2014-03-01

Sense of Community in a Blended Technology Integration Course: A Design-Based Research Study

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A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Science

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March 2014

ABSTRACT

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This design-based research study explored whether Sense of Community was maintained while flexibility in the course was increased through an adoption of a unique blended learning model. Data collected in this study show a significant drop in the sense of connectedness score from a mean of 50.8 out of 66 to a mean of 39.68 in the first iteration. The score then began to gradually increase, reaching 50.65 in the third iteration. Results indicate that transitioning to a blended learning environment may be a suitable option to increase flexibility while maintaining a Sense of Community in a project-based course. Future research into specific aspects of course design such as maturity of design, age-level of participants, and context would further develop understanding in this area.

Keywords: blended learning, sense of community, design-based research, connectedness

ACKNOWLEDGMENTS

First, I would like to thank my wife and daughter, Anna and June, for their continual support over the last several years as I have worked to complete this thesis.

I would like to express my appreciation and gratitude to Dr. Rick West for his mentorship since starting this program. I would especially like to highlight his patience and guidance while critiquing my writing abilities. None of this would have been possible without him. I would also like to thank Dr. Charles Graham and Dr. Randy Davies who have helped me over the years deepen my understanding of scholarship. Their continued efforts have helped shape how I view the field and where I fit in it. I couldn't have picked a better committee.

I am humbled to have been given the opportunity to work alongside the instructors of IPT 286. I thank each of them, and those that preceded us, for the stellar work and careful attention they put into this course. I learned daily from them. The results of this study are just as much theirs as they are mine.

Finally, I would like to thank everyone in the IPT department, notably Dr. Andy Gibbons, Dr. Peter Rich, Dr. Stephen Yanchar, Michele Bray, and all of the graduate students in the program. Thank you for making me feel welcome and providing an environment that allows ideas to flow freely. IPT is my home away from home.

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CHAPTER 1: INTRODUCTION TO ARTICLE-FORMAT THESIS

This thesis is written in an article format, with an introductory chapter, followed by a draft of the submitted article and an extended review of design-based research.

Blended Learning

Due to recent advances in technology and the increased saturation of high speed Internet within the community, new educational models have emerged that may provide relief to some traditional constraints in education. Blended learning is one model in particular that aims to blend the best characteristics of face-to-face instruction with the flexibility of online learning. Often this is seen as a solution to the loss of face-to-face interaction in online education that might cause students to have a low sense of community in the course, leading to student burnout and feelings of isolation (Rovai & Jordan, 2004).

Blended learning as a model has existed since the turn of the century (Bonk & Graham, 2006). It has been argued that the inception of the learning management system was in large part due to instructors' desire for a tool to facilitate blended learning (Ross & Gage, 2006). Adoption of blended learning typically begins as an experiment by teachers in order to improve learning outcomes. As attention from administration increases, blended learning is used to reclaim and efficiently manage finite resources (Picciano, 2006). The process from individualized experimentation to institutional practice of blended learning is "gradual" and "negotiated" with constant critique and debate (Wallace & Young, 2010, para. 3). This critique and debate is important to address pedagogical concerns surrounding blended learning. For some, however, it is only a matter of time for blended learning to become an inevitable component of all universities (Garrison & Kanuka, 2004). Garrison and Kanuka argued that in order for the transition to blended learning to occur gracefully, clear policy on blended learning and strong leadership are required. As we have seen a progression of both the technology behind blended learning as well as the theory, there is a greater need to move past models to look at what effect specific design attributes have on blended learning courses (Graham, 2012).

There are many models of blended learning, however most focus on the physical dimensions of the learning environments and speak generally to pedagogical concerns (Graham, 2012). Graham instead stressed the need for more research in blended learning to identify the factors that impact achievement and success. Garrison and Kanuka (2004) also mentioned the need for continual reflection on new mediums used in education. They stated that research "must seriously reflect on how to design and deliver higher education" and that blended learning offers possibilities to create transformative environments that can effectively facilitate critical, creative, and complex thinking skills (p. 99).

