Learning Environ Res (2012) 15:171–193
DOI 10.1007/s10984-012-9108-4

ORIGINAL PAPER

How learning in an inverted classroom influences cooperation, innovation and task orientation

Jeremy F. Strayer

Received: 30 December 2009 / Accepted: 18 October 2010 / Published online: 20 July 2012

Abstract Recent technological developments have given rise to blended learning classrooms. An inverted (or flipped) classroom is a specific type of blended learning design that uses technology to move lectures outside the classroom and uses learning activities to move practice with concepts inside the classroom. This article compares the learning environments of an inverted introductory statistics class with a traditional introductory statistics class at the same university. This mixed-methods research study used the College and University Classroom Environment Inventory (CUCEI), field notes, interviews and focus groups to investigate the learning environments of these two classrooms. Students in the inverted classroom were less satisfied with how the classroom structure oriented them to the learning tasks in the course, but they became more open to cooperative learning and innovative teaching methods. These findings are discussed in terms of how they contribute to the stability and connectedness of classroom learning communities.

Keywords Blended learning · Classroom flip · Educational technology · Intelligent tutoring systems · Inverted classrooms · Mathematics education · Statistics education

Introduction

Educators know all too well the persistent challenge of how best to use technology when helping students learn. With the increased availability of the internet and computer applications over the past 20 years, college and university professors have strengthened their commitment to use computer technology to enhance classroom learning. As with any educational tool, there are many strategies for using computer technology. One such strategy relies on technology to introduce students to course content outside of the classroom so that students can engage that content at a deeper level inside the classroom (Baker 2000; Collins et al. 2001; Gannod et al. 2008; Lage et al. 2000; Strayer 2009).

J. F. Strayer (✉)
Department of Mathematical Sciences, Middle Tennessee State University, 1301 East Main Street, Murfreesboro, TN 37132-0001, USA
e-mail: jeremy.strayer@mtsu.edu

Because this way of structuring the classroom turns around the more traditional pattern of introducing students to content inside the classroom and assigning homework to engage content at a deeper level outside the classroom, it is referred to as the *inverted classroom* (Lage, et al. 2000) or the *classroom flip* (Baker 2000).

Perhaps the inverted classroom design has been around for decades as teachers have required students to read course material before coming to class and engage the concepts at a deeper level during class. In addition, some could say that teachers who used educational television or computer-assisted instruction during the past 40 years of educational technology use were inverting their classrooms. However, what makes the concept of the inverted classroom as presented in this article novel is the *regular and systematic use of interactive technologies* in the learning process. Indeed, the inverted classroom has arisen within a broader 15-year pedagogical development in higher education that has seen an increased mixture of face-to-face classroom experiences with online learning experiences from the distributed learning tradition. This mixture of methods has garnered the name *blended learning* (Bluic et al. 2007; Chandra and Fisher 2009; Donnelly 2010).

Research has shown that, for blended learning environments to be successful, it is important to structure the face-to-face and the online portions of the learning experience so that they coherently support one another to help students to achieve the learning goals for the course (Ginns and Ellis 2007). When the online and face-to-face portions of the learning experience are not carefully aligned, studies have shown that technology can become a barrier for students as they choose how fully they will invest in the learning goals of the classroom (Buerck et al. 2003; Elen and Clarebout 2001). Other research has shown that successful blended learning occurs when teachers go beyond just replacing the lecture with an online learning event. Interactive technologies make it possible for educators to qualitatively reconceptualise the teaching and learning dynamic. By augmenting the fast-paced interaction and dialogue that happens in the face-to-face setting with an online learning environment that gives students space to take in new ideas, deliberate and carefully express their thoughts on the subject, teachers are able to create learning communities that are more connected and more stable than we have seen in the past (Garrison and Kanuka 2004; So and Brush 2008). Learning environment theories connect strong classroom community with positive perceptions of the learning environment. Further, it is well documented that students' perceptions of their learning environment in the classroom community are positively related with quality learning, with recent research showing that this correlation holds for blended learning environments as well (Chandra and Fisher 2009; Ginns and Ellis 2007).

As already mentioned, the inverted classroom course design was developed out of the desire move the lecture outside the classroom (if not replace it with technology) to make room for in-class investigations. This motivation contrasts with Garrison and Kanuka's (2004) call for blended learning to bring about a reconceptualization of the learning process that results in stable and connected learning communities, rather than just a replacement of the lecture with technology. In this investigation of the learning communities of classrooms, I used a mixed-methods comparative study of the learning environments of two college-level introductory statistics classrooms: one of them inverted and the other a traditional lecture-homework classroom. Guided by the research question "How does the learning environment of an inverted introductory statistics classroom compare with the learning environment of a more traditional lecture-homework introduction to statistics classroom?", I investigated the learning environments of these two learning communities. The motivation behind this research was a desire to inform teaching practice and suggest implications for structuring productive classroom learning

communities. As the analysis of this research unfolds, I gained insight into the stability and connectedness of these two learning communities and the effect that the course design had on their respective learning environments. These findings will have useful implications for educators and researchers interested in blended learning and learning environments.

Design

As with many blended learning research studies, this research compared a blended and non-blended classroom and it took place in the researcher's own classroom. Following Bliuc, Goodyear and Ellis' (2007) recommendations for these research settings, I combined case-study methods that provide rich description of the classrooms under investigation with more-developed grounded-theory qualitative analysis and quantitative survey methods. One classroom in this study was an inverted classroom that used an intelligent tutoring system to introduce students to classroom content outside the classroom, and the other classroom was a more traditional lecture-homework style classroom. Students in both classrooms responded to the College and University Classroom Environment Inventory (CUCEI) (Fraser et al. 1986) to assess their perceptions of the learning environment (both what they preferred and what they actually experienced). Other data were collected using audiotaped classroom sessions, individual and focus-group interviews, field notes from research team members, and reflective journal entries.

Intelligent tutoring systems

An intelligent tutoring system is a computerised learning system designed to help students learn content by engaging them in the way in which human tutors do. This study used the ALEKS (Assessment and Learning in Knowledge Spaces) intelligent tutoring system in the inverted classroom to help students to learn introductory statistics content outside class.

Assessment and Learning in Knowledge Spaces uses artificial intelligence techniques, advancements in the area of expert systems, and knowledge space theory to model student learning of items in a specific knowledge domain (Falmagne et al. 2006). Knowledge space theory is built on the premise that the domain for a given topic can be described using a formal mathematical structure without any reference to its interpretation in human minds (Lukas and Albert 1999). Each bit of knowledge in the domain is called an item. The theory contends that each student has mastered a certain number of items, and these items are called the student's knowledge state. Based on students' knowledge states, they will be ready to learn new items in the domain. These ready-to-learn items are called the outer-fringe. Similarly, there would be items that students understand but have not quite mastered; these items are called the inner fringe. According to knowledge space theory, as students strengthen their understanding of inner-fringe items, those items become part of their knowledge state and, as students work to learn new content, outer-fringe items move to the inner fringe. Working in this way, students are able to progress through a learning path of ever-growing knowledge states, eventually ending with mastery of the domain (Albert and Schrepp 1999; Doignon and Falmagne 1999; Falmagne 1993; Falmagne et al. 2006).

