The Pennsylvania State University
The Graduate School
College of Information Sciences and Technology

AN INVESTIGATION OF TECHNOLOGY DESIGN FEATURES FOR SUPPORTING
INVERTED CLASSROOM TEACHING

A Thesis in
Information Sciences and Technology

by
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Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

August 2015
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ABSTRACT

New technologies and teaching approaches are having enormous effects on education practices. The inverted classroom has emerged as an unconventional approach to structuring a classroom environment to enhance active learning. This model allows instructors to provide engaging content but also to cater to different learning styles by reserving significant amounts of classroom time for student interaction and problem solving. Many learning responsibilities are correspondingly shifted to the student, which leads to a sense of autonomy.

The implementation of the inverted classroom pedagogy varies depending on the instructor, learning objectives, activities, content, and available teaching resources. Instructors use whatever technologies are provided to enable and complement this pedagogy; however, there has been no effort to analyze or design technologies that would be most appropriate for this teaching method. Instead, instructors turn towards a mix of external technologies, the learning and integration of which detracts from accomplishing other teaching tasks.

In my first study, I used qualitative methods to study the practices of instructors using the inverted model, guided by Activity Theory as my theoretical lens. I found a number of themes pointing to a need for more flexibility and customization of the support tools. These early findings have led me to argue for the design of a system that could aid “inverted instructors” with their tasks and as a result help to transform the activity of teaching in this context.

My second study was guided by my previous findings and used Scenario-Based Design (SBD) to create low-fidelity prototypes and scenarios that would allow me to explore my preliminary design ideas through participatory design sessions. I shared these design ideas with instructors, and use their feedback to refine my high-level design ideas that in the future will enable me to design and build a concrete artifact.
In this thesis I describe the activity analysis and iterative design process that I have followed, drawing from Activity Theory as a lens, and producing design recommendations for technology that can support inverted teaching practices.
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ACKNOWLEDGEMENTS

I would like to thank my advisor, Mary Beth, for being extremely supportive since the first day I entered the M.S. program in the College of Information Sciences and Technology. Regardless of her busy schedule, she always found the time to give me advice and guide me through graduate school. Next, I would like to thank the members of my committee, Jack Carroll and Eileen Trauth, for agreeing to partake in my defense. They also provided invaluable advice that helped my thesis along, including an early project in a qualitative methods course taught by Dr. Trauth and regular team meetings with Dr. Carroll and other members of the Learning Technologies group in our research lab. I would also like to thank my cheerleaders, other supporters, and friends including Patrick Shih, Jess Kropczynski, Erika Poole, Tamara Peyton, James McDonald and Brian Dorn. You all have been such an influence on me and have provided some form of guidance on my academic path. Last but not least, I would like to thank my family for helping me through my Bachelor’s degree and for believing in my ability to succeed in graduate school. Thank you.
Chapter 1

Introduction

The inverted (flipped) classroom (IC) has received lots of attention. As student-centered approaches teaching are increasingly touted as leading to more effective learning experiences, instructors are constantly exploring new student-centered approaches of teaching. The inverted classroom is an emerging unconventional approach aimed at enlivening a dry traditional-lecture setting while employing active learning activities that enhance student engagement, assessment, and experience (Lage & Platt, 2000; Bishop & Verleger, 2013). Instructors are constantly looking for efficient and effective ways of presenting information to their students. Furthermore, instructors may sometimes feel time-deprived in a large lecture hall and, therefore, may not have as much time to help struggling students. The inverted model introduces a balanced approach to time management where the instructor has the control to place content outside and interactive discussion and problem-solving within. The added advantage is a self-directed learning approach that is adopted by the students. Equally important, this pedagogical method caters to different learning styles which are extremely beneficial, especially in a classroom where students may be more advanced in a topic.

In the context of education, many instructors do not possess the ability to program and may not have the technology skills to support novel media construction and delivery needs; nonetheless, they may want to design and develop their own tools to implement in their classrooms. Although they are motivated to enrich their teaching, they may not know where to start. In contrast, other instructors may even have computer science degrees and feel comfortable to build their own tools, but they struggle with the need to integrate separate platforms. This may
be a hassle to integrate into one’s classroom along with university-based resources or content management systems. Other times universities may not provide any allocated resources to instructors, and this can prevent them from attempting new and innovative tools and teaching practices. To alleviate such concerns, I propose an integrated system that combines a set of custom features designed to aid course tasks like content creation and content delivery.

As hybrid, blended, and online learning are becoming more prevalent in education, the creation of tools to support these methods is increasing. My research is exploratory in nature. I am seeking to understand the inverted classroom phenomenon as a whole, but with a specific focus on the tools that instructors are using to support this teaching model. With a better understanding of how instructors use specific technologies, important design features and functional choices can be made for a prototype custom system devoted to inversion. Thus, not only is this research critical to the inverted classroom, it may also benefit the future of education more generally, by giving educators and educational researchers a glimpse into alternative classroom structures and associated support. My research will also provide a careful analysis of the technological side of the inverted teaching approach. While student success is imperative and an indicator of success in the inverted classroom, for the purposes of this thesis, I shift my focus to the improvement of inverted classroom (and hybrid learning) tools for instructors.

**Contributions**

The contributions of this thesis are threefold. First, I hope to advance the existing research knowledge base regarding the inverted classroom as a pedagogical method, aiming at the field of education in general. Second I will be working toward the design of a system to support this approach to teaching, ultimately making a contribution in future applications of the inverted
classroom. The third contribution is unearthing and documenting the instructor’s perspective in inverted classroom implementation and technology usage.

**Structure of Thesis**

The structure of this thesis is as follows: Chapter Two provides a comprehensive review of the literature surrounding the inverted classroom phenomenon and associated tool usage. Chapter Three discusses the research methodology that I have employed, including my theoretical lens, data collection and data analysis procedures. Chapter Four present my findings from the first study that I conducted. Chapter Five presents the second study. Chapter Six discusses the implications of the two sets of findings with respect to how instructors might use new or existing technologies in preparing for inverted teaching. Finally, Chapter Seven presents my conclusions and thoughts about future work.
Chapter 2

Literature Review

The Inverted Classroom

There are several definitions of the inverted classroom; the simplest definition describes the approach as a reversal of traditional lecture activities (Lage & Platt, 2000). For instance, whereas homework usually occurs outside of the classroom, this activity is performed within the inverted classroom; lectures that might normally be delivered in the classroom are provided outside of classroom time (Lage & Platt, 2000). Bishop and Verleger (2013) define the inverted classroom as the combination of, “interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom.” Their purpose was to narrow the audience associated with the inverted model and provide a detailed definition, as they claimed the broader one seems to undermine its relationship to historical models and theories. Nonetheless, for the purposes of this thesis I accept the first one.

The inverted classroom has several advantages. For example, students can absorb the new course content at their own pace, encountering it whenever and in whatever context is best for them. Instructors use an existing system, usually their content management systems (CMS), to house video lectures, PowerPoint presentations, documents, and other course-related materials. Students can repeat materials as needed for clarification and review, in contrast to an in-class lecture where time constraints dictate how much time an instructor has to explain concepts. Moreover, homework within the classroom means that instructors are immediately available to students for questions and help. Many have argued that students need time in the classroom to attack homework problems with the presence of an instructor, instead of sitting quietly and
listening to lectures without hands-on activities (Gannod, Burge, & Helmick, 2008). The instructor becomes less authoritative and becomes more approachable as a facilitator while students are held responsible for their learning. For first time instructors, this concept may be hard to grapple with, as they must learn to coach and become a guide.

The inverted classroom is also extremely flexible, in that it can be molded to fit the needs of instructors and students (Findlay-Thompson & Mombourquette, 2014). Instructors can pick and choose even within a semester which lessons can be best accomplished with a more rigid or loose variation of the structure. Past research has indicated that science, technology, engineering, and mathematics (STEM) courses are typically ones that apply this approach in their classrooms (Gannod, Burge, Helmick, 2008). This most likely is because STEM content is practical, with a significant emphasis on problem solving; students are often taught a systematic way of arriving at a solution and expected to practice it many times on problems that vary in topics, structure and complexity. STEM courses also feature heavy technical content and long-term projects that may benefit from the inverted format that provides time across multiple class meetings to work on more complex projects (Gannod, Burge, Helmick, 2008). The more abstract and symbolic content of many humanities and liberal arts courses tends to be subjective and may need a more interactive format for delivery itself.

To some extent, the concept of the inverted classroom has existed for decades. However, one of the first ‘coined’ implementations of the inverted classroom was by Lage and Platt (2000) at the beginning of the new millennium. It is critical to recollect the status of the internet and information technology at the time of their course design. In an economics undergraduate business class, they built a simulated website that mimicked a student’s real world, though it was meant to mirror traditional classroom activities (Lage & Platt, 2000). Their purpose was to create this virtual environment to boost classroom activity and participation, but more importantly, improve critical thinking skills and cater to different learning styles. For example, students may
be visual or auditory learners, so they believed the freedom provided by the inverted classroom was part of the solution to this problem.

Despite the fact that instructors are clearly an important set of stakeholders in the application and success of inverted classrooms, there are also other interested parties such as instructional designers, curriculum developers, system developers, education administrators and even policy makers. The outcomes observed for instructors and students in inverted classrooms are mixed, though most practitioners have reported positive results. For example, researchers have compared traditional-lecture style classrooms with inverted style classrooms quantitatively and qualitatively by collecting student feedback through observations, interviews, surveys, and log data. Instructional designers have reported ways of modifying content for discipline-specific courses (Warter-Perez & Dong, 2012). Lastly, Mason (2013) compared the student performance between an introductory level and upper level course of inverted classrooms of similar content courses. Research indicates that most students are open to alternative teaching methods, and although they are used to the traditional-lecture routine, they will take some time to adjust (Peña & Rosson, 2014). Many students like the autonomous nature of the inverted classroom but others find it hard to remain motivated when tackling content outside of the classroom (Zappe, Leicht, Messner, Litzinger, & Lee, 2009).

**Constructivism**

To understand the inverted model, one must begin with its underlying constructs. The vision of the inverted classroom is founded on active learning practices that shift the student and teacher relationship. As described earlier, the staple of traditional lecture classrooms is the teacher-centered approach, where a primary goal is content delivery. In contrast, an active learning view would move the student away from passive behaviors in the classroom, with
instructors creating opportunities for hands-on activities that take place in engaging and collaborative environments (Bishop & Verleger, 2013). In addition, the inverted classroom is closely associated with problem-based learning which at its core is concerned with developing problem solving skills, self-directed learning, and effective and flexible knowledge. Both of these teaching approaches stem from the over-arching framework of constructivist learning. It is important to note that there are several viewpoints of constructivism; I this review I rely on Vygotsky and Piaget’s perspectives (Vygotsky, 1980; Grabinger & Dunlap, 1995).

Constructivism defines learning as an active process (Cunningham & Duffy, 1996). The learner processes and elaborates new information, transforming it into knowledge and that includes the building of associations between prior knowledge and newly constructed knowledge (Phillips, 1995). In this view, knowledge construction is a continuous process impacted by the human experience; as a result, direct “instruction” may or may not have an effect on learners’ mental representation of their knowledge. The way one acquires knowledge dictates how it can be used later on. In constructivist learning, knowledge is context-dependent; in other words, one recognizes that knowledge can be applied when in particular situations. What is most intriguing about the inverted classroom paradigm is that it assimilates advanced technology practices that are positioned together with active learning approaches.

The purest example of constructivism is the unambiguous engagement and participation of students in the classroom (Steffe & Gale, 1995). Not only will they have acknowledged and recognized stimuli, but they have moved forward in an active search to make sense of things (Steffe & Gale, 1995). Similarly, instructors must nurture this type of environment, where students are able to construct and interpret pieces of knowledge. At its core, constructivism is theoretical in nature and should not dictate specific teaching practices (Fosnot, 2013). It is not meant to describe how to teach in the classroom. Rather, it proffers ideas that describe how one experiences evolution and development through learning.
Fosnot (2013) offers principles for what it means to apply constructivism directly to education. First, the classroom should encourage dialogue while developing a community of learners that engage in discussion by inspiring others to do the same. Second, reflection and generalization should be encouraged, so that learners can think critically about the knowledge they have obtained while revisiting the concept from different viewpoints. Third, contradictions and errors should not be ignored; rather, they should be recognized and examined carefully to reach a more thorough understanding of a difficult concept. I take note of these principles of constructivist learning, but do not see any of them as required or mandatory. As an elaboration, I also suggest that the constructivist perspective implies that instructors should be reflective about their own experiences in preparing for and delivering their teaching activities.

