AN INVESTIGATION OF DESIGN FEATURES FOR INVERTED CLASSROOM SUPPORT TECHNOLOGY

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Abstract

New technologies and teaching approaches are having enormous effects on education practices. The inverted classroom has emerged as an exciting 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 more classroom time for 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; at this point there is no analysis or recommendation of standard design features for tools that can best support this teaching method. Using interviews as a way to extract rich and detailed experiences from instructors who have implemented this pedagogy, and Activity Theory as an interpretive theoretical lens, we are investigating current practices surrounding inverted classrooms to (1) understand the phenomenon as a whole; and (2) elicit design requirements for tools that can support and enhance this pedagogy.

Keywords: Inverted classroom, flipped classroom, active learning, online education

1 INTRODUCTION

The inverted (flipped) classroom has received much attention recently. As student-centered approaches to framing a classroom are being refined to provide more effective learning experiences, instructors are opening up to new approaches of teaching. The inverted classroom is an unconventional approach that can invigorate a dry and traditional lecture setting, while employing active learning activities that may enhance student engagement, assessment, and experience. 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 – or to challenge those who are already performing at a high level. The inverted model introduces a balance of time management where the instructor has the control to place exposure to specific content outside and interactive discussion and problem-solving within. An added advantage is the self-directed learning approach that is adopted by the students. Equally important, this pedagogical method caters to different learning styles, and this is extremely beneficial, especially in a classroom where students may be more advanced in a topic.

As hybrid, blended, and online learning are becoming more prevalent in education, the appearance of tools intended to support these methods has accelerated. The current exploratory research seeks to understand the inverted classroom phenomenon as a whole, while investigating the types of tools instructors are using to support this 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 also benefits the future of education by giving educators a glimpse into classroom structure alternatives, while, building a stepping stone towards tool design. Last but not least, this research will provide an improved glance at the technological infrastructures available to support this educational approach.

2 LITERATURE REVIEW

2.1 The inverted classroom

Many definitions of the inverted classroom have been generated. The simplest definition describes this pedagogical approach as a reversal of traditional lecture activities where homework occurs within the
classroom and lecture content happens remotely [16,17]. One of the first implementations of the inverted classroom was discussed by Lage et al [16,17] in an economics undergraduate business course. Due to the ever-growing needs of students with technological preferences, learning styles, and educational technology innovation, some researchers have proffered a more elaborate description. Bishop and Verleger [2] define the inverted classroom as the combination of, “interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom.” An example of this structure would have an instructor pre-record their lectures into videos, storing them online, and asking students to be responsible for the content intake; in the classroom, students participate in review, homework, and hands-on activities.

Past research has reported several findings. To start, Gannod et al [9] argue that computing curricula lends itself particularly well to the inverted format structure. Most courses in STEM disciplines involve heavy technical content that can be studied in advance, but also include many hands-on activities and long-term projects that can be the focus of the interactive in-class sessions. Next, the inverted classroom has had very positive reactions from students; even though it has at times been met with opposition [2]. As many students are routinely used to traditional-lecture formats, the inverted approach does require some adjustment in student expectations [2]. Some students enjoy the autonomy and responsibility given to them but others are not as self-directed outside of class as or motivated to engage while in class. Student buy-in is vital to the success of an inverted implementation and instructors must outline the syllabus in excruciating detail to provide a full view of the course structure and expectations [18,24]. Furthermore, instructors take on new roles in the inverted format; this can be hard to grapple with: they must become facilitators and guides, leaving behind their authoritative position. This leads to students gaining more time with their instructor then they normally would. Instructors realize that organizing, preparing content and structuring an inverted course will be time consuming, especially if it will be their first time teaching it [2]. There is a learning curve with the material creation for content delivery [18]. For example, instructors who have never prepared online content, such as videos, must suddenly learn to do so. This can dramatically affect the pedagogical implementation and course delivery.

Published research on inverted classroom pedagogy has focused on content delivery, assessment, engagement, and student experiences [1,4,5,6,8,9,10,11,17,18,19,22]. Several studies have compared traditional lecture courses versus inverted classroom structures, collecting student feedback in order to improve the inverted course [8,10,19,23]. Instructional designers have reported studies on curriculum development and course design for discipline-specific courses [25]. Mason [19] contrasted student performance in an inverted classroom for an introductory course versus an upper-level course. Lockwood and Esselstein [18] provided a brief discussion of the types of technologies instructors used to design and implement their inverted course, while also describing the learning curve associated with video production. Similarly, Zappe et al [28] have listed several software tools that have alleviated preparation time for inverted classroom implementation such as Adobe Captivate, CamStudio, and UltraVNC Screen Recorder. Overall, most research has focused on the pedagogical ideology behind forming content and curriculum around the inverted approach, and course design.