In an inverted classroom, teachers can use an intelligent tutoring system such as ALEKS to introduce students to course content outside the classroom. ALEKS gives a full explanation of course content and provides examples of the concepts when students are ready to learn them. Well-developed intelligent tutoring systems tend to have minimal

technical difficulties and are designed to have a comprehensive knowledge base that should satisfy teachers' requirements for content coverage. Because the ALEKS programme met both of these criteria, it was chosen as the technology system used in the inverted classroom course for this study.

A learning environments framework

The CUCEI used to assess the learning environment in this study follows Moos' seminal framework for describing human social environments (Moos 1979, 2003). In Moos' framework, variables that influence human environments fall into one of three domains: relationship, personal growth, or system maintenance and change. The *relationship* domain describes those things in the environment that encourage people to be involved both with one another and with what is happening around them. This domain can be thought of as the extent to which community is developed in the environment. It deals with how freely people share information with one another, how invested people are in the common goals of the environment, and how deeply people participate in the tasks of the environment. The *personal growth* domain describes the way in which the goals and structure of the environment support and encourage the personal development and learning of the people in the environment. Critical variables in this domain explain how free people are to act, how much importance is placed on the personal growth of those present, and how competitive or cooperative the environment is. The *system maintenance and change* domain describes the day-to-day practical structure of the environment. It explains the norms with regard to appropriate behaviour, daily procedures, communication and how the structure of the environment equips those present to deal with change when the expected norms are not achieved.

Setting

This research took place in two different introductory statistics classrooms taught by me at a U.S. university. A demographic analysis of students at this university shows that a typical student at this university is a middle-class White American from the Midwest. At the time when the research was conducted, I had taught in the mathematics department for 6 years and had a great deal of experience in teaching introductory statistics using both traditional and innovative teaching methods.

For this study, one statistics class was structured according to the inverted classroom format and met in a computer laboratory. Outside class, students were introduced to new content by working with the ALEKS intelligent tutoring system. When students came to class, they completed activities that were designed to help them to engage the content they were learning in ALEKS in a different context. Students could interact with each other and the professor in class as they worked to strengthen their understanding of the more formal mathematical material presented in ALEKS. Often, the in-class activities required students to use a spreadsheet programme as a tool for data analysis.

The other statistics class in this study was structured according to a traditional lecture-homework format with students coming every day to a classroom with tables and chairs and hearing a lecture about statistics content. These lectures were heavily content driven. I would introduce statistical concepts and then work through examples that used those concepts. During the lectures, students had opportunities to ask questions or answer my questions related to the examples discussed. In this way, I made an effort to make the

lectures as interactive as possible. Every two or three class periods, students were assigned a set of problems from the book to complete as homework.

Participants

Most students in the inverted and lecture-homework sections of introduction to statistics agreed to participate in this research. Twenty-seven of the 28 students in the lecture-homework classroom consented to participate, as did 23 of the 27 students in the inverted classroom. One lecture-homework participant dropped the class a few weeks into the semester for scheduling reasons, leaving 26 participants who finished the study in that class. Participants from both classes were evenly split by gender (13 females, 13 males and 12 females, 11 males). The majority of students in both sections were in their first or second year of university study: 21 in the lecture-homework class and 14 in the inverted class. Also, the academic interests of students in both classes were quite diverse. Fifteen different majors were represented in the lecture-homework class, including Business, Psychology, English, Mathematics Education, Biology, Spanish and Theological Studies. The inverted classroom had 14 different majors, including Accounting, Chemistry, History, Sociology and Sports Management.

Quantitative data collection

Since the beginning of the semester, students in the two different sections of introduction to statistics had experienced learning in their respective environments (inverted vs. lecture-homework). With 2 weeks left in the semester, the CUCEI (Fraser et al. 1986) was administered to provide insight into (1) students' perceptions of their actual learning environment and (2) students' opinions of what their ideal (preferred) learning environment would look like. The CUCEI is grounded in Moos' (1974) theory that all human environments contain relationship dimensions, personal development dimensions, and system maintenance and system change dimensions. Accordingly, the CUCEI measures perceptions of the learning environment using seven scales: Personalisation (relationship and personal growth), Innovation (personal growth and system maintenance and change), Student Cohesion (relationship), Task Orientation (personal growth and system maintenance and change), Cooperation (relationship and personal growth), Individualisation (personal growth and system maintenance and change) and Equity (personal growth and system maintenance and change). The development of this instrument was guided by findings of studies that used similar validated instruments to measure learning environments in elementary and secondary schools. Further, the CUCEI's internal consistency reliability for the seven scales has been reported as quite acceptable in multiple studies, with Cronbach's alpha coefficients ranging from 0.70 to 0.90 (Fraser 1998; Fraser et al. 1986).

Qualitative data collection

Qualitative methods were used in this research to study the learning environments of the two classrooms in their natural setting. The primary goal was to provide data that could be analysed using a descriptive and analytic approach so that I could better understand the participants' perspectives on the learning communities under study (Marshall and Rossman 2011). Towards that end, researchers regularly collected data from the classrooms using

participants' words and actions as the chief data source because authentic interaction with the participants would be crucial to establishing credible findings.

First, field notes were collected to gain insight into student behaviour in the classroom. Recognising the importance of triangulating data sources (Patton 2002), four researchers were enlisted to be part of a data-collection team to observe and take field notes for the classroom settings during the middle and again towards the end of the semester. The data collected from participant observation field notes were taken in a way that sought to minimise observer bias by keeping recorded observations at as low a level of abstraction as possible and avoiding making assumptions and generalisations when observing events (Pelto and Pelto 1978).

Other data were collected during selected class sessions (at the beginning, middle and end of the semester) using sound recordings produced as I taught the courses while wearing a microphone. When classes were over, tapes were transcribed and analysed. I also made observations in a reflective teacher journal after these and other class sessions throughout the semester. In this journal, I reflected on how the class was going in general, specific struggles and successes, the emotions that I felt, how well that I thought that students were learning, and how I changed course instruction throughout the semester to help students to learn.

Three members from the data-collection team also conducted one-on-one and focus-group interviews at the end of the semester. During these interviews, participants told their storey of what was happening in class (Seidman 2006). In telling their storeys, participants reflected on their experiences, gave order to those experiences, and then told a storey about those experiences in order to communicate the meaning that they had derived from the event under study. These interviews produced valuable data that served to focus the research effort during analysis (Wolcott 2005).

Data analysis

The purpose of this research was to compare learning environments in a way that informed teaching practice and suggested implications for classroom learning communities. With this goal in mind, mixed-methods data analysis techniques were used to analyse data from both the analysis of variance and the grounded-theory data-analysis traditions. Qualitative data were initially coded, quantitative analysis was conducted, and then further qualitative analysis was performed. This approach to mixed-methods analysis was employed in an effort to let the data speak for itself and to minimise any initial bias that the quantitative survey could bring into the qualitative analysis. After establishing a strong base of qualitative analysis, an analysis of the quantitative data helped to focus the further analysis in ways that were productive and consistent with current developments in the field of learning environment studies.

