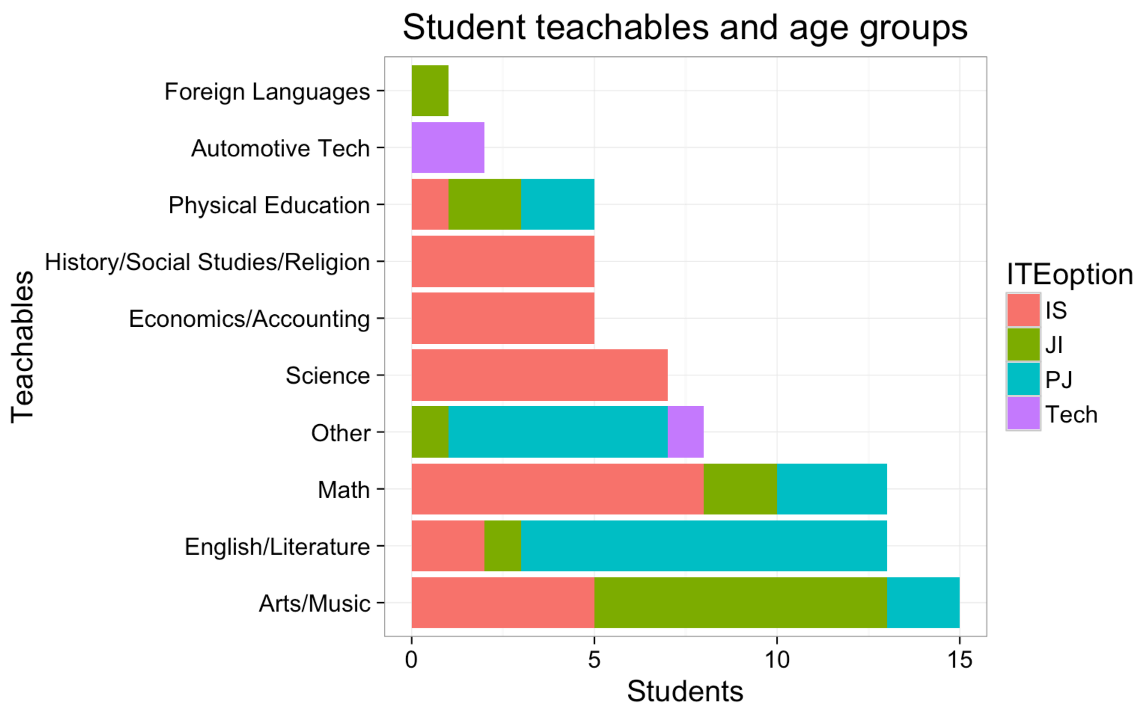



**Figure 15 - Student teachables and age groups**

### 4.3.2 Student Artefacts

Students generated a range of artefacts throughout the course. Groups of 2-3 students designed and delivered a total of 30 technology resource presentations, which entailed filling out a wiki template with information about the resource and their approach to presenting it, as well as links to further resources. Students then led their classmates through an interactive presentation lasting approximately half an hour, with ample opportunity for other students to get hands-on experience with the technologies in question. This was concluded with a peer-review vote by the other students in the house. Students generally rated each others' presentations very highly ($M$ = 4.46 / 5, $SD$ = 0.23). A full list of the topics for the technology presentations is presented in Appendix F.

Students were grouped into 15 SIGs, which all participated in Etherpad discussions during class sessions, and contributed to various collective inquiry tasks for homework. One of these inquiry tasks was the Jigsaw script, where students contributed resources and applications for the resources related to the tangible and embodied learning.

In the Brainstorm script, students contributed 20 issues to be discussed in week 6 (related ot equity and diversity), and 10 issues to be discussed in week 7 (related to ethics).

The crux of the course was students' design of a lesson plan in their target discipline and age-group, in which technology was meant to be used in a pedagogically meaningful way, ideally for some form of student-centred inquiry.

In total, students produced 34 lesson designs, in the form of Microsoft Word or Confluence wiki documents (they had a choice), with a median length of 3004 words (see Figure 16). These were highly iterative documents, with a median of 26 edits (see Figure 17), and some documents going through more than 100 edits. The lesson designs received uniformly high grades from the instructor ($M$ = 17.89/20, $SD$ = 1.26).

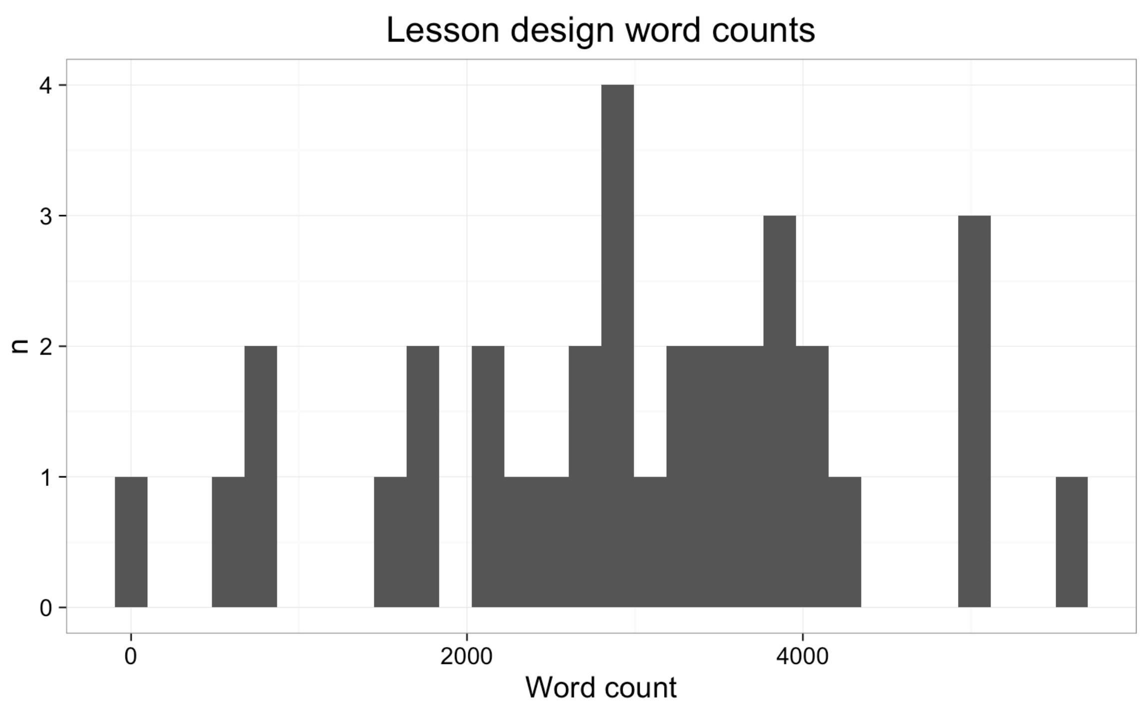



**Figure 16 - Histogram of lesson design word counts**

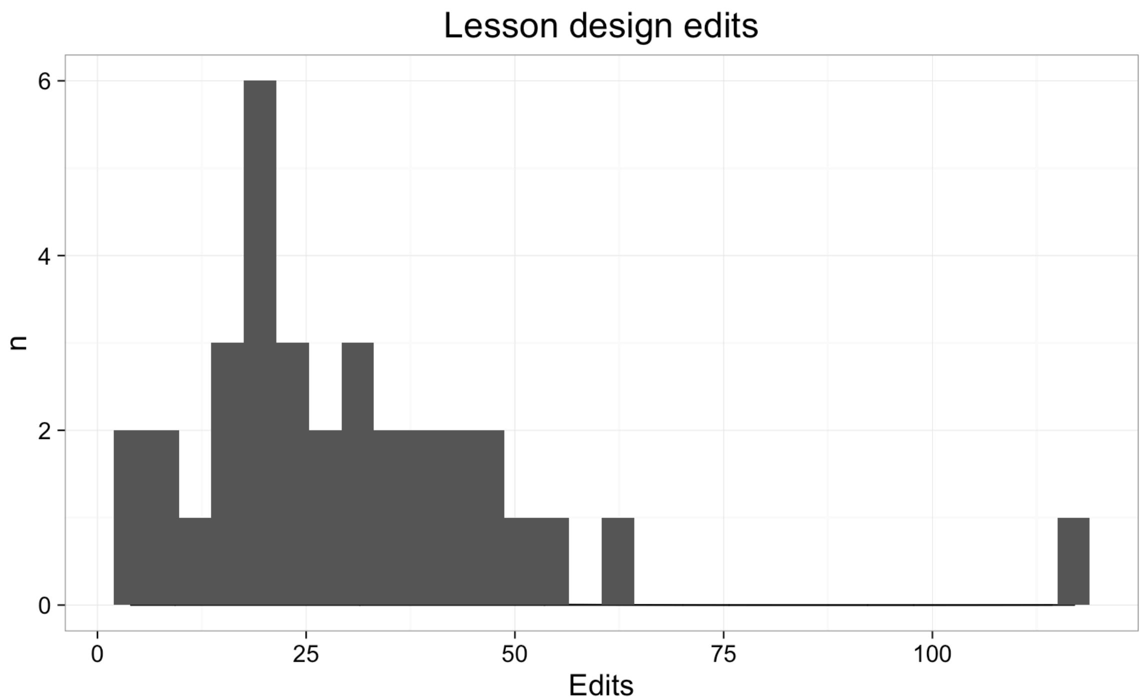



**Figure 17 - Histogram of lesson design edit counts**

### 4.3.3 Orchestrational Interplay Between Technology and the Teacher

While the scripts described earlier in this chapter were closely coupled with technological tools and environments that aimed to support the instructor in orchestration of those scripts, they are always manually triggered, as there was no automaticity or intelligence built in. If the script required some form of processing of student data, this was performed either before the course began or between class sessions, so that it was ready to go on class day. For example, the grouping of students during the first and second week (into houses, SIGs, design groups and presentation groups) was conducted via software processing, such that the instructor could automatically push out homework assignments (personalized, if necessary), prepare SIG Etherpads, move information from Etherpads to wikis, etc.

Other software was written to aggregate process data and support the instructor in maintaining an overview of student progress, making it feasible to provide individual feedback. The instructor could extract data about when students were logging in to do their homework, how many edits they had made in the design documents, and whether they were actively contributing to their SIG knowledge base.

Such software processing was only employed to a small extent during class sessions. In the first week, a software routine was run after everyone had completed the survey, to generate a descriptive statistics interface that the instructor uses with the class to design the houses, as well as during the brainstorm script (described above), which served to generate the issue pages and index, after all student ideas had been entered.

In class, students got used to the regular weekly activity structure, and knew where to access instructions on the wiki and on Etherpads with specific prompts and weekly activities. The instructor, together with the teaching assistant and the community assistant, could see how groups were progressing through the various weekly activities, and was able to repair and alter the script based on house peculiarities.

## 4.4 Achieving KCI Design Principles

This section evaluates the design and enactment of our pre-service course according to the four KCI principles. Because the design itself was guided by KCI to a great extent, there was a clear mapping for most elements of the model. The specific context of the course made it challenging to implement some elements, and these are discussed. In sum, students did feel part of a course community, and they did understand the epistemological commitments of collective inquiry.

They tagged resources with the knowledge that it could be of service to others in the community, and offered peer feedback because they understood that it was a valuable inquiry activity—not because it was assessed for course credit. There was a growing knowledge base that was recognized as an asset by all students in the course, and strong identities within most of the SIG groups. Hence, our overall design goals were satisfied, that students worked in the course with a sense of collective engagement, a knowledge base was developed, which often served as an important resource during further inquiry.

By enacting the course, we can evaluate the efficacy or fidelity of design features (i.e., in terms of working as predicted, strengths and limitations). This will contribute to subsequent iterations or extensions of this design. The following sections offer short evaluations of the course for each of the major KCI principles, drawing connections where possible to specific data and findings presented earlier in this chapter.

#### 4.4.1.1 Principle 1

*Students work collectively as a knowledge community, creating a knowledge base that is indexed to a specific content domain.*

The wiki represented the central knowledge base for the course, and was divided into a number of sections. SIGs, technology presentation groups and design groups all had their own spaces on the wiki, but the information entered in those sections was available to everyone in the class. Importantly to this principle is that the wiki was directly indexed to the specific learning goals of the course, ensuring that students would build knowledge according to that schema. The weekly themes served as the backbone of the course syllabus as well as the wiki (i.e., the main topics), and each theme was supported by a carefully structured set of resources. These included links to relevant resources and activities for the week, the technology presentation pages, and SIG pages specific for that theme. Selected readings and Etherpad links were also distributed across the themes, as well as any homework resources. This design ensured that all members of the community could contribute and locate knowledge resources, organized according to major course learning goals.

The technology features of the wiki-knowledge base also served to scaffold the structure and content of the knowledge base. For example, different categories of pages were scaffolded with prompts according to the category. Technology presentation groups completed a presentation plan according to a template, which became a record of their presentation and the resources they found and created, for everyone to access after the presentation. Design groups did their work in the open, scaffolded by prompts and headers, which increased in sophistication during the length of the course, and which explicitly related the lesson design work to the weekly course themes and SIG discussions. SIG groups had the most complex scaffolding, with different prompts and functionality to aggregate ideas and information, and support reflection, each week. A key task of the SIG group members was to take an active role in maintaining and growing their group knowledge base, by cleaning up and reorganizing the raw discussion notes and ideas entered during class.

#### 4.4.1.2 Principle 2

*The knowledge base is accessible for use as a resource as well as for editing and improvement by all members*

Beginning with the epistemic treatment during the first class session, and then the first inquiry task, which asked students to engage with lesson designs produced by students from previous iterations of the course, students were able to understand the importance of the community knowledge base for their own work, and the importance of their own contributions to the knowledge base, for their peers' success and learning.

In all aspects of the course, we tried to design scripts that explicitly linked to the knowledge base or at least required that students refer to particular elements as a resource. The lesson design project, which was woven through the entire course, included clear links to each major theme, such that it was impossible to complete the task without addressing all of the content learning goals of the course, and relying on knowledge generated by the community.

When there was no specific linkage into the knowledge base, we had some level of success with students taking initiative in browsing and searching the artefacts generated by other student groups and houses. Further, several of the inquiry tasks, and some of the scripts, such as Jigsaw and Brainstorm (see above), directed students to specific forms of engagement with ideas generated outside of their own group.

#### 4.4.1.3 Principle 3

*Collaborative inquiry activities are designed to address the targeted domain learning goals, using the knowledge base as a primary resource and producing assessable outcomes*

A key principle of this course was to let the students experience the kind of learning that we would like them to provide for their own students. We designed an inquiry activity where students present a technology tool or environment, and engaged their peers in actually using the tool. The goal here was for students to become comfortable enough with various technologies to consider using them, and to understand deeply how the various affordances of technologies could be used to enable different ways of teaching, learning, collaborating and knowledge co-construction. Through the weekly themes and the hands-on technology presentations, students engaged in a repertoire of approaches to pedagogy, and technological resources to support their teaching.

We also demonstrated our principles of scripting and orchestration through the multiple ways of grouping and collaborating, and the variety of different tools and environments. Students were able to see, through their direct experience in these activity designs, the deep pedagogical content of the course.

Finally, we leveraged the knowledge base wherever possible as a resource. This began in the first class session where we oriented students toward the collective nature of the course and stressed the importance of our wiki space and shared resources. In our lesson design activity, which progressed across all themes, we connected directly to the knowledge base, actually requiring that students connect their designs to the weekly theme, and add relevant resources wherever possible. The lesson design project functioned as a central coordinating activity script, and was scaffolded with a template specifically indexed to the learning goals of the course.

In the lesson design groups and the peer review activity, students discussed the activity structures of their lesson, drawing on the weekly themes relating to technologies and pedagogical approaches. As the course progressed, and student understanding became more complex, they began discussing how their lesson design would help students develop an understanding of the targeted topics, adding pedagogical notes on the role of the instructor, and finally an assessment plan. To the extent that students succeeded in designing a complete lesson (using our template), they successfully incorporated all of the course objectives. In addition, they did so in collaboration with others (lesson design team), using a variety of collaborative technologies (wiki, Etherpad), and drawing on the community knowledge base as a resource.

Thus, our activity designs exposed students deeply to the learning goals of the course, which included a notion of collective inquiry. By connecting to the community knowledge base, students experienced first-hand what it means to learn as a knowledge community.

#### 4.4.1.4 Principle 4

*The teacher's role must be clearly specified within the inquiry script, in addition to a general orchestrational responsibility*

The instructor’s role was a matter of deliberative design in the course, and included a role for a TA who led discussions in one of the three houses. To begin the course, the instructor led an epistemic treatment in the first class meeting, to orient students towards what he described as a new way of learning and interacting, and one not necessarily congruent with their expectations and previous experiences. He made it clear that to help them all learn to teach with inquiry and technology meant that he needed to engage them in learning about that topic through inquiry activities and using technology in meaningful ways. These were sufficiently “meta-level” topics that they warranted some discussion, and one role of the instructor was to ensure that such an orientation had occurred.

Each week thereafter, the instructor played a role of authority and experience, summarizing and extending the readings and the weekly themes, and motivating participation in all of the course activities. This entailed a plenary lecture, typically 30-40 minutes, and extended discussion of typically 30 minutes in length. Afterwards, the instructor set out to demonstrate or exemplify the kinds of teacher-student interactions that were the content of the course: spending short windows of time with each SIG group or design team (depending on what point in the script), calling the whole class to attention occasionally for points of clarification or logistics, and generally managing the flow of activities in an orchestrational mode. In the week where the course was held online, the role of the instructor was made even more explicit, through a written script that specified his role in lecturing, leading discussions, and visting with break-out groups

The instructor shared orchestrational load with several major technology environments, as computer scripts were responsible for group formation, aggregation of student resources, distribution of reflection prompts and etherpad prompts amongst others. These technological scripts were manually triggered by the instructor based on his understanding of the readiness of the students.

## 4.5 Discussion

Facing the scaling up a course from 25 to 80 students, but wanting to keep the focus on student collaboration and knowledge co-creation, the design of a meaningful hierarchy of groups became crucial. The pedagogical scripts had to support meaningful group formation, but also enabled bi-directional assumption of content, allowing us to also benefit from the increased size and the diversity of the class.

Orchestrating a course with multiple levels of groups added complexity for the teacher, and would not have been possible to do without the support of technology. In this course, we leaned very heavily on existing tools, such as Etherpad and the Confluence wiki, which on the one hand gave us much of the functionality “for free”. On the other hand, given that these technologies have no intrinsic understanding of structure or grouping, we were constantly pushing at the limits of what was possible, and the technical solutions were brittle. A further scaling up of the course size would require more custom-written technology that has an intrinsic understanding of semantics and grouping.

The fact that the course met in person for four hours every week, allowed the students to “gel” into well-functioning groups, and for a lot of the coordination and logistics to happen in a fluid manner. A fully online course would need to rethink both the scripting and the technology support for supporting student coordination and communication.

The KCI model gave us a powerful way of structuring the course, and understanding the role of the various macro-scripts that came together every week through the weekly script. Students benefitted from the way the scripts all built on each other, exploring and investigating the weekly themes from various angles, while gradually building student technology repertoir, and sophistication in lesson design and pedagogical understanding.

# Chapter 5. Design Study 2: MOOC

## 5.1 Introduction

In this design iteration, I studied the scaling of the pre-service course to the much larger context of a Massive Open Online Course (MOOC), called "INQ101x: Teaching with Technology and Inquiry: An Open Course for Teachers", which ran on EdX in the summer of 2015. This course further extended the scaling up, from its original seminar-scale to the lecture-course scale described in the previous chapter, now to a massive online scale. This entailed reimagining the course organization and student grouping to leverage the unique characteristics of MOOC learners and the MOOC learning context. The sheer scale of a MOOC, with potentially thousands of participants, offered a frontier for the research of scripting and orchestration, as well as for the application of KCI as a pedagogical model.

This chapter begins by describing the course learning goals and challenges, as well as the MOOC learning context. It then discusses the course design, focusing on a conception of scripts that tie together multiple levels of student involvement, different group sizes, and past, present and future student generations. An overview of these scripts is presented, followed by more detailed individual description, including the technology scaffolds that enabled the coordination of individuals, activities and artefacts. This is followed by an enactment analysis, using student artefacts and learning interaction traces to analyze success of the course design, and a short summary of the achievement of KCI principles.

### 5.1.1 MOOC Learners and Context

Moving from a university course of pre-service teacher candidates to a MOOC for in-service teachers necessitated the consideration of a number of different factors, including the characteristics of the learners, their motivation and the course expectations, the number of learners, and the modality of learning and communicating. In terms of timing, working teachers are busy during the school year, but might have more time for professional development during the summer, when the MOOC was scheduled to run. In-service teachers also bring a wealth of experience and ideas that can be actively solicited by the script and brought into the learning community as a rich resource. Like the pre-service teachers in our previous iteration, these practitioners would also benefit from access to a knowledge base of resources and teaching ideas that they could apply in their own classrooms.

As in our pre-service context, in-service teachers for different age groups and disciplines have distinct needs and interests when it comes to technological tools and pedagogical designs. However, there are also approaches and tools that can be applicable across many different contexts (e.g., the use of think-pair-share strategy, or the Google Docs platform). We also recognized the opportunity for cross-fertilization within our in-service cohort, by enabling exchange between teaching disciplines that rarely talk to each other (e.g., what might high school physics teachers learn from primary school arts teachers?). Hence, our designs should support both teachers finding and sharing with other teachers within the same discipline/age group, but also support exchanges across the whole MOOC.

### 5.1.2 MOOC Motivation, Participation and Completion

Whereas students' motivation and learning strategies in a for-credit, on-campus course are somewhat regular or predictable, there is a much wider range of interests, motivations, and styles of participation in a MOOC setting. The pre-service students described in Chapter 4 had all chosen the course "Curriculum, Technology and Instruction" as their elective, and were required to complete the course satisfactorily in order to complete their program of studies, and qualify to work as a teacher. They had gone through a competitive application process for entry into the program, were paying tuition, would be using their grades in future job applications, and had set aside time weekly for classroom work and homework.

MOOCs, though, have a much lower barrier to entry, and students receive less tangible benefits from completing and receiving the Course Certificate. Although our course was targeted towards in-service teachers, anyone could sign up, and indeed must sign up to access any of the course material beyond the introductory video and some introductory text. We knew from the literature that MOOCs have a very high drop-out rate, mainly from students who sign-up simply to see what a course is about, but never end up engaging with it, as well as many students who begin studying in earnest, but end up leaving the course without completing it.

Even students that engage with the course until the end vary significantly in their approaches to learning and level of engagement. Some students focus on social interaction, and might actively visit discussion forums, without even watching videos or doing assignments. Others view courses as textbooks, and watch all the material without completing any assignments. Some students use quizzes to test their existing knowledge, and will go through a course doing only the quizzes, until they begin failing, and only then begin studying the course material.

To address this variation, we needed to make the course appealing and useful to a wide audience, aiming for broad motivation, but also explicitly catering to different groups of learners. Ideally, we would not only offer different ways and levels of participation, but also design the script such that those different groups served as important resources for one another. This is one of the real promises of a knowledge community approach, that it captures and benefits from the diversity within the community, as opposed to conventional lecture-based or didactic pedagogies that typically address the lowest common denominator.

### 5.1.3 Modalities of Learning and Communication

While online learning can take place both asynchronously and synchronously, the vast majority of MOOCs are completely asynchronous, meaning that participants can log in whenever they feel like accessing materials, participating in discussions or completing assignments. This has many advantages, making learning more flexible for people with busy lives who come from many different time zones. However, it also brings certain design challenges.

Motivation and time management are both affected by the asynchronous nature of MOOCs. While there are a number of interesting ways in which to design interfaces for asynchronous learning and collaboration, it can be difficult to match the excitement and immediacy of a live conversation with another human being. There is also a fundamental difference between adding a two-hour block to one’s calendar each week (i.e., for a face to face instructor-led course), where the choice is either to show-up or not, and fitting something more open ended (e.g., "log in to the MOOC, read the forum, watch videos, respond to other learners") into one’s time at the laptop. The latter can be challenging in terms of time management, competing with many other things that consume people’s laptop time.

Asynchronous interfaces are particularly challenging when it comes to facilitating deep collaboration and project-based learning, because of the problems of coordination and turn taking. This is particularly true for a MOOC, where many participants will only log in once or twice per week. For piecemeal tasks where the sequence does not matter and participants do not need to coordinate their activities, an asynchronous interface can work very well. For example, hundreds of people could log on at various times to perform small edits on Wikipedia—adding a link here, fixing a typo there, editing an image here. Sections below will present our design of a script that accommodated a variety of participation patterns and engagement levels, and indeed benefited from that variation, allowed for primarily asynchronous activity, but sustained highly synchronized coordination of community knowledge construction, small group inquiry and individual reflection.

### 5.1.4 Situating the Course Within the MOOC Ecosystem

In Chapter 2, we looked at the emergence of so-called cMOOCs, which are connectivist and constructionist, more like open-ended communities around a "red thread" provided by the instructor, with students self-organizing on various platforms outside of the control of the course, and take their learning in the direction they want themselves. As a contrast, xMOOCs are often on large professional platforms (learning management systems), with very clearly prescribed weekly activities, quizzes, short videos, grades and deadlines.

It is ironic that a phenomenon as young as the MOOC already feels to some as a constricting label, but especially among frequent MOOC participants, there is already a shared understanding of what a MOOC should look like, and the internal scripts for MOOC participants. There have been several attempts at pushing at the boundaries of what MOOCs should look like, often constrained by the technological choice of either staying within existing, confining platforms, or the almost-impossibility of trying to construct a brand new platform from scratch.

This study describes an attempt at exploring a space between xMOOCs and cMOOCs—housed on an xMOOC platform, but very much inspired by the history of student participation cMOOC and other open educational efforts, it used LTI technology in an innovative way to integrate sophisticated interactive tools seamlessly with the existing platform.

Where inquiry approaches emphasize the development of shared understanding within small groups, the Connectivist approach emphasizes large distributed networks and emergent knowledge. However, both perspectives share a value for open-ended, authentic learning activities, and both struggle with implementation and reproducibility. The KCI framework takes a more scripted, activity-driven approach than most other knowledge community approaches, with explicit connections to the learning goals. Our MOOC design, guided by KCI, is thus carefully designed to guide students along certain pathways, with scaffolded activities and group-support. But it also provides a large space for students to explore their own interests, provide rich input and ideas into the community, and co-create an authentic final product (i.e., that is relevant to students' professional lives).

## 5.2 Course Design

Figure 18 provides an overview of the various meta-scripts that make up the course design, showing a number of scripts that span several weeks, and which overlap in timing. The graph shows the dependency and interaction of various meta-scripts, exchanging student artefacts, and connecting both to the outside world, and to the knowledge generated by previous—and future—offerings of the course.

These meta-scripts are described in detail further below, but are introduced here at a high level. The first is called the Pre-Course Teacher's Lounge, and entails creating a student model, and informing the design of grouping conditions (i.e., we used the information provided in this pre-course script to gain an understanding of who was coming into the course, and how we could group them). Next is the weekly script that was repeated for each of the six weeks, centred around each week's theme. I then introduce a major design feature where we included two "strands" of the course—one called the "Foundation Strand" that aimed at the broad audience of participants, and one called the "Design Strand" that engaged those who wanted to put the course principles into practice in creating a technology-enhanced inquiry lesson suitable for their classrooms.

A unique feature of our course script was that these two strands interacted, feeding valuable pedagogical content into one another, as the larger Foundations group provided a "rain cloud" for crowdsourcing content and review to help the design teams, and the design teams provided pedagogically rich content that served as a source of course materials for the Foundations group. All of these interactions and exchanges were carefully scripted and supported with a novel application of technologies. A number of the meta-scripts were designed to explicitly feed into the community knowledge base, which offered a continuous, accessible, ever-growing resource for students.