2.2 Technology and tools

Course content development in an inverted classroom typically involves audio and video editing, file management, Content Management System (CMS) management, and annotation, file creation through Word or PDFs, and much more. While many of these tasks overlap with course management for traditional lecture-style courses, the amount of digital content and activity design is significantly increased. Instructors’ success in these tasks depends on the resources available to them, the type of content that is being covered in the course, their preferences and willingness to learn, time constraints and cost.

Examples of tools and technologies that have been used in studies of inverted classroom are varied. For example, Gannod et al [9] used podcasting as an innovative way to record and deliver lectures online, as well as, iMovie, iWeb, ProfCast, and a courseware system to aid in delivery. Lockwood and Esselstein [18] created online videos using Camtasia Relay and Jing through tablet PCs. Bates and Galloway [1] used clickers in an inverted classroom to encourage peer instruction. Campbell et al [5] recorded seventy-five videos lasting about 5 to 10 minutes and hosted them on Coursera (a MOOC platform); unfortunately, they did not describe the software used to record videos, though they did report spending about 600 hours preparing videos for their course. Haden et al [11] used tablet PCs and Camtasia Studio to create content modules for weekly concepts; these were translated into QuickTime or Flash videos for viewing on a host site. Houston and Lin [13] learned HTML in order to
develop a website that hosted her video content; she also recorded tutorials and aggregated other relevant material from sites like YouTube and vimeo. Lage and Platt [16] constructed a website that simulated a student’s real world environment; the site was split into a desk, library, the classroom, and a coffee shop. McLaughlin et al [20] used Echo360 screen capture software to record classes for anytime access for students. Papadopoulos et al [21] elected to create their own content modules through Moodle, a Learning Management System (LMS) platform and PowerPoint. Strayer [23] used an intelligent tutoring system to help students appropriately engage with content outside of the classroom. Walter-Perez and Dong [27] used tablet PCs with the DyKnow classroom management software, and a Yahoo group with embedded course materials to support their inverted model. Last but not least, Zappe et al [28] used iTunesU to host recorded lecture videos for out of class time.

The common theme in all of these studies 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 we 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 [8] 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 exploratory research question:

RQ: What are the design features of a tool that best support the inverted classroom environment structure?

3 METHODOLOGY

3.1 Theoretical framework

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 create the inverted environment, along with unique course experiences. Theory-based qualitative methods were chosen to tackle the research question, complemented by an interpretive epistemology for in depth comprehension of the phenomenon. In particular, Activity Theory was elected as the theoretical framework of choice. Hashim and Jones [12] state that Activity Theory has been used in a variety of fields like psychology, information systems, and management, and more importantly, 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 [12]. In education, researchers have used Activity Theory to guide an optimum design of tools to support computer-supported collaborative learning [12]. As Hashim and Jones [12] 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. Three versions of the framework have been elaborated and discussed, starting with Vygotsky [26], Leont’ev [7], and finally Engestrom’s most expansive formulation [7]. This 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 [7]. 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 [12]. In this 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 [7].

The aforementioned activity components are known as units of analysis. Instruments are also known as mediating artefacts, 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. For the objective of this study, major focus will be given to the instruments unit, where technology support and tool usage is most likely to be discussed.

Fig. 1 demonstrates the components arranged in the activity triangle discussed by Engestrom [7], using 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 artefacts. The division of labour depends on the size of the course, but roles for instructors in this structure include facilitator and coaching, 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. Finally, the object is the successful combination of tools and pedagogical strategy that then reach the final outcome of the activity, increasing active learning through an inverted classroom implementation.

The hierarchical system of this 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 [14]. Within these varying levels of activities, there exist sub-levels of contradiction. Contradictions are “historically accumulating structural tensions within and between activity systems [7]” (p. 137). Through use and change over time, units shift and create tensions between units; such a tension is referred to as a contradiction [7]. Sources of contradiction in this 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. 1 these potential interactions can be seen in the lines in between units of analysis. For the purposes of this study, this detailed level of investigation is unnecessary; instead a basic application of Activity Theory will be used, 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 is not appropriate.

![Activity System for the Inverted Classroom](image.png)

Figure 1 – Activity System for the Inverted Classroom

### 3.2 Data collection

Semi-structured interviews were chosen as an investigatory method, because this type of data collection supports our goal of broadly exploring this phenomenon and investigating best practices in regards to technological support. This method allowed us to extract rich and descriptive experiences from instructors. Each interview was used 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 working with 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. Overall, seven interviews were conducted and audio recorded while notes were taken concurrently. Pseudonyms are used when discussing specific comments made by participants.

The interview questions were initiated with general demographical questions to familiarize ourselves with the participant, followed by questions regarding their general educational experiences, and finally 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. Further, the questions were loosely based on the units of activity theory. The questions did not directly relate to the units of analysis because I needed to understand participants’ overall experiences, not coerce these experiences into top-down but inaccurate meanings.

3.3 Data analysis
After conducting and manually transcribing the interviews, a first-round coding process was performed guided by the Activity Theory framework. As mentioned previously, for the purposes of this study, only the general components of the framework were utilized. Analysis will not use the hierarchical system levels of activity, as these are complex in nature and require a more specific research problem where comparing different levels of activities is warranted. 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 us 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.