The body of qualitative data were first analysed using open coding. After writing a number of exploratory memos on the unfolding analysis and coding the qualitative documents (including student reflections, focus-group observations, interview observations, exploratory memos, classroom observations and transcripts of class sessions), CUCEI data were analysed using a number of quantitative methods including Cronbach's alpha reliability coefficients, discriminant validity measures, exploratory data analysis, repeated-measures multivariate analysis of variance, t tests, and Cohen's d effect size calculations.

After the quantitative data were analysed, the qualitative analysis continued using techniques consistent with grounded theory to explore further questions that emerged with regard to learning in an inverted classroom environment. The data analysis included

organising the data, generating categories and themes (through axial coding and memo writing), testing hypotheses (through axial coding, selective coding and memo writing), searching for alternative explanations (through axial and selective coding) and writing the report (Charmaz 2000; Strauss and Corbin 2008; Marshall and Rossman 2011).

Findings

Findings for this research are reported in two main sections. An analysis of the quantitative results first provides a picture of what happened in the two classrooms under study. Second, a report of the qualitative findings is given not only to corroborate the quantitative results, but also to colour in and bring into focus the picture that was sketched by the quantitative results. The concluding main sections synthesise the findings and culminate in recommendations for practice and further study.

Quantitative results

Let's begin by reporting reliability and discriminant validity measures for the CUCEI. Each scale of the CUCEI is listed in Table 1 together with its Cronbach alpha reliability. Observed correlations between the scales are reported above the diagonal, whereas correlations corrected for attenuation due to unreliability are reported below the diagonal. Apart from Individualisation, all CUCEI scales have reliability measures above 0.7. This result is consistent with other administrations of the CUCEI with much larger samples. Because all corrected correlations are below 0.85 (see Table 1), discriminant validity can be assumed.

Because of the multidimensional nature of the CUCEI data, and because each student took the preferred and actual version of the CUCEI using a paired design, repeated-measures MANOVA was used to analyse the data. For each student, I paired their actual and preferred answers for each scale and used these as the within-subjects factors. I used instructional method (traditional or inverted) as the between-subjects factor for the analysis. Results from the MANOVA are shown in Table 2. We can see from these results that the version of the CUCEI (actual or preferred) explained 64.2 % of the overall variation in the data. Instructional method explained 44.5 % of the overall variation in the data. Both of these effects were statistically significant. Further, the interaction effect between version of the CUCEI and instructional methods explained 35.5 % of the overall variation in the data.

To investigate which of the scales had significant effects on CUCEI scores while taking into account the between-subjects factor involving which class the students were in, I performed a test of between-subjects effects. Table 3 presents these results and shows significant effects for Innovation, Cooperation and Task Orientation. It also appears that the Personalisation and Individualisation potentially could show a trend towards significant effects.

Because the MANOVA yielded significant results, paired and independent t tests were used to further analyse the data. One question of interest was how students think of their actual learning environment compared to their preferred learning environment. In Table 4, the means and standard deviations for each of the scales of the CUCEI are presented for the actual and preferred versions. Students as a whole felt that their actual learning environment was not measuring up to their preferred environment. Every mean for the actual version was statistically significantly lower than for the preferred version.

Table 1 Alpha reliability and discriminant validity (scale intercorrelations) for the CUCEI

Scale	α	Scale intercorrelations						
		Personalisation	Innovation	Student Cohesion	Task Orientation	Cooperation	Individualisation	Equity
Personalisation	0.90	–	0.37	0.27	0.35	0.37	0.34	0.53
Innovation	0.71	0.46	–	0.33	0.02	0.56	0.46	0.31
Student Cohesion	0.78	0.32	0.44	–	−0.06	0.38	0.29	0.15
Task Orientation	0.74	0.43	0.02	−0.08	–	−0.01	−0.08	0.67
Cooperation	0.94	0.41	0.69	0.44	−0.01	–	0.29	0.12
Individualisation	0.67	0.43	0.67	0.40	−0.11	0.37	–	0.16
Equity	0.93	0.57	0.39	0.18	0.80	0.13	0.21	–

Observed correlations reported above the diagonal, whereas correlations corrected for attenuation are given below the diagonal

Table 2 Repeated-measures MANOVA for version of CUCEI (actual vs. preferred) and Instructional method (inverted vs. traditional)

Effect	*df*	*F*	*p*	Effect size (Wilks')	Effect size (multiple $\hat{\eta}^2$)
Version of CUCEI	7, 40	10.25	<0.001	0.358	0.642
Instructional method	7, 40	4.58	0.001	0.555	0.445
Version × instructional method	7, 40	2.75	0.02	0.675	0.325

Table 3 Tests of between-subjects effects for the CUCEI

Source	Measure	*df*	*F*	*p*
Class	Personalisation	1	3.62	0.063
	Innovation	1	13.91	0.001***
	Student Cohesion	1	0.28	0.597
	Task Orientation	1	5.55	0.023*
	Cooperation	1	10.92	0.002**
	Individualisation	1	3.57	0.065
	Equity	1	1.79	0.188

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 4 Difference between scores for actual and preferred versions of each CUCEI scale

Scale	Actual		Preferred		Difference
	Mean	SD	Mean	SD	*t*
Personalisation	3.93	0.80	4.44	0.53	−0.51**
Innovation	2.91	0.54	3.45	0.68	−0.54**
Student Cohesion	2.84	0.67	3.57	0.67	−0.73**
Task Orientation	3.75	0.61	4.46	0.52	−0.71**
Cooperation	3.44	0.89	3.89	1.00	−0.45**
Individualisation	2.48	0.59	3.21	0.57	−0.73**
Equity	4.41	1.00	4.83	0.41	−0.42*

* $p < 0.05$; ** $p < 0.01$

Another question of interest was whether students' scores on the CUCEI differed between the traditional and the inverted classrooms. Table 5 shows the means and standard deviations for each subscale of the *actual* version of the CUCEI for the traditional and the inverted classrooms. Statistical significance was assessed using independent-samples *t* tests and Cohen's *d* was used as a measure of the effect size. There are significant differences between the traditional and inverted classrooms on the actual version of the survey for the Innovation, Task Orientation, and Cooperation subscales. Also effect sizes were sizeable.