I then describe the specific scripts used to support the Foundations strand, including (1) the resource adding/sorting script, (2) the lesson design review script, and (3) the brainstorms/live sessions. Finally, I describe the scripts used to guide the Design strand, including (1) the design group formation, (2) the lesson design activities, (3) exchanges with the Foundations strand, and (4) supporting connections to future cohorts via a persistent gallery walk.

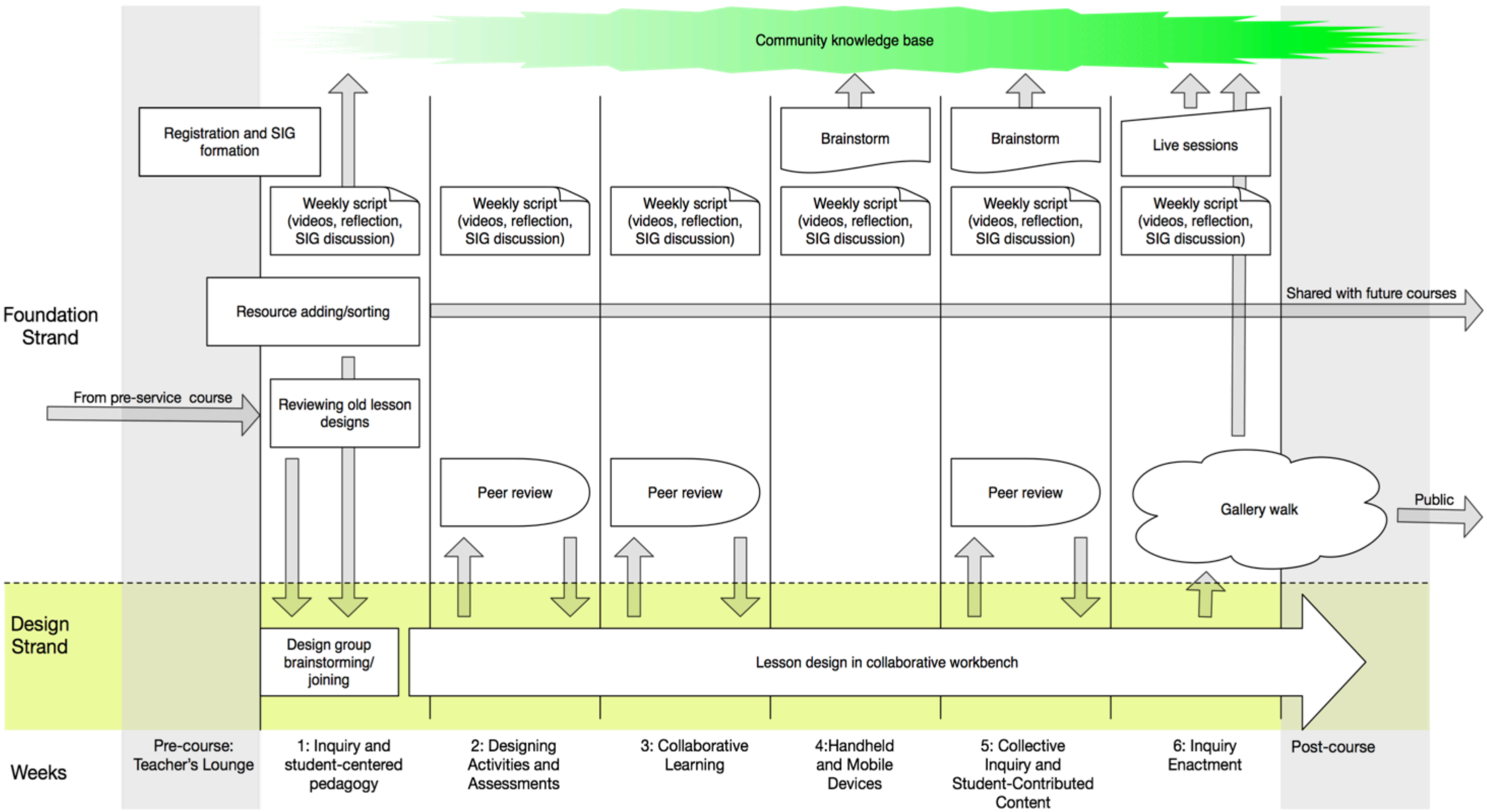



**Figure 18 – MOOC course script overview**

### 5.2.1 The Effects of Large Numbers

Apart from the variance in individual characteristics of MOOC learners, including their levels of motivation, the sheer number of learners is an important way in which MOOCs distinguish themselves from traditional courses. While some general-interest MOOCs can have up to 50,000-150,000 learners, even smaller (i.e., more specialized) MOOCs can have several thousand students. While this scale obviously brings up new challenges, it also introduces some distinct new opportunities. To understand this better, it will be useful to separate between scripts, or pedagogical approaches, that let us continue to engage students in intensive collaborative work in small groups, despite the large numbers of students; and scripts that let us experience ways of building knowledge that are possible because of the large number of students.

One dimension of large courses is an increased level of diversity. In a globally distributed MOOC for in-service teachers, this factor was prominent: we not only had teachers from all over the spectrum (i.e., from private schools and public inner city schools, teaching English to kindergarteners, or engineering to high school students), but we also had teachers from all around the world, with widely varying access to to technology, a wide range of approaches to curriculum planning and technology, and different constraints from their respective educational systems—not to mention language and time zone issues!

How could such a diverse sample become an asset to our course design? The large number of students, and their diversity, could be leveraged in two ways. The first is concerned with the wider span of ideas, experiences, values and styles of participation. Of course, this is only relevant if the script calls for students to *contribute* content and ideas; most MOOCs simply ignore the diversity because they are primarily in the mode of didactic, content dissemination, aiming at the lowest common denominator rather than trying to leverage the breadth of the community. Understanding the course as a single large community, one could expect the “collective mind” of all students to come up with a wide variety of perspectives, ideas and approaches (i.e., more than a smaller, or more homogenous community).

Obviously, this breadth would need to be harnessed and distributed in an intelligent fashion, so as not to drown students in an “ocean” or "firehose" of peer contributions—imagine having to read 2,000 blog posts each week, even if there were some perfectly relevant entries in the mix.

However, using social and semantic metadata about the students to intelligently group them, we could help ensure that students find the most relevant peer contributions that help them connect the course principles and tools into their own reflections about teaching and learning.

Student diversity also extends to diversity in approaches to learning. If only one in ten students are interested in committing to engaging deeply with creative knowledge building work, having several thousand students means that we still end up with several hundred students engaged in deep work, which is important in order to allow students to find partners with similar ideas.

### 5.2.2 Curriculum Themes and Basic Course Structure

The MOOC was designed to support in-service teachers in their efforts to integrate inquiry and technology into their lessons. Although open to anyone, it was explicitly marketed to in-service teachers, and was designed to build upon their professional experience and respond to their real challenges, providing tools, examples and approaches that could be directly applied within their professional settings.

The course came out of a collaboration between the University of Toronto Schools (UTS), a university-affiliated private secondary school, and the Encore research group led by Dr. Jim Slotta, enabling us to provide an integration of academic and theoretical ideas, with applied practice. Both the UTS principal, as well as a number of their experienced teachers, contributed to the design and the contents of the MOOC. In particular, we wanted to showcase the specific cases of technology-enhanced inquiry that were happening at UTS, including some that were the result of research collaborations with Dr. Slotta's group, and some that had occurred spontaneously within the school.

The following weekly themes were chosen to bring participants into contact with a variety of technologies and pedagogical topics relevant to their teaching: (1) Inquiry and student-centred pedagogy; (2) Designing inquiry activities and assessments; (3) Collaborative learning; (4) Handheld/mobile devices; (5) Knowledge co-construction and student-contributed content; and (6) Inquiry enactment.

For each theme, we created a short (3-5 minute) video documentary of one or two UTS teachers whose technology-enhanced lesson illustrated that theme, and also a short video from the UTS administrators (Principals, Vice Principals, and curriculum coordinators) that spoke to how this theme was supported in the school. We also created a short lecture from Professor Slotta including power point slides and linked examples, which led the weekly activities. Each week included a script (detailed below) where participants worked through the videos, added personal reflections, participated in discussions, and completed short surveys. There were also inquiry activities added at various points that served the purposes of higher-level scripts, such as by interconnecting the Design and Foundation strands. The following sub-sections detail the specific scripts used in various parts of the course.

### 5.2.3 Setting the Epistemic Context: Teacher's Lounge and Orientation

The course officially spanned a six-week period, which is not a long period of time to familiarize students with a new format of learning, and group students based on their own teaching interests and age groups. Therefore, we decided to take advantage of a fairly substantive period of time after students had signed up for the course, and before the course began, which was up to 4 weeks in some cases. We opened a pre-course session, which we called the Teacher's Lounge, and made an appeal to all participants as they signed up in EdEx to please go to the lounge, complete an entry survey (which included their teaching interests and other metadata that we could use in our subsequent scripting), and then to engage in the activities and discussions that we had provided. The Teacher's Lounge was also a place where we could share our vision for the course with students, and the nature of learning that would occur. We wanted to express clearly that students' own ideas and experiences were consequential, and that everyone would be contributing to a shared knowledge base, which would be organized and indexed in a way that it was useful to students' own professional practice, and the inquiry projects in the course.

In addition to helping familiarize students with the EdX interface and our course materials, and letting them interact with other students in the discussion forums, students were asked to complete the survey, which entailed registering on our LTI (Learning Technology Interoperability) server that was used to coordinate all the non-EdX functionality. This was very important to accomplish before the actual course started, as it provided both the metadata by which we could group and communicate with students (i.e., within the script), and also the technology registration by which we could handle their data. Once inside the Teacher's Lounge, participants were also asked to submit a "favorite technology resource" to the community's collection, with explicit framing that these would grow as a pool that would serve as an important resource in subsequent course activities. This resource pooling and tagging activity will be discussed in more detail below, in the resource script section.

One important outcome of the Teacher's Lounge entry survey was the collection of metadata about participants' teaching interests and experiences. While we did have some initial ideas about the range of teaching interests that should be present within a cohort of thousands of in-service teachers (e.g., secondary math, elementary science, etc.), we did not have any way to accurately predict either the range of interests (which categories should be included) nor how many people would be in each category. Yet we wanted to design a script that centred around "Special Interest Groups" (SIGs - described below).

Thus, we recognized that we could develop a very clear sense of participants' interests by including it as a survey item. The Teacher's Lounge survey turned out to be extremely important in informing our subsequent designs, providing a valuable source of information that would feed directly into our script. By examining the response data in the days immediately before the course launched, we could build a much more accurate set of SIG categories that teachers could select from, and have confidence that we were providing the right set.

## 5.2.4 The Foundation Strand

### 5.2.4.1 Weekly script

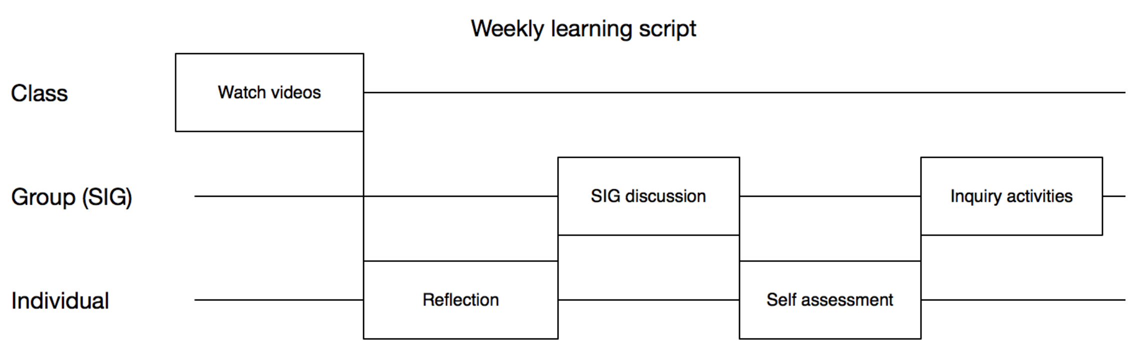



**Figure 19 – Weekly MOOC learning script**

Just as in the pre-service course described in Chapter 4, the organization of the MOOC could be seen as a matrix, with a number of extended meta-scripts spanning multiple weeks, represented through a common script that guided each week's activities and fed into the cross broader course-level scripts. The general pattern of the weekly script can be seen in Figure 19, where students begin by watching three short videos (see the examples in Figure 20). The first video was the weekly welcome message from Professor Slotta – an informal introduction to the current week's activities, including reflection upon some of the activity and contributions from the preceding week. This video was less than 2 minutes in length, and was recorded each week by Professor Slotta using his laptop camera with minimal editing.

The main content featured videos that were prepared before the course began, with much greater effort going into the scripting and post-processing of the videos. The first was an introduction to the weekly theme from a theoretical perspective by Dr. Jim Slotta, followed by a presentation from UTS administrators (including the school principal and vice principals, and curriculum coordinator), followed by a video documentary of how these these theories and ideas are applied in classroom teaching, featuring authentic footage from inquiry classrooms and commentary by the relevant UTS teachers. The content in the videos was enhanced by PowerPoint slides and links to external readings and resources.

Students were then asked to complete a personal reflection consisting of a few open-ended or multiple choice questions. These reflections were not visible to other students, and were aimed at helping students begin to connect the content from the videos with their own experiences and ideas, and also to provide some insight into the student learning process to the instructional team. An example of one personal reflection prompt, for Handheld/mobile devices theme, is:

Imagine your classroom with all students bringing their own smart phones or being provided with personal tablet computers. What kinds of activities could you design that would engage them and promote learning?

Because of their personal reflection, students were “primed” to participate in a general discussion (held within their Special Interest Groups) with carefully selected prompts. These discussions used a “forum” format, thus inviting students to not only post their initial thoughts, but also to engage and respond to threads that they found particularly interesting. An example of a discussion prompt for the Handheld/mobile devices theme is:

> Lets think about the mobile aspect of smart phones and tablets. Within our SIG, what are the advantages (for learning) of a device that students take with them from class to class and place to place?

Appendices K and L provide the complete list of all personal reflection and online discussion forum prompts. The next activity in the weekly script was a personal self-assessment of their participation in the week (i.e., in reflection and discussions), which is used for grading purposes.

The activities described above were consistent each week – purposefully so, to give students a consistent structure to their experience. A final section of the weekly script consisted of inquiry activities that varied every week, aiming to engage students in more creative, productive and critical approaches to the material in a structured manner. This is a central goal of KCI, to define inquiry activities that target the specific learning goals (in this case, the weekly theme), and also that employ the community knowledge base as a resource. Specific activities within this part of the weekly script include adding and tagging resources, reviewing previous lesson designs, peer reviewing lesson designs from the Design Strand, and a live hangout event. These will be described in detail below.


**Figure 20 – MOOC Lecture videos**

### 5.2.4.2 Resource script

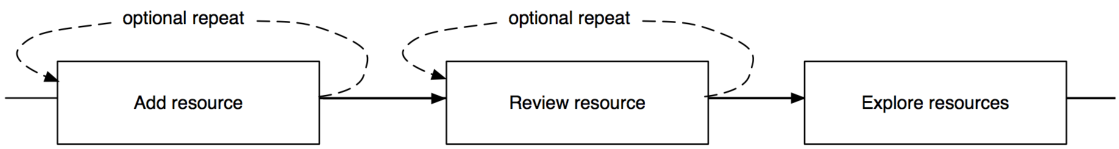



**Figure 21 - Resource script**

Most of the students in the MOOC were in-service teachers or others who work in the field of education and have teaching experience. Collectively, they have used and explored hundreds of different digital resources and tools. Some of these resources are specific to their disciplines, such as a simulation of a particular physics phenomenon, whereas others could be used in a wide variety of disciplines in many different ways, such as Google Docs or Socrative. In this script, we asked teachers to share their favorites, with no limit on how many they could contribute. This script (shown in Figure 21) was employed both in the Teacher Lounge as well as in the first week of the course:

*First,* we asked students to enter digital resources that they had personally found useful, or had heard positive things about. To do so, they filled in a form including title or name of the resource, description, a URL to the resource, and whether the resource was discipline-specific or "of general use". They were then asked to add keyword "tags" to describe the resources, or choose from the existing list of all tags (i.e., a folksonomic tag set), where any tag they started to type that was already in the list was auto-completed, encouraging the reuse of tags.

*Second,* once the resources had been submitted, the next step was for students to rate and review resources submitted by others. Upon entering this activity, students were presented with a random resource submitted either by a SIG member, or marked as "for general use" (i.e., applicable to all SIGs). They were allowed to modify the description, add more tags, and comment on how this resource could be used pedagogically, as well as to rate the resource from one to five.

*Finally,* students were able to further explore all the resources submitted, using the metadata that were attached to the resources. We provided a list of all the resources that were submitted for that SIG (or marked as "applicable to all SIGs"), sorted by score, as well as a tag-cloud where students could choose only the resources belonging to a specific tag. This "resource exploration" view was also brought into the Design Strand as a tab, where students working on defining their lesson design projects could quickly survey the community knowledge base to find relevant resources and approaches for their specific lesson plans (see screenshots in Figure 22).

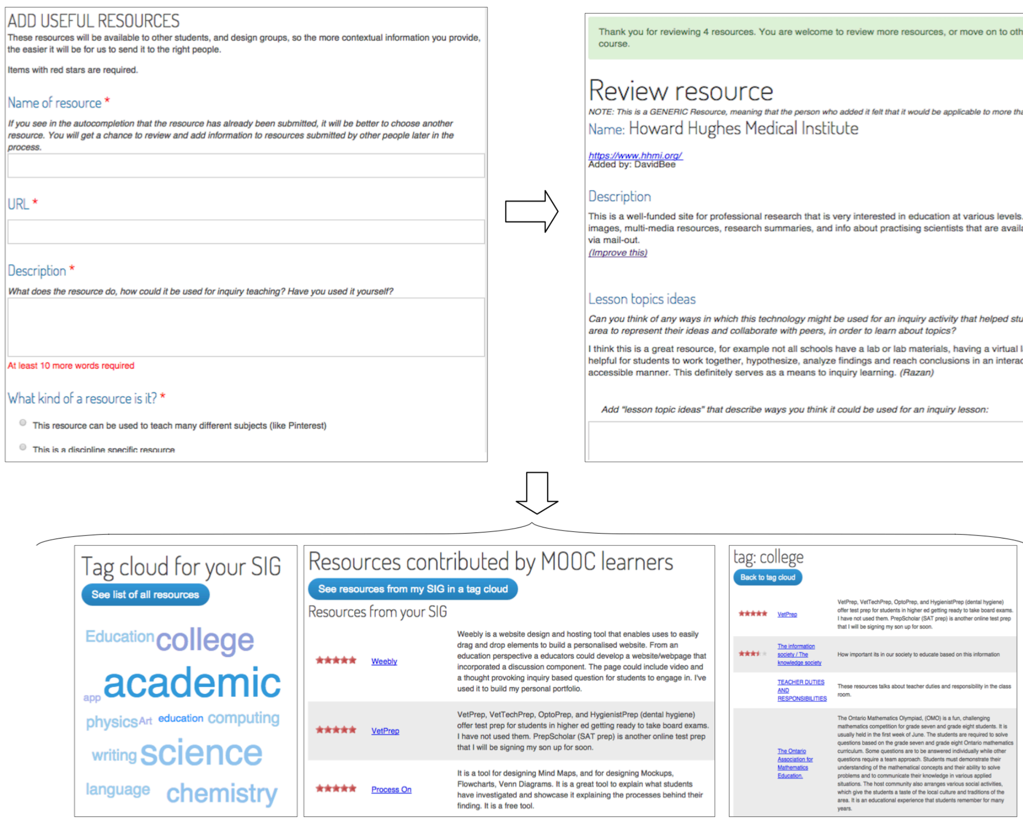



**Figure 22 - Resource script screenshots**

### 5.2.4.3 Reviewing previous lesson designs

In inquiry-based courses, students often work together to create and organize artifacts, working collaboratively to design and develop projects together. At the end of the course, all of this creative effort is typically shelved, deleted or archived, and the next iteration of the course begins from a clean slate. While there is value in creating something from scratch, sharing artifacts "forward" from one course generation to the next could also be of real value, providing a rich means of connecting students within a wider, ongoing community of learners.

By providing model lesson designs from previous generations, we can inspire students to be more ambitious about their own designs, particularly as they have access to the creativity and ideas from past generations (i.e., which would add ideas and approaches to the current generation's brainstorms). Knowing that their final design might be made available as a resource for future cohorts of students could also serve as an added motivation to a design team. This was a mechanism used reliably for nearly a decade in the pre-service course described in the prior chapter.

Because the present MOOC had never been run before, we chose to enable this use of prior student designs by drawing on the products of the pre-service course, where students had engaged in a very similar assignment of designing a technology-enhanced inquiry lesson. 22 of those existing lesson designs were harvested from various earlier course offerings and put into a consistent format, then made available to MOOC students during the first week, for exploration (see screenshot in Figure 23). These spanned the various SIGs as widely as possible, and they were provided as an inquiry activity in the first week for all students (i.e., in the Foundations strand, not just the Design Strand). Students were asked to review as many as they liked and to leave comments. One role played by this activity was to try to motivate as many students as possible to join the Design Strand.

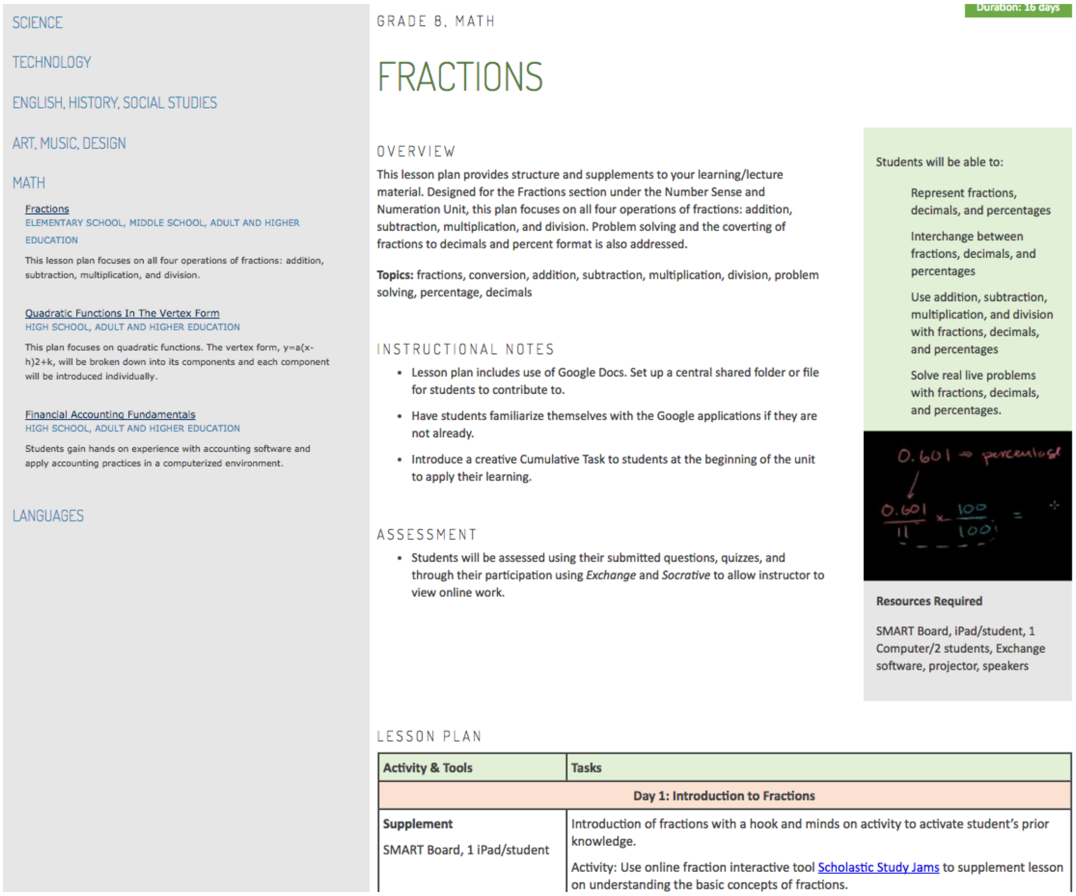



**Figure 23 - Previous lesson design screenshot**

### 5.2.4.4 Peer review

One of the inquiry activities was to provide to peer review for in-progress lesson designs from the Design Strand, during weeks 2, 3 and 5. This peer-review should be distinguished from the typical approach to MOOC peer-review in a few ways. Typically, before serving as a reviewer, a MOOC participant must first submit an artefact for review, whereas in our case we had a large group of people in the Foundation Strand who would be peer-reviewing artefacts from the Design Strand, without having participated in any lesson design.

Second, artefacts are usually peer-reviewed a single time in most MOOCs, resulting in a summative evaluation that provides a source of assessment. In our case, the lesson-design project was a process that continued throughout the course, and in some cases beyond. Given that there was no course credit given for participation in the Design Strand, we were not interested in students ranking, rating or evaluating the quality of a lesson design, but rather to think about how they could contribute to improve it—asking students to see it not as a finished product, but as an "improvable idea". The purpose of the peer review was therefore to serve as inquiry activity within the script whose purpose is to promote reflection and help to further the progress of participants working in the Design Strand.

Thus, each week students were asked to visit and comment upon in-progress lesson designs. Some weeks, they were assigned random lesson designs, with the option of "rolling again" if they didn't like the one they had been assigned, or if they had completed it and wanted to do another one. Other weeks, students were able to choose from a list of all active lesson design projects within their SIG. Once they entered, they would see the most recently updated wiki page from the lesson design group (not the chat, or Etherpad discussions, which were private to each group), and given specific prompts relevant to the weekly theme. For example, in week 3, when the weekly theme was "Collaborative learning", students were provided with the following peer review prompts:

- How is this lesson incorporating collaboration? If it is not, can you help think of any ways the designers could add collaboration?
- How could collaboration help improve students' learning in this lesson?
- What should the designers keep in mind, as they think about weaving collaboration into their lesson? Will it take more time, or add possible confusions for students?

The feedback from all students to a certain group was aggregated, and made available to that group as one of the panes in their collaborative workbench (described below).

### 5.2.4.5 Brainstorm discussions

As part of each week's script, students were asked to participate in online discussions within their SIGs using the EdX forums. While these discussions served to engage students in expanding on the ideas from their personal reflections, we wanted to experiment with other ways of organizing an exchange of ideas. The design and functionality of a computer-mediated communications tool can have a large effect in structuring the kind of discussion or exchange that takes place. Thus, we prototyped a Brainstorm tool in weeks 4 and 5, which combined social network "feeds" like those of Facebook or Twitter with a discussion forum and a chat tool (see Figure 24). In week 4, we first used this tool to ask students about their ideas around connecting their SIG topic with approaches for using tables and smart phones in inquiry lessons. In week 5, we asked them about possible uses of student-contributed content and collective inquiry.

As shown in Figure 24, ideas could be simply entered in a box near the top, similar to a Facebook status update or Tweet. Once the idea had been entered, it appeared below in a ranked list. Students could easily "up vote" interesting ideas using the heart icon, and add comments below each idea. Once loaded in a student's browser, the brainstorm board was "live", meaning that it would automatically update when other people voted or added comments, without having to reload this page. It was hoped that this sense of immediacy and co-presence would encourage a better exchange of ideas.