Though constructivism is well known in education and often lauded by education experts, not all are in agreement. For example, Kirschner, Sweller, and Clark (2010) complain that there is no scientific evidence that presenting learners with any form of information will augment their ability to construct knowledge. They note that education researchers studying constructivism regard observation as proof and dispute its sufficiency in drawing generalizable conclusions. Learners should be carefully guided through new information when they first encounter it (Kirschner, Sweller, & Clark, 2010). They found that instructors who organized their classes using a minimalist guided constructivist approach ultimately changed their approach towards the end of class. Instructors became frustrated with student learning and felt they needed to provide more guidance to facilitate learning. Additionally, Matthews (1992) argues that the knowledge construction depicted in constructivism tends to ignore cognitive, social, and cultural dimensions of context and to consider learners as individuals. He also questions the usefulness of allowing students to “make sense” of information that is patently untrue; he worries about the eventual outcomes of teaching content that is known to be false but is taken seriously so as to contribute to knowledge construction (Matthews, 1992).
These criticisms of constructivism have merit, but at the same time suggest another question, namely how should constructivism be implemented? To what extent will its success be context-specific (e.g., depending on the education domain, instructor, student backgrounds and so on)? For instance, compare a course in art history with a mathematics course. The art history course provides information on past artists and their work in a cumulative fashion, and usually relies on interpretive discussions based on the meanings of their work. The course relies on students’ interest in the subject matter and making sense of this information. In this case, it is might be easy to conclude that knowledge construction and new mental models are being developed. In contrast, a mathematics course requires a student to learn a variety of formulas and techniques to arrive at the solution of an equation. Students must follow a clear-cut approach that follows rules with no allowance for interpretation in reaching an answer. In this case, knowledge construction might be promoted through a mix of successes or failures when solving interesting problems. Often a new idea (one solution) must then be applied elsewhere to make sense of a bigger picture. Both cases can exhibit constructivist tendencies, but the instructor must set the objectives and tone of these courses appropriately to achieve the desired constructivist outcomes.

**Challenges with Inverted Classroom Practices**

The problem at hand is to alleviate the stresses of an instructor’s environment and provide more support to access, learn and troubleshoot these technologies while enabling the expansion and creation of usable artifacts. Past research has suggested that inverted classroom instructors, who may not possess software development skills, can still have the power to repurpose and create tools suitable for their needs. I will first describe the current situation—by listing factors that affect technology usage or lack thereof and discuss features of inverted classroom instructors’ tasks that may influence how they decide to do their work.
An interview study by Wiedenbeck (2005) offers detailed explanations about specific technology choices that are made by instructors and what ultimately contributes to their successes or failures in the classroom. To start, instructors rely heavily on their own knowledge and their current ability to apply it; this knowledge base includes their teaching or pedagogical experience (Wiedenbeck, 2005). This is central to their choice of technology and how they choose to build applications for their students. Although the instructor interviewees reported feeling confidence with instructional design activities like lessons and learning outcomes, they found it difficult to translate that knowledge into technical requirements relating to tool selection and use. Faced with short time periods for creating technologies and applications for class, instructors found that developing and expanding an artifact often took too long. When exploring websites, books, and tutorials, they felt the material was too dry and dull to follow. These are general situational factors that affect how instructors work with technology to perform their course tasks, and one would expect similar issues in developing materials for inverted teaching.

There are several tasks that are unique to the inverted classroom structure, in the general areas of content creation and content delivery. Content creation tasks equate to developing actual course materials, digital or tangible whereas content delivery tasks are to distribute the aforementioned materials. For example, online video lectures are integral to delivering an inverted classroom; these materials are often created to replace the face-to-face lecture style in a traditional classroom. Because inverted classroom instructors expect that much of their courses’ will be consumed outside of class, creation of online video lectures has become routine. Other resources like podcasts and supporting documents are common as well.

During class itself, the time saved from offline lectures can be transformed into group activities, homework help, long discussions, or one-on-one tutoring sessions. Here, technology is applied to boost the interactive classroom experience to either enhance collaboration among teams of students, enrich forums or group chats, aid in peer assessment, critical thinking, and
problem solving. Instructors, instructional designers, IT support staff, and administrative colleagues must understand the needs of the inverted classroom and hybrid learning environments as a whole to be able to provide adequate assistance.

Not only are these tasks important to the inverted classroom, they share similar characteristics with other hybrid and blended learning environments. For instance, the MOOC paradigm (Massive Online Open Courses) is rapidly expanding in adoption as the technologies and populations for online distance education become more pervasive. Partly because the scale of a MOOC is so large, such courses continue to encounter issues with retention, engagement, and technical problems (Zheng, Shih, Rosson, & Carroll, 2015). One major difference between MOOCs and the inverted classroom is flexibility; an inverted class might incorporate a mixture of online and face-to-face interaction. In regards to technology, MOOCs wholly rely on their platforms like Udacity, edX, and Coursera which are comparable to content management systems.

Some MOOC instructors are starting to act as end-user developers (EUD) within the platforms they use, trying to support student interactions that are not as structured or routine as in a regular university-sponsored course. Other instructors have begun to try out MOOC platforms in support of their inverted classroom teaching, finding that the features offered by MOOC platforms are a good fit for their courses (Martin, 2012). There are also independent systems like Khan Academy, an enormous repository of lecture and tutorial videos on STEM topics. Inverted classroom instructors might use Khan Academy to host and create video lectures, or use existing material, but they would likely still struggle with issues of integration.

Even though the current practice is to integrate existing technologies in preparing for any kind of teaching, my sense from informal interactions with inverted classroom instructors is that such integration is a struggle, both with respect to finding and using the multiple technologies, and with respect to delivering different kinds of content and learning experiences in a coherent
and cohesive way within a classroom. Why not build one system that can address a variety of features? Or at least provide one basic platform system that expects and easily integrates with a mix of outside tools? I believe that I can make teaching tasks more efficient by better anticipating the needs of inverted classroom teachers, and by removing the extra time they spend finding, downloading, learning and integrating new technologies.

**Educational Technology**

Januszewski and Molenda (2013) define educational technology as “The study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources” (p.1). Educational technologies are tools and multimedia that assist in the communication and exchange of information that is transformed into knowledge. One of the first “technologies” designed in support of education was in fact not digital in nature; it was the chalkboard. For centuries, the chalkboard stood as the tool that effectively stored information taught by teachers during the day, though, at some point it had to be erased (Molenda, 2008). Ironically, many chalkboards remain in the classroom even if they are not used; however, smart boards and other digital displays have transformed the basic concept of the chalkboard. As computers started to become available in the 1960s, educators began to envision the use of computing in many novel contexts (Molenda, 2008). After the creation of word processors, spreadsheets, and other visual tools, the personal computer movement evolved. By the 1980s, schools and universities installed machines for students to perform course tasks like taking notes, writing essays, and programming. Also, computer training became available to teachers, librarians, and other staff. Little by little, Americans started to buy machines to accomplish their professional goals and their personal goals. Shortly thereafter, in the 1990s, the World Wide Web was born and computer use was never the same again (Molenda, 2008).
In general, the addition of technology to the classroom has many benefits. For instance, digital materials can be easily replicated online, removing the need for tangible paper documents that must be printed and transported. Some instructors do not have the luxury of free printing. In addition, the sharing of physical materials may be less effective because students will have a limited ability to interact with the content. Technology can make for easy and accessible distribution of course materials, which in turn allows students to work at their own pace. Last but not least, external online resources from all over the world are available to students, whether they are collaborating on a project problem in the classroom or from home, instructors can point students to those appropriate resources to help them along. This does not mean have the technology explicitly replace the instructor, but rather, assist the instructor to help the student.

To better assist instructors with an integrated system, one must first understand the current technologies and applications research landscape. In specific, one must analyze the existing tools in this problem space by dissecting their quality features as well as their shortcomings. In Table 1, I have compiled a list of tools that is representative of those reported in the inverted classroom literature. Each tool is listed and then particularized on a surface level. Some tools are tangible technologies while others may be computer software. Some tools are uniquely appropriate for particular course tasks within the inverted classroom; for instance, online video lectures are a staple in the inverted classroom. In other cases, the list includes external tools that instructors have repurposed for their own needs. Now, I provide an in depth overview of the technologies in tools used by instructors to support their inverted classroom tasks in the advent of content creation and content delivery.
Table 1. Existing Tools for the Inverted Classroom Space

<table>
<thead>
<tr>
<th>Tool/Tech/App</th>
<th>Course Task Purpose</th>
<th>Quality Features</th>
<th>Shortcomings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Podcasting (iTunesU)</td>
<td>Content creation; creating and editing audio files for lessons</td>
<td>Audio editing, Online Delivery, Mobile Accessible</td>
<td>Application Dependent (if using iTunes, must download Apple Software, etc.)</td>
</tr>
<tr>
<td>YouTube; Khan Academy (Video repositories and resources for tutorials)</td>
<td>Content creation and content delivery; creating and editing videos on the platform as well as housing them</td>
<td>Video editing, Online Delivery, Mobile Accessible, Social network compatible</td>
<td>Too widely available, may not be suitable if instructor wants classroom privacy</td>
</tr>
<tr>
<td>Content Management Systems (Moodle, Canvas, Blackboard, ANGEL)</td>
<td>Content creation and content delivery; may accomplish a variety of tasks</td>
<td>Discussion boards, forums, online quizzes, downloading and uploading files, administrative tasks</td>
<td>University-dependent; some may or may not have these systems in place; if they do diverse features and functionality may not always work</td>
</tr>
<tr>
<td>Social Networks (Facebook, Twitter)</td>
<td>Content delivery; groups and communities, formal and informal communication</td>
<td>Mobile Accessible, Sense of community, IM chat, Convenience</td>
<td>Not everyone may have an account and there are learnability issues; may not feel authentic</td>
</tr>
<tr>
<td>Web Design (HTML, CSS, JavaScript, Drupal, Wordpress)</td>
<td>Content delivery; hosting content on personal webpage</td>
<td>Mobile Accessible, Freedom to change and edit personal webpage</td>
<td>Learnability issues if tackled for the first time; expert users may find difficulties in integrating their site based on a number of dependencies</td>
</tr>
<tr>
<td>Piazza, Stack Overflow, etc.</td>
<td>Content creation and having peer/expert community answers to questions</td>
<td>Question and answer (Q &amp; A) system and wiki-style learning, Mobile Accessible, Sense of Community, argumentation and structured critical thinking model of learning</td>
<td>Organization and structure of systems, irrelevant messages and posts, troubleshooting glitches</td>
</tr>
<tr>
<td>Massive Open Online Course Systems (MOOCs) [Coursera, Udacity, edX, etc.]</td>
<td>Content Delivery; Hosting materials and resources</td>
<td>Large scalability factor, similar features to CMS’es</td>
<td>Lacking sense of community, everything virtual, technical issues are much more severe and widespread, may be considered restrictive</td>
</tr>
<tr>
<td>Prezi, PowerPoint, Scribd, Google Presentation</td>
<td>Content Delivery; Communicating and hosting lessons or textual/images</td>
<td>Local or Web access, variety of presentation aesthetics, collaborative potential</td>
<td>May be difficult to integrate elsewhere, may not properly be compatible to CMS or translate elsewhere (fonts, add-ons)</td>
</tr>
</tbody>
</table>
Technology is an important part of the inverted classroom because it helps in organizing materials, generating new materials, delivering and communicating about materials, and the construction of activities and lessons (Bishop & Verleger, 2013). The supporting technologies fall into two general categories: technologies made for educational purposes or technologies made initially for other contexts that have been repurposed and/or modified for educational purposes. For example, universities and schools often provide instructors with a course management system (CMS) or some analogous toolset that provides administrative and instructional support to produce and host materials online. Some examples of these are Blackboard and Moodle. However, if an institution does not provide such resources, instructors always have the option to look elsewhere for free or reasonably priced alternatives (Peña, Shih & Rosson, 2015).

Developing course content usually consists of audio and video editing, file creation and management, system management, and specifications for how students are expected to interact with course materials. Lockwood and Esselstein (2013) investigated the technologies instructors have used to design and implement their inverted class environments. They were particularly interested in the learning curve associated with video production, because video lectures have been such a key element of most inverted classroom efforts (Lockwood & Esselstein 2013). Some instructors have created online videos by enlisting outside software support from Camtasia Relay and Jing through tablets (Lockwood & Esselstein, 2013). Zappe et al (2009) listed tools that have lessened preparation time for instructors like Adobe Captivate and CamStudio. Other instructors like Gannod et al (2008) have experimented with audio techniques and outputs for their lectures. Still others have been exploring podcasting—another versatile tool readily available to students who are already familiar with music libraries like iTunes.

Regardless of the tools selected, the costs of integrating technology into one’s teaching practices can be significant. For example, Campbell et al (2014) reported spending six hundred hours preparing video lectures for their inverted classroom course; they recorded seventy-five
videos, each lasting up to ten minutes for presentation via Coursera (a massive open online course (MOOC) platform). This is a prime example of instructors exploring technologies they are unfamiliar with to achieve a course task, in this case, content creation. Another set of instructors (Lage & Platt, 2000) constructed a website that acted as a simulation of a real world environment by including places students would most like need for academic purposes; a desk, library, classroom, and coffee shop. McLaughlin et al., (2014) used Echo360 screen capture software to record lectures and cater to students’ erratic schedules. Strayer (2012) used an intelligent tutoring system to ensure that students were interacting with content outside of the classroom and exhibiting comprehension skills. Bates and Galloway (2012) introduced the use of clickers in their classroom to facilitate peer instruction. Walter-Perez and Dong (2012) elected to use tablets with DyKnow classroom management software along with Yahoo groups to implant materials for their course. Haden et al., (2009) created weekly modules by using Camtasia Studio and tablets which were edited into Flash videos; afterwards, they were hosted on a website. Houston and Lin (2012) sought to learn HTML in order to design their custom website that supported video content. All of these efforts involved the learning and application of new technologies, often as a separate activity managed by the instructors on their own (although some resources such as Lynda.com do offer online instructional videos for professionals).