I next performed the same analysis between the two instructional approaches for the *preferred* version of the CUCEI. Table 6 shows the means and standard deviations for each scale of the preferred version of the CUCEI for the traditional and inverted classrooms. Differences were again analysed using an independent samples *t* tests and Cohen's

Table 5 Difference between instructional groups for actual form of each CUCEI scale

Scale	Traditional		Inverted		Difference	
	Mean	SD	Mean	SD	*t*	Cohen's *d*
Personalisation	3.74	0.82	4.13	0.75	−1.71	−0.51
Innovation	2.74	0.44	3.08	0.60	−2.22*	−0.67
Student Cohesion	2.69	0.61	3.00	0.71	−1.61	−0.48
Task Orientation	4.00	0.40	3.51	0.69	3.00**	0.88
Cooperation	2.97	0.91	3.90	0.59	−4.24***	−1.24
Individualisation	2.38	0.62	2.58	0.56	−1.15	−0.34
Equity	4.63	0.80	4.19	1.13	1.52	0.46

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 6 Difference between instructional groups for preferred form of each CUCEI scale

Scale	Traditional		Inverted		Difference	
	Mean	SD	Mean	SD	*t*	Cohen's *d*
Personalisation	4.32	0.56	4.56	0.49	−1.58	−0.47
Innovation	3.14	0.58	3.76	0.64	−3.52***	−1.04
Student Cohesion	3.65	0.64	3.50	0.71	0.79	0.23
Task Orientation	4.48	0.64	4.43	0.37	0.37[†]	0.10
Cooperation	3.60	0.98	4.18	0.96	−2.09*	−0.61
Individualisation	3.08	0.56	3.35	0.57	−1.67	−0.49
Equity	4.84	0.50	4.82	0.30	0.16	0.05

* $p < 0.05$; *** $p < 0.001$

[†] Significant for actual version but not for preferred version

d. Students in the inverted class preferred an environment with greater Innovation and Cooperation when compared to the traditional class. There was no evidence of a difference in preferences for the other scales (including Task Orientation).

Comparing the preferred version results with the actual version shows that students felt their preference for Innovation and Cooperation were met in the actual experience of class. However, the lack of a difference in *preference* for Task Orientation in the traditional and inverted classrooms combined with a significant difference in their *actual* experience shows that students in the inverted classroom likely felt the task orientation aspect of the learning environment was not meeting their expectations. This result provides a useful lens for viewing the qualitative findings in this study.

Qualitative findings

Using grounded theory analysis techniques, I conducted a theme analysis with the qualitative data to provide insight into the study's guiding question: How does the learning environment of an inverted classroom compare to the learning environment of a lecture-homework classroom? The overall qualitative analysis began with an initial open coding of the body of data. This coding included 115 codes such as student interactivity, learner

engagement, task completion, confusion, humour, relaxed and shift-in-thinking. Through the process of memo writing and constantly revisiting the original data and original codes, I determined the following major categories in the data: classroom relations, logistics of class, theoretical influences on learning, practical influences on learning, personal/emotional influences and classroom peculiarities. Next, I revisited the data and, reflecting on possible linkages between codes, I observed properties for each category and built dimensional ranges for each property. For example, two of the properties of the logistics of class category were atmosphere (which ranged from structured to loose) and innovativeness (which ranged from same old to new). After identifying a number of properties and dimensional ranges for each property, I returned to the data to check the fit of these properties with the data. I went through this process multiple times and, as the analysis progressed, I felt that I was swimming in the data. There was just so much going on and so many directions in which the analysis could go.

At this point, I allowed the guiding question of this investigation to focus a theme analysis of the data on the cultures of the two environments under study. When I investigated the interconnectedness of the properties and dimensional ranges of categories in the data in light of the culture of the learning community, three areas emerged as major contributors to how students interacted with the material, the professor and each other in the classroom. The three areas were types of activity, homework dynamics and in-class dynamics.

Types of activity

Inverted classroom students completed a number of different types of learning activities throughout the semester. The course began with a 3-week open ended investigation into data 'collected' from fictitious customers of a fictitious business owner named Jack. After completing this investigation, students revisited the Jack data throughout the semester to complete smaller activities lasting from half a class period to two class periods. Students also completed smaller investigations from data examples at various times. Finally, students completed longer problems towards the end of the semester to practise inferential statistical techniques. Peppered throughout the semester in the midst of these activities, I offered explanations, examples and mini-lectures during class.

All of this varied activity influenced the culture of the classroom so that students never really settled into a pattern for 'how to do class'. At times, students clearly did not know what to expect or where class was going. In one interview, a student expressed this by saying that "Mr. Strayer tries to explain stuff well, but he doesn't explain stuff from the beginning." While many other data sources supported this unsettledness of classroom activity, perhaps the most telling was the following focus-group interchange with inverted classroom students (all names are pseudonyms) referring to mathematics that 'magically' appears.

Jenny I like when we do the sample problems. He passes out the little handouts and you have to work through them. And the first time we did one of those, like that's the first time it starts to make a lot of sense. Because when you're just up there doing it on the board, or he's just clicking through his PowerPoint and all of the solutions are just magically on the slide, I mean do you guys learn from those? I know I don't. I don't really follow the math that's magically on the board. I mean if he hands me a couple of formulas and says anytime you have this problem, you use this formula, I can memorize that.

	But if he hands us a problem and lets us struggle through it, and we have to try to come up with the formulas on our own, I think we remember them better
Amy	Apply what you learned
Jenny	Yeah
Amy	Uh huh
Facilitator	Say that again
Amy	Apply what you've learned
Facilitator	Okay
Amy	It's pretty much, I mean if you do take, I take extensive notes. Just because, very detailed notes, because it is … it seems pretty slow, so you have to know what you've done, and then I'll go back and look at them. And then, if he does give like the handouts, I'll be able to apply what I've learned
Facilitator	Do you ever have opportunities to apply what you've learned?
Amy	Uh huh
Facilitator	In what context?
Jenny	He'll hand us little half-sheets with a question on it, and then we work with the person beside us in partners to answer the questions
Amy	Yeah
Facilitator	How does that go usually?
Amy	Usually pretty well
Jim	(laughs) Sometimes you get (clears throat)
Charles	Distracted
Jim	(clears throat) Yeah, or neither of you know what you're doing. (David sheepishly laughs.) And then it becomes you just sit there for like 20 minutes. And then he'll go up to the board and then go over it
Jenny	Although, when he does that though, he walks around the class and, if there's a group that has gotten it and the group beside them hasn't, he'll be like well, you explain it to them. And he'll keep walking around, and so eventually he tries to get some one on one attention with every group
Charles	Jenny usually just explains it to me and Jim (Laughter)

In this interchange, when Jenny expressed her dislike for mathematics that "magically appears on the screen", the rest of the focus group confirmed that most students felt lost and did not know what was happening in class. These statements are examples of the unsettled feelings caused partly by such varied activity in the classroom.

In another individual interview, a very bright student (Laura) said that class moves really fast because "there's always something to do … there's always something to do". Laura spoke in her interview of being uneasy with different class activities and being troubled about "taking a stab in the dark" at different problems. In an interesting turn of phrase that illustrates the difficulties of adjusting to varied activity, Laura said: "I'd rather him pick a problem that we were actually working on at home, either in-class or exam-type problems. I would get lost when he would make up a scenario and keep going because a lot of it just came out of his head." The problems that "came out of my head" were problems that involved collecting data from students during class and then conducting a hypothesis test on that data. For example, if I wanted to do a hypothesis test that compared two means, I could test the hypothesis that female students at the university have a different number of pairs of shoes than males, and collect data from students in class to see if this hypothesis is

supported. When I did investigations like this in class, I would have the problem written out in a spreadsheet file and ask the students to copy it down. Then I would ask students to enter the data into the computer as we collected it so that we could go through the analysis together. Laura reacted to activity that "just came out of his head" perhaps because it felt arbitrary; she preferred to have a problem written out exactly the way in which it would be on homework or the examination. Laura represents those students in the class who found it difficult to learn from and see the value in the many different types of in-class activities in which the class engaged.