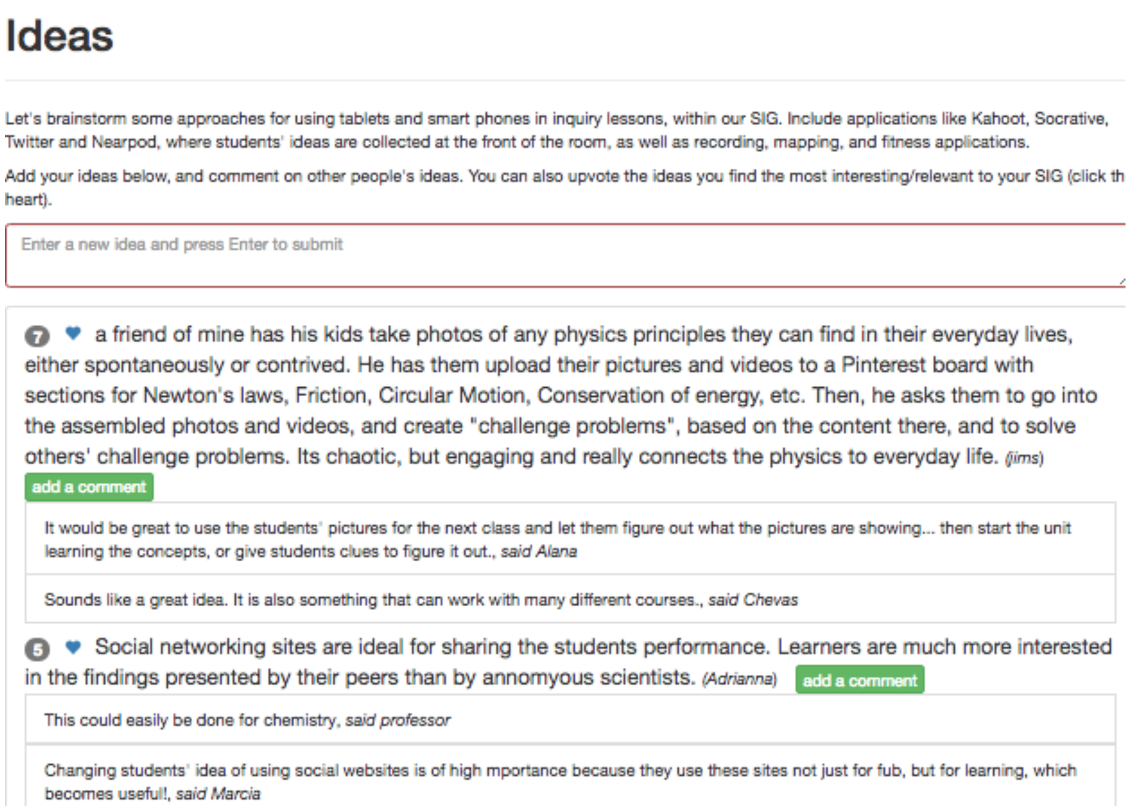



**Figure 24 - Brainstorm interface screenshot**

### 5.2.4.6 Live events

During the final week of the course, we wanted to design an activity that provided some closure to the course, and also provided a sense of celebration for all the students and instructors that had worked so hard throughout the course, creating a remarkable community together. To do this, we organized two live events (to provide some flexibility for students in different time zones), and invited the UTS staff, Principal, and teachers who had appeared in the weekly videos.

Organizing a participatory, synchronous event with hundreds of participants raised technical and design-related questions. We had previously used Google's "Hangout on Air" in the pre-service course, in which Google Hangout is used to video-conference among a few people, and the resulting video session is then streamed on-line via YouTube to an unlimited amount of viewers. This worked well in a broadcast-sense, but the tools for audience participation were very limited.

Thus, we decided on a hybrid approach where we embedded the resulting YouTube video, but provided the audience with our own interaction tools. Many live events provide various "backchannels" (e.g., Twitter) or purpose-built tools for the audience to discuss among themselves, suggest questions or feedback to the presenters. However, keeping an eye on a fast-moving stream is very challenging for a person doing a presentation. We thus decided to separate the two concerns—participant discussion about the presentation, and questions to the presenters.

For the questions to the presenters, we were inspired by the now-defunct Google Moderator tool, and used the brainstorm boards that we had already used in weeks 4 and 5 to allow students to quickly suggest questions, and vote these up. Instructional staff had additional options, allowing them to very quickly either delete an irrelevant question (with the option to undelete), or archive a question that had already been addressed (moving it to the bottom of the list). This meant that presenters could quickly see the current top questions that had not yet been addressed, and glance at the discussions taking place in the comment space directly below.

In addition, students had a chat box on the side of the screen, which was open to general discussion. We opened these pages several days before the live events, and invited students to post questions for our presenters. Figure 25 shows a screen capture of one of the live sessions, including the embedded chat and brainstorm tools.

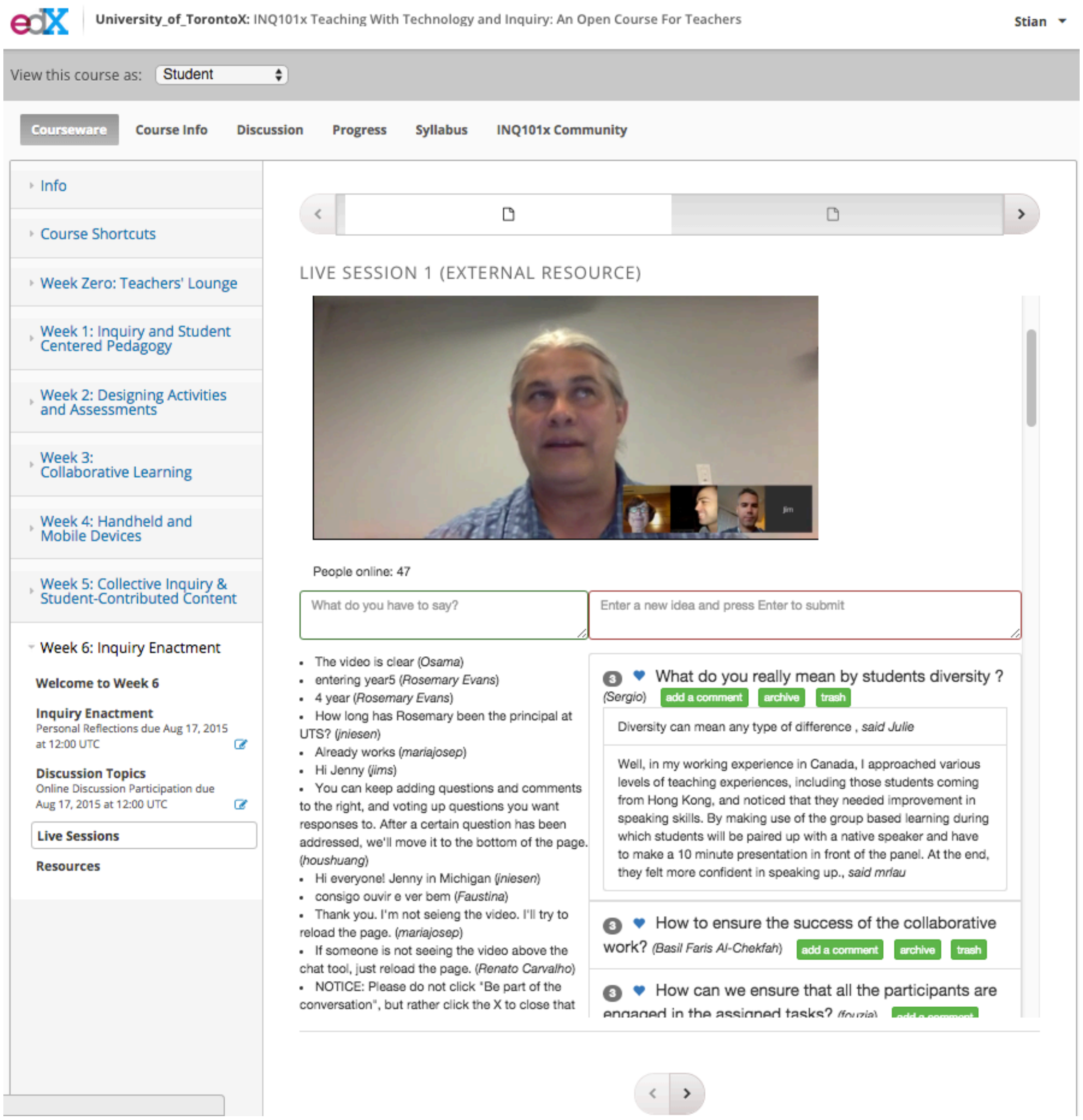



**Figure 25 - Live event screenshot**

## 5.2.5 The Design Strand

In the pre-service course (Chapter 4), the lesson design activity was an important cross-cutting script and capstone project completed by all students. While the MOOC was inspired by that course, and included then same themes and KCI foundations, it was seen as unfeasible to ask all students to engage in creating a lesson design, or to make this a central part of the course. If we had done so, we would have certainly lost the majority of our participants, for whom MOOC engagement did not entail major design work. We addressed this concern by making the lesson design an optional activity, but one that participants were required to make a deliberative choice about. During the first week, they were asked a simple question: “Do you want to stop here, or would you like to proceed to join the Design Strand?”. They were informed that any design activities would not be factored into the formal assessment of MOOC participation.

The process of designing a technology-enhanced inquiry lesson provides students an opportunity to apply theoretical ideas and specific technologies and resources from the course to their own teaching interests and disciplinary knowledge. With students working in small groups, the project requires an intense level of collaboration and constant coordination, supported with digital knowledge tools. Through the connections to weekly themes, scaffolding of scripted activities, and multiple opportunities for feedback from peers and instructor, the lesson designs would ideally growth in sophistication, reflecting of the students' growth in understanding of course topics.

Translating this script to a MOOC context was a design challenge for a number of reasons. First and foremost, we knew that a majority of the MOOC students would not be able to contribute the level of effort necessary to sustain a group collaboration around creating a lesson design. This is not what the large majority are looking for, although there is a general interest in less passive learning experiences, with peer interactions and interesting activities. We wanted to offer a lesson design strand that some could choose, if they were ready to take on an extra level of work, but that would also allow some legitimate means of participation to the wider cohort of participants.

For example, we could draw on the large crowd, asking all participants to contribute their favorite technology resources, then tag those resources with possible topics, and vote on the resources contributed by others. This would create a growing pool of design resources that could be accessed by the smaller set of designers. In general, we wanted to create scripts for both the Design and Foundations strand where the large group provided resources and review services for the small set of designers, which would provide an inquiry experience for the Foundations strand and a sense of connection to community for the Design strand.

Other design challenges included (1) ensuring that lesson design topics could emerge from within the community, growing from student brainstorms, (2) that design groups would emerge along lines of shared interests or geography, and that (3) these groups would be supported and sustained through a 6-week script. The major design challenges are enumerated in section 5.2.5. Wherever possible, designs were guided by KCI principles.

Once students had decided on a general topic, and joined together in a team, we needed ways of enabling and sustaining their collaborative effort, creating a sense of a collaborative team, among people who had never met before, in a mostly-asynchronous, fully online environment. A key part of orchestrating the Design strand was the collaborative workbench—a unified interface that provided a design team with all the necessary information and functionality required for doing its creative work and group coordination. Upon creating a new design team, or joining an existing design team, students entered the full-screen interface shown in Figure 26.

### 5.2.5.1 Collaborative workbench

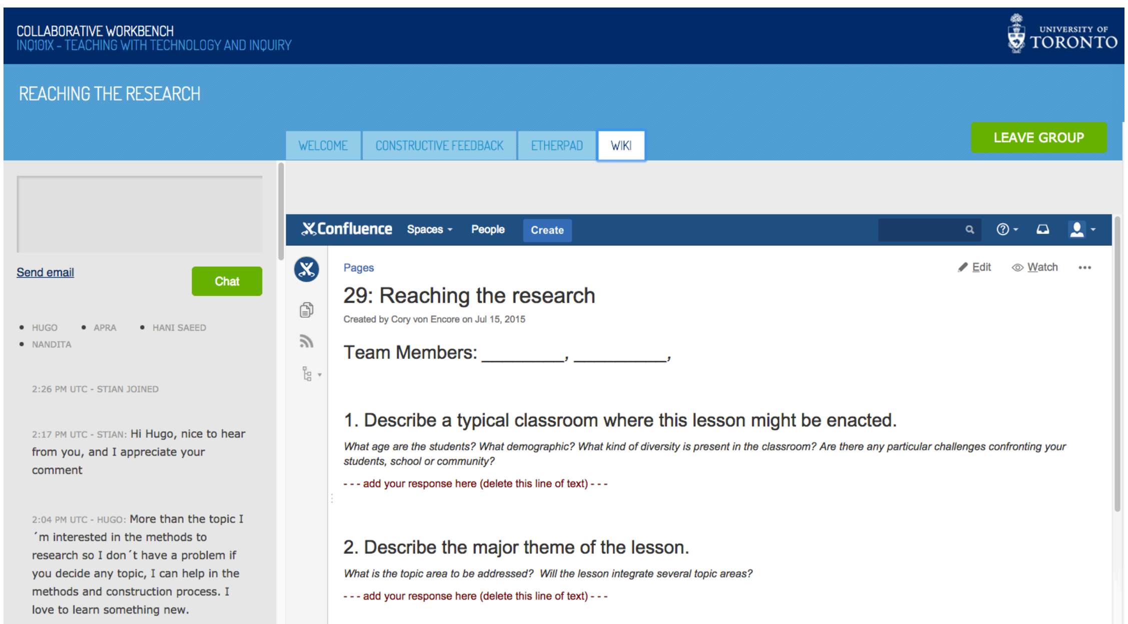



**Figure 26 - Collaborative workbench**

The left sidebar of the Collaborative Workbench contained communication and social presence tools, including a list of the members of the group, with a green symbol showing who was currently online in the collaborative workbench. Students could send chat messages, which were persistent (i.e., students could scroll through the entire chat history of the collaborative workbench, including messages that were sent while they were not logged in)—a design that combined the functionality of chat and notice boards. There was also a button to send e-mail, which opened a small window where students could send all group members an e-mail message.

This worked by automatically creating an ad-hoc mailing list for the group, maintaining privacy of student e-mail addresses.

The right part of the Collaborative Workbench was for working on content creation and ideation, and had several main “tabs” that allowed various major functions to occur. The first tab contained a welcome message, including prompts and activity tasks for the current week. This message was updated each week. The other tabs varied with each week, often bringing content or ideas from the larger course. For example, the first time that students entered the Workbench, they got access to the resource explorer, to find resources that could inspire their lesson design. A third tab aggregated the feedback and suggestions from other students on their lesson design as it progressed. Because these different tools were presented as tabs instead of separate pages, students could switch between them without loosing context or data. This was important for students who were in the middle of editing the wiki, and wished to look something up in the Etherpad, or in the external review comments, for example.

To begin sketching out ideas and approaches, we embedded Etherpad (live collaborative text-editing) as a means of collaboratively developing their design ideas. A new Etherpad was created each week with different prompts, and Etherpads for previous weeks were available through a menu. During the first week, students were asked to use the pad to introduce themselves to their group members, and began brainstorming the topic of their lesson, how it was positioned in the wider curriculum, and its length.

A dedicated wiki page for the lesson was introduced in week 2, to serve as the platform for the final product (i.e., the final lesson design). This was a Confluence wiki page embedded directly into the workspace, where students were automatically logged in and sent to the right page. This page included a template, with pre-designed headers that would help ensure all major elements were present within their design. Initially, only a few headers were visible, in order to avoid distraction, and keep the design focus on the important early stages (i.e., coming up with a topic, some core technology resources, and a sketch of an activity plan). As weeks went by, new headers were added, corresponding to the weekly theme. The complete lesson design outline is shown in Figure 27.

1. Describe a typical classroom where this lesson might be enacted.
2. Describe the major theme of the lesson.
3. What are the learning goals of the technology-enhanced lesson?
4. Some aspects of the design (complete any that are relevant)
    a. Student-Centered Design
    b. Peer Collaboration
    c. Use of Handheld or Mobile Computers
    d. Supporting Equity and Diversity
5. What is the activity structure of the lesson?
6. Assessment notes.
7. Enactment notes.
    e. Ethics or enactment concerns

**Figure 27 - Lesson design outline**

The chat and the Etherpad content were private to the group, and only the lesson overview (title, description, etc) and the wiki text was ever made available to the wider Foundations community. During the final week of the course, we pooled all lesson designs that had been completed, and curated them into a "gallery walk" that was made available to the whole course population This gallery walk was later put on a public URL, and will be available to future course generation, as well as to the general public (see Figure 28).

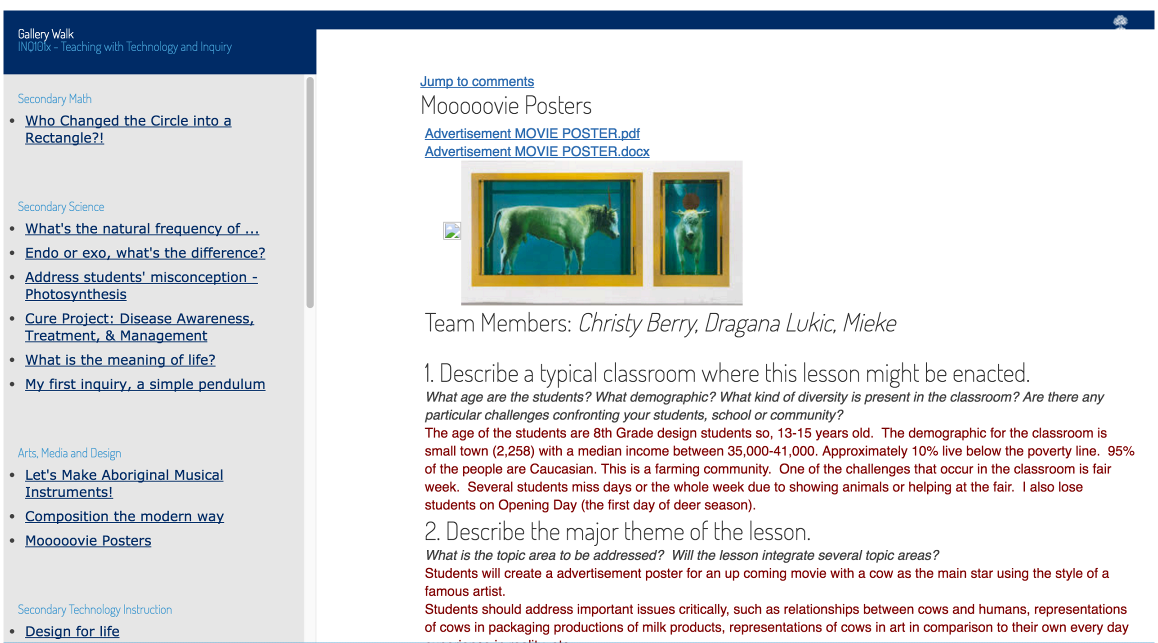



**Figure 28 - Screenshot of gallery walk**

### 5.2.6 Key Design Challenges

In Chapter 4, we introduced three Key Design Challenges related to supporting complex inquiry scripts and a community oriented pedagogy in large groups. Given the much larger sample of MOOC participants, and the complexity of a mostly asynchronous environment where participants had varying levels of engagement, interest and experience to offer, we needed to build on the lessons learnt from the pre-service course, in order to address these challenges.

Below, I describe how we designed a pedagogical script that addressed these challenges, First, I review how we defined student groups, how we orchestrated student assignment to and activity within these groups, and how student models informed grouping and collaborative scripts. Next, I describe how we ensured bi-directional assumption of content, as richly illustrated in the Lesson Design scripts described above. Finally, I discuss challenges with coordinating student-led group formation in an asynchronous environment, and the challenges of supporting deeply collaborative work among dispersed groups.

#### 5.2.6.1 Orchestration of group assignment

Traditional university courses typically offer only a single mode of participation, with all students expected to complete all course assignments to receive course credit, although some instructors allow occasional auditors that sit in on lectures, but are not required to complete course work. MOOC students arrive with widely varying levels of motivations and interest. To accommodate such variation, we could offer a set of straightforward materials, such as videos, readings and online discussions, and reduce our expectations about how students will or will not interact with them. Conversely, we could construct an elaborate design with high requirements and correspondingly high initial barrier to entry, which would ensure that only the most dedicated students entered the course.

We chose a design path instead that included two distinct modes of engagement, but where the different modes of engagement were interdependent, and benefitted from one another. The various levels of engagement with the course, and the access to materials and activities, can be described as a series of concentric circles, as illustrated in Figure 29. At the outside is the general public, people who have not registered with the EdX platform or signed up to take our course. This course made no particular effort to engage with this group, although there were both tweets and a Facebook page which could share ideas from the course with the outside world. In addition, the final gallery walk (the best lesson designs) was made available on a public URL, and other resources from the course might be shared publicly in the future.

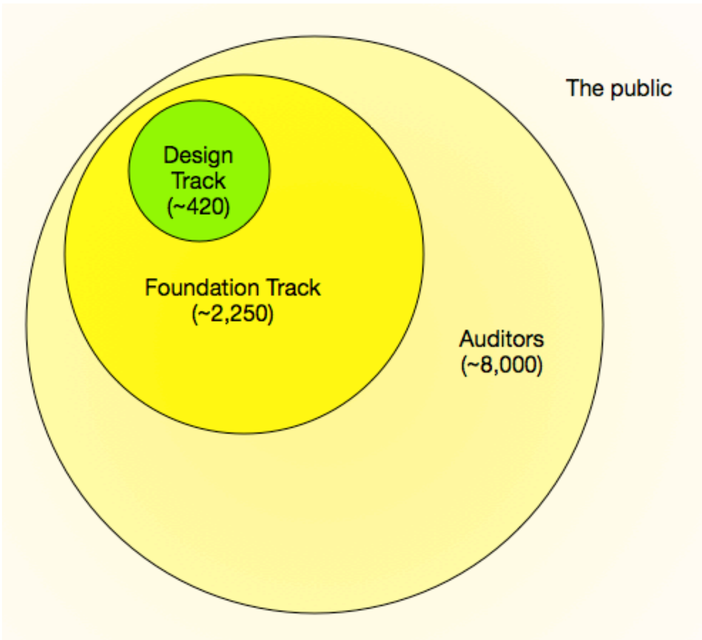



**Figure 29 - Modes of participation in MOOC**

In our case, we consider Auditors as students that signed up for the course in EdEx, thereby gaining access to all the content hosted on the EdX platform (videos, quizzes, discussion forums and further readings), but did not participate in any of the interactive exercises (whether Foundation Strand or Design Strand), and were thus not eligible to receive Course Certificates. While a sizeable proportion of these students signed up simply to be able to preview the course material, and did not stay active in the course for very long, some may have found a meaningful experience, watching the videos and even engaging in the online discussions. Because these participants were not highly engaged in the course (i.e., not even to the level of taking the intro survey and getting themselves authenticated so they could conduct the inquiry activities), we did not consider these students in our design or analysis.

Any student that managed to make it through the LTI registration (which was achieved by completing the pre-course survey and thereby ensured seamless access to any subsequent LTI component) were considered as part of the Foundations Strand. Just like the auditors, they had access to the video material and other content, but in addition, they were asked each week to complete individual reflections, participate in forum discussions within their SIGs, self-assess their performance, and participate in various inquiry activities that were designed to promote reflection and learning while also providing inspiration and feedback to those in the Design Strand.

As shown in Figure 29, students in the Design Strand completed all the activities of the Foundation Strand, but in addition they had signed up to work as part of a small team on designing a technology-based inquiry lesson. As such, they had access to the Collaborative Workbench as described above, and received weekly prompts and scaffolds to support their work. They built upon the resources and ideas collected by the Foundation Strand students, and received weekly feedback from the community on their design work.

To emphasize the fact that participation in the Design Strand should be seen as an extra opportunity for a rich engagement with other learners in creating a product that could be useful in one's future professional work, we chose explicitly to give no course credit for the Design Strand. Students could earn 100% marks simply by participating in the Foundation Strand activities (including submitting resources, providing feedback on lesson designs and contributing actively in other ways).

##### 5.2.6.1.1 Tagging and student model

Most of the interactive features of the MOOC were hosted on an external server, and served through the LTI interoperability framework, which allowed us to use the single user sign-in and authentication performed by EdX, then launch any number of LTI "frames" that could embed apps, all of which maintained user authentication and security. Anyone accessing these features, who had not yet completed the entry survey, were asked to first go back to the registration link in week 1, before they could continue.

Upon launching the pre-course survey, students were asked what name we should call them, which they were told would be shared publicly on the artefacts they created, and was a way to avoid sharing private information, such as the names they used to register on EdX. To help us determine what SIG groups were likely to be applicable, we also asked about which age group they currently teach, and which areas of Science, Technology, Engineering, Arts, Mathematics and Other best define their teaching interests. Based on their responses to the high level categories (e.g., "Math"), they were offered a tag selection interface which auto-completed any tag they started typing based on a list of pre-seeded tags, as well as tags already entered by other students that had selected the same letters (e.g., “algebra”).

The ease of entering new tags combined with the increased likelihood of selecting already existing tags (i.e., due to the auto-complete mechanism) resulted in a rich set of tags that described our users, which we used to define the most appropriate Special Interest Groups for our student population (together with their demographic and teachable data). The self-description tags were also used as a means of automatically matching students with possible design partners, or with appropriate resources. Figure 30 presents a graph of the most connected student tags (the more users that have selected the same two tags, the stronger the connection between those two tags). The size of the tag represents the number of students who have chosen that tag, and the size of the links the strength of the connection between the two tags. This gave us an intuitive sense of teaching interests among our MOOC participants.

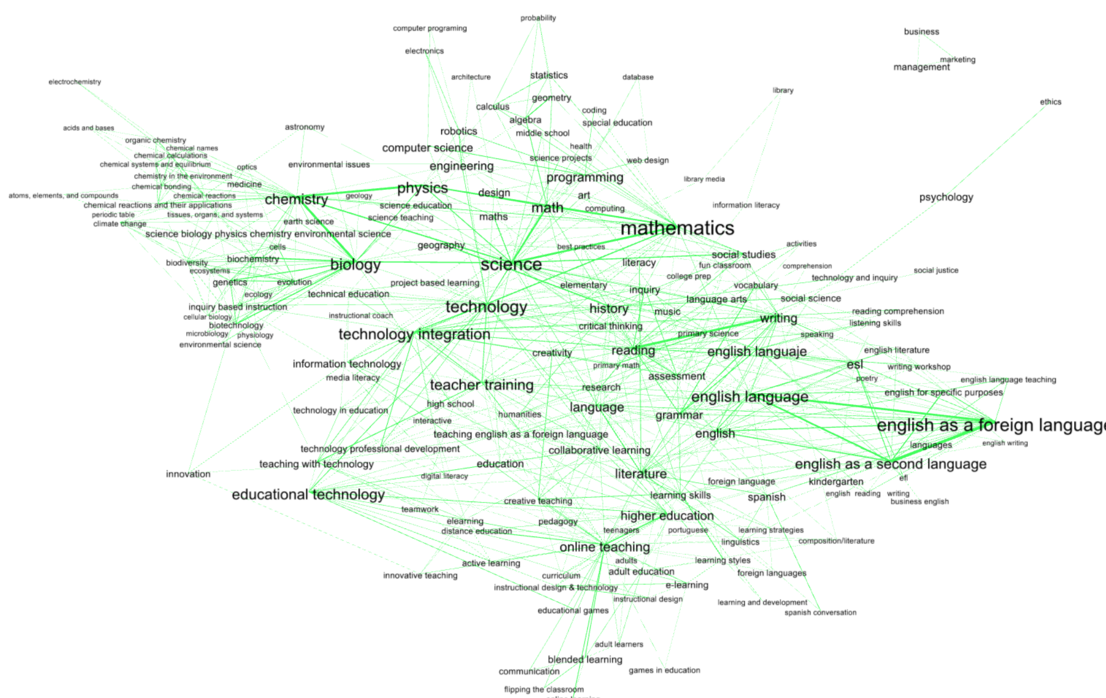



**Figure 30 – Visualization of MOOC user tags**

The fact that our external LTI server maintained comprehensive records allowed us to construct a fairly comprehensive student model, shown in Figure 31, which was accessible to inform all LTI activities. The fact that we could maintain a dynamic student model opened up many possibilities for adaptive scripts. For example, students could be shown different screens (resources, designs, etc) based on their preferences or activity history. Or the LTI script could send out notifications and tailor e-mails to specific sub-groups.