Another type of technology that has promise for education is social networking tools. For example, tools such as Yammer, Facebook, and Twitter have been used in the classroom to reinforce groups, communities, course projects, participation, and collaboration. Research has shown that social networking sites can have positive outcomes to improve sense of community but must be carefully organized in order to gain those effects (Hung & Yuen, 2010). Moreover, Piazza, a question and answer service (Q&A) especially created for an educational purpose has become quite popular in the classroom. It offers a combination of forum and wiki features in one platform. Piazza focuses on collaboration and rich discussions that can occur in and outside of the
classroom. Students can become experts in topics when they answer questions from their peers and instructors can equally contribute. Research on Piazza has shown that it can be repurposed to support debate-like discussion structures and critical thinking elicitation (Wu, Shih, & Carroll, 2014). In sum, researchers have explored many different technologies and approaches to support educational objectives. Importantly, instructors are often willing to learn about and integrate external technologies to support their teaching goals, even when the learning and extra effort required is significant. One must note instructors for their creative efforts and view this as essential descriptions of current practices of technology usage in the inverted literature.

The duality behind the inverted classroom calls for a combination of hands-on activities that take place in the class (and may or may not be supported by digital technologies), plus some form of technology that is used to support and present content (or “lessons”) outside of the classroom. Thus even if the classroom experience is very discussion-oriented, or relies on paper and pencil techniques, the instructor will need to make a significant technology investment when planning and delivering materials outside of class. Because these technology-supported tasks are so critical to success in the inverted classroom, and because such tasks currently take so much time, I argue for increased attention to the tools that are available for instructors working within the inverted paradigm. A particularly useful approach to this may come from teacher preparation literature, where the instructor is viewed as the developer of digital resources for teaching.

**Instructor Preparation**

The first portion of my thesis research focuses on the discovery and reporting of instructor’s perspectives surrounding inverted course preparation, technology implementation, and the processes behind these tasks. Unfortunately, most of the literature regarding the inverted classroom has been attended to the successes (or failures) of the approach from the student
perspective, for example by operationalizing success as numerical learning outcomes or retention metrics. In fact in general, most literature in education concentrates on the success of various teaching approaches by analyzing and evaluating student satisfaction. In contrast, my goal is to better understand how instructors experience their professional activities in the process of encountering and adopting new practices (in my case, the practice of inverted teaching).

Clark (1988) provides an overview of research on the cognitive activities of teachers who are preparing and delivering instruction. Clark states that research on the professional development and planning surrounding teacher activities in the classroom was once disregarded, and that many viewed this activity as irrelevant (Clark, 1988). However, as more research began to surface, researchers in the field of education and teacher education began to acknowledge this as an important topic. Clark believes that the activities associated with classroom teaching have become more time consuming, intense, and complex than ever, and that those interested in educational research must understand and appreciate the dedication teachers put forth in their teaching.

Clark summarizes a body research on how teachers think about their tasks and highlights one aspect of their thinking that he terms “dilemma and uncertainty”. This aspect of teaching cognition emphasizes the fact that teachers never know what to expect during their day-to-day classes nor in the long-term even though they spend considerable time planning (Clark, 1988). If they teach a given class over and over, they form perceptions of incoming students’ behaviors (Clark, 1988) and they use these in their planning. But any preparation they do is plagued by decision-making processes must take place during the actual interactive teaching sessions. Teachers must spend energy trying to anticipate student questions and reactions as they go, and their well-intended planning is often wasted due to spontaneous events.

I see an impact of this aspect of teacher cognition in activities that take place in a technology-rich environment (i.e., as is common for inverted teaching). Inverted classroom
instructors are likely to experience a similar cost of uncertainty as they are transitioning from traditional to non-traditional teaching approaches and experimenting with technology. Regardless of how much time is spent preparing, there will be technical errors, dissatisfied students, and other things that may go wrong in attempting new classroom procedures.

In an effort to support teachers who want to learn and adopt new technologies, Rosson, Dunlap, Isenhour, and Carroll (2007) developed and studied an online teacher community called Teacher Bridge. This community system offers a suite of tools that aims to help middle and high school teachers build activities and enhance their professional development (Rosson et al., 2007). These researchers used scenario-based design methods to guide several rounds of prototyping and usage scenarios. They also conducted interviews and a baseline survey as a way to develop deeper understanding of instructor’s activity building, technology use, and knowledge and resource sharing (Rosson et al., 2007). They reported descriptive statistics regarding these practices: 63% used computers weekly to find teaching resources, 90% agree or strongly agree that education can be improved by collaboration, and finally, 30% agree that they are satisfied with current teaching practices. These findings characterize teachers as professionals who believe that more collaboration will aid their teaching practices and that technology plays a routine role in gathering resources for course activities. Although Teacher Bridge was not designed for university teaching, the findings from that teacher support project offers some justification for building a shared system to supported inverted classroom instructors.
Chapter 3
Research Methodology

Rationale and Epistemology

My research adopts an interpretive epistemology, pursued through qualitative study and interaction design. Qualitative research allows us to examine phenomena by observation of social and cultural contexts where people exist (Creswell & Miller, 2000; Mason, 2002). It boasts richness, description and holistic accounts of experiences (Mason, 2002). Interpretive research assumes that our access to reality and our knowledge surrounding it is socially constructed (Mason, 2002). As my research is aimed at open-minded discovery of a phenomenon, there is neither hypothesis testing nor any set of predictions. My intent is to explore the phenomenon of inverted teaching and uncover current practices, experiences, and suggestions for design.

Fig. 1 shows the research overview taken in this thesis. It follows an iterative structure and displays the theoretical and methodological work that has guided my research on the right, while the feedback paths within the process are shown to the left.
A common thread drawn from my literature review is that instructors use a wide variety of individual pieces of technology to support the inverted classroom. As this method of teaching continues to rise in classrooms nationwide, attention must be given to supporting instructors in their implementation endeavours. How do I make this easier and less time consuming? Because the technological aspect plays an important role in almost every component of the inverted model, one would have imagined more literature addressing the lack of a custom tool that provides comprehensive support for the inverted approach; in fact, Choi (2013) notes that effective multimedia solutions for the inverted classroom have not yet been discussed nor measured. As a result, our motivation lies in the need for a tool approach that encompasses the many necessary components that support an inverted classroom. This leads to the following overarching exploratory research question:
RQ: What are the design features of a tool that best support the inverted classroom environment structure?

To address this question, I have followed a two-phased process. First, I conducted a qualitative study of the current practices of inverted classroom teaching using the lens of Activity Theory (Engestrom, 2001). Activity Theory is a descriptive tool for a system that characterizes level of hierarchical system activities and people as socio-culturally embedded actors (Vygotsky, 1980). Second, I used the findings from my first study to guide a process of scenario-based design and evaluation (Carroll, 2000; Carroll, 1995), with findings from a second round of interviews to gather feedback on my initial design ideas that will enable future work on building a concrete system. Scenario-based design is intended to envision future system use while system operations are put on the backburner and human-centred tasks and activities become a major focus.

Activity Theory

I adopted Activity Theory as my theoretical framework. As noted by Hashim and Jones (2007), Activity Theory has been used in a variety of fields like psychology, information systems, and management, and importantly for my work, in education and HCI. Researchers have realized the benefits of using this rich theoretical framework to observe actions and better understand relationships between technology and people (Hashim & Jones, 2007). For instance in education, researchers have used Activity Theory to guide an optimum design of tools to support computer-supported collaborative learning (Hasim & Jones, 2007). As Hashim and Jones (2007) suggest, “Activity Theory is geared towards a practice which embodies a qualitative approach that offers a different lens for analysing processes and the outcomes.” (p. 172).

Activity Theory is a conceptual framework with multi-faceted constructs and hierarchical levels. Previously, three versions of the framework have been presented and discussed starting
with Vygotsky (Vygotsky, 1980), Leont’ev (Engestrom, 2001), and finally Engestrom’s most expansive formulation (Engestrom, 2001). This most recent framework seeks to comprehend the actions involved in the outcome of an activity, as well as the socio-technical context in which the activity is embedded (Engestrom, 2001). Importantly for our research question, Activity Theory focuses on the ways in which technology mediates efforts to achieve the outcome of an activity. It provides us with descriptions of activities within activities and how changes interrupt other components that then shift all the others (Hasim & Jones, 2007). And it allows us to talk about the artifact that has emerged to support a specific practice and how practice developed over time may change the use of that artifact. Under the lens of Activity Theory, human actions are decomposed into their constituent operations, and human behaviours are analysed according to the communities, rules, division of labour, objects, subjects, and instruments that have emerged to support the activity (Engestrom, 2001).

The aforementioned activity components are known as units of analysis. Instruments (also known as mediating artifacts), may be realized as tools or other types of technologies (e.g., a paper form) that have emerged to support humans who are working towards an outcome. Subjects are actors; they represent the people in the activities that are immersed in the processes. Rules are sets of conditions that aid in our determination of how individuals act. Community represents the surrounding group of people or activities. Division of labour can be understood as roles; this represents the distribution of actions across a community of workers. An object is acted on by the subject and motivates the activity, e.g. acting as a goal. In my study I will focus particularly on the instruments unit, where technology support and tool usage is most likely to be discussed.

Fig. 2 demonstrates the teaching activity components arranged in the activity triangle discussed by Engestrom (2001), annotated with constructs from the inverted classroom teaching model. The outcome of the activity can be seen as successful learning by students enrolled in an inverted classroom course. The instrument represents the tools instructors are choosing to mediate
that effort, such as how it is being supported; these tools may also include non-technical items like syllabi, assignments, and Word documents. The subject is the instructor him or herself. The rules are syllabi, teaching policies, or supporting documents that govern the teaching activity, for example outlining activities, deadlines, and behaviour. Some of these rules will be specific to a teacher and course; others will be “inherited” from the larger teaching community of a department, university or even academia in general. The community comprises the supporting faculty and staff who operate with or around the instructor, as well the students in the classroom. Both groups have an effect on the learning outcome, as well as an effect on the mediating artifacts. The division of labour depends on the size of the course, but roles for instructors in this structure include serving as facilitator and coach as well as TAs or LAs who help the instructor with sub-activities such as content delivery and assessment, and students who complete the work given in the role of learner. Finally, the object is the combination of tools and pedagogical strategy – the inverted classroom – that are used to obtain the final outcome of the activity, which is successful student learning.

Figure 2. Activity System for the Inverted Classroom.
The hierarchical system of the Activity Theory framework encompasses varying levels of activity – operation, action, and activity, where operation is a granular micro-level view, and activity is the whole macro-level perspective (Jonassen & Rohrer-Murphy, 1999). Within these varying levels of activities, there exist sub-levels of contradiction. Contradictions are “historically accumulating structural tensions within and between activity systems (Engestrom, 2001)” (p. 137). Through use and change over time, units shift and create tensions between units; such a tension is referred to as a contradiction (Engestrom, 2001).

Sources of contradiction in the inverted teaching context may uncover details about technology usage support that may be advancing activity goals and other ways in which it seems to be interfering. In Fig. 2 these potential interactions can be seen in the lines in between units of analysis. For the purposes of my first study, this detailed level of investigation is unnecessary; instead I relied on a basic application of Activity Theory, focusing on the central constructs and how they operate in an inverted classroom teaching activity. Normally, investigating deeper and more grounded research problems necessitate this level of analytical perspective and thought. However, our research question is strictly a preliminary venture into unknown territory, so the intricate hierarchical structure of activity levels was not necessary for analysis.

Scenario-based Design

Scenario-based design (SBD) is a set of techniques designed to envision the future use of a system early in the design process (Carroll, 2000; Carroll, 1995; Rosson & Carroll, 2009). This approach (shown in Figure 3) allows for rapid communication and feedback using the simple vehicle of scenario creation and analysis. Designers always look for efficient and effective ways to quickly gain suggestions about usage possibilities from their user base to refine their
prototypes (Rosson & Carroll, 2009). Scenarios are an interesting way of quickly presenting problems and capturing human activities and particular actions that correspond to technical functions (Carroll, 2000). Scenarios represent the usage context within which a system is intended to operate; a scenario consists of settings, actors, tasks, and goals (Carroll, 2000).

Because system designers normally write design scenarios, other parties should be engaged to raise concerns, address questions, and introduce any missing ideas (Carroll, 2000). One must always remember that design scenarios and prototypes are fluid, in other words, they are never fixed, but rather change as the actors and goals change. However, designers should iteratively gather as much feedback as they can to make informed decisions about the visual aesthetics and functional aspects of the system (Carroll, 2000).