Current research in blended learning has highlighted some of its benefits, including greater access to educational opportunities (Picciano, 2006). Though access is an important factor to consider when blending a class, the amount of time a learner has available to engage in a course could also impede progress (Picciano, 2006). Therefore, design for greater access should address both space and time constructs.

In addition, many researchers have used the theory of transactional distance to frame blended learning research (Graham, 2012). Transactional distance was defined by Moore (1991) as "a distance of understandings and perceptions, caused in part by geographic distance, that has to be overcome by teachers, learners, and educational organizations if effective, deliberate, planned learning is to occur" (p. 3). The introduction of technology into the classroom inherently generates the question of whether technology will replace the need for human interaction; however, human interaction has been shown to solidify attitudes and murky concepts (Rossett, Douglis, & Frazee, 2003), increase a social presence (Baker, 2010), and lessen frustration and anxiety (Hara & Kling, 2001). Learners feel most comfortable in self-paced learning if the process is monitored and supervised by the instructor (Tick, 2006). Thus, scholars are seeking ways to improve models of blended learning so that this important human interaction is not missing. In particular, emerging technologies that provide the ability to have high-fidelity synchronous or asynchronous communication between two or more people using the Internet show promise in providing quality distance education while maintaining a sense of community through human interaction. However, these recent technological and pedagogical advancements necessitate further research to determine how effective they are and whether they can effectively maintain students' sense of community when transitioning to blended modalities.

Statement of Thesis Purpose

This design-based research thesis explores our experiences transitioning a preservice instructional technology course from a face-to-face model to a blended environment. Our goal was to increase flexibility by blending the course without adversely affecting sense of community that is more easily established in a traditional face-to-face setting. Throughout these iterations we measured the impact on sense of community to determine whether or not we were successful.

Structure of Thesis

Chapter 2 contains the article version of the research conducted, followed by Appendix A: Adapted Classroom Community Scale and Appendix B: Extended Review of DBR Literature.

Target Journal: The article in Chapter 2 was written for a distance education journal whose audience is scholars and practitioners interested in open and distance learning.

CHAPTER 2: ARTICLE

Introduction

In recent years, blended learning adoption has increased rapidly (Graham, Woodfield, & Harrison, 2013). Commonly defined as "learning experiences that combine face-to-face and online instruction" (Graham, 2012, p. 7), blended learning is adopted primarily for three reasons: (a) improved pedagogy, (b) increased access/flexibility, and (c) increased cost effectiveness (Bonk & Graham, 2006). The access that blended learning provides goes beyond physical distance, also allowing for greater flexibility in the time both the student and instructor engage in a course (Picciano, 2006). This increased flexibility provides instructors with more individualized time to spend with those struggling in a course; however, though blended learning offers solutions to rigid course structure, the introduction of online instruction may bring potential challenges of its own.

One concern in moving to a blended environment is that a lack of in-person communication could diminish the students' overall Sense of Community (SOC) and social presence experienced in the class. Aragon (2003) defined social presence as salient interaction with a "real person" (p. 60) and extolled its importance to SOC, stating that "social presence is one of the most significant factors in improving instructional effectiveness and building a sense of community" (p. 57). Diminished SOC was seen by Stodel, Thompson, and MacDonald (2006) while researching social presence in their online course. They observed that "although there were indicators of social presence" it appeared "that [social presence was] still what the learners missed most when learning online" (p. 8). Rovai (2001) supported the necessity of social presence in building a strong sense of community by imploring that "instructors must deliberately structure interactions to overcome the potential lack of social presence" (p. 290) in an online course. Rovai argued that as social presence goes down, so does SOC. As the instructor of a course increases the awareness of social presence, frustration and distress diminish in the online community. Given the importance of a strong SOC, it was necessary to understand the impact on this psychological construct in transitioning to a blended format.