Although students expressed frustration with an environment full of varied and unexpected activities, they both adapted their learning strategies and came to see value in helping each other learn with a cooperative approach. These features of the classroom are corroborated in the focus group in the following segment:

Facilitator	So what do you have to do, then, to adapt in order to maximise your learning?
Amy	Learn how to ask questions, learn how to keep his attention right on you. If you don't understand, he'll move on real quick from one subject to the next, and if you don't understand that one, you have to like move him back. Which means wording it just right - and keeping his attention on that part strictly right there. So you have to like learn how to adapt on his thinking to get him to help you out the way you think
Facilitator	Those of you who are in the business of helping others during class, how does that affect your learning in the classroom?
Jenny	You learn more
Facilitator	You learn more by helping?
Jenny	Uh huh
Charles	I think that with me and Jim we're about on the same level,
Jim	However high or low that may be. (laughs)
Charles	But the thing is, is that sometimes Jim gets things that I don't get and I get things that he doesn't get and so we kinda help each other. You know I'll be like, no this is the way you do it, and he'll be like, no this is the way you do that
Jim	And sometimes it's just the blind leading the blind
Facilitator	It's the hand in the air
Charles	Or Jenny
Jenny	Yeah, I'll help
David	You retain a lot more knowledge if you teach it to somebody
Amy	Uh huh
Jenny	Yeah, a lot more
Facilitator	OK (drawn out and raised inflection in voice. The facilitator seems to be saying, "Do you guys get it?")
Charles	That could be a good tool within the class is to have after you do something, say this partner teach this partner right now and then five minutes later this partner kind of explains it. You know, I don't know. Because, for a lot of people, I know that to teach it is a good tool
Jenny	That was the one good thing. I don't think it was the Jack, it was the follow-up to Jack. Where we had to explain like what we did. We had to write up an explanation of what we'd done. I think that was really helpful
Jim	Oh right, our report
Charles	So if we did that maybe more often, then that would have been…

Jenny	Yeah, you really have to understand what you're doing to explain what you did. Not just show the math or show the work or whatever
Bill	I thought Jack's problem, I mean like even though he didn't teach us, it kinda showed us what we'd be learning and how it would be useful, like if we had our own business, you know it showed us how like
Facilitator	Are you a business major?
Bill	Yeah, I thought I was like, that kinda got me interested a little, I mean a REAL little (laughter)
Charles	If you were a statistician
Jim	See, most business people, they just pay a statistician
Jenny	Yeah
Charles	Yeah

With the traditional class, we see a strikingly different activity pattern in class. There was a set blueprint for class activity and we rarely deviated from it. Speaking about the course in an interview, Mark (a mathematics major) said: "You always know what to expect from him. There is structure in the class. He'll tell a story to get people's attention, then take notes from PowerPoint, then provide one or two examples from what we learned and, by then, we've pretty much used up the class period." Another traditional class student (Jacob) gives a nice contrast to Laura's statements above when he said in an individual interview: "Sometimes he'll just make up a problem that we'll do. We'll go through the PowerPoint. He's good at making sure that we don't rush through everything. He's good at making sure you pick up on the key points." Jacob clearly does not seem to have difficulty with problems that I "make up". In this class, because discussions were usually held at the whole-class level, students were rarely broken into smaller groups to complete a task. Further, there was no evidence in the data that students formed small study groups outside class to help one another learn.

The above analysis captures nuances in the differences between the two different classes' learning activity types and how these differences influenced the overall culture of the classroom. For the traditional classroom, having a set pattern to class activity made it possible for students to better tolerate slight changes in the way in which the class was conducted. However, for the inverted classroom, students seemed always to be on edge, never feeling completely comfortable with how to engage with the material or use the class time. Within this environment (and perhaps because of this environment), students saw the value of cooperation and a group learning approach as they came together to help each other complete the course.

Homework dynamics

Although the inverted classroom completed homework using ALEKS and the traditional class completed homework out of a book, there were similarities in the homework dynamics between the two classes. Students in both classes clearly expressed that it was difficult to stay up with the homework and complete what was assigned. For the inverted classroom, because the homework was due every 2 weeks, it was easy to put off and try to complete all at once. Many students felt guilty about this because I encouraged them to work regularly on ALEKS, but this guilt was not a successful motivator. For the traditional group, students in the class were never sure if I would collect the homework or not on any given day. They felt that the homework was easy, and many of them put it off until the last minute. These students were frequently unwilling to complete the homework and just hope

that I would not collect it that day. Clearly, for both classes, completing homework was not a top priority for everyone.

Though there were similarities, there was an important qualitative difference in the homework dynamics between the two classes. To get the most out of the homework in the inverted class, students needed not only to complete the ALEKS assignments regularly, but to connect the concepts from in-class activity to the assignments in ALEKS. Because sometimes ALEKS explained concepts and procedures differently from the way in which we discussed them in class, it took a considerable amount of discipline and effort make the connection between the two. In an environment where students struggled just to complete the ALEKS assignments, it was often difficult for students to consciously make the in-class connections with ALEKS.

Students in the traditional class, on the other hand, did not experience this complication. When students from the traditional class completed their assigned homework, it looked very similar to what we did in class. If some students did not complete their homework, they would still get to see some of the assignment completed if a student asked a question at the beginning of the class when it was due.

When the traditional classroom students received sample examinations from which to study, all of the problems looked similar to what they had seen in class and what they had practised for homework. Because of the online nature of ALEKS, it was inevitable that the examinations and assignments that we did in the inverted classroom would look and feel different from ALKES work. In theory, this could be a benefit. Students in the inverted section would see concepts in many different contexts, from diverse in-class activities to varied online assignments in ALEKS. In this environment, students have the opportunity to transfer their knowledge between contexts and thus strengthen their conceptual understanding. However, in the way in which the class unfolded, the environment was just not focused enough for students to successfully accomplish this type of learning in practice.

In-class dynamics

The dynamics of in-class interaction in both classes were quite complex. As the professor, I wanted students to feel free to speak when they had questions or comments, as well as to feel engaged by the material and the professor. I also wanted students to engage with the material in class as much as possible. Therefore, I worked to create an informal atmosphere that took learning seriously for both of the classrooms under study. Here, I present two segments from the focus groups to illustrate the atmosphere in each class. The first segment comes from the inverted class, whereas the second segment comes from the traditional class:

David	Um, I think students should be expected to do what Strayer says. If he says don't mess around with the computer, then don't mess with it. I think we're expected to be awake and attentive and taking notes in his course… everything that I don't do
	(Laughter)
David	We should be expected to do it. And I try to do it sometimes because I feel guilty, but I don't know, I don't feel *that* guilty to do it all the time
Facilitator	Ok, what do some of the rest of you think should be expected of students inside the classroom?
Jenny	Well, I think like what he said. To a large extent it's just acting like an adult and putting value in your own education to be motivated to care and like do it.