Scenarios are advantageous for the reasons described above; however, they have some downfalls. For example, designers can become tempted to consider many design possibilities after every iteration, and sometimes it is difficult to arrive at a final solution, regardless, one must do this.
Figure 3. The Scenario-based Design Framework.

However, it is important to note that I have undertaken certain parts of the scenario-based design framework, not the entire process. Figure 4 shows a revised SBD process where pieces of the framework have been adjusted to fit my needs and goals. Due to the qualitative and exploratory nature of this research, I did not iterate through each SBD component in detail which is why I decided to construct my own mini-framework that still incorporated parts of SBD.
I have adopted SBD to guide an iterative design process that will encompass various prototype creations and revisions based on formative evaluation. Problem scenarios depict issues in the *current world* of the user, for instance, as Mike follows through a simple functionality task he finds that one feature is absent or that he cannot accomplish his task properly which indicates a deficiency with the current application or technology (Rosson & Carroll, 2009). In my case, problem scenarios (see an example Table 2; others are shown in Appendix E) address a problematic narrative that instructors encounter while attempting to implement features into their innovative teaching practices. Each problem scenario is meant to describe an imagined narrative that follows a sequential set of events in an instructor’s implementation process while highlighting specific opportunities for one or more new design features. These problem scenarios
were constructed after the interviews with inverted classroom designers in my first study; thus they represent a synthesis of issues raised in that investigation and became a starting point for my design thinking.

Table 2. Problem Scenario Narrative for Video Task.

<table>
<thead>
<tr>
<th>Problem Scenario 1 - Video</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane is organizing her business analytics course which begins in the next few weeks. Jane recently attended a university-wide workshop and noticed an emerging trend of new teaching approaches and technologies being used in the classroom. Due to the success of other instructors, she has elected to use the inverted classroom structure as her teaching approach this semester. As there are lots of modules of content in this specific course, Jane is looking to upload video lectures of the core concepts in the course. Jane is extremely frustrated in that her current course management system does not provide editing tools to support her content creation endeavors. She believes that her university-based resource should provide this or should be able to integrate this feature into their system. As she is under a tight timeline, Jane ventures online to find an external tool to help her record and create her videos. The high quality tool she desires, requires payment, so she makes a payment out of pocket to start the process immediately. Unfortunately, the tool is much more complex than she had originally thought, regardless, she still manages to complete 3 videos.</td>
</tr>
</tbody>
</table>

One key element of a scenario is the actor(s) who enact or are influenced by the activity that takes place. In SBD, these actors are also a synthesis of likely or actual people in the current world that is being analyzed and supported. These actors are described using personas, a character that captures user details that are thought to be important to the actor’s experience in any given scenario (Grudin & Pruitt, 2002).

An example persona appears in Figure 5 (a complete set is in Appendix F). Personas are a method of improving engagement with the participants in a design feedback session, while also extending the scenarios into caricatures of conversations (Grudin & Pruitt, 2002). They do not replace the use of scenarios or prototypes but rather enhance the design concept as a whole while complementing the other representations (Grudin & Pruitt, 2002). My personas were derived from the first study where participants represented three main types of instructor profiles that were highlighted by their experiences with the inverted classroom. Instructor profiles contain
fictional characteristics and attributes that are unique to their category representation. The three representative characters are:

- **The Newbie** - this profile presents a young and determined instructor who is passionate about new teaching approaches and technology implementation in the classroom, though are not as technology-oriented to do so.

- **The Skillful** – this profile represents a more established professor who has been experimenting with various teaching approaches and tools for quite a while. This profile exhibits strong technology skills which have been displayed through individual tool building for their own courses.

- **The Traditionalist** – this profile represents the instructor who is opposed to change or trying out new technologies and approaches in the classroom. Perhaps, a bad experience attempting a new tool or approach backfired and has discouraged them from experimenting with anything new.

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Figure 5. Persona for “The Newbie” Instructor Profile

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1 I recognize in hindsight that there is a correspondence between gender and lack of technology expertise. This relationship was unintentional.
After generating problem scenarios and personas, I created rough paper sketches that illustrate possible solutions to the issues raised by the problem scenarios. As Erickson (1995) proposes, working prototypes can be used as a design medium; such prototypes should be accessible or understandable but should also exhibit “roughness” so as not to preclude additional brainstorming and development. For instance, any member of a design team should feel free to modify an artifact and make their contributions. Roughness also creates ambiguity; this is important in evoking details or corrections to fill in what may be missing (Erickson, 1995). Later on in the design process, one can return to the working prototype and resolve ambiguity issues differently than once originally ideated (Erickson, 1995). Past research has indicated that roughness in prototypes as opposed to neatly drawn or computer-based prototypes, has led to satisfactory results in the final design (Black, 1990).

An example of a prototype sketch appears in Fig 6 (again, the full set of prototype sketches is in Appendix G). Instead of depicting the current world of the user, the paper prototype presents the new world or the new story for this persona. In this design view, Mike follows the same functional task that was documented in the problem scenario, but the experiences he has are based on the paper prototype that represents the new idea. This encourages the design participant (in my case, these were instructors) to discover subtle differences in system functionality given the new ideas; the roughness of the paper sketch emphasizes that they have considerable freedom in expressing opinions. In other words, they should feel encouraged to be critical. Each paper sketch corresponds to problems conveyed by the problems scenarios and refers to new ideas about how I might support inverted classroom teaching.
Figure 6. Paper Sketch for the Video and Cross-Compatibility Problem Scenario
In this chapter, I present the first phase of my thesis. In order to develop a tool that provides custom support for inverted classrooms, it is imperative to understand current practices in inverted classroom teaching. Also, it is important to understand the activities and components that constitute the inverted classroom paradigm. Theory-based qualitative methods were chosen to tackle the research question, complemented by an interpretive lens to aid in comprehension of the phenomenon.

Data Collection

I used semi-structured interviews as my investigatory method, because this type of data collection supports my goal of broadly exploring a phenomenon and investigating best practices in regards to technological support. This method allowed me to extract rich and descriptive experiences from instructors. In each interview I attempted to create an intimate setting for instructors to discuss specific details about their thoughts on the inverted classroom approach and thereby to extract design requirements for future support.

Participants were instructors recruited across the Pennsylvania State University main campus using a snowball sampling method: a few names were nominated by staff members who support course development projects, and each interviewee was asked to nominate others. The only criteria necessary for participants was to have applied this teaching method previously and to be located on the main campus. When participants received their recruitment email, they were asked to provide suggestions for other possible instructors who may have implemented the inverted approach previously.
After the recruiting period, I noticed that all of my volunteers were STEM-based instructors. This sampling was not intentional, but is consistent with others’ observation that inversion adapts well to common STEM learning activities like problem solving and critical thinking (Gannod, Burge, & Helmick, 2008). Overall, seven interviews were conducted and audio recorded while notes were taken concurrently; the sessions lasted from 60 and 120 minutes. Pseudonyms are used when discussing specific comments made by participants.

I began the interviews with questions about general background that allowed me to familiarize myself with each instructor; I followed these with questions regarding their general teaching experiences, and finally engaged them in a more focused discussion of their inverted classroom experiences, including their thoughts on the advantages and disadvantages of the inverted model as well as the types of technologies they used to support this structure. The questions were only loosely based on the units of Activity Theory; I did this because I needed to understand participants’ overall experiences, and I did not want to coerce those experiences into top-down categories offered by the theoretical framework.

**Data Analysis**

After conducting and manually transcribing the interviews, a first-round coding process was performed, guided by the Activity Theory framework (subject, mediating artifacts or tools, community and so on). As mentioned previously, for the purposes of this first investigation, only the general components of the framework were utilized. The analysis did not use the hierarchical decomposition of activities associated with Activity Theory, as this decomposition is complex in nature and requires a more specific research problem that warrants comparison of different levels of activity granularity. Because understanding technology usage in participants’ inverted classroom experience was important, special attention was paid to the *instrument* component of
the activity triangle, as this component represented the tools in the activity. This allowed me to conduct a more focused analysis and discovery of technological features and design principles that were important. A second round of coding was performed to analyse emergent themes not suggested by Activity Theory but those relevant to design. This round was specifically carried out to support consideration of new design features.

Findings

Instructors as Subjects

After skimming my notes taken during the interviews, I found that specific pieces of information on participants’ backgrounds were informative. All of these instructors were similar in several ways. They all had a STEM-related background, such as engineering and science, which relates to Gannod’s (Gannod, Burge, & Helmick, 2008) argument on the inverted structure matching particularly well with computing curricula that require considerable “hands-on” experience. Next, all but one instructor had accrued experience teaching online as well in both traditional and inverted classroom courses. Another interesting observation was that four instructors had received at least some formal training in education, for example through certificate training or an advanced degree.

These observations lead me to speculate that instructors such as these may be attracted to the opportunity for informal research through their teaching practices. Because the courses were in STEM areas, they likely had an increased need for students to practice hands-on problem solving. In this case they may be using inverted teaching methods to see how it meets their understanding or goals with respect to education theory and practices. Not surprisingly, from the perspective of flipped teaching adoption, there may be a tendency for instructors who are
teaching STEM subjects or who already have an orientation toward pedagogical experimentation to lead the way.

The ultimate goal with a snowball sampling was to aggregate a diverse group of participants. Participants did have quite a range of teaching histories, and worked in four different colleges at the university. However, the similarities noted here may have implications for the type of content the inverted model. One might be most likely to see in early adopters, and for the kinds of instructors who might lead the way with inversion pedagogies and tools.

The Surrounding Community

I found that instructors often gravitated towards the use of particular external tools through a recommendation from another instructor experiencing success. (Pseudonyms refer to individuals)

[Linda] I saw another instructor showcasing their work at an event and I saw all the cool things they were doing which influenced me to try it out.

[Harold] {Another colleague} has been really good to me.

The above statements reflect the role of community in one’s teaching practices, where instructors are influenced by a community of like-minded instructors to move toward a certain tool or approach to doing something differently. These observations underscore the importance of sharing or collaboration mechanisms in any technology infrastructure I intend to develop to support inverted teaching.

In another comment, Harold talked about an academic administrator in his department who has offered years of encouragement and support in his teaching approaches, in particular using the flipped method. This is important to note as it suggests that individuals at a more senior level than the average instructor, such as full professors, deans, committee chairs, or other senior
staff may have a direct or indirect effect on whether and how an instructor is encouraged or supported in their attempt to try a non-traditional approach. Although this comment may not influence tool design, it points to socio-organizational implications for how a college or department might initiate, recruit participation in, or provide incentives to instructors willing to experiment with inverted teaching.

**Inverted Classroom as Object**

Instructors spoke at great length about their experiences implementing the inverted classroom and their own thoughts on what constitutes this new approach to teaching. Most have had great experiences with inversion and they highlighted their students’ positive reactions, their course assessments as proof of effectiveness and success, and their thoughts on the benefits.

*Joe*] what I do was that I had students watch video lectures outside of class, and then they came into class just for lab help to do the assignments and then I walked around and helped them.

*Michelle*] It allows me to cater material to different people at different times. There is more room to cover technical content and meet the needs of students.

*Lisa*] ...application of ideas during course time, flexibility, and more time available.

*Tara*] ...the thing that I think is the sweet spot is to make the connection for the student. They are learning and they don’t even know they are learning, they are more engaged in the learning process.

*Nicole*] I definitely prefer flipped, I mean, the online, as you can imagine - very separated from the students, I don’t know what they look like, yeah... I don’t like it. Somehow with the flipped course they feel like I’m on their side.
At the same time, several instructors noted that the model does come with caveats, for instance, knowing when to implement this structure at the right time, letting students obtain learning autonomy, and constantly keeping the course in synch. Harold and others discussed different learning styles and approaches:

[Harold] I don’t believe there is any one size fits all solution, everyone is different.

[Tara] It’s harder in some ways because you have to be very creative about the application of it.

[Nicole] You do give up control when you’re flipping… I see myself as more of the guide on the side.

Two instructors reported negative experiences with differing results – one was eager to try again but the other was completely turned off by the model, leaving it alone for good. In the first case, Linda was able to tweak some aspects of her material and course structure to accommodate this approach. And with another try, she was able to get the effectiveness and success she desired. Linda views flipped as, “an extra opportunity to enhance face to face.” However, in her initial try she almost completely discarded the approach. She said,

[Linda] Yeah I almost got fired. I had students really angry, saying they didn’t learn anything. It was extremely frustrating.

In the second case, Joe, tried the inverted model only once and gave it up. Among my interviewees, Joe was the only instructor who no longer uses the approach. He simply believes it does not work:

[Joe] The concept works great if the student is participating and buying into it… it’s a perfectly valid concept, the problem is that students are not that self-directed.

[Joe] Automating a bad process just makes a bad process more efficient… the bad thing is if you didn’t sign up for that, “I didn’t ask to be indoctrinated into a certain way of thinking”.
In sum, the inverted classroom phenomenon is a pedagogy instructors are willing to try at least once. All of these instructors are looking for better ways to present what they see as “dry” technical content in an effective and efficient manner. It is encouraging to find that most instructors are open to new ideas and are extremely motivated to provide inspiring learning experiences for their students. Although the inverted model requires significant planning and development, and seems to work to the expectations of the majority of these instructors, caution must not be thrown into the wind, as there are still trade-offs with using this approach.