4 FINDINGS
4.1 Instructors as subjects
After a brief reading of notes taken during the interview, essential pieces of information on participants’ backgrounds proved to be intriguing. For example all of these instructors were similar in several ways. All of the instructors interviewed were of STEM related background, such as engineering and science, which relates back to Gannod’s [9] argument on the inverted structure matching particularly well with computing curricula that require considerable “hands-on” experience. Next, all instructors but one has experience teaching online as well as traditional and flipped courses. Another interesting observation is that four instructors had some formal background in education already through certificate training or an advanced degree. This group of instructors are conducting informal research in their teaching in order to test varying levels of the inverted classroom as well as other parts of 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 and with an orientation toward pedagogical experimentation to lead the way.

The ultimate goal with a snowball sampling was to aggregate a diverse group of participants. Our participants did have quite a range of teaching histories, and worked in four different colleges at the university, the similarities discussed here may have implications for the types of content and instructors who will be best matched with inversion pedagogies and tools.

4.2 The surrounding community
We found that instructors often gravitate 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 statement is acknowledged from a community perspective, where instructors are being influenced by a community of like-minded instructors to move toward a certain tool or approach to doing something differently. Likewise, Harold talks about a higher 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 such as tenured faculty, deans, committees, and senior staff may have a direct or indirect affect in whether an instructor is encouraged or supported in their attempt to try a non-traditional approach.

4.3 Inverted classroom as object

Instructors spoke at great length about their experiences implementing the inverted classroom and their own thoughts on its definition. Most have had great experiences, highlighting 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 discusses different learning styles and says,

[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 once and was finished using it. He was the only instructor who no longer uses the approach; he 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 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.
4.4 Technology and tools as instruments

4.4.1 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 is viewed 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 most likely 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.

4.4.2 External technology and tools

Moving away from Angel, instructors set out to find more interactive and innovative tools to enhance the 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 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.

5 DISCUSSION

5.1 Theoretical and design implications

As mentioned previously, our primary unit of Activity Theory analysis was 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 partake in many tasks by creating content and delivering it which students have access too, however, the rules 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, as it has been formerly stated that tensions can exist in a relationships between units.

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 worthy of 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. Above findings uncover several things. For instance, Angel is seen negatively, it is not their ideal template of what a functioning and aesthetically pleasing default system should be. Moreover, by limiting their use of Angel, these innovative instructors compensate 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 in negativity towards the tool affects the object and outcome directly.

Therefore, a tool devoted to this inverted style must capture the necessities of the administrative tasks like Angel but contain customizable features, almost like apps in a smartphone, such as the ability to disable them or remove them if they are not useful to your content or preference. Next, a responsive interface that adjusts to compatibility across all browsers and platforms is necessary to allow for convenience in the classroom and outside of it, for instance, mobiles, tablets, laptops, and wearable and ubiquitous technologies. Convenience is a crucial component to allow instructors to interact with students whenever or wherever. Though, not as much detailed design features were discussed or revealed, several ideas for prototypes were discussed based on current tools instructors are using to help support the inverted model.

6 CONCLUSION

In this paper, we reported a small-scale exploratory study on the use of support technologies of the inverted classroom. The goal of the study was to better understand the inverted classroom phenomenon and elicit design basic features for tool that best supports 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.

In terms of design and technology, a custom prototype 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 prototype must incorporate the important administrative features while including the interactive pieces such as blogs, wikis, video and audio creation and production, the last one especially unique to the inverted classroom.

The importance of these findings may lead to other technological studies on the inverted classroom or create a space for research to move forward in this direction. Joe put it ever so clearly,

"[Joe] I think distance ed is seventy percent of the future of education and something people have to pay attention to it."

Not only is the field of education changing through technology, but designs of technologies for applications in education are undergoing a big transformation as well. Whether it is online, hybrid, blended, or inverted, these discussions are not going away anytime soon. Further research must take a look at the role of technology in the inverted classroom.

7 LIMITATIONS AND FUTURE WORK

Limitations of this research include time constraints, as we had a relatively short period for data collection and analysis (all of it needed to be performed by the end of April 2014). If allotted more time, multiple data sources would have been collected to reach a greater means of triangulation. Further, a bigger sample of instructors would have generated a greater variety and depth of findings. Last, 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 the processes instructors entangle themselves in.

Based on these results, future work may head in several directions. For instance, one option would be to continue the interview-based approach on a larger scale by interviewing a larger set of instructors on their inverted classroom experiences and employing multiple sources of data collection to enhance the quality of research. Due to promising leads on the types of technological implementations to
support the inverted classroom, another option would be employ a design-based research study where low-fidelity prototypes of a system are user tested in several case-based scenarios. On the other hand, a quantitative 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. Further consideration will be given towards the next step in this work.

REFERENCES