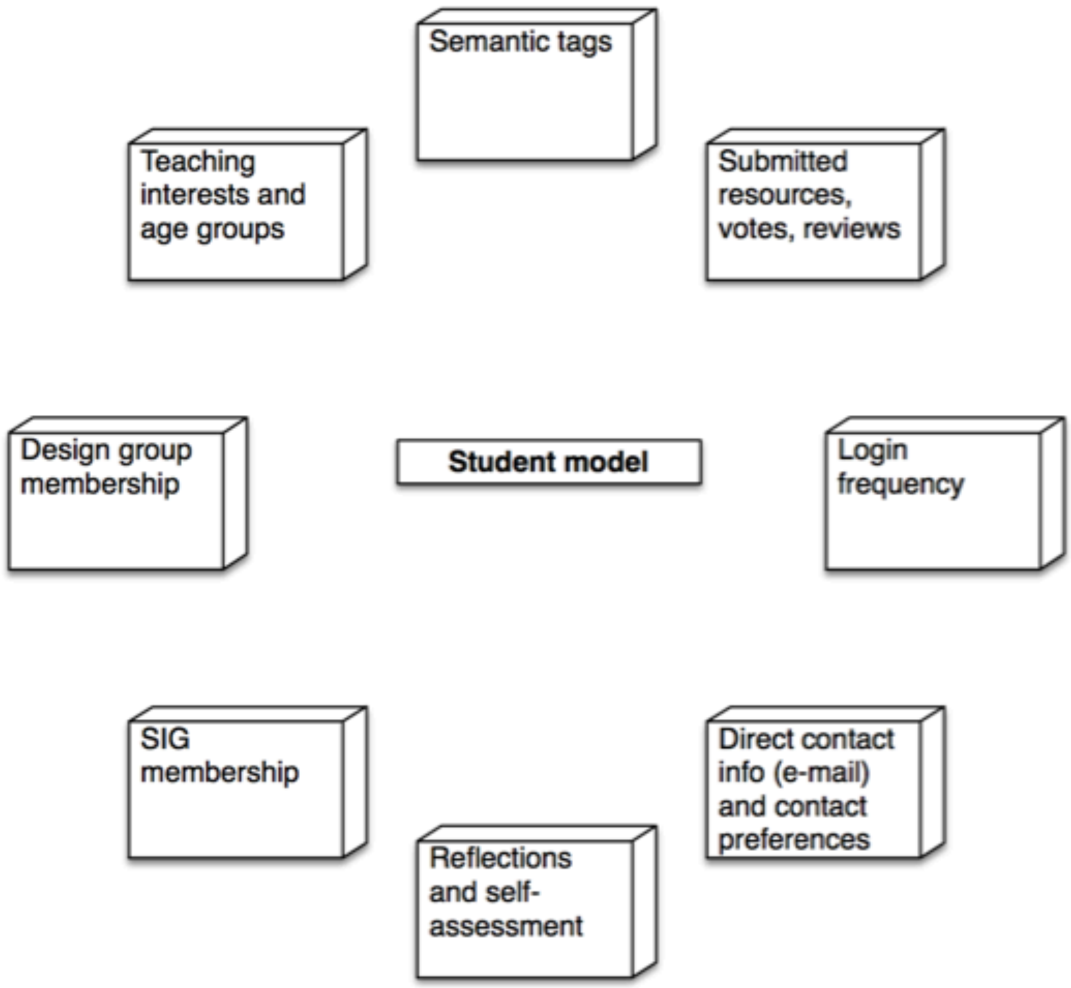



**Figure 31 – MOOC user model**

#### 5.2.6.1.2 Special Interest Groups

Based on the meta-data provided by participants in the pre-course survey, including topic and age level, and semantic tags, we derived 18 distinct Special Interest Groups (SIGs), as shown in Figure 32. Rather than automatically assigning students to these SIGs, we decided instead to ask them to choose from these 18, since many would be eligible for more than one, and any newcomers (i.e., who signed up after the SIGs had been derived) would need to choose as well. Hence, we made it obligatory to select a SIG group. For students who had already registered, a SIG group selector was shown before their first interactive activity, and had to be completed before moving on. For students who had not yet registered, a SIG group selector was added to the obligatory registration page that they had to complete.

The survey data from student registrations revealed the need for several SIGs that were outside the context of formal K12 teaching: Informal Learning in Museums and Out-of-school settings, as well as a Higher Education and Online Learning. This latter SIG actually became the most popular in the MOOC, and would not have been offered had we not informed our groups with the participant survey data. Moreover, we further refined our SIGs according to observed student selections during the first week of class. Because we wanted to ensure that all SIGs had a critical mass of students (i.e., to support more dynamic discussions and inquiry designs), we consolidated several of the SIGs in week 2, as shown in Figure 32.

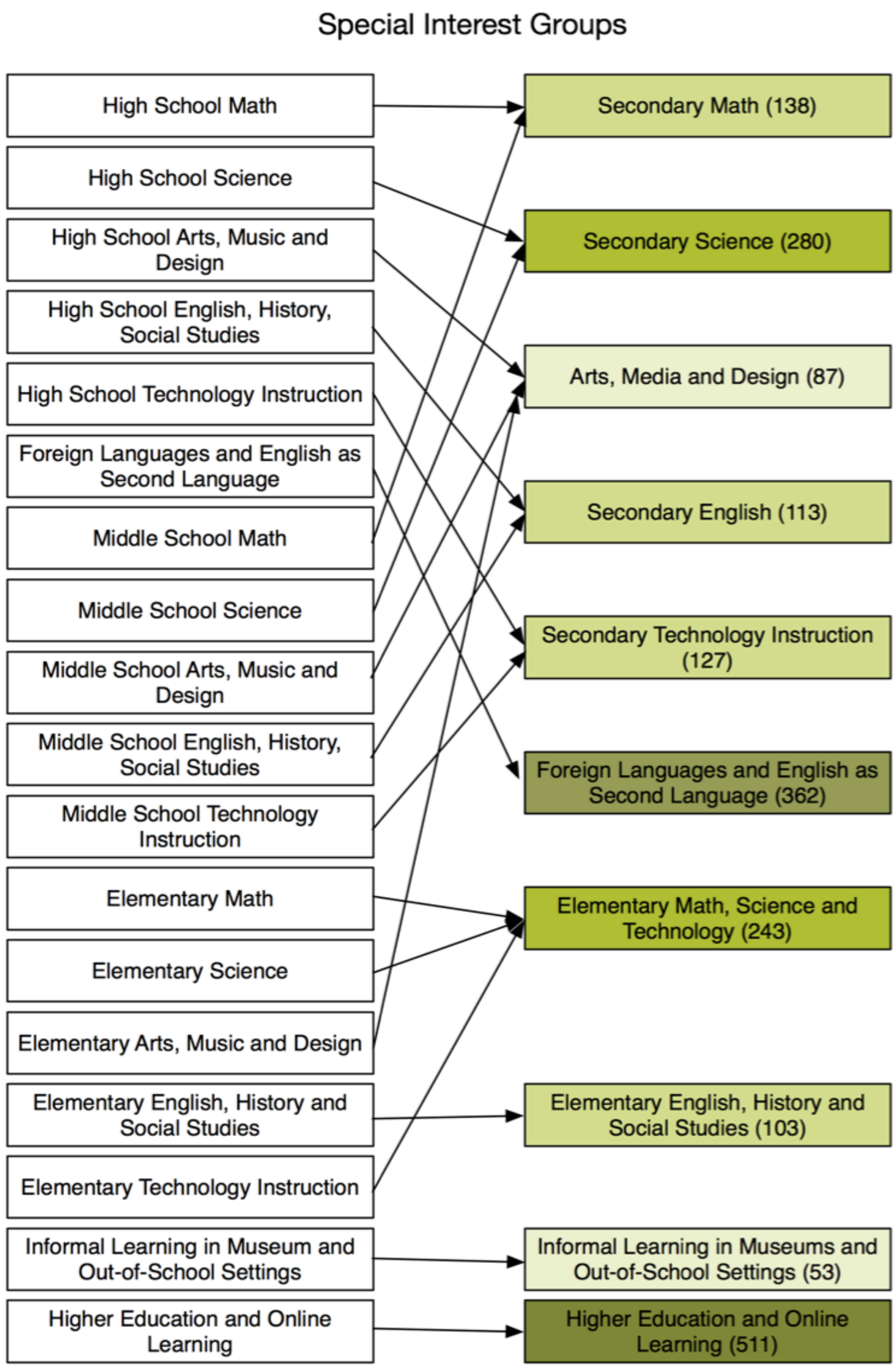



**Figure 32 - Special Interest Groups**

### 5.2.6.2 Supporting bi-directional assumption of content

Figure 18, above, (the Course Script Overview) illustrates the way different scripts in the MOOC depend on one another, interacting and exchanging artefacts. By grouping students in SIGs, forum discussions and lists of design groups were more manageable and focused on common interests. But several aspects of our broader script were designed to help cross-pollinate SIGs, such that resources, ideas and insights were shared across the wider community. In the “add a resource” script described above, participants could mark their resources as applicable to all SIGs, with any such resources then becoming available to all other SIGs for viewing and commenting. Similarly, the live event brought students together across all SIGs, using an interface designed to enable productive synchronous exchange, even with a large number of concurrent users. As well, the final gallery walk highlighted the best examples of lesson designs from the entire course, for all users, and the general public.

The creative work of lesson designs happened in small groups within the Design Strand, which had their own private spaces for collaboration (i.e., the Collaborative Workbench, with its Etherpad, wiki, persistent chat and email). But these groups were engaged in a constant exchange and dialogue with the broader SIG community, through bringing in community resources (such as the resource script), the weekly peer-review feedback sessions, and the fact that the lesson design drafts on the wiki were publicly available as part of the community knowledge base. In this way, we designed aspects of our global scripts where the larger majority of participants in the Foundations strand served as an important “cloud” resource for the lesson design groups, but the lesson design groups, in turn, produced a steady stream of products that provided a source of inquiry and critical reflection for the wider community.

### 5.2.6.3 Enabling online collaborative inquiry

The overall design of the MOOC pedagogical scripts, and the various technological environments, aimed to support online collaborative inquiry. In this section, I discuss two specific challenges of group coordination in online asynchronous environments where students only log in once or twice per week. I focus on our scripting and technology designs that responded to this key challenge.

#### 5.2.6.3.1 Lesson design selection

When we were designing the script for proposing and selecting a lesson design team, we initially articulated a fairly involved process where students first brainstormed a number of lesson design ideas, then voted for several, and if lesson designs received a certain number of votes, they would be “opened for joining,” whereupon students could join them, etc. One problem with this approach was that setting up and getting the students assigned to design teams would take two or three weeks, because of the necessity for them to visit at a number of different stages – even though the activity required at each stage would be minuscule. This is an interesting example of something that could easily be done in a classroom, where everyone is in "sync", and you can simply ask them to brainstorm and choose groups, and then proceed to the next stage. In the asynchronous MOOC environment though, we would need to wait for appreciable time periods between every small phase of the activity.

We responded to this problem by dramatically reducing the number of steps necessary, and making it much easier to change groups in mid-stream. Thus, immediately upon suggesting a group, a person would be automatically entered into that group and begin working, and anyone else could immediately join that group (up to the size limit of 6 members). However, one could at any time leave a group and join another, in case a group failed to attract a critical mass of members, for example. In Figure 33, you can see the two approaches compared. The key issue is not the number of steps, but the number of stages, because between each stage, students have to wait for all (or most) other students to complete the same stage, before they can move on to the next stage.

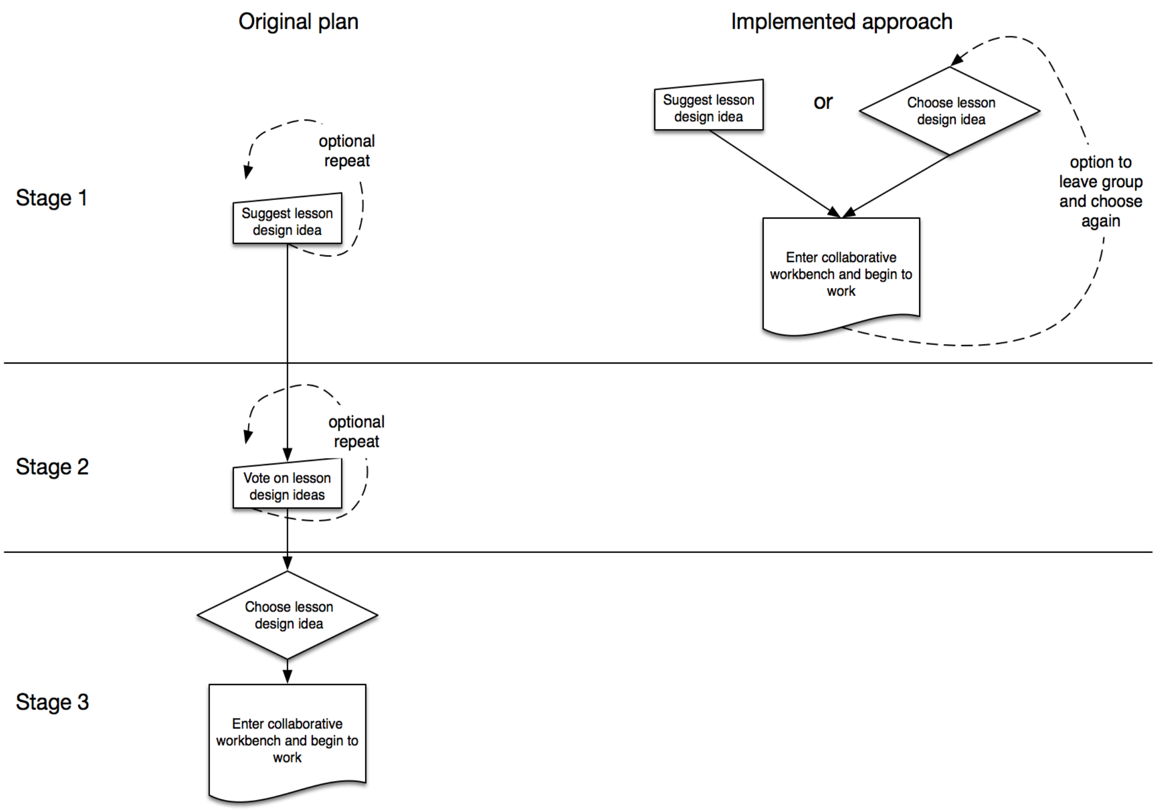



**Figure 33 - Lesson design selection flow**

## 5.2.6.3.2 Coordinating work in small groups

Another issue that became apparent during the enactment of the MOOC was challenges that design teams faced over coordination. Many group members were reticent about making decisive changes (for example going from the brainstorming around possible topics to selecting a single topic for the group to focus on) without consulting with the other members, but without the ability to effectively communicate with other group members in a timely fashion.

The design team members could access their collaborative workbench with a persistent chat interface, the weekly prompts, and a collaborative editing space (Etherpad). In the first week, members joined a team that already had a title and some minimal context, and were asked to brainstorm possible approaches and more specific goals for the team. This went well, because the task could be categorized as atomic or additive, i.e., “I'm adding my comment, and you're adding yours. I don't need to know what you are writing, or come to agreement with you before adding my comment”.

However, in week two, design teams needed to choose one particular lesson topic and inquiry approach for their design project, narrowing it down from the ideas in their brainstorm. At this point, we observed a blockage in many design projects, where members were reluctant to make a decision without consulting their teammates, but lacked an effective way of consulting one another because of logistical challenges. Their only medium for discussion was the persistent chat in the Collaborative Workbench. However, the likelihood of two or more group members being logged in at the same time was low, and without any social notifications, they would have had to log in repeatedly to check for new messages.

To address this, and to support the design groups in more effective decision making and communication, we made two user interface changes. The first was to send out e-mail notifications to group members every time a group member logged on to the collaborative workbench. These emails included special links that, when clicked, would log a user directly into the collaborative workbench, without needing to go through EdX and typing their password etc, as well as a link to unsubscribe from such notifications (see Figure 34). This feature proved to be quite effective, since many wanted to engage directly with others in their design group, and followed the link quickly to log into the collaborative workbench, since they knew that the other member was in the Collaborative Workbench at that time. As a result, there were some very engaging chats which greatly improved capabilities for design teams to make decisions and move their designs forward.

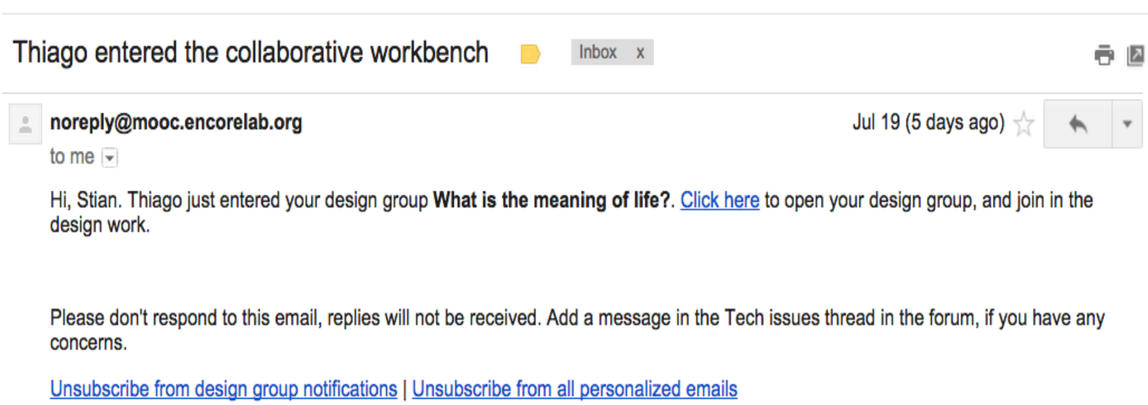



**Figure 34 - Social notification email screenshot**

The second feature added was the ability to create an ad-hoc mailing list for the design group. Maintaining privacy for all MOOC users was a technical challenge, and the feature was only made available in week 3. Users could click a button in the collaborative workbench and enter a message, which would be sent to all members of the group who had not unsubscribed to notifications. This message was sent with a unique “from:” address, meaning that and any replies to the message could be forwarded around to group members, without revealing anyone's personal email addresses.

Contrary to our hope, this feature did not receive much usage, perhaps because it was added too late, and without sufficient communications on our own part to the design groups. Or perhaps users found emailing others to be too intrusive. The design of such collaborative work environments is an exciting area for future research, to be informed by our design experiences in this first version of the Collaborative Workbench.

## 5.2.7 Technology Environment

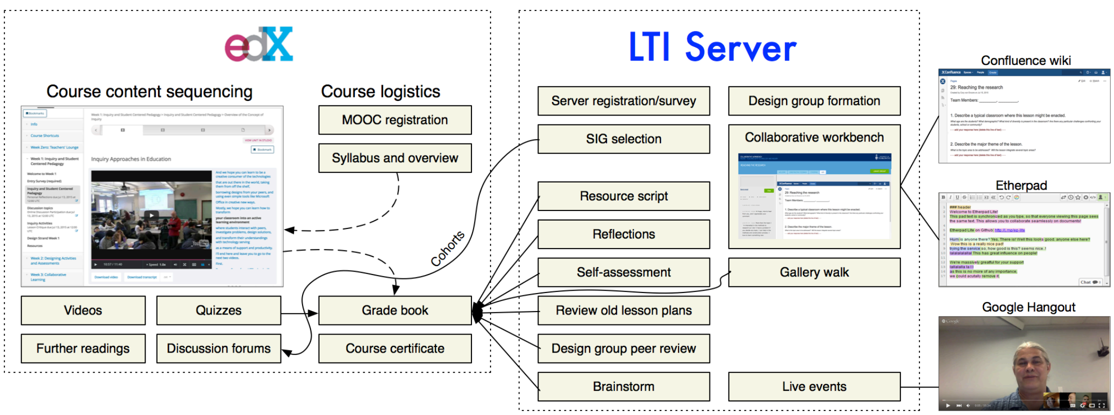



**Figure 35 - Technology environment overview**

The technology environment (shown in Figure 35) was composed of the EdX platform and the external LTI server, as well as a few external Web 2.0 applications. This section describes the functionality of the EdX platform, the LTI integration and the custom-built LTI server, as well as the external components that we used.

### 5.2.7.1 EdX platform

The OpenEdX platform is an open-source learning management system for MOOCs. Upon visiting EdX.org, learners were asked to register, and were able to browse lists of courses. Upon selecting a specific course—for example our MOOC, INQ101x: Teaching with Technology and Inquiry—they then entered that course (see Figure 35). Students first landed on the "News" page, and were then able to use the navigation bar on top to go to see the syllabus, visit the forum or see their own progress. However, most of the interaction with the course happened through the Course tab, depicted in Figure 36.

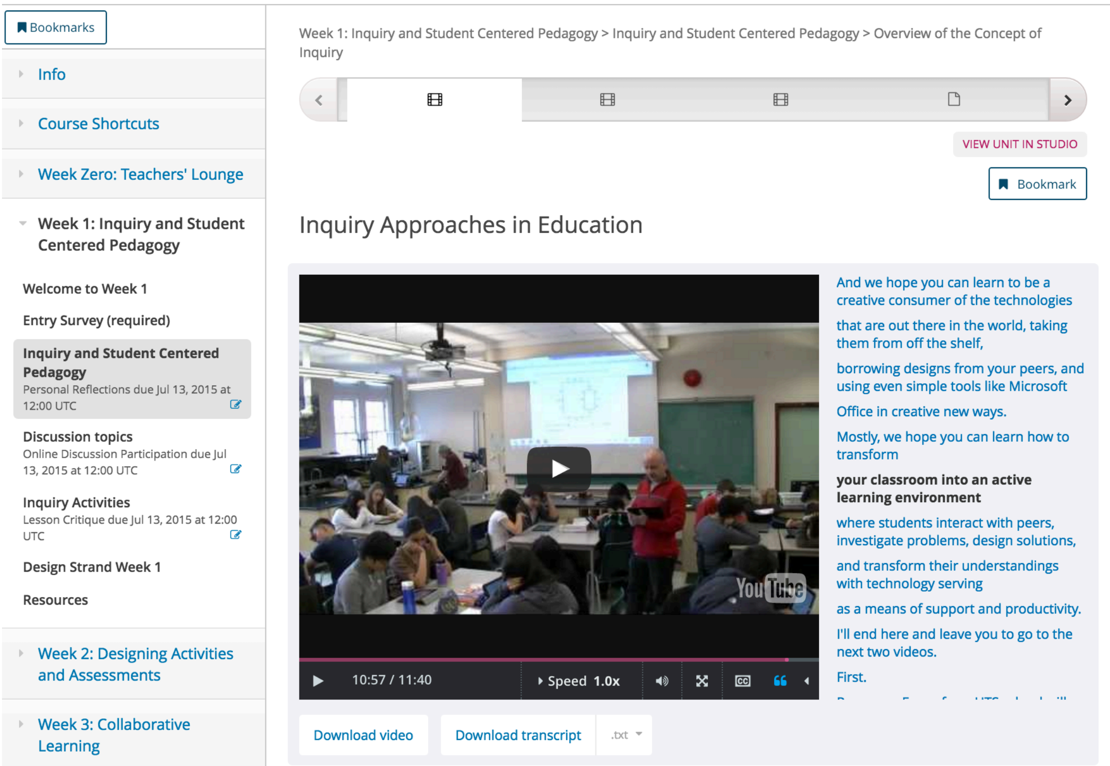



**Figure 36 - EdX screenshot**

In the left sidebar was an accordion-style menu with headers that could expand to show activity sequences. Traditionally, courses use weeks as an organizing principle, but we also added sub-menus for course information and course shortcuts. Each of the activity sequences can consist of a number of xBlocks, displayed as row of icons above the content. These xBlocks can be videos (displayed above), text, quizzes, peer-review or built-in interactive exercises and simulations, or external LTI components.

The EdX platform has a number of limitations when it comes to enabling complex pedagogical scripts:

- Although the user interface suggests a certain sequence, students are free to jump to any component that has already been released to the whole course—there is no possibility of making access to B conditional of students having already completed (or even visited) A.

- Some of the functionality that we had initially hoped to use was not flexible enough for our needs. For example, the peer-review functionality only offered a single possible mode of use where students first have to submit a product for review, before they are able to review other people's submissions. This constrained functionality did not allow for other designs, such as having a small subset of students producing lesson designs that serve as learning content for the larger community..

- The discussion forum is not scriptable, with no API to allow automated insertion of messages. It only allows for grouping students into cohorts, and designating certain discussions as specific to each cohort (ie. members of a given cohort only see messages from other members of the same cohort). There is no API for adding students to cohorts, instead a CSV file of students and cohort-assignation must be uploaded manually.

- While the xBlocks functionality allows instructional designers to design complex functionality that integrates deeply with the EdX platform, courses on EdX.org do not currently allow integrating any custom xBlocks.

Edx.org hosts an official version of this software, which offers courses from a variety of universities around the world. Because of the open source licensing and active developer community, I was able to install and host a version of the OpenEdX software using my Macbook Pro laptop as a server, and thereby have full access to modifying the source code, and developing custom extensions using the xBlocks extension mechanism. Still, with courses hosted on EdX.org, instructors are limited to using the existing code base and the built-in functionality. The use of the LTI protocol allowed me to develop all custom scripting and orchestration software outside of EdX, with seamless integration of users (i.e., single log-in and authentication).

#### 5.2.7.2 External server and LTI

Learning Tools Interoperability (LTI) is a protocol for connecting external tools to learning management systems, and it is the only feasible way of extending EdX.org courses with rich functionality. External components can either be embedded in a frame in the EdX interface, or open a new webpage. Requests from EdX to the external tool are cryptographically authenticated, and contain some metadata about the current user. LTI tools can optionally submit grades back to EdX.

While some existing Web 2.0 tools support LTI integration, most do not, and even those which do might not let us configure the way in which they should be used (such as respecting grouping). We overcame this by providing most of the functionality through a custom-built server software, and by proxying access to external tools through the LTI server. This allows the development of discrete LTI activities that can be seamlessly scripted into a learning design. It also defines a wide space scripting and orchestration of complex inquiry designs, including KCI and related active learning designs. This will be further discussed in Chapter 6 under Future Research.

The first LTI activity provided to our MOOC participants was to complete the pre-course survey, which also served to register them an interactive user (see Group formation, above). Because this component was launched by the student explicitly clicking a button, and acknowledging that their private information will be transferred to an axternal component, we could receive the EdX username and password from EdX, together with a student identifier. The username enabled us to connect learning analytics information from the LTI server with data exports from EdX, and the e-mail enabled us to contact individual students directly. The registration portion was done as the very first part of the survey, and in fact, the remaining portions of the survey were presented as optional (90% of all those who completed the registration went on to complete the survey).

All of the responses to the initial registration, and the optional survey, as well as all future actions by the students (regardless of which LTI component they happen in) were recorded in the same data store (a PostgreSQL database), enabling us to make elements of our script conditional (e.g., on student progress or group affiliation), providing activities or materials according to features that emerge only during enactment of the script. On the EdX platform it is not possible do make access to one activity conditional upon the completion of another, but if students attempted to access any LTI component without having gone through the registration, they were asked to complete registration first.

The external server was hosted securely as part of University of Toronto infrastructure, and was written in Elixir using the Phoenix web framework. Elixir is built on top of the Erlang Virtual

Machine, which has a long heritage growing out of the telecom industry, and is characterized by supporting highly parallelized and distributed operation that is very fault-tolerant. This makes it highly appropriate for writing MOOC software, since the large number of potentially concurrent users requires a system that can easily scale up, and the rapid pace of development and live adjustments requires a fault-tolerant system that will continue running even if a single component becomes faulty.