Technology and Tools as Instruments

Angel

Angel is the default content management system used at the university. As a result, Angel was used as a benchmark to discuss what is useful and functional in a tool and what is not. Instructors began to express their thoughts about the system, improvements, and incorporating features for a potential prototype. For the most part, Angel was described in a negative light, for example,

[Harold] I have already expressed my displeasure about the replacement of Angel, yeah but Angel sucks, yeah but I’ve already learned it, we are all gonna be lost. I know what it takes to break technology. I keep separate Excel workbooks, I don’t trust Angel.

[Tara] Angel sucks! There’s not that many other tools to use, I put a syllabus and readings and assignments and I use it because it’s within the system.

[Nicole] Yeah, Angel is totally, it’s dinosaur-ish, I have thought about using Yammer. I spend a lot of time in the summer with my kids, so if I’m sitting there and I got my phone
and someone pings me a question in Yammer I can answer it. I can’t do that through Angel, it’s not intuitive.

[Joe] I use Angel as mostly a communication tool, emails, and announcements. TAs and LAs assist with answering questions online.

Most of the instructors use Angel as just a communication tool and because it is convenient (it is coordinated with the university registrar, so class mailing lists and other student management services are provided automatically). Student email accounts are linked to other university-wide or college-wide systems so it is easier to use and less of a hassle.

**External Technology and Tools**

Moving away from Angel, instructors set out to find more interactive and innovative tools that could enhance their inverted classroom environment. These tools aided in various tasks across the implementation of the model such as note taking, content delivery, and assessment. For example, Linda and Michelle used Doceri, PDF annotator, Camtasia Studio and Google Calendar. Joe went a step further and created his own custom system for assessment and computer programming. Tara uses WordPress blogs, Prezi, Voice Thread, Twitter, Tumblr, and YouTube. Nicole uses a Wacom tablet to take notes and aid in video lecture creation. Lisa uses Yammer, Wordle, Google Docs, and Adobe Connect.

To summarize, most instructors did not have any specific recommendations of what features an environment for support of inverted classrooms should contain; they were simply quick to say, “Basically, not Angel.” They were equally as quick to describe the neat tools they had discovered. Again, the reasoning behind these extra and external tool choices lies in their greater functionality, convenience, flexibility, and ease of use.
Efficiency Factors with the Inverted Classroom

I also found factors that affect the efficiency of content creation and delivery specific to the inverted classroom. For example, cost of resources can be problematic for those without the financial or university-based support. Also, the process of creating technology and programming is not always intuitive; there are domain-specific vocabularies, standards, and formal logic involved in the building of different types of applications. Time constraints limit the ability to take on new responsibilities outside of class, borrowing from time that is normally reserved for personal and other professional duties. The type of course content is important because it is used as a blueprint to create applications that cater to students. Furthermore, current technologies at the disposal of instructors may have the potential to provide thorough performance and support but are lacking in upgraded features. CMS environments are a university-based resource, almost like a default system provided for instructors to accomplish multiple course tasks. I think that these large all-purpose systems may be constrained by political or financial factors; in other words, either they are resistant to needed changes or they are managed externally, removing control.

Summary and Implications for Design

Using the Activity Theory analysis as a springboard for my scenario-based approach proved to be worthwhile. As I broke down the components of the inverted classroom as an activity, I found factors that were unrecognized. On the surface, it was simple to uncover pedagogical and technological events or subparts that help create the activity as a whole. However, other factors such as community, instructor perspective, varying outcomes, and governed rules influenced major modifications to the activity triangle as well as the design process. Uncovering this led me to consider system design. I began to construct my scenarios,
 personas, and prototypes based on the formation of the triangle and I began to delineate the importance of the components and their translation into potential design features.
Chapter 5

Scenario-Based Evaluation of Technology for Inverted Teaching

In this chapter, I present the second phase of my thesis which is the design feedback sessions. The design ideas were built upon my first investigation. During the interviews of my first study, many instructors expressed a generally positive reaction towards this research and were interested in possible outcomes with respect to supporting technologies. Thus I decided to delve deeper into design ideas I had heard from some of these initial participants, along with other ideas that emerged as implications from their stories of practice. Thus I moved to a phase of design-based research investigation, considering specific opportunities for design of a system that could support teachers in their preparation for and delivery of inverted teaching. The intention was to formulate my ideas in a way that was concrete enough to elicit feedback but not so developed as to imply the design work had been completed. My goal was to extract hypothetical experiential information from instructors, and thereby to extend our activity system of the inverted classroom.

Data Collection

My design feedback sessions were conducted as one-on-one interviews, where I integrated a simple “talk through” of the prototype sketches with open-ended interview questions. That is, I took each interviewee through the new ideas, following the same task goals I had documented earlier in the problem scenarios, and asking for reactions along the way; I followed each such talk-through with several open-ended questions. Specifically, the questions I asked after each scenario talk-through included: What do you think about this scenario? What do you
think about this new story for this character? Do they depict real problems? (see Appendix C and D).

This combination of a prototype “demonstration” and interview allowed me to extract rich and descriptive reactions from my instructor interviewees; it also allowed me to enrich what they were saying with their facial expressions by using a combination of observations, notes, and audio recordings.

My participants were a mix of instructors from my first investigation as well as some newly recruited instructors from the Pennsylvania State University main campus. In total, there were four from my first study and six new instructors from this second phase. I returned to previous interviewees from my first study so as to create some consistency from that study with my current design ideas, but to also gather any new experiences or changes in their thinking. I recruited new participants so as to expand the experience base and gather new and fresh perspectives for my design choices. In this case I was interested in a broader set of instructors (i.e., who may or may not have taught in the inverted model); however I did screen participants to be certain that they were knowledgeable about the inverted model.

Participants received an email with a description of my design investigation and were asked to provide a preferred date for a face-to-face meeting. Overall, ten design sessions were conducted, with sessions lasting from 60 to 90 minutes. Each session was audio recorded and notes were taken concurrently. Pseudonyms are used when discussing specific comments made by participants.

Because this procedure is more involved than the initial interview study, Fig. 7 documents the step-by-step process I followed. I created two versions of my script, to accommodate the needs of previous as well as new participants (see Appendix C and D). I included questions about demographics, explanations about the scenario-based approach, and a brief introduction to the three pieces of design materials they were about to interact with (6
scenarios, 5 prototypes, and 3 personas). Next, the interviewees were presented with three personas and asked to read each profile, afterwards I asked them for their reactions to the profiles and whether the representations were plausible. Next, a scenario narrative was read aloud and any misunderstandings were discussed; afterwards, the participant was shown a paper sketch that reflected a “solution” for that problem scenario.

The direct comparison between the problem scenario and the possible solution became a source of intense discussion between me and the interviewee, and produced many alternative design ideas of interest. This portion proved to be invaluable. This comparison process was repeated for each scenario narrative and prototypes pairing until all were discussed. At the end, I asked participants a few final questions regarding the cohesiveness, relevancy, and consistency of the narratives and sketches as a unit. During the process, I ensured that participants felt comfortable sharing their thoughts and voicing their own suggestions, by giving them as much time as they needed to digest my materials.
Data Analysis

After transcribing the design sessions and sorting through observational notes, an open coding technique was used to categorize design ideas and expectations about inverted classroom teaching activities and experiences. I used a second round of coding to ensure that I had not misinterpreted the meanings of participants’ suggestions. The findings were organized by each of the three design representations ( personas, scenarios and prototypes).
Findings

Instructor Demographics

In my first study, I interviewed seven instructors who had varying levels of experience with the inverted classroom. In this second study, I recruited ten people who were a mix of previous and new participants. Similar to my first study, all of the instructors had a STEM-related background. All of the instructors had experience teaching a mix of traditional and flipped courses, while one had also taught online. The participants’ years of experience varied. For example, five of the instructors had less than five years of teaching experience, while the other half peaked at about 20 years. In terms of research duties, six of the instructors had research duties along with teaching, while four did not. Finally, all of the instructors were open to trying new technologies and were happy to participate in the design discussion and feedback.

Personas

Reactions toward the instructor profiles were positive. All of the participants believed that the profiles seemed authentic and believable. They thought it was plausible to actually encounter, and in some cases they have already encountered these instructor profiles in the real world. The two experienced instructor profiles provoked the most comments:

[Larry] It’s interesting that Dr. Jones and Dr. Schmo’s profiles look the same in terms of experience. But it is not about age, it’s more of the context and mind-set that determines how open they are to new teaching approaches and technology.

[Bill] They definitely seem believable; it’s kind of funny to see these fake profiles. But ironically, I do know someone that fits the description of Dr. Schmo. He is always building something for his class.
[Mary] These profiles seem believable but other characteristics should be taken into account such as what type of responsibilities the professor has like a lecturer versus a tenure-track professor. There are so many factors in between. A lecturer or an instructor without research duties has more time to dedicate to reaching out to students and focusing all of their time in their own courses. But with people like me, who are tenure-track we have to split our time between research and teaching and it becomes a trade-off. So maybe that should be included here.

[George] Yes. I’ve definitely encountered faculty who are much more prone to experimenting with new technologies such as the ‘newbie’ or the ‘skillful.’ I’d say that I fall into the ‘newbie’ category. The ‘traditionalists’ that I have encountered tend to take a wait-and-see approach because they don’t want to waste their time on adopting something prematurely.

[Kara] These are interesting to read, I love the attention to detail in their background and technological skills. I think it seems realistic to me.

The above statements stirred conversations about specificity within the characteristics and qualities the instructor profiles possess. It will be worthwhile to revisit the profiles and consider expanding them to consider other factors such as research versus teaching faculty roles. Larry has also reflected upon other characteristics of determination and ambition that may play a role in an instructor’s decision-making process when considering new teaching approaches and technology. It is not the experience that matters (even though it would be helpful) but rather the outlook one carries regarding teaching philosophy and desired course outcomes. George seems to identify with one of the instructor profiles and has definitely encountered those non-believers who would rather view the evidence instead of going on blind ambition.
Scenario and Prototype Reactions

Not surprisingly, the scenario narratives and paper prototypes garnered many constructive reactions, which I elaborate in the following paragraphs. Because the participants were presented with a sequential pairing of a scenario and its corresponding design sketches, I follow this same format here. I felt that some comments mirrored other comments and overlapped in their content, so I have gathered the most representative quotes without being repetitive. Recall that the full set of scenarios and sketches are in Appendices E and G.

Video Creation and Use

[Ron] This happens all too often when instructors are trying to utilize new technologies in their courses. The good thing is that most platforms offer some sort of trial period at no cost to the instructors these days. The issue is commonly that after I spent a considerable amount of time developing course materials for a specific platform, there’s no way to transfer it to another novel platform that comes along later. Too often this creates scattered information for both the instructors and the students, and is extremely confusing for everyone.

[George] I think that people have different needs and experience levels. If they have simple needs, they want a simple platform to use. I like the video feature and all of its elements but it might be too much. I like the LMS testing output box at the bottom that would be very useful. I see this as not a replacement for tools but integration.

[Sara] It seems like what you are proposing here is a monolithic approach sort of a one size-fits-all approach by making everything possible together. I would have a more
modular approach because if you're an expert in... let's say... netbeans, then I want to use that, consistent with what I introduced in my lectures and with certain activities. [Kara] I like this idea but there is a trade-off with complexity of use. How difficult is it going to be to use? Can having a complex video editor be detrimental to other features in terms of workload? Final cut pro is a very specific and expensive program designed to do these things... I think you will run into trouble deciding what will and will not be necessary.

These comments about how to handle video include a variety of ideas proposed across different instructors. For instance, there was some disagreement with incorporating all content creation features into a single integrated system. It could be very complex to maintain and it will certainly be a gruelling process trying to decide which features are more important than others. Based on my first study, I selected features that had been proposed or implied in those interviews, though it seems that this group would prefer that I should remove some and focus on two or three features. Alternatively, I could include all of the features but support the task at a very basic level, trying to minimize the system’s complexity.

**Awareness and Collaboration**

A second scenario and prototype emphasized the possibility of awareness and social sharing within the system. This feature boasted a recent activity pane such as the one on Facebook and a tagging system to categorize content that I hoped would encourage instructors to either collaborate with other similar instructors interested in the same topics, or simply query and view what other instructors are doing. The imagined “digest” of notifications has settings to adjust or completely remove the viewing of activities. This idea was well received, with the proviso that it should be optional or customizable about when and how it is displayed.
[Larry] I feel a social network vibe from this which is never an entirely bad thing. I would call this like a feed collecting and aggregating resources for you from people at PSU. And this could work because Penn State is sooo big. This wouldn’t work as well in a small institution but you figure the network here is so massive, even with all the extra workshops and events people still miss each other.

[Bill] This seems more like a dashboard as opposed to a system if you get what I’m saying... For example, it’s meant to have everything there in front of you and give you easy access to everything. There is a lot of configuration to customize how you would like to see it and that entirely depends on what is important to the instructor.