Research Questions

The purpose of this design-based research study was to explore our transition from a face-to-face course to a blended environment by measuring the impact on flexibility and SOC. In line with design-based research, we began our research with loosely formed research questions supported by clear pedagogical expectations (Edelson, 2002, p. 106). Thus, our research question was how we could design the course so it would

- allow for more student flexibility in their learning;
- devote more class time to work with struggling students;
- provide ample support and resources to more advanced students;
- not negatively impact students' sense of connectedness and SOC to each other; and
- not negatively impact student satisfaction with the course as represented in the student ratings.

Literature Review

In order to understand issues surrounding Sense of Community and how it can relate to online learning, we will first review the literature regarding social interactions in distance education in general and how these interactions are part of establishing a SOC among students. Second, we will review the literature regarding the importance of SOC.

Interactions in Distance Education

Rovai (2001) claimed that Moore's (1991) theory of Transactional Distance was especially helpful in understanding online learners' SOC. In Moore's theory, he stated that special considerations should be taken regarding dialogue and structure in order to mitigate the negative impact of distance education. Moore determined that "the success of distance teaching is the extent to which the institution and the individual instructor are able to provide the appropriate opportunity for, and quality of, dialogue between teacher and learner, as well as appropriately structured learning materials" (p. 5). Similarly Rovai (2001) offered two considerations on structure and dialogue with regard to SOC. First, Rovai argued that since additional structure tends to increase psychological distance, SOC in turn decreases. Second, by utilizing communications media appropriately, dialogue could be increased and transactional distance reduced, which would theoretically increase SOC (p. 289). To better understand these considerations, each of Moore's (1989) three elements of interaction are discussed in turn, along with a fourth element added by Bouhnik and Marcus (2006). This fourth element is similar to the learner-interface element discussed by Hillman, Willis, and Gunawardena (1994). These elements of interactions include (a) interaction with content; (b) interaction with the instructor; (c) interaction with the students; (d) interaction with the system.

Interaction with content. Interaction with content occurs as the learner is exposed to new information and attempts to integrate this new content with the learner's previous knowledge on the subject. In today's technological landscape, this interaction could take place online or face-to-face, individually or collectively, alone, with peers, or with a teacher. Moore (1989) argued that interaction with content is the "defining characteristic of education" since without it there could be no education (p. 1). According to Moore, it is the process of "interacting with content that results in changes in the learner's understanding."

Interaction with the instructor. When discussing transactional distance, Moore (1989) warned that physical distance between the learner and the teacher may result in a psychological and communication gap between them. Moore discussed how a teacher could provide effective support, motivation, clarity, and experience with the material and concluded that interaction with the instructor is most valuable during testing and feedback. This interaction leads to better application of new knowledge by the learner.

Hara and Kling (2001) found that students were more likely to feel frustration, anxiety, and confusion when taking an online class if they encountered communication problems. In particular, during an ethnographic study of a small, graduate-level online distance education course, they found that lack of communication with the teacher produced stress in students. They stated "students reported confusion, anxiety, and frustration due to the perceived lack of prompt or clear feedback from the instructor, and from ambiguous instructions" (p. 68).

From a voluntary survey of 699 undergraduate and graduate online students at a mid-sized regional university, Baker (2010) recorded that instructor presence had a statistically significant positive impact on effective learning, cognition, and motivation. Here, instructor presence was described as being actively engaged in an online discussion, providing quick and personal feedback to assignments, or being available frequently throughout the course (p. 6).

Interaction among students. Moore (1989) was also concerned with the transactional distance between the students themselves. Moore posited that inter-learner interaction could become an "extremely valuable resource for learning" (p. 2). Although important, Moore observed that inter-learner interaction was most impactful among younger learners. It was not as important for most adult and advanced learners who are more self-motivated. That may be one reason as to why Baker (2010) found that instructor presence had a greater influence on reducing frustration and increasing social presence than peer presence (p. 23).

Interaction with the system. Bouhnik and Marcus (2006) added to Moore's (1989) original three interactions by including the interaction students have with the system itself. They posited, "there is a need to make sure that the technology itself will remain transparent and will not create a psychological or functional barrier" (p. 303). If interaction with the system produced conflicts that were not resolved quickly, a student's level of satisfaction and ability to accomplish learning outcomes could be negatively impacted. Specifically, when designing a technological system, Bouhnik and Marcus stressed the need for "building a support system, with maximum accessibility" (p. 303).