The Phoenix web framework has built-in support for web sockets, a protocol for live two-way communication with web pages, which enabled us to prototype and build out live-updating components. Most of the web components were built using HTML and CSS, with minimal Javascript. However for the live-updating components we used the React web framework, which makes it easy to write rich, dynamic interfaces. Etherpad was hosted on the same server, and another server hosted the Confluence wiki system. The only fully external service used was Google Hangout for the video portion of the live events.

#### 5.2.7.3 Analytics dashboard

Access to real time individual and group learning analytics data enables instructional staff to get a continuous sense of how different students and groups are progressing, and which groups are encountering difficulties. They can also point to specific parts of the course content that are more or less challenging, or course features that are being underutilized and may need to be redesigned. This kind of feedback would be especially important and useful in learning at scale, where instructors lack the usual visual feedback or awareness from a physical classroom setting, and it is not possible to manually follow all the different discussions and group spaces do to the size of the class.

In addition to offering at-a-glance insight into student progress, the learning analytics can provide an index to quickly access content created by students, or ways of entering into student-spaces as an instructor, going beyond the use of analytics as a tool to gain global understanding to instead enable rapid diagnosis and intervention (e.g., for groups lagging behind).

In the case of a complex learning systems, data is often distributed across multiple systems and formats. EdX hosted data (i.e., about forum participation, video viewing and quiz outcomes) is only available as a data dump once per week. However, data on student participation in interactive components was available immediately from the LTI server. In the Collaborative Workbench, much of the important work is done on locally hosted Etherpad and Confluence wiki servers, which need to be regularly polled to gather data. The latter two have less intrinsic structure (the API reporting on the content of a page cannot distinguish between the scaffolds automatically inserted by our tools, and the edits and additions done by students), and need additional processing to extract actual student work and progress.

In addition to numerous ad-hoc queries of the LTI server database to ensure that tools are functional and being used, we developed a dashboard for tracking progress of student design groups. This informed our own development and adjustment of tools during the course, allowing continuous monitoring of access through streaming student logs. The dashboard lists all design groups, and for each design group shows detailed information about the number of chat messages, number of emails sent, number of peer-reviews received, total content added to the wiki, as well as number of Etherpad edits and unique editors per week (see Figure 37).

In addition to providing a quick overview, both of the general health of the ecosystem, as well as identifying particularly struggling or successful groups (all column headers shown in Figure 37 can function as sort keys), most of the database entries are directly linked to their relevant artefacts, allowing, for example, a quick jump to a certain group's Etherpad entries, their wiki edits, etc. In addition, clicking on the group's name brings the instructor or researcher directly into their Collaborative Workbench environment as a "ghost" visitor. This visit is not logged, and no e-mail announcements are triggered, but the visitor could potentially become visible, e.g., to add comments to the group chat.

## Design groups

| id | SIG | Title | Members | Currently online | Chats | Emails | Review wk1 | Review wk2 | Wiki authors | Wiki revs | Wiki diff | Etherpad wk1 authors | Etherpad wk1 diff | Etherpad wk2 authors | Etherpad wk2 diff | Etherpad wk3 authors | Etherpad wk3 diff |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 170 | 2 | Address students' misconception - Photosynthesis | 4 | | 8 | 0 | 3 | 2 | 2 | 3 | 2019 | 3 | 473 | 1 | 215 | 0 | |
| 63 | 2 | What's the natural frequency of ... | 5 | | 6 | 0 | 2 | 1 | 2 | 10 | 1104 | 4 | 1317 | 1 | 290 | 2 | 922 |
| 149 | 3 | Let's Make Aboriginal Musical Instruments! | 1 | | 0 | 0 | 2 | 1 | 1 | 6 | 992 | 1 | 486 | 0 | | 1 | 553 |
| 114 | 6 | ESL Taught with Critical Thinking | 6 | | 20 | 0 | 12 | 2 | 4 | 6 | 982 | 8 | 1005 | 6 | 563 | 3 | 421 |
| 70 | 3 | Composition the modern way | 5 | | 42 | 1 | 3 | 2 | 5 | 7 | 953 | 2 | 465 | 1 | 317 | 0 | |
| 157 | 18 | Computer technology, then and now | 3 | | 5 | 0 | 3 | 2 | 1 | 4 | 853 | 1 | 299 | 0 | | 0 | |
| 21 | 3 | Mooooovie Posters | 6 | 1 | 6 | 0 | 5 | 2 | 3 | 6 | 731 | 6 | 1410 | 4 | 470 | 0 | |
| 108 | 2 | My first inquiry, a simple pendulum | 6 | | 35 | 0 | 5 | 2 | 3 | 6 | 641 | 12 | 1164 | 0 | | 1 | 242 |
| 87 | 6 | Teaching English to Spanish speakers | 6 | | 15 | 0 | 4 | 3 | 2 | 5 | 637 | 6 | 1008 | 3 | 319 | 1 | 508 |
| 188 | 2 | Cure Project: Disease Awareness, Treatment, & Management | 7 | | 34 | 1 | 7 | 2 | 2 | 10 | 621 | 4 | 834 | 3 | 360 | 1 | 230 |
| 3 | 13 | Exploring the meaning of art | 6 | | 94 | 0 | 2 | | 1 | 3 | 615 | 7 | 3061 | 2 | 588 | 0 | |
| 11 | 4 | Experiences of the First World War | 5 | | 22 | 0 | 1 | | 2 | 5 | 543 | 10 | 1649 | 1 | 204 | 1 | 264 |
| 10 | 2 | What is the meaning of life? | 6 | | 6 | 0 | 5 | 3 | 2 | 5 | 526 | 7 | 1084 | 2 | 831 | 1 | 428 |
| 56 | 15 | Interaction with the environment in an ancient society | 4 | 1 | 4 | 0 | 5 | 1 | 1 | 5 | 504 | 2 | 615 | 1 | 271 | 1 | 442 |
| 28 | 13 | The Earth Sun and Moon System , How do they compare? | 6 | | 76 | 0 | 2 | 2 | 1 | 3 | 502 | 7 | 1545 | 0 | | 1 | 409 |
| 2 | 6 | Writing a storyboard. | 2 | | 1 | 0 | 4 | | 1 | 2 | 465 | 1 | 358 | 1 | 205 | 0 | |
| 202 | 6 | BBC website supply the students with resources | 4 | | 6 | 0 | 1 | 3 | 2 | 5 | 373 | 2 | 538 | 1 | 230 | 1 | 386 |

**Figure 37 - Learning Analytics dashboard**

## 5.3 Enactment

This section will present a brief analysis of the enactment of the curriculum. While substantial discussion was just given to the design of all script elements, technology scaffolds and curriculum content, this was all just design. It remains to be seen if the design plays out as envisioned, if groups form, if they use the workbench, and if their lesson designs served as resources for the wider community. We had never delivered a MOOC before, and were more than a little nervous when the doors first opened to the Teacher's Lounge, or any subsequent aspects of the course.

Sub-sections below detail exactly what happened, using a variety of graphs and tables, including discussion of the efficacy of the design, or any serendipitous or otherwise unexpected phenomena. While the analysis does not go deeply into the content produced by such interactions (e.g. by examining the detailed content of lesson designs, or of chat logs), it does examine the movement of individuals, groups, and artifacts within a KCI script, including the creation and use of a collective knowledge base. Each subsection examines a specific aspect or script within the broader KCI design.

## 5.3.1 Demographics

Of the teachers who signed up and listed their years of teaching experience (n=1923), median years of teaching experience was 3, and mean years 7.47. Almost 25% of teachers had more than 10 years of teaching experience. Figure 38 presents the number of teachers who said they taught in particular grade-level (i.e., K-12) classrooms, where some teachers are represented in more than one category.

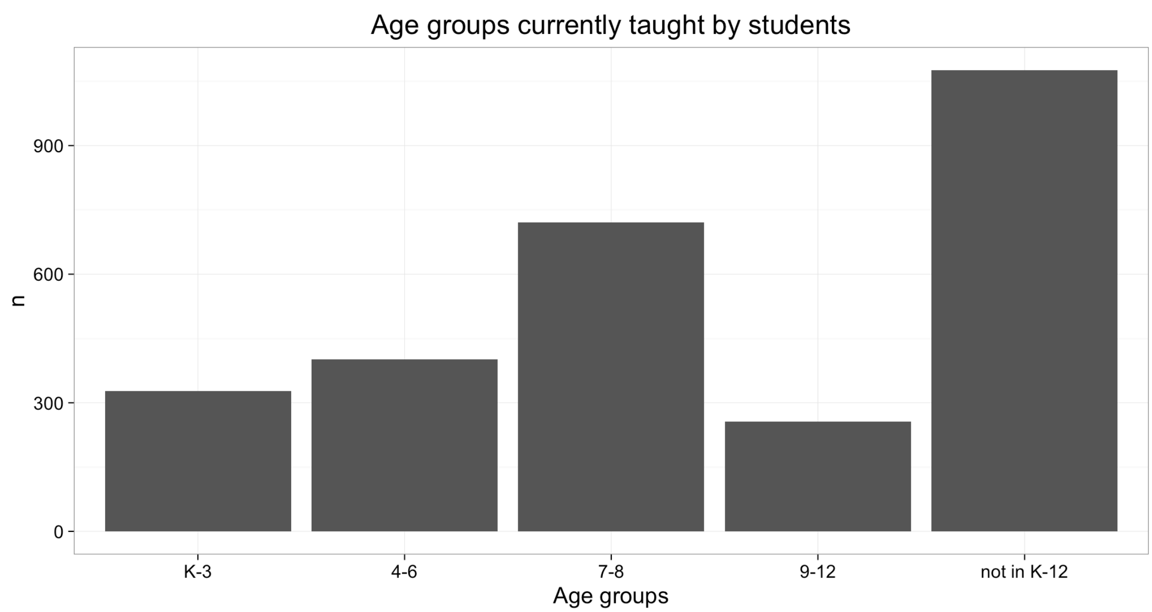



**Figure 38 - Age groups taught by learners**

There was also a large group of participants involved in education in roles other than that of K-12 teacher, including school administrators, workers in higher education, and people involved in continuing and informal education. Figure 39 shows the most common categories of employment for the 1076 respondents who identified as non-teachers.

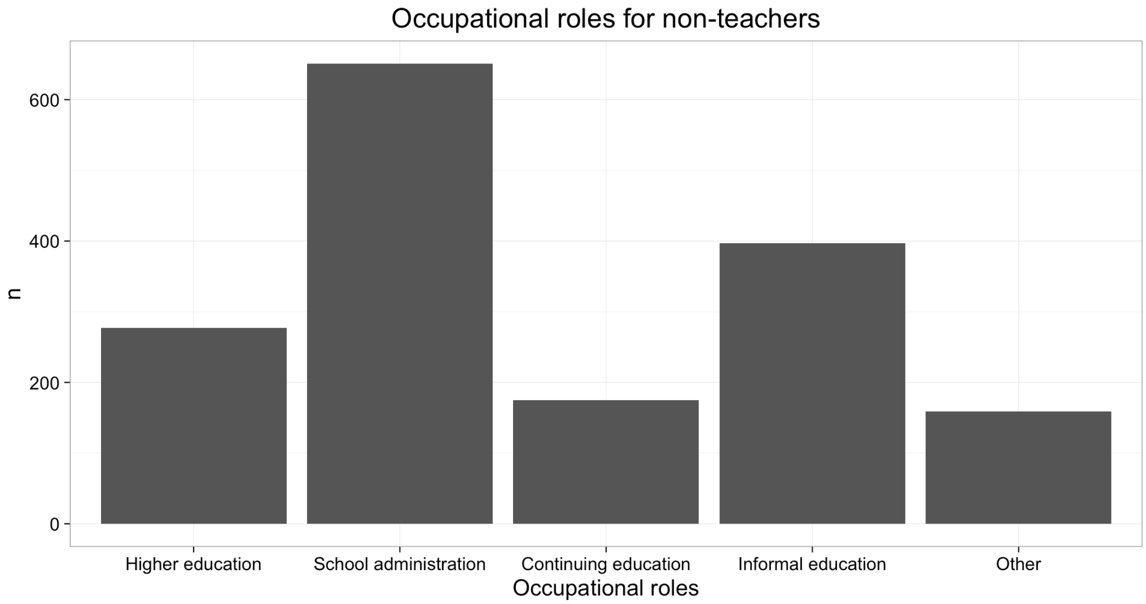



**Figure 39 - Occupational roles for non-teachers**

## 5.3.2 Design group reviews

1,368 reviews of lesson designs were created by 387 users. These were unevenly distributed among lesson design groups, with a few groups receiving more than 40 reviews, but most groups receiving less than 10 reviews, as shown in Figure 40.

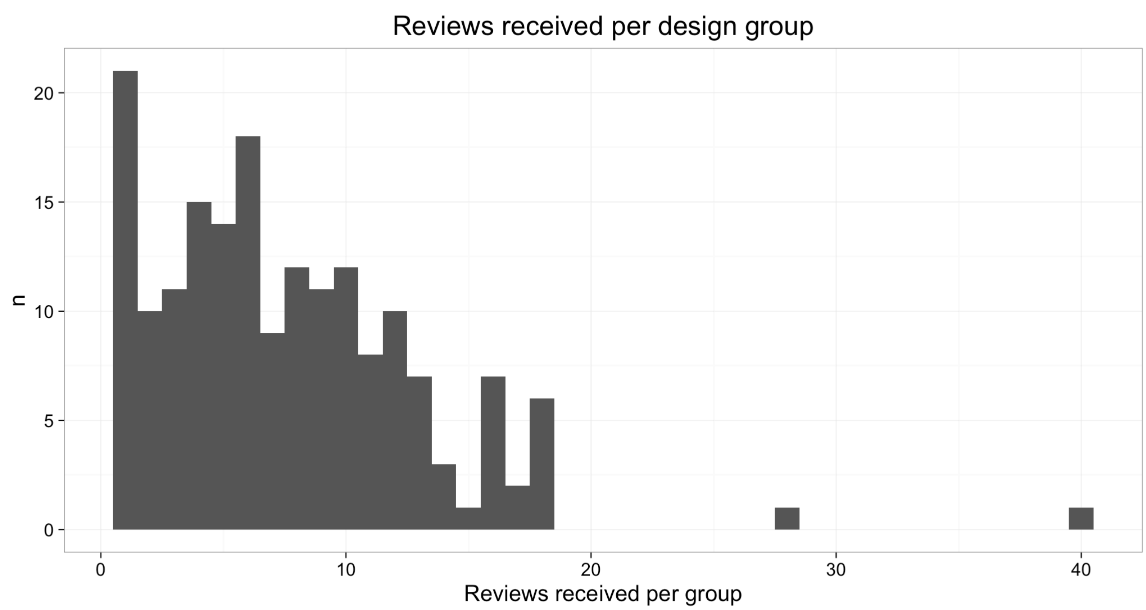



**Figure 40 - Reviews received per design group**

Perhaps people commit more reviews to projects that are more active, or projects are more active when they receive more reviews, but there was no correlation found between the number of reviews received and the length of the final design document, $r(37) = 0.10$, $p = 0.70$ (see Figure 41).

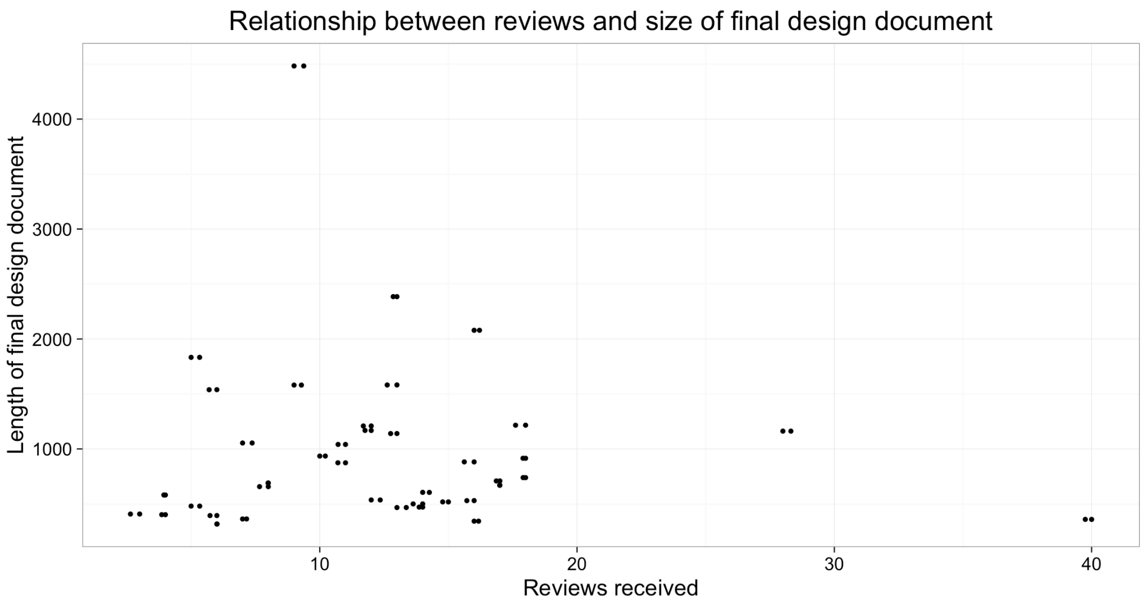



**Figure 41 - Relationship between reviews and size of final design document**

### 5.3.3 Reflections

Students were asked to write personal reflections each week, which consisted of one or two questions, and sometimes quick multiple choice items. They were also asked to self-evaluate their performance in the forums after having participated in discussions. Figure 42 shows that the number of people who submit the self-evaluations each week, and who self-evaluate their participation in the forums, are very similar (slightly fewer people submit the self-evaluations), but that the number of active participation in the Foundation Strand does decline in week 2, with a notable decline in the drop-out rate for the remainder of the course (see Figure 42).

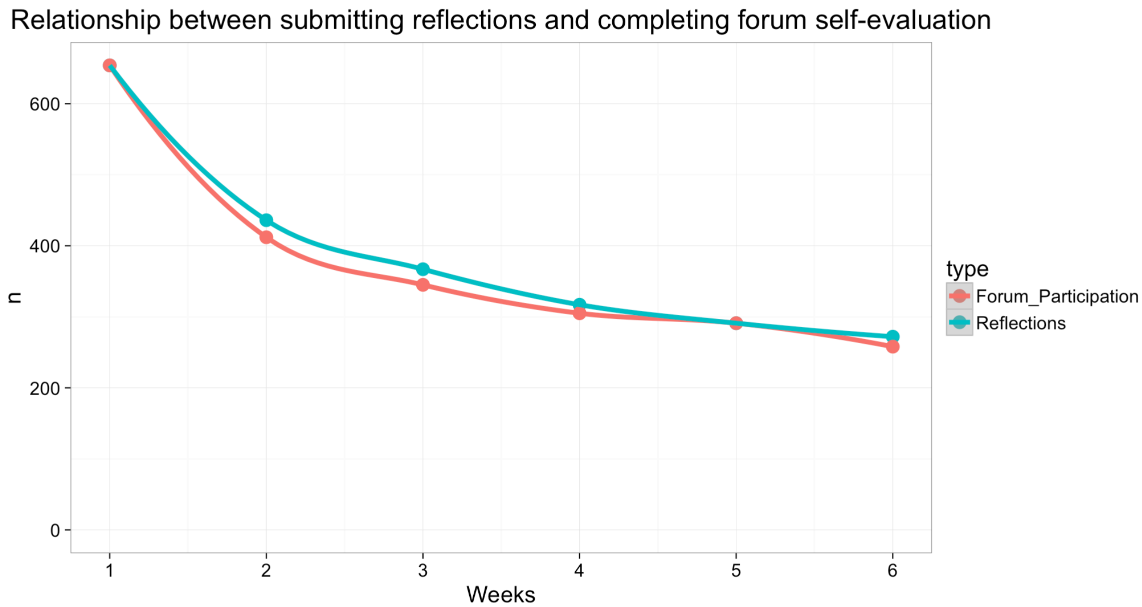



**Figure 42 - Relationship between submitting reflections and completing forum self-evaluation**

## 5.3.4 Resources

Students submitted a total of 1320 resources, with 827 resources tagged as "applicable to all SIGs", and 492 resources tagged as "SIG specific". Students added an average of 2.147 tags per resource, out of a total of 431 unique tags, with more than 100 resources receiving more than 10 individual tags. 407 resources were ranked by students (a mean of 2.67 votes per resource), with a mean score of 3.8 out of 5, and 91 resources receiving a maximum score of 5.0. Of the 840 students that participated in the resource script, students visited (submitted, reviewed and just viewed) a mean of 7 resources each.

Having collected 1320 resources, more than 800 of which were said to apply to any SIG, we were eager to see if our sorting and filtering designs succeeded in tailoring the resources displayed to any given participant. In the resource review view, students were randomly assigned a resource either from their SIG, or marked as generally applicable, and had the option to edit the description, add a comment, and adding tags. We especially invited students to add comments focusing on how they could use this resource in their own teaching/discipline. The randomization ensured that as many resources as possible got processed by at least a few other students.

After this step, we opened an “exploration view” of the resources (see Figure 22). Students could see all resources submitted by their SIG (or tagged as "generally applicable"), sorted by the rating students had given, or could choose to explore semantically using a tag cloud. The detail view they arrived at when selecting a resource, still allowed them to contribute rates, comments and tags.

Finally, this exploration view was also made available in the collaborative workbench, to inspire lesson design groups and suggest resources for them to incorporate into their lesson designs. A public view of the resources collected was also made available for future generations of the course to build upon.

### 5.3.5 Live chats

183 students participated in the first event, and a total of 351 students visited the page for the first event (including before and after), posting a total of 48 questions, 83 comments and 133 chat messages. For the second event, 109 students participated, and a total of 247 visited the page. They posted a total of 48 questions, with 64 comments, and 105 chat messages.

In their chats, students expressed gratitude towards the instructors for offering the course, and enthusiasm about the course and the community. Several students also mentioned how they really enjoyed the opportunity to chat with other students directly, which had not been available previously in the course (apart from in the collaborative workbench, constrained to the small design groups). We left the live event pages open, and many students continued using it as a chat board for hours and days after the live event was over.

### 5.3.6 Design groups

428 students joined one of 142 design groups (out of 348 suggested groups), and design groups had an average (mean) of 3 members each. Design group members visited the collaborative workbench an average of 7 times each during the course. The members of the design groups selected to be displayed in the public gallery walk visited the collaborative workbench an average of 17.4 times during the course.

If we look at the total number of visits to the collaborative workbench by all members of a design group, the average number of total visits is 22, whereas the members of the design groups displayed in the public gallery walk visited their collaborative workbench an average of 80 times during the course. The total number of visits is correlated with the length of the finished product, *r*(104) = .40, $p < 0.01$ (see Figure 43).

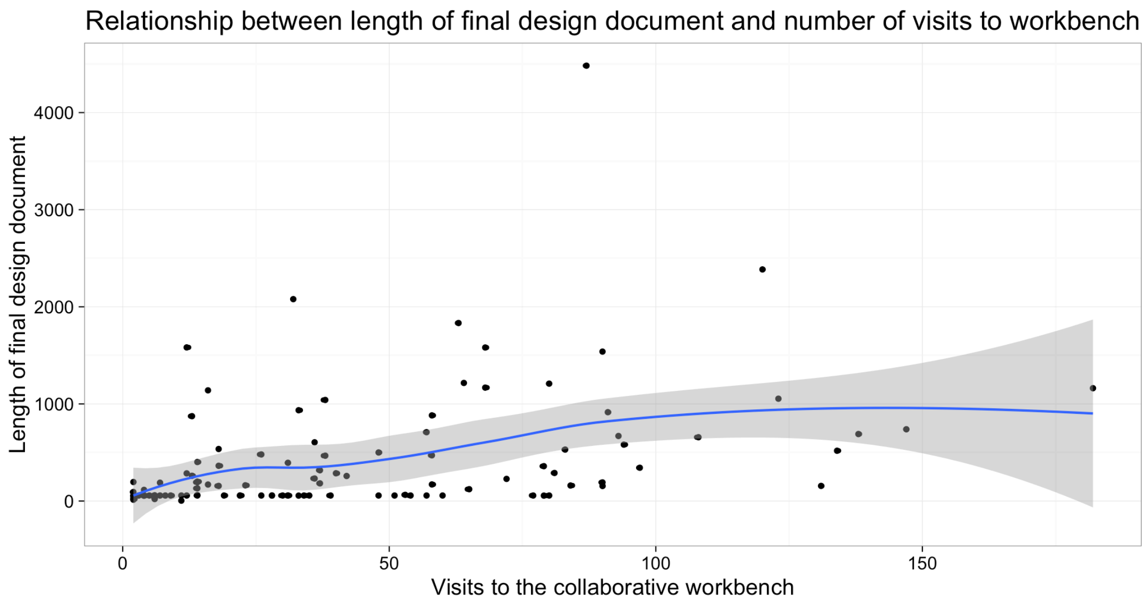



**Figure 43 - Relationship between length of final design document and number of visits to workbench**

## 5.3.7 Chats and emails

1867 chat messages were sent through the system, written by 318 unique users, in 125 different design groups. In the 125 design groups that used the chat system, a mean of 7 chat messages were sent. Limiting ourselves to groups that used chat, and submitted something to the wiki, there is a correlation between number of chat messages exchanged and the length of the wiki product, *r*(85)= .29, *p*=0.006 (see Figure 44).

A group that used chat extensively was a group designing a lesson plan for English in primary school. The group had three members, but one only wrote two chat messages, the other 2 teachers, one from a Commonwealth country and one from an Asian country, exchanged a total of 190 chat messages in the span of five weeks. They began by introducing themselves, and exchanging ideas about their teaching contexts, and the assignments. They then regularly discussed the assignment, and seem to also have been connecting through Facebook and Skype. In the last messages, towards the end of the course, they thank each other for the collaboration and appreciate the friendship that has emerged, and exchange email addresses to stay in touch.

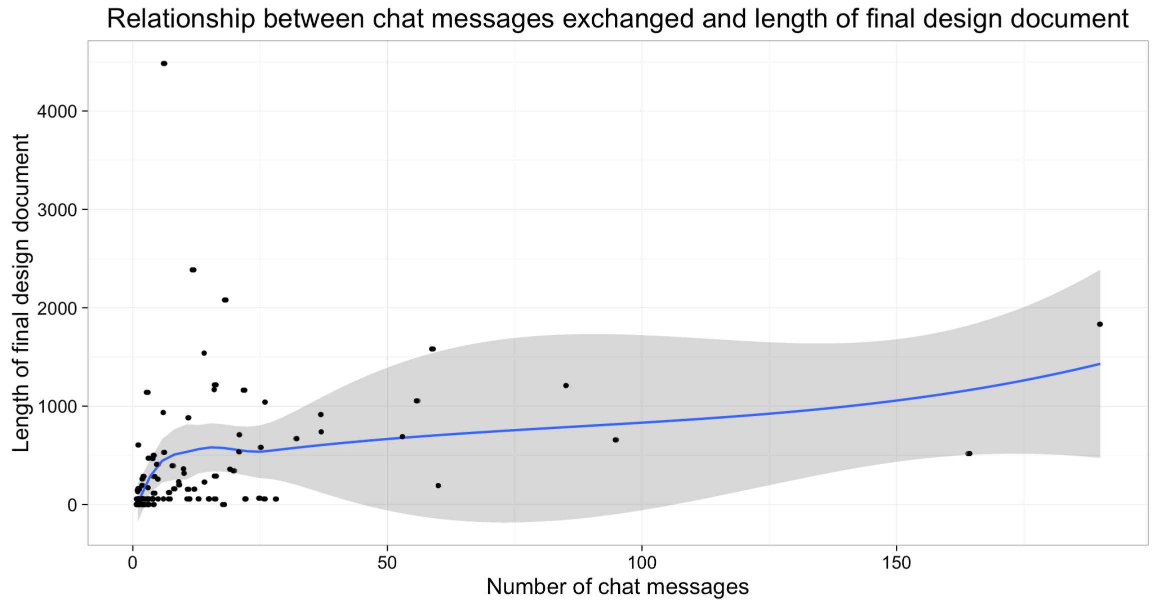



**Figure 44 - Relationship between chat messages exchanged and length of final design document**

Only 23 design groups sent any emails at all, and even these groups only sent an average of 1.23 emails per group, suggesting members attempted to invite collaboration, but received no answer. An example of a group that used e-mail productively was a group working on a lesson around the natural frequency of music instruments. Over a period of 5 days, two group members exchanged 8 e-mails, discussing specific elements of their lesson design project.