[George] Now this is important. This idea is great. I think that collaboration and social sharing are crucial to education. It is the future. Having instructors create communities with other like-minded individuals not physically within their vicinity and be able to have stimulating conversation about teaching approaches and technologies... definitely. I wanna see this.

[Mary] This might be really distracting with everything else going on in this system. As long as there is an option to not participate, it could be fine. However, you really don’t want to discourage people from looking elsewhere for tools and ideas. But I see your vision in trying to encourage collaboration and some awareness here.

[Sara] I certainly wouldn’t be interested in this level of detail. I mean when I first started teaching it would have been nice to see how other people grade or structure their courses. Would that be something I get through having this mechanism? I would not really care about who is uploading what or content categories.

[Kara] How about awareness of students? Maybe having a way to see if they accessed content, viewed a video, or did some sort of action? Not sure that was the kind of awareness you have displayed here but that could be a thought...
The awareness pairing evoked some comments showing concerns as to its place or role in the system. Though I agree to some extent that it may be a distraction, teacher preferences would be available, allowing them to adjust the awareness feed to their needs. However I do want to consider other modifications to the feature to see whether its distraction character can be lessened. Kara seemed to have students in mind when considering the opportunities for promoting awareness, though it seems that this would be more useful during and after a specific course, not necessarily for teacher preparation and developing course materials specifically. At this point I am not clear whether the same technology features will be useful for both teacher preparation and course delivery, and my scenarios focused on the former as these seem to be less prevalent in the education research literature.

*External Tool Integration*

Although most of the design ideas were met with considerable positivity and interest, others were not. The tool integration scenario and sketch was one that produced quite a bit of resistance from my participants. This feature was meant to support a teacher’s “grabbing” of external apps that would otherwise not be available as default features, bringing them into the system via its workspace area. For example, a teacher might use Photoshop frequently and prefer it over any built-in tools for image editing; this person drag Photoshop into the platform where it would create a sort of alias to the application such as those available through virtual machines.

[Michelle] What if the external app is running on a local machine and not on the campus network? If the instructor worked at home where he has his original copy of the software, would it transfer to the temporary file of what is created on campus? It seems like a very complex idea that needs more thinking, though I understand what you were going for.
[Lisa] What if you replace this mini section of external apps with file structures like Dropbox? For instance, the same idea you have here is fine with local and campus copies but substitute the external apps for file organization. I always have multiple places where I put everything in one semester and then I forget. It would be great to have an enhanced filing system. They could be seen as shortcuts like ones on a desktop.

[George] The problem with this is workload and licensing. For example, if you propose that anyone can basically drag any piece of software onto this system then how would it handle all of the memory and RAM being used by these robust applications. For example, like Endnote, Final Cut Pro? I mean they are costly and I am assuming you would need to have a license to get even a VM-like copy of the software on your system. Very complicated but ambitious and interesting.

[Kara] I don’t think this would be realistic to do. It is extremely over the top. I think there is another solution here though I am not sure exactly what that is. Focusing on perhaps the video and awareness features may be worthwhile instead of this?

In hindsight, participants were right to be dismissive of the external app integration idea. This concept was designed with good intentions but the functionality and workflow left a lot to be desired. It seems that the file structure suggestion seems reasonable though other features will be considered first.

Community and Collaboration

The sense of community and collaboration pairings was discussed at length. Participants raised some interesting questions and offered some insights into whether these sorts of support were necessary. Essentially, the sketch proposed for these problem scenarios showed how one might aggregate on-campus resources to engage instructors in experimenting with innovative
teaching practices. Most of the participants were not as excited about this feature when compared to the others.

[Nicole] I think the question depends on if the instructor is willing to make the commitment to find resources to make it work? Providing a bunch of resources and external resources is tricky. Departments may have their own stances on this and the type of resources and support IT does. I think what you propose here has some overlap with the awareness piece; you should revisit both.

[Lisa] Honestly, I’ve taken up reading professor blogs. There are professors out there around the country who try out new things in the classroom and write journal entries of their experiences from day-to-day. I keep track of them as best I can to understand how other people do things and try to reach out to collaborators by commenting on their posts.

[Mary] I think that sense of community is important for new instructors to feel at home. If they are open to trying out new approaches in the classroom then I agree there should be something to guide them, but I am not sure whether it should exist within this system. How does a system encourage sense of community and collaboration? It can’t be as simple as just providing stuff and hoping for the best.

As evidenced above, participants were not as enthusiastic about this feature as the other ones. Nonetheless, they were able to offer suggestions about how realistic a system feature can provide or enhance feelings of community and encouragement of collaboration. More thought is definitely needed to sort out the sketches and perhaps the problem scenario itself.
**Personal Experiences and Approaches**

Lastly, participants reflected upon their own implementations of hybrid learning environments. This prompted a discussion about the loosely based structure of the inverted classroom, where different variations seem to be common. There is no guide to follow; an instructor experiments little by little and relies greatly on trial and error. An important factor is the resources they have at their disposal and the content needed for the course.

[Kara] *I created my materials on a needs basis. For instance, as I was trying new activities, I developed things on the go and I thought that was how I should be testing things. I had a general outline and then changed my mind all the time. It was crazy but that is how I operate.*

[Sara] *I did this weird thing where my semester was split in half. For example, I tried the flipped method for the first half and switched back to traditional towards the last half. I wanted to just give students a taste of the approach and I wanted to lighten the load for myself. I figure if I can try it out for a few weeks that would be an indication of how it could pan out in the long run. It was pretty successful. It kept everyone on their toes. And I did not have to really create more materials and use other resources; I just transitioned to the traditional lecture.*

[George] *The funny thing is I taught a class two semesters ago and I was talking to this colleague of mine who is big into trying new approaches in the classroom. And we were just talking about what work and didn’t work and how I structured my class. Then he was like, “wow it seems like you did some flipped classroom thing there...” and I was taken aback because in retrospect I never thought of it that way. And basically that is what I did! I guess I am just not into the whole buzzword thing.*
As seen above participants reflected upon the different forms of inverted classroom structures they have implemented before, such as full semester inversion, half semester inversion, and even bits of trial and error sprinkled throughout the semester. These answers are consistent with the literature, which tells us that 1) there is a lack of consensus as to the definition of the inverted classroom and 2) because it is flexible and caters to many needs, there is no uniform way to implement it.

**Summary from Scenario-Based Design Study**

The scenario-based approach allowed me to have in-depth discussions with participants about the design materials. Each material presented whether that was the personas, scenarios, or sketches definitely enhanced discussions for system design. More importantly, participants felt included in the design process by elaborating on their design decisions, reflecting on their personal experiences, and providing critical and constructive feedback. I learned several things. For example, although the goal was to create a one-size-fits-all approach system, most of the participants were against this idea. They would rather see a few focused quality features that are unique to the inverted classroom. However, if the one-size-fits-all approach was carried through, every feature should maintain basic functionality so as to not deter instructors from working with outside tools. The goal should be to make the system less complex and in turn, make those inverted classroom tasks efficient and effective. Instructors should not be struggling to learn new and intricate features, they should be intuitive.
Chapter 6

Discussion

The findings I assembled across my two studies were very thought provoking. Below I share some high-level thoughts about what I have learned thus far.

Instructor’s Expertise

Instructors’ level of expertise varied greatly. Table 3 is organized by each participant (using their pseudonym) and indicated their advanced training discipline, which phase of my thesis they participated in, how many times they have used the inverted classroom and the discipline they teach. There was some difficulty in making concrete statements, arguments, and justifications on how inversion is being implemented and the reasons why it is more common in STEM fields. It is important to note that only a handful of instructors carry strong expertise in this area. From the fourteen total participants, only four are experts based on years of experience (Harold, Nicole, Ron, and George). There were also four overlapping participants that participated in both study phases. Nicole has actually published several papers on her flipped implementations and is very invested in its usage.
<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>Discipline</th>
<th>Description</th>
<th>Study Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linda</td>
<td>Statistics</td>
<td>Taught 2 flipped semesters</td>
<td>1</td>
</tr>
<tr>
<td>Harold</td>
<td>Computer Science</td>
<td>Taught using variations of method for 20 years</td>
<td>1</td>
</tr>
<tr>
<td>Joe</td>
<td>Computer Science</td>
<td>Taught using flipped once</td>
<td>1</td>
</tr>
<tr>
<td>Tara</td>
<td>Information Systems</td>
<td>Taught flipped variations for 2 years; ongoing</td>
<td>1</td>
</tr>
<tr>
<td>Michelle</td>
<td>Chemistry</td>
<td>Taught flipped for 2 semesters</td>
<td>1, 2</td>
</tr>
<tr>
<td>Lisa</td>
<td>Mathematics</td>
<td>Taught 2 semesters of flipped</td>
<td>1, 2</td>
</tr>
<tr>
<td>Nicole</td>
<td>Civil Engineering</td>
<td>Taught 4 years of flipped and published research on it; ongoing</td>
<td>1, 2</td>
</tr>
<tr>
<td>Ron</td>
<td>Computer Science/HCI</td>
<td>Taught variations of flipped for 10 years</td>
<td>2</td>
</tr>
<tr>
<td>George</td>
<td>Information Systems</td>
<td>Taught using variations of flipped for 5 years</td>
<td>2</td>
</tr>
<tr>
<td>Kara</td>
<td>Computer Science/HCI</td>
<td>Taught flipped for 2 years</td>
<td>2</td>
</tr>
<tr>
<td>Sara</td>
<td>Information Systems</td>
<td>Taught flipped variations for 2 years</td>
<td>2</td>
</tr>
<tr>
<td>Larry</td>
<td>Security</td>
<td>Taught flipped for 1 year</td>
<td>2</td>
</tr>
<tr>
<td>Bill</td>
<td>Computer Science</td>
<td>Taught 2 years of flipped variations</td>
<td>2</td>
</tr>
<tr>
<td>Mary</td>
<td>Computer Science/HCI</td>
<td>Taught 3 years using variations of flipped</td>
<td>2</td>
</tr>
</tbody>
</table>
Instructor Perceptions of Students

Most of the participants mentioned positive experiences appropriating this approach in their courses. However, as evidenced earlier, two or three participants had negative experiences using it. One participant was almost fired though her attempted implementation and her students were a big part of it. They were dissatisfied with the approach and the outcome of the course. This instructor took these reactions and worked hard to restructure her course because she felt it would make a difference. Initially, she had this terrible experience which was transformed once she tinkered with the structure and tried again. She now believes her students are effectively absorbing the material and learning foundational concepts in her course.

Another instructor tried it once and gave up on it. This instructor was adamant about his stance regarding the inverted classroom and other hybrid structures. His beliefs stem from traditional lecture style classrooms and old schools of thought regarding computer science. Students were complaining that the structure was confusing and that the materials created were not helping them learn anything. Once he received negative feedback from students, he dropped the format and is happy with his decision. Interestingly enough, although the inverted classroom did not work for him, he was also negative about his students’ work ethic. His reasoning went beyond higher institutions of learning but down towards the elementary level, when students first learn basic concepts. From his perspective, there is a problem in K-12 education, and that problem stays with them forever.

The rest of the instructors were pleased with their use of the inverted classroom. Most have seen a difference in student grades, group work, level of enthusiasm, and most importantly, their understanding of course concepts. Though many will mention that students at first will be reluctant to adapt, eventually they will form a routine and learn to enjoy its flexibility, hands-on structure, and collaborative spirit.
Revising the Activity System for the Inverted Classroom

In my first investigation, I focused on the Activity Theory construct of *instruments.* However, other relationships were discovered, such as the influence that a community has on the tools and approaches instructors use. Further, the limitations of resources may restrict their tool usage therefore affecting the object and outcome of the inverted implementation. Instructors carry out many tasks by creating content and delivering it to students; however, the organization’s rules (and often other constraints imposed by tools) dictate how freely students are able to interact with pieces of content. These statements can similarly be viewed as contradictions between the units affecting the overall activity, causing tensions to exist.

The actions surrounding these units of analysis acknowledge the complex nature of tasks involved in the inverted classroom. As this was a broad look at the activity system for an inverted environment, intricate sub-systems of triangles are not generated here; further investigation into specific follow-through of activities for this pedagogy is needed to uncover historical and cultural contexts of an inversion implementation. It is also worth noting that inverting the classroom as an activity can be seen through several different perspectives so this system is subject to change.

Instructors value many aspects of their roles, technologies, teaching methods, and community. As illustrated by the findings, instructors use a wide range of tools to help them in different tasks, which ultimately impact the effectiveness of the inverted classroom implementation. Further illustrated by Activity Theory, as units of analysis shift other components shift, thus, changing the overall activity.

My findings uncovered several things. For instance, Angel is seen negatively, it is not the ideal image of what a functioning and aesthetically pleasing default system should be. Moreover, by limiting their use of Angel, these innovative instructors have compensated with use of several technologies during a semester to aid in the support of inversion. This is time consuming, not
responsive, nor agile. This response creates negativity towards the tool, which mediates energy directed toward the object and outcome.