	And the sad thing is that we're not. I mean we *don't* care. I think that, for most of us, I mean we're in stats because we have to be. I mean none of us are statistics majors. We don't even offer that. So we're all in here kinda like, "This is retarded; it has nothing to do with my major. Why am I here? But I'm required to take it." And that's just kind of our attitude, and I think that might be the biggest downfall of the class is just … that's kind of what we all think
Facilitator	Not necessarily ALEKS per se, or the style of the professor …
Jenny	No
Facilitator	But the attitude…
Jenny	It's just *why* we're here
Charles	Yeah
Jenny	And that's one of the other things, like I think Strayer does a really good job of being our friend, but I don't think he did a very good job of ever getting our respect. I mean like he says turn off the computers and we go, ''Aw, Come on Strayer, you don't really mean it." And he never, I mean he never yells at us. He never gets mad about it. He doesn't care (Laughter)
David	He yells at me all the time
Amy	Yeah he does
Jenny	Yeah, but he just jokes around about it, he's not mean, I mean he's not
Amy	I don't know, he can be
David	This one time, I started sleeping in his class, and I sit in the front row, and my feet were sticking out the desk and he kicked me! (Laughter)
Facilitator	Did it wake you up?
David	Yeah, it freaked me out. I was like dreaming
Facilitator	Let me ask you this. A lot of you guys mentioned personal responsibility oriented things. You know this is what you *should do*. You actually accentuated those words. What would get you to that point, do you think? … In a class that you are required to take that doesn't necessarily grab you?
Jenny	I think if the professor made it really interesting. And like if he could somehow *make* us care. And like somehow, apply (some members of the group are laughing), I mean do you know what I mean? I mean if he could apply it to something where we could be like, "Wow this is cool." Or make us feel like we're really smart because we know how to do this, and so we'd be like, "Wooo hooo! We learned it!" I don't know
Jim	Sometimes I feel bad because like *he* gets excited about it
Jenny	Yeah (Many laugh)
Jim	He's like, "Stats is awesome, you guys are gonna love this!" And he goes through it and we're like, "I could care less."
Facilitator	Yeah, doesn't do it for me
Jenny	Yeah if he could like pass that to *us* somehow, magically, then we'd be way more motivated
Facilitator	Do you have professors who are able to do that?
Amy	Uh huh
Jenny	Uh huh
Facilitator	What do they do? What's their magic?

David I don't think it's so much, like, the teacher, because like Strayer, he does ... he's like pretty funny

Bill He's tight

David And I mean he's not … when he lectures, he's not like most people where they just stand there in their boring monotone voices. He's walking around the classroom, you know… I think it's just people just don't care. So, it's not a matter of what could Strayer do to make it more exciting. I think it's just our persons, like we have no like dignity in our work. You know it's just kind of like, "Well, I'll do my homework in the last second and I won't do it because… I don't care." It's just like

Amy He did warn us before our … like our very first class he did warn us that, if we played on the computer, there had been people who had failed the class because of their lack of being able to be responsible with the computer

Jenny Uh huh

Facilitator So it could be that you've learned an important personal lesson so to speak about what you would need to do for yourselves to motivate

Charles I don't know, I take my laptop to classes and type my notes. I think my problem is that we get all the PowerPoints. And I can't do that in a class. Personally, if you give me all of the PowerPoints, then I go, "Oh, I've got all the notes."

Facilitator So you check out

Charles I start counting the ceiling tiles

Next, I present the second segment, from the traditional class:

Facilitator So, what do you expect from a professor in general inside the classroom?

Bob Yeah, I think Strayer likes to keep a lot more looser atmosphere …
(Whole group says "yeah" "uh huh")

Bob … than you would typically think of like a college classroom. He likes people to speak up, even if it's something funny

Adam Yeah

Bob He doesn't mind, you get a good laugh out of it and then you move on

Adam Uh huh

Bob But um, I don't know. I think, in a lot of other classes, it's like I'm here to lecture you, and you take notes
(group yeah)

Adam Yeah, that's true. I don't know if it's expected, but it's nice when there's a little extra, to make jokes with the students or whatever, it just makes it more conducive to learning I think. And I really respect that because you don't feel like it's just a book that can talk. You know, he actually has a personality and cares about what he's doing and that's really important

Facilitator Is it hard to adjust or adapt from a format where you're not expected to talk into a format where there is some expectation that you're going to be speaking?

Adam I think it makes it a little easier because you just get loosened up and you feel like you can be yourself a little bit more. I mean, if you say something stupid, you know he says stuff stupid too
(Groups laughs. Someone says "there's no pressure".)

Adam	Someone's gonna laugh, and it doesn't really matter and I like that about the class a lot
Bob	I definitely think it took a while to get used to. You know. Especially him a little bit just kind of like getting used to like, "Oh, yeah, he is joking." (Laughter)
Facilitator	At first, you're not sure you should laugh because it might not be a joke?
Bob	Yeah because there's definitely some professors you just, you know, they're funny but you don't laugh at them (BIG laughter)
Facilitator	How do you think the environment affects how you learn? You were talking about this informal environment that is more informal and laid back. How do you think that affects your ability to learn stats?
Bob	I think it holds our attention a lot better
Greg	To see him mess up on the smart board or something like that (Laughter. People say "yeah that's funny" "that's pretty funny".)
Greg	That's always entertaining
Nancy	I like it when he finds something new (Laughter)
Bob	Oh my gosh
Nancy	Yeah, he's like "Ooh, Oooo, I didn't know that."
Bob	Yeah he like plays with it (Laughter)

The most obvious feature illustrated here is that students in the inverted classroom commented mainly on the negative things that the loose atmosphere brought to the classroom, whereas students in the traditional classroom talked mainly about the positive things that the loose atmosphere brought to the class. A student in the inverted classroom said that I was good at being a friend to them, but bad at gaining respect and being a professor. These students wanted to be told to get in line and shape up so that they would have "dignity" in their work; they wanted someone to "make them care". Students in the traditional classroom, however, said that they appreciated a professor who was more than a "book that can talk". They liked feeling that the person up front had a personality and cared. Needless to say, this dynamic created a tangible difference in the culture of the two classrooms.

By the end of the semester, students in the inverted class were more willing to work together and engage in activity in the classroom than the students in the traditional classroom. Students in the inverted classroom exhibited a desire to want to explain concepts to other students, feeling as though this is the best way to learn something thoroughly. Students in the traditional classroom, however, were not as willing to engage in the class activities. They appreciated the humour and loose atmosphere but, when it came to participating in class, there were often long moments of silence after I asked questions. They tended to want their attention engaged, but they did not want their participation solicited during class.

Although students in the inverted class were more willing to participate in class, they definitely had a love/hate relationship with activity in the classroom. These students stated that the Jack problem at the beginning of the semester sent the message that this course was a "blow off" course and, as the course got more and more difficult, students struggled to stay engaged. The learning activities were of many different types, with students being asked to do many different things as the semester progressed. Many students found it very

difficult to successfully navigate these in-class expectations. Students were not clear what was expected of them, and eventually they were convinced that most of the students in the class were "lost" by the end.