## 5.3.8 Design documents

112 design groups got as far as creating a design document on the wiki, with groups conducting a mean of 6.3 wiki edits during the course. The resulting documents had a mean length of 400 characters added (outside of the templated text), with 14 groups producing documents ranging in size from 1000 to 4483 characters long. In the last week of the course, the course team manually selected 25 design groups as being complete and worthy of exhibition in the public "gallery walk" exhibition.

## 5.3.9 Participation in various strands

Although we present the different participation strands as concentric circles, where the Design Strand is a strict subset of the Foundation Strand, and the expectation is for participants in the Design Strand to do all the work designated for the Foundation Strand as well, there was no enforcement of this policy on the platform. Thus, we see 80 students that participated actively in the collaborative workbench (logging in an average of 4.9 times), without writing a single reflection or doing a single self-assessment after forum participation.

Retention across all strands was much higher for students engaged in lesson designs. If we use submission of reflections as a proxy for participation in the Foundation Strand, almost exactly 50% of the students completing their reflection in week 1 would go on to at least join a design group. In week 6, 48% of the Design Strand students who submitted reflection sin week 1 were still submitting reflections, but only 25% of non-Design Strand students were still submitting reflections.

### 5.3.10 Orchestration of the MOOC

Orchestration in an online-only course with thousands of students who mostly interact asynchronously with a choice of learning activities takes a different approach than orchestration in an actual classroom, where students are mostly moving in sync with the teacher, and the teacher can quickly read the situation, and make adjustments through oral announcements.

To be able to adapt the course to the progress of the learners in a large course, the instructor first needs to get a real-time sense of how different students are moving through the course, and what difficulties they are facing. Learning analytics systems help with this, both dashboards like the one described above, but also ad-hoc queries of the learner model database, participant observation from being a part of the course, as well as direct feedback from students through for example the discussion forums.

The instructor can then intervene in different ways. He/she can send out messages, either on the platform (text prompts and weekly videos), or in e-mails. These messages can go to all students, or be targeted to students meeting specific criteria. However, the instructional team can also change the code that runs the interactive LTI elements to display other elements, or to add conditionality.

For example, within the lesson design script, the prompt displayed in the welcome message (as well as the Etherpad template) each week is one form of orchestration, but the actual panes displayed (which also changed every week), and the exact way in which certain information is aggregated and displayed to groups, is another. While both prompts and code might have been prepared before the course even began running, they can all be modified during the running of the course, based on incoming data.

While all the welcome messages, prompts and templates were continually refined throughout the course, and in this sense represented a form of adaptive orchestration, a specific example of script repair is the combining of SIGs. After analyzing the data from student registrations in the pre-course teacher's lounge, we created 18 SIGs, designed to maximize the distribution of students, and ensure a critical mass of students in each SIG. Although doing this based on student input was better than a priori determining groups (and led us to create the informal learning and higher education groups, which we had not planned, the latter of which ended up being the single most popular SIG), we did not know how many students would end up signing up for the course, and how students would self-distribute when we published the SIG list.

After the first week, we realized that certain SIGs had too few members to foster rich discussions, and based on actual numbers, we combined a number of SIGs, bringing the number from 18 down to 12 (see details in 5.2.6.1.2).

## 5.4 Achieving KCI design principles

The design of all scripts in this MOOC was guided by KCI, following the previous iteration of the pre-service course. Examining the enactment in the previous section was helpful affirmation that the various scripts designed were implemented with some level of fidelity to their design. Here, I discuss how we satisfied the four KCI design principles.

### 5.4.1 Principle 1

*Students work collectively as a knowledge community, creating a knowledge base that is indexed to a specific content domain.*

Students collaborated within their SIGs and design groups to co-create a knowledge base supported by scripted activities and scaffolds, and indexed to the weekly themes and learning objectives. Instead of pushing all of the created artefacts into a wiki, like we did in the Pre-Service Course, the knowledge base in our MOOC was more tacit and revealed to users as needed. The large number of learners necessitated a more complex structure of knowledge spaces. We custom-built interfaces that supported interactions with the knowledge artefacts and exploring the knowledge base in new ways—i.e., semantic tags, voting, adding comments, and embedding the resource tag explorer in the Collaborative workbench. In the Design groups, persistent chats and Etherpads were private to the group, and specifically meant as spaces for rapid prototyping of ideas, whereas the wiki pages were public to the entire SIG, and a space for the group to showcase the current stage of their design process, to receive constructive peer feedback (itself a public knowledge artefact).

The Lesson designs were large, coherent documents, structured with explicit indexing to the weekly themes (i.e., which were themselves the index of the community knowledge base) and completed through an increasingly sophisticated spiral of student learning and pedagogical thinking. This contrasts with the collection of discrete "atoms" in the resource collection, which were individually simple elements, but could be reorganized, structured and explored in multiple ways, due to the amount of metadata attached.

### 5.4.2 Principle 2

*The knowledge base is accessible for use as a resource as well as for editing and improvement by all members.*

The MOOC built on artefacts that were generated during prior enactments of the course (i.e., when it was a pre-service university course, but students were still designing lessons and contributing resources). The current generation of students continued to build on this knowledge base, using the same index, contributing successful lesson designs, adding, tagging and organizing technology and inquiry resources. These, in turn, will be made available to future course generations, and the wider public. This supported our goal of giving the students a strong sense of working in a knowledge-creating community, where ideas and artefacts generated were consequential to the learning of their peers, to their own subsequent inquiry, and to the growth of the community.

The dialogue between the Design strand and the Foundation strand members was an important backbone of our design. Brainstormed resources and ideas helped kickstart the Design work, and the design process was then supported through a weekly back-and-forth. In-progress designs were made available to the Foundation strand students, and their constructive feedback, structured around the weekly theme was aggregated and fed back to the Design groups. This made both groups feel responsible for contributing to the shared knowledge base.

### 5.4.3 Principle 3

*Collaborative inquiry activities are designed to address the targeted domain learning goals, using the knowledge base as a primary resource and producing assessable outcomes.*

The Collaborative Workbench functioned as a structured environment in which students participating in the design strand were scaffolded in the design of a lesson plan throughout the length of the course. Each week, the design task was structured through three different prompts. The welcome message in the first "tab" provided a high level overview of the week's activity, whereas the Etherpad prompts provided specific targets for discussion and co-creation. Finally, new headlines were added as scaffolds to the lesson design on the Confluence wiki, which would serve to guide the ideas added by the team to their lessons. In addition to the prompts and instructions, The Collaborative Workbench also provided an aggregated view of constructive feedback provided by peers from the Foundation track, structured around the weekly theme. For example in Week 3: Collaborative Learning, students were asked to provide feedback about:

- How is this lesson incorporating collaboration? If it is not, can you help think of any ways the designers could add collaboration?
- How could collaboration help improve students' learning in this lesson?
- What should the designers keep in mind, as they think about weaving collaboration into their lesson? Will it take more time, or add possible confusions for students?

In this way, the script ensured that all students were focused directly on the specific learning goals of the course, organized by weekly theme, and that the knowledge base (in the example above, the lesson designs) served as a primary resource.

### 5.4.4 Principle 4

*The teacher's role must be clearly specified within the inquiry script, in addition to a general orchestrational responsibility.*

Given the large number of students, and the fully-online nature of the course, the teacher's role is of great interest, especially given students' need to feel that they are being attended to within the

MOOC (i.e., that some instructor is seeing the comments they make in the discussions, or their lesson designs). One approach to providing a sense of instructor presence was the weekly “welcome” videos, which were recorded during the course, and reflected upon the progress of the community in real time, distinguishing themselves from the pre-recorded “documentary-style” videos through their more informal approach. These videos were prepared by Professor Slotta in extemporaneous form, and typically involved screen casting where he showed examples of student ideas, read comments allowed, and tried to synthesize what had happened in the previous week, and how it would be relevant to the coming week’s theme.

Both the primary instructors (Professor Slotta and Dr. Evans from UTS), and the wider instructional team were active participants in the discussion forums, answering student questions and highlighting interesting comments. We made sure that at least one member of the instructional team was assigned to each of the Special Interest Groups, with particular responsibility to shepherd the group discussions and support the Design groups in that SIG. To support this role, we created a Learning Analytics Dashboard, which let instructional staff see, at-a-glance, the progress of different Design groups, with quick links into the Collaborative workbench of various groups, to support their knowledge creation and design process.

Finally, a key role of the instructors in such a large and complex course was to continually monitor the development of the course community, and to modify the design of the scripts and technological components (e.g., the prompts and scaffolds) to better support student learning. Examples of adjustments that were carried out during the course include the combination of SIGs to arrive at a smaller number of SIGs, each with a critical mass of students to support lively discussions and collaborations, as well as many small design revisions to the Collaboration workbench, and adding the communication channels available to Design groups, to support their coordination and collaborative work.

Hence, the MOOC design team was quite deliberative about the teacher’s role, in order to address this principle, and our decisions made a clear impact on the quality of the course. This is clearly a topic for further work and investigation in future online learning designs, and there are several interesting questions that could yet be addressed from the data collected in this MOOC (e.g., looking for differences in how the various instructors interacted with each SIG, and whether that resulted in any important variations in how the SIGs progressed).

# Chapter 6. Discussion and Conclusion

## 6.1 Introduction

This thesis reported on two design studies—a Pre-Service Course at the University of Toronto, and a MOOC for in-service teachers on the EdX platform—that investigated the challenges and opportunities that large participant numbers bring to scripting and orchestration of knowledge communities. Beginning with an existing course design which had run for a number of years for class sizes of around 20 students, our first challenge was to design a course with a consistent weekly script or pattern of activities, but that also included several macroscopic scripts that spanned the length of the course. These macroscripts would need to fit within the weekly scripts, and have interdependencies that reinforced the principles of KCI (e.g., requiring students to make use of the knowledge base in the course of their inquiry activities). I discuss our approach to Scripting across the curriculum in section 6.2.

Our first Research Question was "How can the pedagogical perspective of knowledge communities inform the design of large online courses?". To address this question, I begin with a discussion of student and group homogeneity and diversity, and how to explicitly design group hierarchies and strategies for group formation to maximize learning. Important design goals were to avoid ideas being siloed within small groups and to take advantage of the crowd, enabling bi-directional assumption of content. These are discussed in section 6.3 as Design Principles at Scale.

Orchestrating complex scripts with large groups of learners almost certainly requires the use of technology supports. Moreover, MOOCs are characterized by being almost exclusively asynchronous, which adds a new challenge when it comes to orchestrating scripts that include rich forms of collaboration. Section 6.3.1 discusses our orchestration of small groups, synchronous and asynchronous activities, and how to conceptualize scripts within open-ended environments (i.e., where students can access elements out-of-order and at different times).

The second Research Question was "What are the interactions between technology platform and course design?". Section 6.4 addresses this question by discussing the challenges of scripting and orchestration in traditional Learning Management Systems, or integrating the use of stand-alone

Web 2.0 tools. I discuss how we solved this using scripts and APIs in the Pre-Service Course, and with a custom-written server and LTI integration in the MOOC. The server was supported by a student model, and served script elements as unique LTI components that could be integrated seamlessly with the existing EdX workflow.

The chapter closes by suggesting several avenues for future research, in section 6.5.

## 6.2 Scripting Across the Curriculum

Designing a complete course according to KCI principles—whether it's a 12-week Pre-Service Course, or a 6-week MOOC—requires a matrix of micro and macro scripts that fulfill a number of objectives, while responding to logistics and course constraints. In the case of the Pre-Service Course, the students met in person for four hours each week, with a set of recurring elements and activities that defined a weekly script. In the case of the MOOC, although students could log in at any time and participate at varying levels of engagement, the platform still had a clear weekly regular structure. In both cases, we had a number of learning objectives for students: we wanted them to learn about and experience a number of different technologies and resources for learning; to become familiar with a number of theoretical approaches and themes and have the opportunity to reflect on how these new ideas relate to their own teaching practices; and to use creativity and critical thinking in integrating the course topics with their existing knowledge to create a lesson design.

We were thus challenged to develop a script that addressed these various learning goals, without overly confusing students, or presenting them with many disjointed activities. Our design approach took the form of a matrix of scripts. Each week had a similar structure, and treated a distinct topic, beginning with readings and lectures (or videos), going through tech presentations (Pre-Service Course), small group discussions, inquiry tasks (MOOC), and ending with continuing work on the lesson design. Thus, we were able to treat each of the course themes in a rich way, while simultaneously letting a number of course-scripts unfold from week to week. Each week, the students and groups increased in their knowledge and sophistication, having access to a growing personal and community knowledge space.

In the Pre-Service Course script, detailed in Figure 2**,** the interdependence of the course-long scripts came mainly from this growth in sophistication and knowledge. For example, because students participated in more and more of the technology presentations as the weeks went by, they developed a better understanding of the range of options, and began incorporating some of these specific tools or platform into their SIG discussions or lesson design.

The MOOC script was more explicit in how it addressed this interdependence (see Figure 18), including a number of pathways by which artefacts were exchanged as a means of connecting micro and macro level scripts. For example, in the resource script students begin by brainstorming useful resources in their teaching topic, then reviewed, tagged and voted for resources submitted by others. This resulted a substantive list of resources, indexed by topic and student age level, which was then presented to the lesson design teams (i.e., in the Collaborative workbench) as part of their ongoing design script.

Figure 18 also shows how the MOOC (as in the pre-service course) is connected to previous course offerings through a database of previous lesson designs, how it leaves a legacy for future generations (lesson designs and indexed resource collection), and even how it shares resources with the greater public.

## 6.3 Design principles at scale

This research project has focused on the scaling up of pedagogical scripts that were initially designed for small student groups—first to the size of a university lecture, and then to a small MOOC with several thousand students. A key issue in the design process has been how to approach the issue of course size as an opportunity rather than as a challenge. When designing the curriculum and interaction model (i.e., the script) for a large course, we sought to leverage the large numbers as a potential advantage for rich collaborative learning and interaction between students and in small groups. This entailed seeking opportunities where students could benefit from the "wisdom of the crowd", leveraging the breadth and depth of ideas, experiences and interests. Thus one can talk about scripts that work "despite of the scale of the course", and others that work "because of the scale of the course". However, many scripts straddle this boundary. For example, we might design a small group script in order to enable students in a larger course to gain the benefits of deep collaboration. However, it is the very size of the class that provides sufficient diversity to allow for script that assemble groups based on something more than just size – e.g., to group students according to supplementary or complimentary interests.

Below, I discuss how our MOOC leveraged the opportunities afforded by large numbers of students—particularly the diversity of students in such a large course population. While small groups can provide a rich context for collaborative inquiry, there would be a great loss of opportunity if all ideation were siloed, or restricted to the boundaries of groups. In the final section, I therefore discuss the challenge of enabling bi-directional assumption of content, where the small group products were then returned to the larger community as a resource for further inquiry.

### 6.3.1 Scripting and Orchestration of groups

A common approach to enabling collaborative learning despite large numbers of students, is to subdivide the students into groups. This often happens in K-12 classrooms, with cohorts of 20-30 students, where the teacher asks students to form groups of five or six to discuss a topic. In large lectures, students are often asked to "turn to the person next to you" and discuss a challenging problem projected on the front screen. The EdX MOOC platform provides "cohort functionality" to automatically divide students in random smaller groups, limiting the number of posts they see in the discussion forums. However, these groupings are all done at random, with no attention given to the intrinsic or emergent semantic properties of every student, which could inform more intentional grouping dynamics.

The question of group design, group formation, and orchestration of group activities is crucial to the design of large-scale collaborative learning scripts. The design of a group hierarchy is central to the pedagogical goals of the script, but must also take into account the logistical constraints within any given learning situation. For example, in the pre-service course we had access to one large space that could house the entire class for a purposes of plenary lecture, and could be subdivided into two distinct spaces, as well as a separate classroom. This meant that we could begin each week with a short plenary session, and then split into three "houses", which would each get their own physical learning space. This logistical constraint meant that we sought a script that included three major groups, and we proceeded to design the script such that we came up with an appropriate segmentation that allowed for the important pedagogical commitments of KCI.

The kinds of interaction that are possible within the script also changes with the size of the group, but depends on the medium. In the pre-service course, having more than 70 students in a large classroom meant that we were restricted to a largely teacher-led lecture, with questions and comments from the audience, and some use of interactive audience feedback technology. However, in the MOOC, Special Interest Groups of several hundred people were able to have active discussions in the discussion forum.

In very large learning contexts, a hierarchy of groups is often called for. Rather than a simple subdivision of students, this means groups nested in groups, possibly at multiple levels, but could also mean cross-reaching groups rather than a pure hierarchy. In our two design studies, we designed group hierarchies to simplify logistics (easier to organize students into small groups when they are already in their physical "houses"), and to limit the orchestrational load. To ensure cross-fertilization, we designed scripts that enabled artefacts to cross group-boundaries, as described below under in the design principle of Bi-directional assumption of content.

When designing scripts for a specific group level, we need to consider their ideal size, and the level of homogeneity or diversity desired along various dimensions. For example, the "Houses" level in the pre-service course, and the Special Interest Groups in the MOOC were designed to optimize homogeneity regarding target age level and discipline taught. Because of the much larger number of students in the MOOC, the Special Interest Groups could be much more specialized, despite their larger size, as discussed in the following section on diversity and homogeneity.

#### 6.3.1.1 Group homogeneity and diversity

A key element in scripting CSCL interactions is managing student diversity. Even in bringing two students together to collaborate on a task, there is a native challenge of bridging between their potentially different backgrounds, ideas, experiences and approaches, as well as the challenge of communicating ideas, convincing, overcoming information asymmetry and externalizing internal ideas to promote learning.

As the size of the class grows by orders of magnitude, so does the diversity of the class, and the number of possible constellations between students that could be engineered by the instructor. Groups can be diverse along many different dimensions. For example, an undergraduate class at the University of Toronto might be quite ethnically diverse, but otherwise fairly homogenous (i.e 18-20 year olds living in the same city, being at the same level in their studies). In contrast, MOOCs typically cater to students of all ages, physically distributed all around the world, and with a larger variety in level of experience and existing knowledge.

Much of this information about student diversity can be captured at the beginning of the course. If the student model employed in a MOOC included information about student geographic location, teaching subject, approach to social learning and experience with technology, this could inform group-formation algorithms, e.g., that maximize or minimize group diversity along specific dimensions relevant to the script. However, other scripts might include the elicitation of attitudes directly before the group formation, reminiscent of the ArgueGraph script, by Jermann & Dillenburg (1999), in which students were asked their opinion on a controversial topic immediately before being placed in groups that maximize diversity of opinion. Other scripts explicitly engineer diversity, or information asymmetry, such as the Jigsaw script (Aronson, et al., 1978), in which students are first assigned to a set of groups that represents a comprehensive coverage of a certain domain, and then each take on specific "hats" within their group, becoming specialists in different aspects of the same topic. In later stages of the script, they can be re-grouped with all members of their specialization, completing the jigsaw design.

While it is often useful to maximize diversity while forming smaller sub-groups, at other times it might be desirable to maximize homogeneity along certain dimensions. In our pre-service course which included a range of interests from kindergarten arts to high school auto technology, it was desirable to form groups according to shared interests in age level and topic area. This allowed for a more effective constructivist design of inquiry activities that connected to the students' specific discipline. In our MOOC, we created SIGs that grouped students of shared interests for purposes of discussions and other inquiry activities. Thus ironically, the scale of these courses, which resulted in an overall greater diversity, actually afforded the creation of more homogenous sub-groups.

#### 6.3.1.2 Scripting group formation

A key part of designing the group hierarchy is deciding how the group formation will happen. The simplest would be to randomly assign students to groups, ensuring groups of similar size and (at least statistically) similar levels of diversity. However, if we want to optimize for homogeneity or diversity along a certain dimension, and particularly if we already have a student model that contains the information relevant to that dimension, we can determine a set of group distribution rules that would lead to roughly similar-sized groups, and then automatically assign students to groups according to those rules.

This is the approach we took with Houses in the Pre-Service Course. After students had filled in a survey, we were able to look at statistics around age levels and teaching disciplines, and determine a set of rules that ultimately drove the constitution of the three Houses. Based on these heuristics, all kindergarten teachers were assigned to House 1, all math teachers who are not kindergarten teachers to House 2, etc. We automatically assigned students to houses, which including setting their wiki access permissions and updating their student models.

In the MOOC, we took a hybrid approach to the Special Interest Groups. Having groups of exactly the same size was not as important, since an online discussion forum is more flexible than a physical classroom, but we still wanted groups of roughly the same size. However, we did not know anything about the students since they had not signed up yet. Hence, we began by using data from students that signed up to the MOOC early (a sample of all students) to inform a list of groups. However, rather than automatically assign students to groups based on their survey responses (even though these responses had informed our group categories), we let them choose freely among the groups that we had designed—both for students whose data were part of the initial sample, and students who arrived after we had designed the groups. Later, we consolidated the SIGs based on membership numbers in order to consolidated groups. At this time, some SIGs were combined, and students were automatically "moved" into their new higher-level SIG.

Another approach was to have students themselves suggest group topics/titles, and decide which group to join. This was desirable for the Lesson design teams, but introduced a challenge of constraining group size. Because we wanted to maintain a range of group sizes (between 2 and 6 members of a design group, for example), this required some for of structure and coordination. In the Pre-Service Course, the formation of the Special Interest Groups, and the Design Groups were coordinated quite informally, using a shared Google Spreadsheet, where students could quickly see which groups were popular, and which failed to gather any interest. In the MOOC however, the asynchronous nature of the collaboration meant that the original script used in the pre-service course had too many steps, and would have required students to log in a number of times just to finalize group selection. In the end, we opted for a much simpler model, which abandoned the careful coordination for an approach that allowed for easy post-hoc repair, after the group had been formed (e.g., by allowing students to leave one group and join another) .

The design of group hierarchies and the scripting of group formation needed to be more flexible in a MOOC than in a university course. In a university course, most of the students active in the first week would likely remain in the course with the aim of completing it, and no students would join the class after the second week. Students were all required to contribute at the same level of effort and complexity. In a MOOC, however, students could join at any time, were much more likely to drop out in the middle, and had varied expectations in terms of effort and contribution. Thus, we needed approaches to grouping that could tolerate this flexibility, allowing new members to join and sustaining the loss of existing members.

### 6.3.2 Supporting Bi-directional Assumption of Content

One way of designing learning activities around a group hierarchy is the granularity triangle mentioned in Chapter 4, where ideas and information flow “upwards” from the base, which represents the whole class (i.e., where there is just a single, large group), through progressively smaller groups—first Houses, then Special Interest Groups, and finally Design Groups—the group size becomes smaller, opportunities for close peer interaction grow, and the ideas themselves become more applied to specific inquiry tasks.

While small groups offer a wealth of opportunity for scripting collaboration, reflection and inquiry, the larger community offers a deeper and wider pool of ideas and perspectives to support the script, as well. We wanted to make sure that this abundance of knowledge was available as a resource for the smaller groups, but also that the products of small group interactions were fed into the larger community. Thus, in designing the course script, care should be taken to ensure opportunities for ideas to flow not only down the granularity pyramid, but also back upwards, as well as horizontally between different groups. From a KCI perspective, this will ensure that all members derive the most benefits from their local group context, as well as the wider community.

In the Pre-Service Course, we had two scripts that were designed to serve this purpose The first was the Brainstorm script, an attempt at bringing students’ practicum experiences into the wider community discourse. Using simple technology, everyone was able to quickly suggest their own ideas and questions online during the plenary session, (where students responded individually using a Brainstorm Etherpad), with their questions and observations then inserted into the Special Interest Group discussions later in the same class, in order to enable each group to respond to the questions from their particular disciplinary perspective.

Jigsaw was another script, run only in the Pre-Service Course, that served to connect the discipline-focused activities and products of the Special Interest Groups with the wider pool of ideas and insight within the class community. In the Jigsaw design, we assigned each member of a Special Interest Group members a specific topic related to the weekly theme (e.g., Augmented and Virtual Reality, Embodied Learning, etc.) and were given access to related resources about that topic and engaged in an inquiry task. The results of their inquiry were compiled on their Special Interest Group page (organized by topic) but also on cross-cutting Topic pages. In this way, the Jigsaw script served to draw the disciplinary perspective of the SIGS together, in order to address these wider topics, as well as to infuse the many topics into the SIG.

In the MOOC, there were also a number of scripts that attempted to connect various levels of the granularity pyramid. Some scripts enabled the whole class to come together regardless of their group affiliations, such as the final live meetings with the course team and students, or the Gallery Walk where everyone came together to see all the final lesson design projects at the end of the class. Other scripts were hybrids, distinguishing information that was explicitly group-based and information that should be shared. For example, the Resource script asked students whether resources they contributed were generally applicable (like for example Google Docs) or discipline-specific (e.g., a physics simulation). Students browsing the submitted resources were then presented with a compilation of discipline-specific resources submitted by members of their own SIG, as well as generally applicable resources submitted by all SIGs.

### 6.3.3 Facilitating Online Collaborative Learning

While a teacher could readily orchestrate a rich collaboration script in a small classroom using sticky notes and flip charts, orchestrating complex scripts with large numbers of students—especially when they are distributed spatially and temporally—is only possible in an technology-enhanced environment. However, to engage small groups of that large community in collaboration scripts carries its own set of important challenges. In this section, I discuss how our scripts responded to the challenge of orchestrating collaborative work in small groups, and raise two issues that are particularly relevant in MOOCs: scripting in asynchronous environments, and representing collaboration scripts and student choice in open-ended environments.

#### 6.3.3.1 Orchestrating collaborative workflow

Given a set of groups, or even a complex hierarchy of groups in an online or blended learning context, technological scripts to support the orchestration of activity within a group become quite important. In the Pre-Service Course, we used tools like Confluence Wiki and Etherpad, which do not in themselves include any concept of groups or orchestration. However, they can be "remote controlled" through APIs, enabling external scripts to automate distribution of customized (i.e, group-specific) materials to all groups, the collection and redistribution of created artefacts, and other orchestrational tasks.

In the MOOC, we developed a customized server that collected and applied the knowledge from the student activities to create a student model, which was a major source of input for our orchestration of student grouping, distribution of artefacts and assignment of activities (i.e., the various script). For example in the resource script, students were able to see all resources submitted by other members of their own SIG, as well as all resources from other SIGs marked as "general resources". We could also send personalized emails to group members, with direct links to relevant resources and activities.

Instructors and other support personnel need to have insight into the activity and development of each group in order to better support that group's knowledge work. Live-updated learning analytics dashboards, like the one we made available in the MOOC, enable instructors to get at-a-glance information about group progress and blockages, and quickly intervene to support blocked groups. This could also be enhanced in the future with machine-learning and pattern recognition, leading either to alerts, or even to automated interventions.

Coordinating work in small groups is a further challenge, particularly in a fully online environment. In the MOOC, we designed a Collaborative workbench, which automatically gave students access to all the relevant resources required for their creative work on lesson designs, complete with presence-indicators and persistent chat with other group members, and ad-hoc, anonymity-preserving mailing list. The group work space was permeable from the larger class (e.g., resources and reviews from the community are made available to the design group, and their in-progress designs are shared with the wider community) while the deliberation space remained private to the group.