After the design sessions, I had a better idea of what features may be important to instructors who use this approach. I also better understood the current state of practices for those who attempt a successful inverted classroom implementation. Fig. 8 shows a revision of the earlier activity system triangle, emphasizing the instructor activity components that may result in an effective inverted classroom. This system contrasts from the one in Chapter 3 in its rules, instruments, and outcome. In the earlier analysis, I broke down the components for instructors that lead to effective learning for students. In this system I consider the components of instructor’s environment surrounding the implementation outcome.

Figure 8. Revised Activity System for the Inverted Classroom
So what does this suggest about the inverted classroom as an activity? I consider this question in more detail in the next section.

**Variations of Course Structures Using the Inverted Classroom**

There are different interpretations of the inverted classroom that in turn reflect its many definitions. For instance, depending on their course demands, technology resources, and student reactions, instructors may implement inversion for a specific amount of time and purpose. For example, some of our research participants mentioned that they split their time over the semester in half, with half of the time used on the inverted approach and have on the traditional lecture approach. Some decided to implement a full semester without worrying about how it was going, while others simply tried it out on occasion, i.e. as interested or possible. Instructors felt that catering content delivery to the students made a huge difference in how they interacted with and understood the course material; some instructors reported that their students were more engaged. In other cases, professors made specific activities mandatory while others did not which affected students’ behavior. For example, attendance was required in George’s class as part of the grading system while Nicole was very loose and advised students to come in whenever they wanted because she saw herself as a guide and facilitator as opposed to an autonomous authoritative figure. Most used online video lectures while some incorporated YouTube videos and audio podcasts. These variations point to a process of individualized appropriation of the inversion concept and associated technologies.
Variations of Technology in the Inverted Classroom

Across my two studies, I observed that instructors use a myriad of technologies to aid their inverted courses and to accomplish different tasks. Some may build their own tools, or adapt existing, sometimes involving an exhaustive search for them, perhaps even paying for them on a personal basis. My intention was to find a way to incorporate necessary tools to further aid inverted classroom implementations by hopefully reducing time spent on other activities like searching for tools and learning them. Though my goal was to incorporate versions of those technologies into features for a customizable system, I found that not all are necessary or desirable. Instead, I learned that I should avoid building a platform that is congested with too many tools and options. This has made me realize that a monolithic approach is probably not the best the solution, but rather I will consider a “lowest common denominator” approach as suggested by Harold and Sara.

If I incorporate basic functions for content creation activities such as video, awareness, testing workspaces, and some file structure integration, then based on the feedback I received in the second study, instructors would be more prone to use it. Features such as external tool integration and parts of collaboration and sense of community seem not to be very important for adoption and usefulness. However, instructors did suggest that revisiting these sketches and scenarios may help in constructing other design ideas. I plan to focus on identifying a few features that provide high function and quality rather than emphasizing quantity and coverage. Overall, I received a huge amount of constructive feedback that will guide my future research endeavors.
Chapter 7

Conclusions and Future Work

Reflections on a Qualitative Study

As a qualitative researcher conducting an interpretive study, understanding outside concerns relating to reliability, believability, and validity is a significant commitment (Creswell & Miller, 2000; Mason, 2002). In order to address these concerns, I can point to several methods I employed to ensure quality, authenticity, and rigor of this research. First, while conducting interviews, my interpretations of responses were confirmed by re-asking questions to participants. Next, while taking notes during the interview, relationships among the ideas I was hearing were made in the moment. In the data analysis phase, triangulation consisted of using multiple sources of data to converge on the truth and the story of the data through written notes, observations, and audio recordings. In the design study, participants played an active role in providing valuable feedback on sketches for system design and also suggestions on modifying the presentation of the design materials. Additionally, as a form of informal member checking, discussions were held with non-participants who are mindful and interested in the inverted model. Finally, I recruited some of my first participants for the second set of sessions focusing on design, to create consistency in past and current data sources. Finally, parts of this thesis project have been recognized by scientific and peer-led communities such as EDULEARN14, IGI Global Handbook of Applied Learning Theory and Design in Modern Education, and the Grace Hopper Conference. These external publications help to communicate the importance of this research.
Limitations

My research is limited by the sample sizes I have recruited. Both studies ranged from 7 to 10 participants; no doubt a bigger sample of instructors would have generated greater variety and depth in my findings. However, when recruiting participants through email and several follow-ups, some failed to respond while others were from other Penn State campuses. I restricted the participants to the University Park campus population. Similarly, some diversity was achieved through having different instructors from different areas of expertise, but perhaps the data would provide another story if I recruited instructors nationally.

Another limitation may be the participants’ backgrounds. For example, all of the instructors taught STEM-related courses that also correspond to be their areas of expertise. Liberal arts and humanities were not considered in this research because I failed to recruit instructors from that population. It would have been interesting to compare perspectives on technology and the inverted classroom between STEM and non-STEM instructors.

Next, interpretive bias, also known as confirmation bias, may be a limitation of my research. Confirmation bias is the inclination to interpret or search for information in a manner that confirms one’s beliefs or hypotheses (Onwuegbuzie & Leech, 2007). In both studies, interview questions prompted various answers that could be open for interpretation. I did my best to converge on the accurate meaning behind what participants said by revisiting audio recordings and notes without adding my own interpretation.

Also, the design materials I presented may have been confusing or interpreted differently by participants than what I had originally intended. It may be that digital prototypes developed in basic HTML would have better represented the functionality and made the elements less ambiguous (although this roughness and ambiguity were a specific goal for the discussions and
did seem to provoke good reactions). There is also a possibility that participants were overwhelmed with too many elements. The design sessions were long and involved exposure to different materials in one sitting; participants might have become tired by the end.

In the data analysis phase, while I was coding for emerging themes and categories, I was the only researcher to perform these tasks. As a result there was no way to assess inter-coder reliability, which may have hindered the interpretation and story I drew from the data. There was no discussion with other parties on conflicts emerging from my sorting of the data, and this may be viewed as an instance of low validity. I hope the other mechanisms for evaluation that I outlined earlier help in validating my research.

Lastly, generalizations cannot be made to theory due the uniqueness of activities, personal experiences of instructors, and the exploratory nature of this study. The ultimate objective was to investigate experiences while exploring possible design features for a tool, not make larger claims about specific technologies or from one teaching approach to another.

**Conclusions**

To conclude, the inverted classroom has a great potential in many educational settings. I focused on instructors rather than the student population, though more research is needed to understand the instructor’s point of view in course task preparation and tool usage in non-traditional learning environments. The rapid evolution of technology and teaching innovation is unparalleled; instructors must move forward to accommodate the ever-changing needs of the education realm. If and when instructors elect to employ the inverted classroom approach, the technologies unique to the inverted classroom must be available to help them succeed at every level. In particular, diverse technological choices must be at the disposal of these instructors in
one place to increase effectiveness and efficiency with course tasks while reducing time spent learning or troubleshooting technologies.

In this thesis, I first reported an interview study. The goal of that study was to better understand the inverted classroom phenomenon and elicit design basic features for tools that could better support the inverted classroom structure. Through the use of a wide range of literature and the guidance of the activity theory framework, several important findings were uncovered. First, the inverted classroom is a unique approach that is only growing in number by the amount of instructors looking to use it; second, it has been mostly effective in STEM related courses, at the helm of very experienced instructors. Although, there are some minor disadvantages of the approach, the payoff is worthwhile.

I also reported a design study as part of this thesis. The goal was to build upon previous research by delving deeper into the technological features of the envisioned system to support inverted classroom tasks. Thus, I have proposed a system that will allow for customization and development of tools founded on an instructor’s skill level and appropriation for a specific course depicted through paper prototypes. As seen earlier in this document, I created other materials such as scenarios and personas to accompany a set of paper sketches that provoked valuable discussions about system design and functionality. Although there was some disagreement about which features are needed or useful, in general the instructors were very positive and offered great suggestions toward the system design.

A custom set of prototypes devoted to the inverted style must not hinder the creativity of instructors by creating restrictions on features. It must be responsive to any browser or machine. It must be robust, functional, and aesthetically pleasing. The prototypes must incorporate the important administrative features while including the interactive pieces such as blogs, wikis, video and audio creation and production. But more importantly, I should focus on awareness, testing workspaces, and some level of cloud file structures.
I found that my depictions of challenges in the inverted classroom (i.e., the problem scenarios) were seen as somewhat accurate, but my proposed solutions for those problems were not always appropriate. One way to summarize this is that I overestimated what was necessary and vital for instructors to accomplish their tasks. Instead of many features, I now believe that only a few will be important. In fact, my participants suggested that my system should not try to incorporate an aggregation of complex features that may congest the system but rather focus on the lowest common denominator, such that many features are supported by just at a basic level. Instructors do want to feel discouraged from experimenting with other tools outside of the system or let go of tools they have been using for years.

Last but not least, I found that there are variations in inverted teaching that stem not only from technology use, but also the implementation of the approach itself. I found that the inverted classroom paradigm serves to meet a range of instructor needs just as it seeks to meet different students’ needs. In fact, instructors used the approach differently based on their comfort level and what fit their particular course needs. In terms of technology, instructors use whatever means necessary to achieve their goals, whether that is paying for tools, searching online resources, asking peers, creating their own, or re-appropriating tools for other purposes, our design must account for these choices.

The research contribution in this thesis is threefold. First, I have offered the early stages of a novel system design to alleviate inverted classroom teaching challenges, based on a review of practical knowledge gleaned from instructor perspectives. Second, I have offered another piece of literature for the inverted classroom, as well as for hybrid and non-traditional learning environments by highlighting current technological and pedagogical practices. Third, I have brought an instructor point of view to this arena of research, setting the stage for similar teacher-centered investigations in the future.
Future Work

To continue this line of research, I would continue to iterate in the scenario-based design process, refining my ideas and eliciting more feedback until the functionality and interactive experience stabilizes. After implementing a working system “in the wild,” I would conduct further testing through longitudinal studies and classroom experiments. I might also consider experimental studies to assess whether instructor’s time is reduced when using my system in comparison to a default university-based platform. Moreover, other experiments can contrast specific features against each other to see which are actually necessary for instructors by collecting log data at the end of a semester.

Another complementary method to enrich the project could be a quantitative survey study where instructors are asked about specific technologies and support mechanisms for different aspects of the inverted classroom design, such as promoting active learning activities or content delivery can be another route. The ability to generate conclusions backed by statistical evidence may enhance the impact of this research to a broader educational research community.

Because the proposed system includes a set of customizable features, one future step might be to consider end-user development (EUD) as an aspect of the system, that is give instructors more power to design and configure their own toolsets. EUD practices are meant to provide novice programmers and technology laypersons with intuitive ways of building custom tools in a simple language or interface. This may prove to be an intriguing way of looking at this problem of tool integration, design trade-offs and hosting a set of tools for inverted classrooms.

In addition, because the two studies I did were small in scale, a larger-scale study might be another useful step to take. For instance, my Penn State sample could be compared against a national or international sample by using Amazon Mechanical Turk or some other mechanism that would allow me to reach a wider group of instructors. This would be an interesting direction
to take and will produce more data which would allow us to make substantial claims and
generalizations for the instructor population about tool usage in hybrid classrooms. Further
consideration will be given towards the next steps.

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Appendix A

Summary Explanation of Exempt Research

(Formerly IST 541 Research Project) Master’s Thesis
An Investigation of Design Features for Inverted Classroom Support Technology

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Overview
Education is drastically changing by way of technology and new approaches to teaching. The inverted classroom has risen as an exciting unconventional approach to structuring a classroom environment that induces learning. The implementation of the inverted classroom pedagogy varies depending on the instructor, learning outcomes, activities, and what resources are available. Instructors use technologies that are at their disposal to complement this pedagogy, however, there is a lack of standard design features for a tool solely devoted to this teaching method. Using interviews as a way to extract rich and detailed experiences from instructors who have implemented this pedagogy, I aim to use these findings to understand the inverted classroom phenomenon as a whole, while, eliciting standard design requirements for a technology that best supports this pedagogy.

Interviews
I would like to conduct interviews to better understand the inverted classroom pedagogy, to understand which technologies have been used in the past and if they do or do not work, and to gain insight into what design features may be developed into a potential system. Individual interview sessions will be conducted at an instructor’s location of choice, preferably their office and will last no longer than an hour. All data collected will be kept in a safe and password protected device, this includes notes taken during the
interview as well as audio recordings, if the participant has agreed to do so. I hope to gather important information regarding design requirements that support the inverted classroom approach.

Thank you, I really appreciate your help and time with this project!

**This project is being conducted as part of a course requirement for IST 541. Data collected will be used for only research purposes.

**If you have questions or concerns, you should contact me, Joslenne Peña at 917-596-6547. If you have questions regarding your rights as a research subject or concerns regarding your privacy, you may contact the Office for Research Protections at 814-865-1775.