As already stated, I believe that the feeling of "being lost" in the inverted classroom is partially explained by the varied activities in the class. In this atmosphere, students were more likely to disengage with the material sooner than students in the traditional classroom. Evidence of this dynamic is given by the way in which students in the inverted classroom failed to distinguish subtleties between similar problem types. When confronted with activities meant to lift out these subtleties in the material, students in the inverted classroom tended to "savour the boredom" rather than engage with the material. Students in the traditional class, however, were more able to distinguish the subtle differences between similar problem types, as evidenced in other segments of the focus-group data.

Discussion

Let's begin a discussion of the findings by first addressing the limitations of the study. The first limitation is that I was both the teacher and the researcher. This made it impossible to write observational field notes in real time or even to observe behaviour that I would have observed if I were not teaching. I attempted to address this limitation by audio-taping class lectures. This allowed me to 'step outside' the teacher role and observe what happened at a later date. While the microphone sometimes picked up student questions and comments, it did not always do so. Also, because of the limitations of the audiotape medium, I was unable to read non-verbal cues and gestures (mine and the students) from merely listening to the lectures. These difficulties made it a challenge to get a robust observation of the class session for myself as researcher. Another way in which the design addressed this limitation was to have various members of the research team observe class sessions during the semester. Three different team members made a total of four observations each. One member observed only one class session.

Other limitations of the study included the fact that some students were reluctant to be forthcoming with criticisms because I had control over their final grade. To address this limitation, I asked students to choose between participating in a focus group, being interviewed by a member of my research team, or writing a reflection paper about their learning experiences. All three of these activities allowed students to describe their learning journey anonymously. Because two colleagues kept the tapes and papers in their offices until the semester was over, neither listened to the focus group or interview tapes nor read the papers until after I had submitted student grades for the semester.

A final limitation is that students were not randomly assigned to either the inverted or lecture-based classroom. Because of the lack of random assignment, this researcher cannot make generalisations to some larger population group in the traditional sense. However, the systematic, purposeful and triangulated design of the data collection and data analysis of this small mixed-methods study still led to empirically-driven results that allow educational researchers to gain a more thorough understanding of the phenomenon under study in ways that a larger scale study simply cannot (Marshall and Rossman 2011; Patton 2002). Further, by providing in-depth descriptions of the classrooms, students, and learning processes that were investigated, this study allows educators to transfer findings to similar contexts with a high degree of confidence in the quality of transferability (Marshall and Rossman 2011). While large-scale randomised studies hold an important place in scientific inquiry, they are not the only means for advancing knowledge (Weinstein 2004).

By carefully enacting qualitative methods that ensure results are rooted in reliable data, and by using quantitative methods to detect important differences in the data, this inquiry produced two major areas of agreement regarding the learning environments under study. I organise the reporting of these areas of agreement using the CUCEI's constructs of (1) Cooperation and Innovation and (2) Task Orientation.

Cooperation and innovation

When administered towards the end of the semester, the CUCEI indicated that inverted classroom students were more open to cooperation when compared with traditional classroom students for *both* their preferred learning environment and their actual classroom experience. This result was borne out in the qualitative data. Many students from the inverted class mentioned the value of learning with partners. Significantly, fewer students in the traditional class mentioned group learning when reflecting on what a successful course would be like.

Even though the qualitative data indicated that students in the inverted classroom had difficulty in making sense of some of their learning activity, based on CUCEI data, these students *preferred* more innovation in the classroom and they reported that they experienced more innovation in the classroom when compared with the traditional students. As part of the qualitative data, students from the inverted classroom mentioned that a successful learning environment would include activities that apply what they have learned. Even though it was a semester full of adjustment for these students, perhaps a semester full of varied learning activities shaped them in ways that made them more open to different kinds of learning activity in the future. In order to reach this conclusion with greater certainty, one would need baseline data from the beginning of the semester, but based on the students' experiences and the qualitative analysis this result certainly seems plausible. The preference for increased cooperation and innovation is further supported by other blended learning studies that suggest that this approach to teaching and learning produces more connections between students in the learning community (Garrison and Kanuka 2004; So and Brush 2008).

Task orientation

Scores from the CUCEI show that students from both the inverted and the traditional classrooms preferred similar levels of task orientation, but students in the inverted classroom indicated that their actual classroom had significantly lower levels of task orientation than their traditional classroom counterparts. This is the most noteworthy result in the study. While students in the traditional classroom did have some issues with task orientation (not knowing when homework was going to be collected and experiencing frequent awkward pauses), the overall climate of the classroom was very predictable. The settled nature of the traditional classroom compared to the fragmented nature of the inverted classroom is a key finding from the qualitative analysis.

Though the inverted classroom was more fragmented than the traditional classroom, it was not a 'free for all'. At the beginning of the semester, students were given a syllabus, discussed when examinations would happen, what the ALEKS homework would look like, how the grading scale would be divided among tasks and examinations, and how the class would be run generally (with investigations, mini-lectures and ALEKS homework). As the instructor of the course, I felt that, after a couple of weeks, most students would adjust and become comfortable with how the class was structured. While some students were able to

make the adjustment, many still struggled with how to orient themselves to the activity in the classroom. The qualitative data indicated that even students who worked hard and were motivated to successfully complete the course found it difficult to connect the online and face-to-face portions of the course. A specific illustration of this point is when Amy spoke of how she adjusted the way in which she asked questions during the small-group investigations. She not only had to make sense of the assignment itself, figure out how to use computers (and other tools) to solve the problem, and work with a partner to negotiate meaning from the activity, but she also had to adjust the way in which she asked questions to me because of the time pressure that I was under for answering questions. These types of adjustments to how students approached in-class tasks were simply not present in the traditional class.

Adjusting one's orientation to in-class activity is not necessarily a negative thing. There are often benefits to taking a different approach (or even multiple approaches) to a specific task. When this is done, students make adjustments to how they orient themselves to the learning activity. In the inverted classroom, however, it seems that students constantly had to make these adjustments. The orientation to the many specific tasks were so varied, and the ALEKS homework so different from the mini-lectures and in-class work, that students experienced a higher level of unpredictability and unsettled feelings when it came to orienting themselves to the learning task at hand.

The more-focused task-orientated environment in the traditional classroom produced an environment with a supporting structure that allowed students to patiently see subtleties within the concepts that we studied. This environment produced favourable conditions for students also to see the inner-connectedness between these concepts (supported by the qualitative data). In contrast, the less-focused task-orientated environment in the inverted class made students more likely to plug numbers into formulas and disengage when activities got boring (again, supported in the qualitative data).

Recommendations

As Bluic et al. (2007) note, the most significant need in blended learning research is information on how best to integrate the online and face-to-face portions of the course into a coherent whole. Because the two different learning experiences are so different, there is a real opportunity for a blended learning environment to have a synergistic effect in which the whole is greater than the combined parts. This current study serves as a warning against ill-connected online and face-to-face components in a blended learning environment, because the comparison with the traditional classroom in this study shows just how crucial integration is for the success of a blended learning course. This study also confirms the ways in which a blended learning environment creates space for stable and connected learning communities to be developed (Garrison and Kanuka 2004). There are opportunities for further research in both of these areas.