#### 6.3.3.2 Synchronous and asynchronous activities

All in-person interactions are synchronous. If you say something and I am physically near you, and attending to you, then I immediately hear and can respond to what you just said. If I am not in the vicinity when you say something, I will never know what you said, unless it was explicitly recorded and made available to me. In online environments, we have the choice between synchronous and asynchronous modes of communication. E-mail is an example of an asynchronous mode: I can send you an email at any time, and it will be waiting for you until you access your mailbox. In most cases, I won't even know whether you have read the message or not, before I receive an answer.

This offers an important level of flexibility, but also represents a coordination challenge, as anyone who has tried to schedule a meeting with multiple participants through e-mail will know. We can think of collaborative activities that may occur within a group along a "granularity of content" spectrum. Sending someone a whole book to review falls at one end of the spectrum (i.e., they will need a lot of time to do the task before getting back to you), whereas collaboration between two musicians improvising a jazz-piece together (i.e., in real time) falls at the other end. Asynchronous communications favour larger collaboration granularities.

The granularity level of collaboration is an important factor when designing scripts in synchronous or asynchronous settings. If we have a discussion on a forum, I might write a long post with detailed arguments that requires you have time to slowly read it and formulate your answer, perhaps replying days afterwards. Whereas if we were holding a live spoken discussion or textual chat exchange via Internet (e.g., with Skype), I might make a single statement before getting your response. Thus, the intensity of collaboration and the sense of connection amongst collaborators can vary substantially depending on the granularity of content and temporality of exchange. In a short-lived course, opportunities for synchronous collaboration are more likely to engender feelings of community and personal connection.

In the Pre-Service Course, students met in a physical classroom for four hours every week, and were able to build personal connections and coordinate their collaborative work. For this reason, all online work was done asynchronously. However, in the MOOC, it was important for us to offer opportunities for synchronous collaboration. Thus, the Collaborative workbench offered a built-in live chat, which was also persistent (thus could also function as a message board), and we sent out notifications whenever a group member entered the collaborative workspace, to increase the chance of two work group members being online at the same time.

We also organized two live events during the last week of the course, where students could meet and interact with the instructional team, and teachers from UTS. Students appreciated this opportunity to meet "live", and asked us why we had not made this available for the entirety of the course.

#### 6.3.3.3 Scripting with open movement

A traditional approach to scripting assumes that the instructor is able to move the class through a number of pre-defined tasks and activities in unison. A classical problem-based learning script represented with Dillenbourg's (2015) orchestration graph might describe how the class will first receive an introduction, distribute into groups, conduct individual research or reflection, then solve the problem in a group, and debrief in a large lecture (see Figure 45).

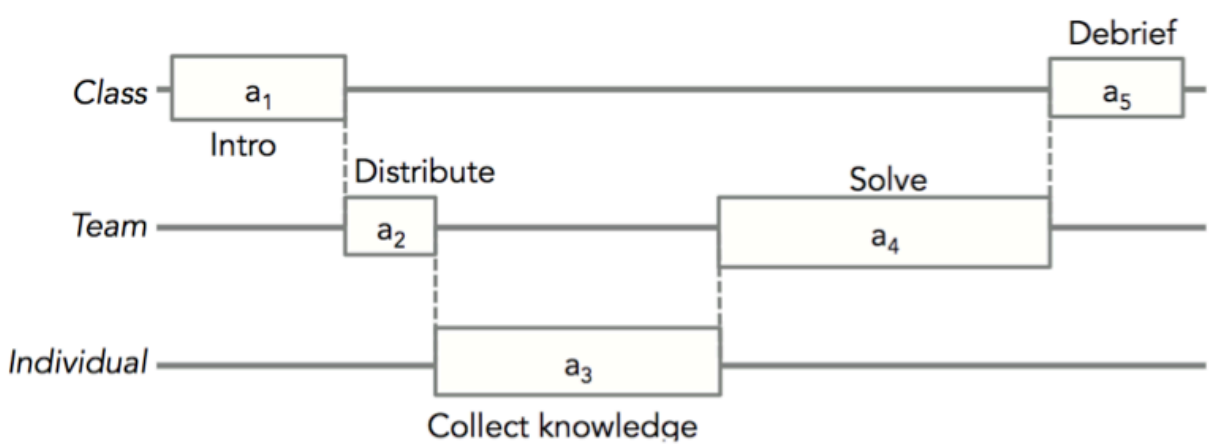



**Figure 45 - Example of orchestration graph**
**From Orchestration Graphs by Pierre Dillenbourg, Lausanne: EPFL Press. Copyright 2015 by Pierre Dillenbourg. Reprinted with permission.**

As a graph, the nodes (activities) are connected through edges (the lines between them), and edges can have a weight, which indicates how strongly they are connected. According to Dillenbourg (2015), the strength of the connection indicates how strongly a subsequent activity is dependent on a prior activity. This dependency could be logistic (a subsequent activity depends on an artefact, a grouping assignment or other produced by a previous activity) or cognitive/emotional (a previous activity motivates/prepares students for a subsequent activity). In the example in Figure 45, the introduction (A1) is useful to motivate the students, but might not be crucial. Thus, the teacher could decide to skip A1 and jump straight to A2 for the entire class. In contrast, without distributing the students in A2, they would not know what problem they were trying to solve in A3. Thus moving directly to A3 would be counter-productive, even in a situation of limited time.

In a MOOC or other asynchronous platform, students have a certain measure of choice as to which activities to engage with, at what time, and in what order. The next two sections will examine these orchestrational decisions from the perspective of the instructor who is orchestrating the class, and from the perspective of the individual student.

#### 6.3.3.3.1 Instructor/orchestrational perspective

To design robust scripts for MOOCs, we might reimagine the strength of an edge between two activities as denoting the importance of a certain percentage of the class having finished A before we release or open activity B. In the excerpt from a script shown in Figure 46, students are first asked to brainstorm resources (Activity A), and then in a subsequent activity (B), to look at the resources suggested by their peers, and add tags and reviews to them.

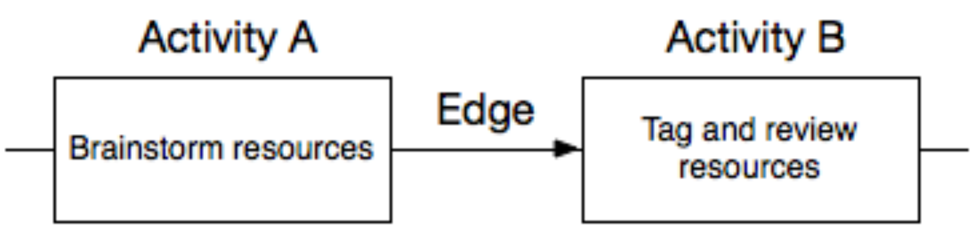



**Figure 46 - Example of flow between activities**

We can analyze the strength of the connection between A and B (the Edge) from two different perspectives. The first is the probability of success from a community perspective. In this case, in order for activity B to be successful, a certain percentage of students should have completed activity A before B (remembering that EdX cannot prevent students from just jumping to B even if they didn't do A). If the assignment of resources to review in B is more sophisticated, for example requiring matching on student characteristics and semantic tags, we would want a large proportion of students to have already completed activity A, to generate a much larger corpus of tags that can be matched to students in activity B.

A second question is whether it is useful pedagogically for students to still do A if they arrive too late (perhaps nobody will be around to review their resource), or to skip directly to B without doing A (they will still be able to review, but will miss the learning opportunity of entering their own resources).

Above, we have assumed that this script concerned the entire class, but we could also imagine that the granularity level of the sequence was lowered, perhaps taking place within each SIG, or at the design group level, requiring only the members of any group to be "in sync". Or perhaps scripts could be redesigned to be more flexible and resilient, for example by employing personalized e-mail messages, where instead of the entire class moving from activity A to activity B, a student could receive an e-mail stating “some new resources relevant to you have just been added, do you want to rate them?”.

This points to an important issue of dissociating the scripting constraints from the platform that supports those scripts. If we hand-built our own MOOC platform (which in much of our case, we did—i.e., for all the LTI elements) we could enforce or enable a much wider range of scripting moves than if we use the existing functionality of EdX or some other MOOC platform. In any case, it is important for the instructor to be aware of the serial dependencies of any sequence of activities, and for the technological environment to support the instructors’ decisions or commitments.

##### 6.3.3.3.2 Student perspective

To understand how to design and orchestrate scripts in contexts with "open movement" as described above, it is important to conceptualize student activity choice. Students in MOOC platforms constantly make choices about their activities. They decide on when and how often to log into the course, which might be structured largely by external factors like job and family, but can also be triggered by things like e-mail notifications and reminders.

The large drop-out rates characterized by most MOOCs are manifested by students one day simply no longer logging into the course. So, understanding why this happens, and finding ways to encourage them to continue logging in, is reasonable strategy for lowering the high attrition rate. In the discussion around synchronous and asynchronous events in Section 5.1.3, we discussed the difference between adding something to a calendar, versus adding it to a To Do list. For students in conventional courses where there is a set weekly class meeting, the default expectation is that they will attend at a certain time and date. However, with an asynchronous course where students are expected only to log in periodically (e.g., at least once a week), then attendance can simply be postponed, to the extent that the student ends up not coming back to the course, without ever taking a conscious decision to leave the course.

Once the student has entered the course platform, he/she has to decide which activity to begin, then after completing any activity, whether to continue or log off, and where to go next. Activities vary greatly in their granularity, and thus the frequency by which the student is given this explicit choice. A small activity might be a short video, a quiz, posting a discussion forum post, or reading a short text. A non-bounded activity such as "working on a lesson design" does not have as many obvious decision-points, leaving the student to continually evaluate whether to keep working or to leave. And of course there are a number of micro-choices the student must make about how to organize his/her work within this larger activity.

A number of factors can influence which activity a student chooses next, many of which are under the influence of the course instructor and designer (see Figure 47). The course design itself, organized around weeks and chapters, and importantly with specific deadlines and grading structures (you only get a grade if you complete a certain unit before a certain time) is one factor. This course design is often instantiated in the website user interface, which might have a hierarchy of menu bars, ribbons and activity sequences.

These vary drastically between different MOOC platforms. For example, Coursera has a list of weeks in the sidebar, and for each week there is a single linear flow of sequences on a long scrolling page, mixing videos, text and quizzes, whereas assignments are found on a completely different tab. EdX, on the other hand, provides the same list of headers (e.g., for each week) on the left, but these are then expanded into a list of sub-activities, containing a variety of content types (including assignments). The list of activities might induce students to jump around within a week, whereas the existence of course assignments within the activity sequence might encourage doing these in a certain order.


**Figure 47 - Factors influencing choice of movement within MOOC activities**

The order suggested by the course interface can be enforced through code, by making access to certain activities conditional upon the completion of previous activities ("unlocking"), or by enforcing a direct move into activity B directly upon the conclusion of activity A. The interface can also conditionally show different activities and materials depending on the user profile stored in the database, for adaptive teaching and research purposes. In traditional MOOC platforms, the only functionality of this kind is timed release, where a given material or activity can be locked until a certain time. However once it appears, it is available to all students. The external LTI server used in INQ101x introduced the possibility of conditional access, which we used, for example, to limit access to any LTI resources for students that had not already registered their profile, or access to the Collaborative workbench for students who were not part of a design group.

Apart from the passive design of the user interface, which might include written exhortations (or video instructions) such as “when you have completed this segment, please go to this other activity”, courses could also feature interventions such as pop-up prompts, e-mails, messages or reminders sent to students asking them to visit a certain activity at a certain time. These could be automatically dispatched by the system based on some logic, or individually triggered by the teacher (weekly e-mails are one form of this). The instructor emailing all students saying “We have now completed 500 resources, and we would like to invite you to vote on your favourite ones” is the equivalent of the instructor in a classroom asking teams to move on to the next activity.

## 6.4 Technology and Orchestration

Traditional Learning Management Systems (LMS) such as Blackboard, as well as new MOOC platforms, such as EdX, offer ways of distributing content, and certain built-in tools for student engagement (such as quizzes, discussion forums, or peer grading). However, these platforms usually do not offer any support for implementing pedagogical scripts, and the collaborative tools are usually inferior versions of single-purpose Web 2.0 tools that exist outside of the platforms.

There are many free-standing Web 2.0 tools that offer innovative ways of creating and collaborating online, from communication tools (chat, voice and video), to collaborative creation tools, including text editors, brainstorming and collaborative mindmapping tools, drawing pads, 3D modeling applications and more. Only a few of these tools are open source and can be hosted locally (like the collaborative editor Etherpad), and most tools have no possibility of single-sign on, or APIs that allow implementing a pedagogical script.

To integrate these tools into our workflow, we would want to enable single-sign on (students can access tools through a link in their LMS and are automatically logged in with their user id) and group awareness (e.g., a Google Doc is automatically shared between the members of a pre-existing MOOC group). We would want to scaffold (automatically insert a template before users begin to edit), and exchange artefacts (take a Google Doc from one group and send it to another group, or extract the text and insert it into another tool, such as a wiki).

In the Pre-Service Course, we used Confluence wiki (which is not open source, but hosted locally, and has a rich API for automatically managing content and users), together with Etherpad (open source, also hosted locally, and with a rich API). We also used a number of custom-written Python scripts to automate the creation of users and groups, insertion of wiki templates, and movement of content between the Etherpad and the wiki, and between different wiki pages. These scripts were all manually triggered, and applied a certain action to the entire class (add a certain page to every student's homepage for example).

Some MOOC teams have used the single-sign on functionality to connect an external platform to their course on EdX or Coursera. For example, the Learning Analytics DALMOOC (Ferschke, Howley, Tomar, Yang, & Rosé, 2015) developed an external social platform called ProSolo, which could be accessed through a link in their EdX course. However, students clicking on this link would "leave" EdX and "enter" ProSolo—a completely separate site, with it's own menu structure and navigational hierarchy. This movement between separate platforms can be confusing to students, who often struggle in any case to understand how they are supposed to engage with course software, materials, peers and instructors.

In our MOOC, we built a server that maintained a student model for each student including demographic data, group memberships, past activities as well as interests and relationships. This served a number of different pages/components, which were embedded at different points in the EdX timeline. Although each component seemed like it was completely separate, they all relied on the same underlying database, and were driven by a unified algorithmic logic embodying the pedagogical scripts. A simple example is conditional access, in which a student could not access a certain component $y$ unless he or she had already completed a previous specified component $x$. This was not possible to do in EdX alone. More complex examples include the transferring of content generated in one component into another component, enabling personalized e-mails, etc.

We embedded two external tools, Etherpad and Confluence wiki into our LTI frames. Using the same APIs as in the Pre-Service Course, we were able to embed these two tools seamlessly into the workflow. For example, we automatically created wiki accounts for students registered with the external server, and when they accessed the collaborative workbench, we automatically logged the student into the wiki, and embedded a view of the appropriate wiki page, depending on their group membership. Having access to all student data, including content generated, group memberships, and activity records, made it possible to generate a comprehensive learning analytics dashboard, where each individual data point linked directly to the artefacts described, and where administrators could quickly enter individual student group spaces as "visitors".

## 6.5 Future research directions

The growth of online learning in higher education, and the emergence of MOOCs, offer exciting new research opportunities for the Learning Sciences community. To make a successful contribution to learning at scale, our community must offer not only theoretical advances, but also applied research to overcome the technological challenges of scripting and orchestrating large numbers of students in fully online and hybrid settings, enabling the development of rich collaborative scripts where students are able to effectively build knowledge together in small groups, and at the same time benefit from the diversity and inspiration from the larger course community.

In our first Key Design Challenge, we looked at how to design a meaningful hierarchy of groups coherent with the semantic and social requirements of the course scripts, and support their collaborative work. More empirical studies are needed to determine the ideal relationships between group attributes (size, group formation approach, diversity among different dimensions) and types of collaborative tasks. Student models are crucial in supporting purposeful group formation, and could be extended through richer student profiles that persist beyond the duration of a single course, indeed groups could also persist across courses. Finally, the design of online tools to support group collaboration could implement more of the research on micro-scripting group interactions, with students being assigned roles and automated prompts based on machine-learning models of group progress (which could also be made visible to students through group awareness displays).

In our second Key Design Challenge, we wanted to enable a flow of ideas and artefacts across groups, and not just down through a hierarchy of nested groups. In the MOOC, we collected a large amount of semantic tags describing users, and resources, but due to engineering challenges, these were used only to a limited extent. Future courses could use semantic data, both explicitly entered as tags and categories, and implicitly extracted through semantic text analysis, automatic image recognition and other tools, to match students to other students, or students/groups to artefacts across group hierarchies. The extent to which this kind of intelligent mapping can replace some of the group hierarchy for the purposes of maximizing homogeneity or diversity, and reducing information overload for students, is an interesting question to explore.

In both the Pre-Service Course and the MOOC, we used technology to support the orchestration of complex scripts, and interdependencies between scripts. In both cases, this required the development of a large amount of custom code. In the Pre-Service Course, we used Python scripts and Application Programming Interfaces (APIs) to integrate a number of different Web 2.0 services, and automate the creation of templates, movement of artefacts, etc. In the MOOC, we custom-built a server for all of our interactive features based on a persistent student model, which was integrated with EdX using the LTI protocol. Most research projects, let alone individual teachers wanting to experiment, cannot afford this amount of technical work to implement a project. How to enable easy instantiation of instructional designs and scripts on technological platforms is an open research question. On one end of the spectrum, we could imagine developing a protocol like LTI which enabled richer linkages between applications, enabling for example the exchange of student artefacts. On the other end, one could imagine embedding more supports for scripting group work directly into MOOC platforms.

In our third Key Design Challenge, we focused on facilitating collaborative work in an online setting. Above, I addressed the need for better collaboration and communication for small groups, use of semantic tags to create connections, and supporting easier instantiation of designs by researchers and instructors. Another aspect worth exploring is better support for rich synchronous meetings. Currently, almost all the interactions in MOOCs are asynchronous (you can log on when you want, and you will see what other people have done while you were away), but synchronous meetings offer important opportunities in terms of motivation, sense of community, and the opportunity to enact dense collaboration scripts that would be difficult in an asynchronous setting, due to the turn-taking effect.

An instructor in a physical classroom with a small group of students might switch between a number of different activities and configurations during a class, jumping effortlessly from talking to the whole class, having students discuss with their partner, and then they might join into table groups and work on a project, while the instructor is circulating and offering suggestions.

However, the default for online synchronous meetings seems to be to meet as a whole group in a Google Hangout or similar tool to have a discussion. There is a need for better tools that enable instructors to transition between many different group configurations dynamically, and integrate rich live-collaborative tools to do real work together. The large numbers of online students also offer new possibilities, such as ad-hoc synchronicity, where students can have the option of engaging another student who just happens to be online at the same moment, working on the same problem, without having to be online at a pre-scheduled time.

Finally, the scope of the two design studies in this research project has been the length of a single course. On-campus learning management systems have been criticized for lasting only for the duration of a semester, with students losing access to their own work after the course has ended, and each new generation beginning with a blank slate. This practice has continued in the design of MOOC platforms, where all social interactions are confined to a single course, and instructors do not have access to any information about student performance or ideas generated from previous or other courses, and students have no way of creating lasting social bonds that transcend individual course communities.

A small attempt to overcome this has been our focus on connecting course generations through the sharing of student artefacts. However, a fruitful line of inquiry would be to look at enabling students to establish social profiles and connections that last through many of their courses (and ideally across different platforms and mediums of learning). Rather than examining what the students have gained in the six weeks that a given course lasted, we could look more deeply into how that course fit into a students' learning and professional trajectory. Six months after the course has ended, is the student incorporating ideas from the course in their professional practice (perhaps even adapting the lesson design they worked in the course)? Is the student still in touch with other students from the course?

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# Appendix A.
# Information Letter and General Consent Form for Students

To: Students of [Teacher's name] in course [#]
From: Stian Haklev
Subject: Participation in a curriculum studies research project at the University of Toronto

I am interested in conducting a research project in your school entitled: ***Fostering knowledge communities in higher education classrooms***. This project will investigate how students can help each other by creating a common knowledge base. Your instructor will design activities that allow you to collaborate with your classmates in small groups or take part in whole class cooperative learning. Different technologies will be used depending on the topic and type of activity. The research team, including myself, and my doctoral supervisor Dr. James D. Slotta, will help your teacher use the technology by providing design assistance and technical support. Example technologies are wikis, online discussion forums, Web-based learning environments, and simulations. The information provided from this study will be valuable to our research community to understand how instructors develop inquiry curriculum, and how students learn from this curriculum. It will also be of value to the university administration, in terms of promoting innovative teaching practices for your instructors.

Your instructor has approved of this research. Most research activities will involve only normal teaching practices. We will examine the teachers' curriculum designs, observe their teaching, and ask them about their assessments of student work. Occasionally we will ask students for an interview to gain a deeper understanding of their experience of the curriculum, as well as their understanding of the topic. If you are asked to participate in an interview, we will give you a separate Interview Consent Form. We may also want to videotape certain class periods, in which event we would give a separate Video Permission Letter to all students in the class (and you will have the option of not being part of the video).

Because any activities associated with this project will occur as part of your regularly scheduled class, they will not require any additional effort on your part. Efforts will be made to make sure this research does not interfere with your regular learning and only improves your learning experience and your teachers' experiences as well. Some possible activities you may participate in include: learning about and using new technologies, having discussions about the course content with your classmates; and participating in brief interviews with myself or my doctoral students. You may also be asked to complete a short questionnaire the beginning of the term so that we can assess your ideas about learning and knowledge. Only myself and my doctoral supervisor will have access to any of the information collected for the study. At no time will your names be identified in public information. All information that is collected will be kept in locked files and will be destroyed upon completion of the research.

There are no risks associated with participation in this study and you are free to withdraw from the research at any time. Your participation in this study in no way affects your grade for the course. If you decide not to participate in the study, or if you withdraw from the study at any time, your grade will not be influenced in any way.

Every effort will be taken to make sure your identity is kept confidential. Most of the information used in this research project will be in the form of computer-based materials used during your curriculum activities. Your identity will be visible to your classmates and your teacher, but will not be available to anyone from outside the school. Our research team will work with your materials, but will never include your name or any identifying information in any of our analyses, reports, or materials. For our own internal reference to your information, we will replace your name with a random ID number (not your student number). Any information will only be accessed from a secure database within my research laboratory. If you are asked for an interview, we will do so either before or after class, or when your teacher is not in the room. All interviews will be conducted in a private room during your lunch hour or after school.

If have any questions about the study please feel free to contact me by phone: 416-462-8866 or through email: shaklev@gmail.com. You can also contact my doctoral supervisor Dr. James D. Slotta by phone (416 978-0121) or by e-mail: jslotta@oise.utoronto.ca. Any questions about your rights as a participant can be directed to the University of Toronto Ethics Review Office at: ethics.review@utoronto.ca or 416-946-3273.

Sincerely,

Stian Haklev
PhD Student, Department of Curriculum, Teaching and Learning, OISE/UT

Published study results will be made available for students who are interested. Please feel free to contact the principal investigator with any questions or concerns.

To: Stian Haklev

From: ___________ (print your name here)

Subject: Participation in a curriculum studies research project at the University of Toronto

I have carefully read and understood the details of the study outlined in this letter, and give my permission to be included as a participant in the study.

___________________________________

Name of Student (please print)

___________________________________

Student’s Signature

# Appendix B.
# Pre-Course Survey for the Pre-Service Course

1. Gender
    - Male
    - Female
    - Other

2. Experience as classroom teacher
    - Less than 1 year
    - 0-2 years
    - more than 2 years

3. ITE option
    - PJ
    - JI
    - IS
    - Tech
    - Other

4. Preferred focus topic
    - Science
    - Math
    - Economics/Accounting
    - English/Literature
    - Foreign Languages
    - History/Social Studies/Religion
    - Arts/Music
    - Automotive Tech
    - Computer Science
    - Physical Education
    - Other

5. Use of technology *(Not at all—To a large extent)*
    - Do you use a personal computer/laptop?
    - Have you used technology in your teaching?
    - Do you use mobile phone applications?
    - Are you skilled in solving technology problems?

6. Use of social media *(Not at all—To a large extent)*

- Do you use sites like Facebook, Twitter, or GPlus?
- Do you participate in online communities organised around your interests? (could be juggling, cooking, sports or academics, for example)?
- Do you know of online communities relevant to your discipline or the courses you are taking now?
- Have you participated in such communities?
- Do you write your own blog or have your own website?

7. Social learning *(Not at all—To a large extent)*

- To what extent do you learn from your peers, and not only from the teachers?
- Would you value more opportunities to learn from your peers?
- Have you joined Facebook or other virtual study groups for classes (not organized by the teacher)?
- If yes, did you find that helpful?
- Have you participated in informal study groups not organized by the professor or teaching assistant?
- If yes, did you find that helpful?
- Have you shown drafts of your papers to other students and gotten feedback, or given feedback on drafts?
- Do you discuss course topics outside of courses with friends, housemates or family?

8. To effectively learn new material, I would prefer to… *(Not at all—To a large extent)*

- Be told what is correct by a teacher/professor.
- Read a full explanation in the textbook
- Have an expert explain it to me
- Do practical activities, make observations and research
- Use what I already know to understand new material
- Use an example to help me understand new ideas
- Discuss with my peers to find the answer together
- Consider one topic at one lecture, and then move to another topic next time
- Understand the deep structure of the domain
- Connect the pieces and parts from different topics into meaningful knowledge base

9. What do you hope to get from this course?

# Appendix C.
# Syllabus for the Pre-Service Course

**Technology, Curriculum and Instruction-- OISE/UT 5574H**

*Last updated: September 7, 2014*

**Professor: James D. Slotta**
*E-Mail*: jslotta@oise.utoronto.ca *Phone:* (416) 978-0121
*Office:* OISE room 11-268 *Office Hours:* By Appointment (*e-mail is always best)*

**Co-Instructor: Stian Haklev** *E-Mail*: shaklev@gmail.com

**Class Schedule**

- Wed 8:30 AM – 12:30 PM, Computer Lab, OISE Room 3-311
- Meetings: September 10, 17, 24, October 1, 8, 22 (no class Oct 15) November 26, December 3, 10
- October 22 (tentative!) – Online meeting.

**Class Overview**

How can we bring technology into our classrooms meaningfully? How can technology-enhanced curriculum help students learn more deeply, and help teachers teach more effectively? In this class, we will consider some of the latest, greatest tools and materials, collaborate with peers, and discuss numerous important issues relating to technology, curriculum and instruction.

The course will include a design project that you work on each week during class. You and a partner (or two) will design a technology-enhanced lesson plan that you could envision implementing in a classroom where you have taught before or will teach in the future. The final lesson plans will include several sections: a discussion of student ideas; a description of technology features; an activity plan; pedagogical notes for teachers; and assessment plans. On the final day of class, you and your partner(s) will present your lesson to the class in a Powerpoint presentation.

**Course Portal:** All materials and online activities will be coordinated through a Wiki environment: our syllabus, contact info for classmates, links to our readings and other class resources, online discussions, design groups and more. Web URL of wiki: http://www.encorewiki.org/display/5574/

**Special Interest Groups and Design Teams:** Much of the activity in class and at home will be done in small "Special Interest Groups" (for exploring the themes and advancing our knowledge), as well as "Design teams" (for making progress on your designs). These groups will use various collaborative technlogies

**Class Activities/Grading**

1. Participate in class activities. *(10% of course grade)*

   a. SIG groups
   b. Contribution to Wiki resources.
2. Participation in homework (*20% of course grade*)
3. Presentation of technology project - sign up for one (*20% of class grade)*
4. Technology-enhanced lesson design (*40% of class grade*)
   a. Preliminary design **due Oct. 8** (*10% of class grade*)
   b. Peer review **due Oct. 22** (*10% of class grade*)
   c. Final design **due Dec. 17** (20%)
5. Presentation of final project **Dec. 10** (*10% of class grade)*

**Student-led Presentations:**
Each week, one or two groups of students will present a technology tool or environment within each House, helping their peers explore the technology and critiquing it according to its strengths and weaknesses. Prior to your presentation, please complete one of the "Presentation Pages" in the class wiki. This way, the whole class can have access to all the information. After the presentation, please add the technology to the "Teacher Technology Resources" page.