**Your participation is voluntary and you may decide to stop at any time. You do not have to answer any questions that you do not want to answer.
Appendix B

Interview Questions from Study 1

General (Background)

1. Name
2. Department/Discipline
3. How long have you been teaching? Anywhere other than Penn State?
4. What courses do you teach?
5. Do you use Angel to support your teaching? How? (If not find out what other support tools/resources they use; goal is to get a sense of their general technology orientation)

General Teaching Experiences

6. What is most important to you in terms of successful learning? What defines student success for you? (grading outcomes, learning outcomes like concepts, motivation, participation, cooperation)
7. How would you describe your teaching style?
8. Have you ever taught online courses? (If so, get brief description, try to get a comparison of the online versus the in-class teaching)

Flipped Experiences

Tell me about a specific instance where you used this approach integrated with technology—both working together. Or give me a specific example where you used technology effectively.

1. When were you first exposed to flipping? How would you define the approach?
2. How many times have you implemented the flipped method? What made you choose the approach?
   a. Can you think of examples where you deliberately chose NOT to use a flipped approach and if so why?
3. What do you most enjoy about the flipped method?
4. What do you least enjoy about the flipped method?
5. What support technologies have you used or are currently using? (system or specific tools)
   a. What did you like or not like about these technologies? What did or did not work?
6. What features would you like to see developed into a tool devoted to the flipped approach? (forums, activity tracking, assessment, peer evaluation, group work, etc.)
   a. Why?
Appendix C

Focus Group Script (old participants) from Study 2

FOCUS GROUP SCRIPT/PROMPT

For OLD participants:

Thank you for agreeing to participate in my second study! As you may remember, part of my thesis is motivated by understanding teaching innovation through technology. In specific, we spoke about current practices regarding hybrid and non-traditional course models like the inverted (flipped) classroom. My goal with this(our) discussion is to propose a system that provides all of the features that instructors need to effectively implement their courses. You will encounter several paper sketches of the system devoted to particular tasks. I would like you to focus on the functionality aspect of the system.

Can you briefly talk about your innovative teaching practices such as technology intervention or novel pedagogies and how they have changed since the last time we spoke? (online, hybrid, MOOC)

Before we start…. Get their acknowledgement below…

*Provide with copy of IRB/consent and notification of audio recording*

Bring the activity theory diagram as a display to jog their memory and as a starting point bridging the two studies

**METHOD:** explain brief overview of SBD approach

- to ask “what if” questions about people using technology
- envisioned system use through storytelling using scenarios and personas
- personas - representative synthesized (creative) characters based on people teaching flipped classroom to highlight (experience, characteristics, attributes)
- scenarios – narratives of sequential actions or events depicting the aforementioned characters in a story about specific use (in this case, problem scenarios) depict current practices/current problems
- paper sketches/prototypes depict the “new world” in which this character lives in, a solution to the aforementioned problem scenario

*(get scenario based reaction, emphasizes the activity designs not the user interaction designs as opposed to visual aesthetics, bring them back to the task flow)*

**Based on my previous study and an extensive review of prior work, I have determined these 3 types of users/characters, they represent the individuals one may encounter in our context…

Introduce personas (characters) do they seem believable to you? Get reaction. And then talk about scenario 1 – show and then read aloud

What do you think about this scenario? Does it relate to current or imagined problems you have or may have? Get reaction.

And here are some ideas I have come up to address that… show paper sketch that corresponds to scenario

Let’s take a look at this problem scenario again…. Now, present the scenario again AKA “Jane’s” problem in this “new world” deliberately with the sketch – Moving from the problem scenario into the prototype. Jane starts with this dashboard in front of her but now with these new functions in front of her, previously she has problem XYZ and now as she follows through her task, she is able to achieve her intended goal.

What are you reactions to that new story for Jane? changed from the scenario…

Ask for more clarification if needed and have them elaborate more, can you please explain?

REPEAT AGAIN FROM ** FOR EACH SCENARIO, THEN PROCEED BELOW WITH FINAL GENERAL QUESTIONS!!

**Final General Questions:**

- Now that you’ve walked through a number of diff scenarios and people, what do you think of the systems overall organization? (tasks support)
- Does this set of scenarios cover the important issues? Does it seem to be consistent?
- Do you have problems understanding what each widget does? Should one widget be removed or placed elsewhere?
- What do you think about the sketch layout? (screen layout) Is there anything that stood out to be inappropriate? Is the system too congested? (lots of elements)
- Would you suggest any other elements or functions or scenarios or a whole other approach?

**Ending:**
Any overall comments you would like to share?  
After all, what do you think about technology support for the inverted classroom? If you are not currently using it, would you?
Appendix D

Focus Group Script (new participants) from Study 2

FOCUS GROUP SCRIPT/PROMPT

For NEW participants:

As part of my thesis I am interested in teaching innovation through technology. In specific, I am interested in hybrid and non-traditional course models like the inverted (flipped) classroom. Recently, I conducted an interview study at an attempt to uncover current teaching practices with technology and current practices with inverted classroom instructors. I uncovered some findings which have led me to believe that current technological tools and resources at PSU may not be enough to aid instructors implementing the inverted classroom. My goal with this(our) discussion is to propose a system that provides all of the features that instructors need to effectively implement their courses. You will encounter several paper sketches of the system devoted to particular tasks. I would like you to focus on the functionality aspect of the system.

Provide with copy of IRB/consent and notification of audio recording

Before starting, ask for Background info/Demographics:

- Courses?
- Affiliation? (College/dept)
- Content/Topic?
- Online/Mooc/WorldCampus/hybrid?
- How long have you been teaching?
- Do you normally incorporate technology in the classroom? // Can you briefly talk about your innovative teaching practices such as technology intervention or novel pedagogies? (online, hybrid, MOOC)

Bring the activity theory diagram as a display, as a summary of where I ended up

METHOD: explain brief overview of SBD approach

- to ask “what if” questions about people using technology
- envisioned system use through storytelling using scenarios and personas
- personas - representative synthesized (creative) characters based on people teaching flipped classroom to highlight (experience, characteristics, attributes)
• scenarios – narratives of sequential actions or events depicting the aforementioned characters in a story about specific use (in this case, problem scenarios) depict current practices/current problems
• paper sketches/prototypes depict the “new world” in which this character lives in, a solution to the aforementioned problem scenario

(get scenario based reaction, emphasizes the activity designs not the user interaction designs as opposed to visual aesthetics, bring them back to the task flow)

**Based on my previous study and an extensive review of prior work, I have determined these 3 types of users/characters, they represent the individuals one may encounter in our context…

Introduce personas (characters) do they seem believable to you? Get reaction. And then talk about scenario 1 – show and then read aloud

What do you think about this scenario? Does it relate to current or imagined problems you have or may have? Get reaction.

And here are some ideas I have come up to address that… show paper sketch that corresponds to scenario

Let’s take a look at this problem scenario again…. Now, present the scenario again AKA “Jane’s” problem in this “new world” deliberately with the sketch – Moving from the problem scenario into the prototype. Jane starts with this dashboard in front of her but now with these new functions in front of her, previously she has problem XYZ and now as she follows through her task, she is able to achieve her intended goal.

What are you reactions to that new story for Jane? changed from the scenario...

Ask for more clarification if needed and have them elaborate more, can you please explain?

REPEAT AGAIN FROM ** FOR EACH SCENARIO, THEN PROCEED BELOW WITH FINAL GENERAL QUESTIONS!!

Final General Questions:

• Now that you’ve walked through a number of diff scenarios and people, what do you think of the systems overall organization? (tasks support)
• Do this set of scenarios cover the important issues? Does it seem to be consistent?
• Do you have problems understanding what each widget does? Should one widget be removed or placed elsewhere?
• What do you think about the sketch layout? (screen layout) Is there anything that stood out to be inappropriate? Is the system too congested? (lots of elements)
• Would you suggest any other elements or functions or scenarios or a whole other approach?

Ending:

Any overall comments you would like to share?

After all, what do you think about technology support for the inverted classroom? If you are not currently using it, would you?
## Appendix E

### Problem Scenario Narratives

### Problem Scenario 1 - Video

Jane is organizing her business analytics course which begins in the next few weeks. Jane recently attended a university-wide workshop and noticed an emerging trend of new teaching approaches and technologies being used in the classroom. Due to the success of other instructors, she has elected to use the inverted classroom structure as her teaching approach this semester. As there are lots of modules of content in this specific course, Jane is looking to upload video lectures of the core concepts in the course. Jane is extremely frustrated in that her current course management system does not provide editing tools to support her content creation endeavors. She believes that her university-based resource should provide this or should be able to integrate this feature into their system. As she is under a tight timeline, Jane ventures online to find an external tool to help her record and create her videos. The high quality tool she desires, requires payment, so she makes a payment out of pocket to start the process immediately. Unfortunately, the tool is much more complex than she had originally thought, regardless, she still manages to complete 3 videos.

### Problem Scenario 2 - External Tool Integration/Workspace

Joe is known for trying out his personal tools in the classroom and for his innovative teaching endeavors. He has built a simulation program that traces nested web application code in a web project for his computer science class. As his content management system does not support external tool integration, he has created his tool in a separate IDE. He is somewhat disappointed that the university system cannot provide sandbox workspaces for testing, development, and implementation. He is forced to iterate these tasks separately. Though he has become accustomed to this, he really feels that external tool integration must be an added feature in the content management system. He also feels that external tools found online should be easily integrated as well when desired.

### Problem Scenario 3 - Awareness

Michael teaches computer engineering. Michael is busy developing content modules for his first inverted classroom implementation. While working in his content management system he becomes curious about recent posts related to his teaching/research topic, he realizes that there is no specific activity tracking tools to understand the landscape of instructors in his field within his university. It would interest him to see what other instructors in similar fields are experimenting with regarding certain tools and topics. He feels that some sort of managed set of notifications with suggested tags may suffice.

### Problem Scenario 4 - Sense of Community & Collaboration

Sarah is undergoing a very ambitious restructuring of her hybrid course. Last semester she tried an innovative teaching practice and failed. Her students were dissatisfied with the course structure. As she is preparing to reorganize she has asked for IT support and other university resources that may help her achieve this goal. Unfortunately, her department is not very supportive. She wishes that her current system encourages innovation and collaboration by providing a set of external pointers, informal communication tools to reach out to other members of her teaching community.

### Problem Scenario 5 - Cross-browser & cross-device compatibility

Joe is concerned with the tool he has designed for peer-graded activities in his mathematics course. These activities are to be done in the classroom and outside of the classroom on designated days. He is worried that it may not work properly in some browsers like Opera and
Internet Explorer 10. Similarly, he believes that mobile accessibility will be limited across Android phones. Unfortunately, there is not much he can do to test these instances and must account for these issues as they arise. He wishes there were a simpler piece of code or conversion tool to ensure his tool works in every instance. Most importantly, he believes mobile accessibility is imperative as students are constantly on them. They will be up to date with work anytime.

**Problem Scenario 6 - Cloud Storage and File Management**

Katherine is importing her security course from the previous semester. As she opens her file, she realizes that some important files were lost in the process. She is extremely irritated because she has limited time to recreate some of those files which are lesson plans and activity sheets. She has about 2 weeks until the start of her course so she looks in her email over a period of time for those attachments and searches her other USB drives and storage drives. She visualizes a simple and integrative cloud files storage system particular to certain levels of filters like course, instructor, and semester.
Appendix F

Personas

Dr. Jane Doe – The Newbie

Dr. Doe is an assistant professor interested in trying out new technologies and teaching approaches in the classroom. She is always looking for new ways to engage her students.

Characteristics
• 32 years of age
• Enterprise Architecture and business applications
• F2F, online, and hybrid

Technical Profile
• Comfortable with general tasks such as using the internet, word documents, PowerPoints, etc.
• Spends lots of time on the computer, reading, writing, and organizing her course
• Windows user, open to apps
• Would refer to herself as moderately tech savvy; would like to improve her skills by attending workshops

Objectives/Goals
• Learn how to create engaging online lecture videos
• Reach students anytime regardless of device, browser (comm.)
• Integrate external tools/apps she found to be useful
• Find more of a like-minded community of instructors
• Wants to do more but does not know where to start

Dr. Joe Schmo – The Skillful

Dr. Schmo is a recently promoted full professor who’s tried new technologies and teaching approaches in the classroom.

Characteristics
• 45 years of age
• Computer programming, databases, and web applications
• Ambitious, creative, innovative
• F2F, MOOCs

Technical Profile
• Computer science skills; can program
• No special preference towards technologies; can build new tools and learn existing ones

Objectives/Goals
• To use whatever means necessary to actively engage students
• Find a way to integrate his favorite applications into a single tool
• Find a sandbox/workflow to test his own developed tools
Dr. Mike Jones – The Traditionalist

Dr. Jones is a senior professor whose been teaching for 30 years. He has barely changed his teaching approach or introduced new technologies.

Objectives/Goals
- Continue teaching using his own methods; tried once and disliked it
- Weary of new technologies, opt out of alternative methods unless mandatory by university policy

Characteristics
- 60 years of age
- Mathematics
- F2F, soon online

Technical Profile
- Does not feel comfortable with new technology
- Would like to stay with available technology
- Barely uses tools unless it is absolutely necessary
- Has basic computer skills, internet use, word processing, spreadsheets
Appendix G

Paper Prototypes
- IT Troubleshooting
- University workshops
- Other software & technology & tutorials
- Chat with college staff & faculty.