This research also suggests some practical recommendations. First, perhaps an inverted classroom is not the preferred design for an introductory course. Many students in an introductory course do not have a deep interest in the subject and could be frustrated when they encounter learning tasks that aren't clearly defined. In more advanced classes, students might be more willing to persist in prolonged investigations and make connections with online learning experiences, provided that the structure of the course supports their meaning making in the activity. Another recommendation stems from a result, supported in the literature (Frederickson et al. 2005) and confirmed here, that students in an inverted classroom become more aware of their own learning process than students in more

traditional settings. Thus, students in inverted classrooms need to have more space to reflect on their learning activities so that they can make necessary connections to course content. This is where the opportunity to reconceptualise the learning environment for blended learning presents itself (Garrison and Kanuka 2004). Using appropriate online communication tools to create space for this important reflection to take place can be crucial for the success of an inverted classroom. Further, because this technology provides opportunities to interact with others, this reflection can happen at multiple levels and can be done in community.

Finally, it is extremely important that teachers adjust the system maintenance and change dimensions of the learning environment to support students' meaning making from activity in an inverted classroom. The disequilibrium or unsettledness that students face in an inverted classroom is not necessarily at cross purposes with successful learning, but students need support structures built into the course so that the teacher and students alike can monitor student learning as they complete tasks. Depending on the classroom, these adjustments could have serious practical challenges (Nijhuis et al. 2005). Therefore, it might be preferable for some teachers to structure a less radical inverted classroom that gives students an opportunity to view course content outside the classroom in a number of different formats, but still includes regular 30-min lectures followed by 30 min of learning activity with homework out of a book. Other teachers might envisage a radical inverted classroom that includes only learning activity in class and the introduction to course content only outside class.

The challenge of how best to teach with technology persists for educators in all subject areas. The inverted classroom design and blended learning in general provide innovative space for teachers to help students to learn. Research will continue to inform best practices with regards to these learning environments in the years to come.

References

Albert, D., & Schrepp, M. (1999). Structure and design of an intelligent tutorial system based on skill assignments. In J. Lukas (Ed.), *Knowledge spaces: Theories, empirical research and applications* (pp. 179–196). Mahwah, NJ: Lawrence Erlbaum.

Baker, J. W. (2000, April). *The "classroom flip": Using web course management tools to become a guide by the side*. Paper presented at the 11th international conference on college teaching and learning, Jacksonville, FL.

Bluic, A.-M., Goodyear, P., & Ellis, R. A. (2007). Research focus and methodological choices in studies into students' experiences of blended learning in higher education. *Internet and Higher Education, 10*, 231–244.

Buerck, J. P., Malmstrom, T., & Peppers, E. (2003). Learning environments and learning styles: Non-traditional student enrollment and success in an internet-based versus a lecture-based computer science course. *Learning Environments Research, 6*, 137–155.

Chandra, V., & Fisher, D. L. (2009). Students' perceptions of a blended web-based learning environment. *Learning Environments Research, 12*, 31–44.

Charmaz, K. (2000). Grounded theory: Objectivist and constructivist methods. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd ed.). Thousand Oaks, CA: Sage.

Collins, B., de Boer, W., & van der Veen, J. (2001). Building on learner contributions: A web-supported pedagogic strategy. *Educational Media International, 38*(4), 229–240.

Doignon, J. P., & Falmagne, J. C. (1999). *Knowledge spaces*. Berlin: Springer.

Donnelly, R. (2010). Harmonizing technology with interaction in blended problem-based learning. *Computers & Education, 54*, 350–359.

Elen, J., & Clarebout, G. (2001). An invasion in the classroom: Influence of an ill-structured innovation on instructional and epistemological beliefs. *Learning Environments Research, 4*, 87–105.

Falmagne, J. C. (1993). Stochastic learning paths in a knowledge structure. *Journal of Mathematical Psychology, 37*, 489–512.
Falmagne, J. C., Cosyn, E., Doignon, J. P., & Thiery, N. (2006). The assessment of knowledge, in theory and in practice. In R. Missaoui & J. Schmid (Eds.), *Formal concept analysis* (pp. 61–79). Berlin: Springer.
Fraser, B. J. (1998). Classroom environment instruments: Development, validity and applications. *Learning Environments Research, 1*, 7–34.
Fraser, B. J., Treagust, D. F., & Dennis, N. C. (1986). Development of an instrument for assessing classroom psychosocial environment at universities and colleges. *Studies in Higher Education, 11*(1), 43–54.
Frederickson, N., Reed, P., & Clifford, V. (2005). Evaluating web-supported learning versus lecture-based teaching: Quantitative and qualitative perspectives. *Higher Education, 50*, 645–664.
Gannod, G. C., Burge, J. E., & Helmick, M. T. (2008). Using the inverted classroom to teach software engineering. *Proceedings of the 30th international conference on software engineering*, Leipzig, Germany.
Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education, 7*(2), 95–105.
Ginns, P., & Ellis, R. (2007). Quality in blended learning: Exploring the relationships between on-line and face-to-face teaching and learning. *Internet and Higher Education, 10*(1), 53–64.
Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *The Journal of Economic Education, 31*(1), 30–43.
Lukas, J., & Albert, D. (1999). Knowledge structures: What they are and how they can be used in cognitive psychology, test theory, and the design of learning environments. In J. Lukas (Ed.), *Knowledge spaces: Theories, empirical research, and applications* (pp. 3–12). Mahwah, NJ: Lawrence Erlbaum.
Marshall, C., & Rossman, G. B. (2011). *Designing qualitative research* (5th ed.). Thousand Oaks, CA: Sage.
Moos, R. H. (1974). *The social climate scales: An overview*. Palo Alto: Consulting Psychologists Press.
Moos, R. H. (1979). *Evaluating educational environments*. San Francisco: Jossey-Bass Publishers.
Moss, R. H. (2003). Social contexts: Transcending their power and their fragility. *American Journal of Community Psychology, 31*(1/2), 1–13.
Nijhuis, J. F., Segers, M. S., & Gijselaers, W. H. (2005). Influence of redesigning a learning environment on student perceptions and learning strategies. *Learning Environments Research, 8*, 67–93.
Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). Newbury Park, CA: Sage.
Pelto, P. J., & Pelto, G. H. (1978). *Anthropological research: The structure of inquiry* (2nd ed.). Cambridge: Cambridge University Press.
Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and the social sciences* (3rd ed.). New York: Teachers College Press.
So, H.-J., & Brush, T. A. (2008). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors. *Computers & Education, 51*, 318–336.
Strauss, A., & Corbin, J. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Thousand Oaks: Sage.
Strayer, J. F. (2009). *Inverting the classroom: A study of the learning environment when an intelligent tutoring system is used to help students learn*. Saarbrücken: VDM Verlag.
Weinstein, M. (2004). Randomized design and the myth of certain knowledge: Guinea pig narratives and cultural critique. *Qualitative Inquiry, 10*(2), 246–260.
Wolcott, H. F. (2005). *The art of fieldwork* (2nd ed.). Walnut Creek, CA: Alta Mira Press.