**Readings:** Occasional readings will be assigned, to be discussed online or in class.

**Alternative Readings:** (While not required, these are good books you can find on Amazon.com)

*1. Integrating Computer Technology into the Classroom* by Gary Morrison and Deborah Lowther. "This text focuses on integrating computers into teaching through the use of an inquiry-based, easy-to-use model for creating lesson plans. Teachers can use this 10-step process to design student-centered learning environments in which computer technology is integrated as a tool for learning rather than as a delivery mechanism" (From the back cover)

2. *Teachers Discovering Computers: Integrating Technology in the Classroom* by Shelly, Cashman, Gunter and Gunter. "Text presents practical ways to integrate technology resources and technology-based methods into everyday curriculum-specific practices. For undergraduate or graduate introductory computer courses for educators."(From Intro)

3. *WISE Science – Web-based Inquiry in the Science Classroom* by Jim Slotta and Marcia Linn. Teachers College Press. This book shares the lessons learned by a large community of educational researchers and science teachers as they designed, developed, and investigated a new technology-enhanced learning environment known as WISE: The Web-Based Inquiry Science Environment.

# Appendix D.
# Reflection Prompts in the Pre-service Course

**Week 1**

- What is one example that you can think of where you either personally observed, or heard about technology being used to help students learn some topic from your SIG, in new ways?
- Describe yourself as a "new technology learner". What is one situation where you personally learned to use some technology, and how did it make a difference in your behaviours?

**Week 2**

- *Look through **About EDU5574** from students in previous years. Find one that is particularly interesting and relevant to your interests, then write about it below.* What topics was this lesson addressing, and how did technology help provide new ways for students to learn and teachers to teach?
- How did technology help students to collaborate with their peers, and learn from one another?

**Week 3**

- Talk about one experience you've had or (if you really haven't had any!) something that you heard about or read about where mobile phones or tablets were used for learning.
- What are some ways that you can think of, that smart phones or tablets could be a feature for K-12 instruction? (noting that they could certainly be a distraction!). Also, please note that the mobile devices could be used by students at home or outside of school hours...

**Week 4 (Part of the Jigsaw script)**

- Your topic is XXX. Please find a brief introduction to this topic here. Please look at the introduction, and then try to find an interesting example of this kind of technology used for teaching. Please edit the table below, and fill in information about the resource.
- How could this sub-theme be relevant to your SIG area?

**Week 5**

- What is the name and URL for the community you joined (you'll need this on Wednesday, so we're having you record it here)
  What were some of the things you found there - resources, or opportunities for teachers to exchange materials or support each other?
- When you are a teacher, how do you think you could use such communities to support your own practices?

**Week 6**

- Please write some thoughtful reflection about your experience in practicum, relating to your understandings about the role of technology for learning and teaching.
- Describe some of the LEARNING challenges (try not to get distracted by classroom management, school policy, etc) - where you may have been surprised by how students learned or what they knew, within your topic area. Talk about how the teacher responded to those challenges, and how you think technology-based approaches (for mind-tools, collaboration, mobile learning etc) could be added.

# Appendix E.
# Etherpad Prompts in the Pre-Service Course

**Week 1**

- What is your SIG Name?
- Who are the members?
- List some of the topics in your interest group that you think will be difficult to teach, and say why
- How do you think technologies could potentially help students?
- Look through some of the technology projects in the class wiki. Find some sites that you think would be interesting, for use in addressing those difficult topics. Paste the name and URL (if available) below, and describe why this might be a helpful approach.

**Week 2**

- How did this technology help your group to represent your ideas in interesting ways?
- What were some of the interesting kinds of features that you discovered?
- Could you imagine using this tool with students in your SIG topics? What kinds of possible activities could be designed?

**Week 3**

- How could the technologies from this week's presentations help support peer collaborations in your classroom?
- What were some of the interesting features that you discovered?
- Could you imagine using this tool with students in your SIG topics? What kinds of possible activities could be designed?

**Week 4**

- How could the technologies from this week's presentations be useful in teaching within your SIG topic area?
- What are any other ways that mobile or handheld applications could be used, in your SIG topic area?
- Think about your possible topics for a lesson (the lesson design assignment). Use this space to briefly describe your topic, and comment on each other's ideas. Try to think about whether any mobile or handheld aspects would make sense.

**Week 5**

- Please go to your SIG page, under Week 4, where you'll find a table of all your comments made about the various categories of tangible and embodied learning. Within your SIG, there should be at least one person who looked over each category, voting on their favorite examples and comments. Each person please share their favorites, and spend some time talking and looking at the various Web sites.
- Now each person add underneath the following discussion: How are tangible and embodied interactions a "different way of learning" than lecture, textbooks, or watching video on the computer screen?
- Why or how might students learn better using these new forms of media and method?

**Week 6**

- What kinds of ethical considerations might be concerned with today's technology presentations?
- In your SIG, generally, what are important possible ethics concerns?

**Week 7**

*Students were asked to structure a discussion around the equity/diversity issues raised in the Brainstorm script.*

# Appendix F.
# Technologies Presented in the Pre-Service Course

**House 1**

- Bank On It
- DebateGraph
- Desmos
- FluidMath
- Geometer's Sketchpad
- Gizmos
- Matlab
- Mural.ly
- National Library of Virtual Manipulatives
- NearPod
- PhET
- PollEverywhere
- PowToon
- Socrative
- Wolfram Alpha

**House 2**

- Blogger.com
- Edsby
- Eliademy
- Garageband
- Pinterest
- PollEverywhere
- QR Codes
- Skype
- Trello
- Tumblr

**House 3**

- Assistive Technologies for Students with Special Needs
- Blendspace
- Document Cameras
- iPads and other tablets

- Kidspiration
- Osmo
- Prezi
- Skype
- SmartBoards
- Socrative

# Appendix G.
# Design teams in the Pre-Service Course

**House 1**

- Algebra (grade 9)
- Analytic Geometry (grade 9)
- Biochemistry
- Business: Marketing
- Cardiovascular System
- Data Management (grade 7)
- Geometry
- Graphing and Scatter Plots
- Molecular Genetics
- Money & Technology
- Physics

**House 2**

- Drama
- English Language
- French
- History (2 groups)
- Korean
- Languages
- Music Composition
- Music Performing
- Music Soundscapes
- Physical Education
- Transportation Technology
- Visual Arts

**House 3**

- First Nations
- Forces and Gravity
- Heritage
- Language Arts – Composition
- Language Arts – Creative writing
- Math Multiplication Tables

- Math: Data Management
- Math: Fractions
- Media Literacy

# Appendix H.
# Pre-Course Survey for the MOOC

1. Why did you sign up for this course?

2. How would you define "learning through inquiry?"

3. What do you think is a good role for technology in supporting inquiry?

4. What is the role of the teacher in an inquiry-based learning environment?

5. What would be an ideal length of time for an inquiry learning experience?
- a few minutes per class period
- an entire class period
- several consecutive class periods
- several weeks of class time
- 1 month or more of class time

6. How often do you think inquiry lessons should be included?
- every day
- once per week
- once per month
- once per unit or semester

7. How important are each of the following learning objectives to your teaching? *(not important—very important)*
- Memorizing vocabulary and/or facts
- Understanding concepts
- Learning test taking skills/strategies
- Learning about process skills (for example: observing, measuring, critical thinking)
- Learning to collaborate and work as a team
- Learning to find, critique and use resources
- Learning real-life applications your topic
- Preparing for further study in your topic

8. How often do students use each of the following instructional technologies in your classroom? *(never—every day)*
- Personal computers, including laptops
- Hand-held computers (tablets, smart phones)

- Classroom response system or “Clickers”
- Smart board

9. How available are each of the following technologies for your students, working in small groups of 2 - 5 students? *(not available—easily available)*
   - Personal computers, including laptops
   - Hand-held computers (for example: PDAs, tablets, smartphones, iPads)
   - Classroom response system or “Clickers”
   - Internet access

10. How much support do teachers at your school receive for innovative use of technology?
    - Teachers are very well supported
    - Teachers receive some support
    - Teachers are on their own, but encouraged to try new things
    - Teachers are discouraged from trying new approaches

11. In your school, is there a clear vision statement about technology integration for learning and assessment?
    - Yes, there is a very clear vision and teachers are actively engaged in pursuing it
    - Yes, there is a technology vision, but teachers are not supported in pursuing it
    - Yes, there is a technology vision, but it is not sufficient, or teachers do not agree with its direction.
    - There is some support for technology integration, but no clear vision
    - No, there is no vision statement about technology integration

12. How confident are you in enacting the following instructional practices? *(not confident—highly confident)*
    - Providing alternative explanations or examples when students are confused
    - Responding to difficult questions from your students
    - Adjusting your lessons to differentiate for individual student needs
    - Using a variety of assessment strategies
    - Monitoring student understanding on an ongoing basis throughout a unit
    - Assessing student understanding at the conclusion of a unit
    - Providing appropriate challenges for high-achieving students
    - Developing lessons that combine subject matter, technologies, and teaching approaches.

13. Please rate the following statements as they apply to your own experiences in learning with your peers *(not at all—to a large extent)*

- You tend to learn from your peers, and not only from teachers.
- You value opportunities to learn from your peers.
- You have participated in Facebook or other virtual study groups for your classes (not organized by the instructor).
- You have participated in informal study groups (not organized by the instructor).
- You shown drafts of your papers to other students and gotten feedback, or given feedback on drafts.
- You discuss course topics outside of courses with friends, housemates or family.
- section

14. What is your opinion of working with your peers in an online course?

- It is important to have frequent discussions and exchanges with other students
- It is important for me to explain my ideas to other students
- It is important to ask other students to explain their ideas to me
- Other students usually listened carefully to my ideas

15. Below are the six themes that we will address in this course - one for each week. Please indicate your level of interest for each *(not important at all—very important)*

- Inquiry and student-centred pedagogy
- Designing activities and assessments
- Student collaborations and peer exchange
- Integrating handheld and mobile devices
- Student-contributed content & collective knowledge building
- Issues reacted to enactment of technology-enhanced inquiry

16. Which of the following statements best describes the level of effort you expect to put into this course?

- I plan to complete all the requirements including watching all videos, completing all assignments, and earn a statement of achievement.
- I plan to watch most videos but not do the assignments.
- I plan to watch some videos, but am unlikely to do the assignments.
- I am not sure.

17. How many MOOCs have you enrolled in so far, including this one?

- 1-3
- 4-6
- 7-9

- 10 or more

18. How many MOOCs have you completed so far?
- 0
- 1-3
- 4-6
- 6-9
- 10 or more

# Appendix I.
# Post-Course Survey for the MOOC

1. As an educator, how much potential do you feel MOOCs have as a form of professional learning?
   - Lot's of potential
   - Some potential
   - Little potential
   - No potential

2. What was the greatest learning or insight about inquiry and technology that you gained from this course?

3. What was something that you gained from this MOOC that you could take back to your own teaching?

4. What were some obstacles or problems that you found with the course?

5. How valuable were these elements of the MOOC for your learning? *(Didn't do it—Very valuable)*
   - Professor Slotta's videos
   - UTS leaders' videos
   - Classroom case study videos
   - Personal reflections
   - Online discussions
   - Inquiry activities
   - Design strand activities

6. How interesting did you find each of the following themes? *(Not at all interesting—Very interesting)*
   - Defining inquiry
   - Designing inquiry Activities and Assessments
   - Collaborative Learning
   - Handheld and Mobile Devices
   - Student Contributed Content and Collective Inquiry
   - Inquiry Enactment

7. How would you describe the role of the teacher in an inquiry-based learning environment?

8. This course put forward a particular vision or perspective about technology-enhanced inquiry for K-12 classrooms. Please rate the following statements about the content of this course. *(Strongly disagree—Strongly agree)*

- There was nothing very new or surprising about these ideas; they are quite basic and familiar to most teachers.
- The ideas and approaches are intriguing, but not likely to be useful for most teachers
- The ideas about backward design are important, and useful for all teachers.
- The role of a teacher in enacting inquiry is quite different from that of normal classroom teaching
- Technology allows for student-centered designs, and there are an increasing number of available tools and applications to support teachers in designing such activities.

9. What would be an ideal length of time for an inquiry learning experience?

- a few minutes per class period
- an entire class period
- several consecutive class periods
- several weeks of class time
- 1 month or more of class time

10. How often do you think inquiry lessons should be included?

- every day
- once per week
- once per month
- once per unit or semester

11. How confident are you in enacting the following instructional practices? *(Not confident—Highly confident)*

- Providing alternative explanations or examples when students are confused
- Responding to difficult questions from your students
- Adjusting your lessons to differentiate for individual student needs
- Using a variety of assessment strategies
- Monitoring student understanding on an ongoing basis throughout a unit
- Assessing student understanding at the conclusion of a unit
- Providing appropriate challenges for high-achieving students
- Developing lessons that combine subject matter, technologies, and teaching approaches.

12. What is your opinion of working with your peers in an online course? *(Not at all—To a large extent)*

- It is important to have frequent discussions and exchanges with other students
- It is important for me to explain my ideas to other students
- It is important to ask other students to explain their ideas to me
- Other students usually listened carefully to my ideas

13. What do you think about the activities and contents of the course? *(Not at all—To a large extent)*

- The level of activities required of participants was appropriate
- The activities helped me to achieve my goals as a learner.
- I enjoyed and benefited from the interactions with peers in discussions and inquiry activities.
- The topics, activities, and resources of this course will be useful to me in my future teaching

14. If you participated in design strand activities, how useful did you find the following collaboration and communication tools? *(Didn't know it was there—Very useful)*

- Live chat with design team members
- Email notifications of when a team member entered
- Email between team members
- Etherpad prompts and editing
- Wiki editing
- Critical review and feedback from MOOC peers
- Welcome message each week in design strand
- Technology and Inquiry Resources that were brainstormed in the early weeks of the course

# Appendix J.
# Course Outline for the MOOC

**About INQ101x**

INQ101x is designed with K-12 teachers in mind. Teacher candidates, higher education instructors, and other educators may also find it relevant. We discuss some of the major themes and challenges of integrating inquiry and technology as a community of practitioners. We collect and share resources and exchange ideas about what works for specific topics and age groups. We also support design groups to collaboratively develop a new lesson.

**About the Instructors**

*Jim Slotta* is an Associate Professor of Education at The University of Toronto, where he holds the Canada Research Chair in Education and Technology. From 1997 - 2005, he led the design and development of the Web-based Inquiry Science Environment (http://wise.berkeley.edu) at the University of California, Berkeley. Since coming to Toronto in 2005, he has directed the ENCORE lab (http://encorelab.org) - a team of students, designers and developers who investigate new models of collaborative and collective inquiry in K-12 science. His research investigates new forms of inquiry for K-12 science classrooms, where students engage with simulations and visualizations, collaborate with peers, and work as a knowledge community to investigate phenomena, contribute their own ideas, develop designs, and create scientific arguments. His research is conducted in close collaboration with teachers, ensuring their role as a learning partner and transforming their classrooms into creative and active learning environments. Professor Slotta maintains collaborations in Europe, North America and Asia, and has published and presented widely on the international stage.

*Rosemary Evans* is the principal of University of Toronto Schools, a secondary school for high achieving students affiliated with the University of Toronto. She received her BA in history from the University of Western Ontario and her MA, BEd, and MBA from the University of Toronto. She has served as a teacher, department head, and subject coordinator for the Peel Board of Education, and later as a vice-principal in the former East York Board of Education. During her time as an instructor in the Initial Teacher Education Program at OISE, Rosemary was the recipient of a Teaching Excellence Award. She later accepted the role of Academic Head at Branksome Hall, where she oversaw the implementation of the International Baccalaureate Programs from junior kindergarten to grade twelve. Rosemary is the author of a number of history textbooks, and has given presentations locally and internationally on topics such as assessment and evaluation, critical thinking and inquiry based learning, and global education.

**Learning Outcomes**

- Connecting theory to practice
- Student learning through inquiry

- The role of the teacher in inquiry classrooms
- The role of technology in supporting students and teacher during inquiry
- Integrating inquiry into instruction
- How much, when, and for what purposes?
- Assessment: revealing and responding to student ideas
- Design: teacher as curriculum designer and action researcher
- Enactment: things that can go right and wrong during the inquiry lesson
- Elements of inquiry designs
- Collaboration
- Integration of internet resources
- Incorporating mobile devices
- Collective inquiry and student-contributed content
- Support for teachers in a school community
- The role of school administrators and technology staff
- The role of peers within your school and in wider virtual communities

**Participation paths in INQ101x**

*Special Interest Groups (SIG):*

Based on your grade-level/subject-matter interests, you will join a SIG where you will collaborate, share ideas, and reflect on lesson design and other projects with other teachers/educators.

*Participation Strands:*

The primary form of participation is the *Foundations strand*, where participants engage in reflection, peer discussion, and lesson design evaluation.

<u>The Foundations strand is all that is required for the verified certificate.</u>

In addition, we offer a complementary *Design Strand* where each week (after completing the Foundations activities) you can engage in lesson design with your peers, with critical review from the wider community.

**Weekly Activities**

In each week of the course, we examine one theme related to the integration of technology and inquiry in teaching and learning. Each week in the "Courseware" section of the EdX Web site, you will find:

A <u>short lecture</u> (video) on the theme by Professor Slotta, approximately 10 minutes.

A <u>school community discussion</u> (video) by UTS administrators, also about 10 minutes.

A case study of a UTS teacher's classroom practice, relevant to the theme.

Inquiry activities designed to engage you in active reflection and exchange.

Activities include self-reflections, peer review, and discussion forum participation, and are outlined in the following sections of the syllabus.

Resources: links to relevant papers, videos, and teaching/learning technologies.

**Course topics and timeline**

Please keep in mind that we might make small changes to the syllabus as the course starts to make the learning experience more relevant to you.

| Week | Theme | Goals | Foundations Strand | Design Strand |
|---|---|---|---|---|
| Week 0: June 12 - 30 | Introduction and Orientation. | Get to know each other before the official start of INQ101x. | Take the Entry Survey; Join a Special Interest Group; Submit resources. | Nothing yet! |
| Week 1: July 1 - 11 (July 1 and July 4 are holidays) | Inquiry and student-centred pedagogy. | Review definitions of inquiry; Discuss challenges and opportunities, and role of technology. | Short lectures on student learning in inquiry; Case study: Middle school science teacher adopts WISE heat and temperature inquiry project; Inquiry activity: Add and critique technology resources. | Create design teams; brainstorm lesson ideas. |
| Week 2: | Designing | Discuss | Short lectures | Articulate |

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| July 12 - 18 | inquiry activities and assessments. | challenges of designing and integrating inquiry into your curriculum; Reflect on learning goals, formative assessment and content coverage. | on inquiry design and curriculum integration; Case study: High school science teacher designs and enacts a NearPod activity on electric circuits; Inquiry activity: Critique lesson design ideas | learning goals, technology resources and main topics. |
| *Week 3*: July 19 - 25 | Collaborative learning. | Review the challenges of designing for collaboration and examine design approaches to promote student engagement. | Short lecture on collaboration and inquiry learning; Case study: A visual arts teacher and a language teacher explain how they integrate collaboration into inquiry; Inquiry activity: Critique lesson designs for collaboration | Add collaboration into your designs; work on activity structure. |
| Week 4: July 26 - August 1 | Handheld/ mobile devices. | Consider the challenges and opportunities of integrating handheld and mobile devices into inquiry designs. | Short lectures on the possible role for mobile devices in inquiry activities; Case study: A biology teacher reflects on her | Add handheld and mobile activities into your designs; work on activity structure |

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| | | | design and enactment of a lesson that uses a mobile app. Inquiry activity: Critique lesson designs for use of mobile and handheld activities. | and assessment |
| Week 5: August 2 - 8 | Knowledge co-constructio n and student-contributed content. | Explore the potential of student-contributed knowledge, particularly for purposes of whole-class or collective inquiry. | Short lectures on the nature of collective inquiry, Web 2.0, and student contributed content; A math teacher and researcher share their design of a "big data" statistics lesson that emphasizes knowledge co-construction; Inquiry activity: Personal plan for integrating inquiry | Add student contributed content and collective inquiry into your designs; complete activity structure and assessment s. |
| Week 6: August 9 - 15 | Inquiry Enactment | Consider the challenges of classroom management and student engagement when enacting a technology enhanced inquiry lesson; | Short lecture on enactment and the role of the teacher in inquiry lessons; Case study: A high school geography teacher explores his | Finalize designs, including teacher enactment notes. |

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| | | examine strategies to respond to such challenges, and roles for school support. | use of games for learning, and discusses the concerns and strategies for success; Inquiry activity: Critique lesson designs for enactment concerns and the role of the teacher. | |
| Afterward | Sustained reflection and community | Resources and lesson designs will remain available to participants | Links will be provided to all lessons from the design strand, inviting final review and comments | |

**Grading Policies**

Activities completed within the week for which they are assigned will receive full credit. Activities completed late will not receive any credit toward the verified or honor code certificate.

| | | | Will be available from | |
|---|---|---|---|---|
| Course | Theme | Assignment | Toronto | UTC |
| Open | Introduction and Orientation. | - Take the Entry Survey;<br><br>- Join a Special Interest Group;<br><br>- Submit resources. | June 12, 8 AM | June 12, 12 PM |

| | | | | |
|---|---|---|---|---|
| Week 1 | Inquiry and student-centred pedagogy.> | - Personal reflections (10 pts)<br><br>- Online discussions (10 pts)<br><br>- Resource sharing, review (10 pts) | July 1,<br><br>8 AM | July 1,<br><br>12 PM |
| Week 2 | Designing inquiry activities and assessments. | - Personal reflections (10 pts)<br><br>- Online discussions (10 pts)<br><br>- Lesson critique (10 pts) | July 13,<br><br>8 AM | July 13, 12 PM |
| Week 3 | Collaborative learning. | - Personal reflections (10 pts)<br><br>- Online discussions (10 pts)<br><br>- Lesson critique (10 pts) | July 20,<br><br>8 AM | July 20, 12 PM |
| Week 4 | Handheld/mobile devices. | - Personal reflections (10 pts)<br><br>- Online discussions (10 pts)<br><br>- Lesson critique (10 pts) | July 27,<br><br>8 AM | July 27, 12 PM |
| Week 5 | Knowledge co-construction; student-contributed | - Personal reflections (10 pts)<br><br>- Online discussions (10 pts) | August 3, 8 AM | August 3, 12 PM |

| | | | | |
|---|---|---|---|---|
| | content. | - Personal planning (10 pts) | | |
| Week 6 | Inquiry Enactment | - Personal reflections (10 pts)<br><br>- Online discussions (10 pts)<br><br>- Final Lesson Review (10 pts) | August 10, 8 AM | August 10, 12 PM |
| End | | | August 28, 8 AM | August 28, 12 PM |

**Course policies**

- With the exception of Week 1, each week is released Monday at 12 UTC (8 AM Toronto time)
- To earn a certificate – either verified or honor code – you must achieve a score of at least 60% on all activities, as described above.
- Any curriculum design products that are created in this course will be added to a wiki that is open to the public, and as such will be offered under a Creative Commons license.

# Appendix K.
# Reflection Prompts in the MOOC

**Week 1**

- What are some aspects of the WISE activity that you thought were most effective, in terms of helping students learn the topics?
- What was Jennifer's role, during the WISE lesson? What new opportunities came a result of using WISE?

**Week 2**

- How is Shawn's lesson design process similar to or different from your own?
- What are some of the greatest challenges in designing an inquiry lesson for your classroom?

**Week 3**

- Think about either Maria or Charlie: how did her/his lesson use technology to support student collaboration? How did the technology help?
- Now think about the collaboration part: What did students gain from this collaboration that made it an important part of the lesson? Why was collaboration effective for learning?

**Week 4**

- Imagine your classroom with all students bringing their own smart phones or being provided with personal tablet computers. What kinds of activities could you design that would engage them and promote learning?
- Assuming, again, that your students all had access to personal handheld devices, why do you think it is so challenging to design effective applications for inquiry curriculum?

**Week 5**

- When you think about your students, what kinds of ideas or products could be supported by the “student-contributed content” approach? How would this help you as a teacher?
- What kinds of advantages could be offered by a “collective inquiry” approach - where students add and build on ideas and resources, then use their collective product as a resource for further inquiry?
- You may have noticed that we have been trying to enact a collective inquiry approach in this MOOC, where the community is organized into SIGS who share resources, vote, tag and comment on ideas, collaborate and support their peers in lesson design. Can you comment on your own experience, as a participant in this approach?

**Week 6**

- Think about your current classroom. What kinds of diversity are there? How could an inquiry lesson take advantage of students' individual differences and highlight the diversity as an advantage of the community?
- Inquiry lessons typically include reflective and collaborative activities, data collection, group projects, designs, and the use of various technology environments. A primary issue is that of engagement, where students understand the activities, and are making progress with interest and enthusiasm. What can the teacher do, before and during the enactment, to help make sure students are engaged?

# Appendix L.
# Discussion Forum Prompts in the MOOC

**Week 1**

- Lets talk about the challenging topics for instruction in our focus group area. In your experience, what topics seem to be the most challenging for students, and why?
- Lets share what we know about how students learn in our SIG topic areas. What are some of the things that you have come to understand about how students learn various topics within our SIG focus areas?

**Week 2**

- Lets talk about integrating inquiry into our courses. How much class time do you think you could give to an inquiry project? Is that enough to make a difference in student learning?
- What opportunities are gained by the teacher when using inquiry and technology? Please use any examples from your own experience, where relevant.

**Week 3**

- What are some of the topics where collaboration could be effective?
- What approaches could be effective, and how could technology play a role?

**Week 4**

- Lets think about the *mobile* aspect of smart phones and tablets. Within our SIG, what are the advantages (for learning) of a device that students take with them from class to class and place to place?
- Now lets think about the *personal* aspect of smart phones and tablets. Again within our SIG, what are the benefits of students' having their own personal device that nobody else uses and can be customized and maintained by the student?

**Week 5**

- In our SIG, where are the real advantages for using student-contributed content? What specific topics would be well-suited for this approach, and how could it be used productively within the curriculum?
- Lets talk about the pragmatics of student-contributed content and collective inquiry. When we assign students to create, capture, upload, 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?

**Week 6**

- Lets discuss ideas for taking advantage of the diversity in our classrooms, and engaging all students in inquiry. What approaches have you heard about or used in your own classroom?
- Now let's discuss the role of the teacher in an inquiry classroom, which includes various logistical and pedagogical interactions: lectures, managing transitions between activities during the lesson, facilitating student inquiry and small group interactions. What are some of the most important aspects of this role? Please feel free to ask questions of each other, and respond.

# Appendix M.
# Completed Design Projects in the MOOC

**Secondary Math**

- Who Changed the Circle into a Rectangle?!

**Secondary Science**

- What's the natural frequency of ...
- Endo or exo, what's the difference?
- Address students' misconception - Photosynthesis
- Cure Project: Disease Awareness, Treatment, & Management
- What is the meaning of life?
- My first inquiry, a simple pendulum

**Arts, Media and Design**

- Let's Make Aboriginal Musical Instruments!
- Composition the modern way
- Mooooovie Posters

**Secondary Technology Instruction**

- Design for life

**Foreign Languages and English as Second Language**

- The importance of sunlight in plants.
- ESL Taught with Critical Thinking
- BBC website supply the students with resources
- Let's learn about other cultures
- Writing a storyboard.

**Elementary Math, Science and Technology**

- Problem Solving through interactive lerning
- The Earth Sun and Moon System , How do they compare?
- Survival & Interdependence, Humans & Plants- a view from Science and Social Studies
- Video Diary Portfolios
- How to teach Water cycle and Carbon cycle?

**Elementary English, History and Social Studies**

- Funny Crazy sentences!!
- Interaction with the environment in an ancient society

**Higher Education and Online Learning**

- Computer technology, then and now
- Exponential functions