Importance of Sense of Community

Sarason (1974), when coining the term, defined SOC as "the perception of similarity to others, an acknowledged interdependence with others, a willingness to maintain this interdependence by giving to or doing for others what one expects from them, and the feeling that one is part of a larger dependable and stable structure" (p. 157). Though Sarason coined the term SOC, it has been the subject of much research, either directly or indirectly, over the last century (Glynn, 1981, p. 791). Due to its broad nature, research on SOC can be found in many fields of study. McMillan and George (1986) stressed the need for more research and understanding on the SOC in order to better inform public policy and "strengthen the social fabric" (p. 16) with more concrete solutions on how to increase community in a variety of settings. Their hope was that research into the SOC would foster open, accepting communities built on understanding and cooperation.

The concept of SOC is not new to distance education. While developing an instrument for measuring SOC in distance education, Rovai (2002a) defined SOC in education as something that occurs when “members of strong classroom communities have feelings of connectedness” (p. 198). He went on to mention that members “must have a motivated and responsible sense of belonging and believe that active participation in the community” (p. 199) could satisfy their needs.

In his review of the SOC research, Rovai (2002b) concluded that classroom community “can be constitutively defined in terms of four dimensions: spirit, trust, interaction, and commonality of expectation and goals” (p. 2). In regards to interaction, Rovai noted that if interaction could not occur in abundance, then the focus should be the quality of interaction. The instructor controls these interactions, and care should be taken to mitigate negative interactions while strengthening SOC. Interactions with the instructor should include both feedback as well as more personable information (Rovai, 2002b).

Shea, Swan, and Pickett (2005) determined through regression analysis that SOC was also influenced by effective directed facilitation, instructional design, and student gender. Their survey of 2,036 students measured students’ perceptions of teaching presence and learning community. The more engaged an instructor seemed in the course, the stronger sense of community and belonging students felt (p. 71). Garrison (2007) cited similar issues when reviewing research on teaching presence in an online community of inquiry. He stated “that teaching presence is a significant determinate of student satisfaction, perceived learning, and sense of community” (p. 67). Baker (2010) stressed the need for further research into the impact of teacher presence in an online environment on the sense of community (p. 23).

In an attempt to research SOC in face-to-face environments, Glynn developed one of the first instruments that could objectively measure sense of community (1981). Glynn argued that SOC could be identified through context-specific attitudes and behaviors. Glynn uncovered 178 attitude and opinion statements that might be associated with SOC. Examples included whether a community member felt that, in an emergency, they would have support or whether they felt SOC is context-specific and research should focus on the community level. Hill suggested that a multidisciplinary approach is required, arguing that, since SOC is context specific, the most effective study would combine the expertise of a researcher familiar with the construct along with the expertise of a researcher familiar with the setting (p. 435).

Rovai and Jordan (2004) have more recently conducted research on blended environments and SOC. Their study involved a comparative analysis between traditional, online, and blended graduate courses. The traditional course covered educational collaboration and consultation. Online technologies were not used in this course, instead relying on textbook activities, lectures, some group work, and authentic assessments for individual students. The blended course focused on legal and ethical issues with teaching disabled students. Both face-to-face and asynchronous online components were used. The blended course began with a face-to-face session with two more sessions spaced throughout the semester. The online course covered curriculum and instructional design, relying heavily on the institution’s learning management system to provide content and communication. Rovai and Jordan’s analysis consisted of a 20-point Likert scale survey with items such as “I feel isolated in this course” and “I feel that this course is like a family.” Each item was self-reported by the participants consisting of 68 graduate students each enrolled in a graduate-level education course. All participants were full-time K-12 teachers seeking a master's degree in education. Their findings suggested that the SOC was strongest in the blended course, with traditional courses having the next strongest community.

Though Rovai and Jordan's results were promising, they are not easily applied to all contexts. In Rovai and Jordan's study, the courses were independent from one another. The traditional, blended, and online courses each focused on different subjects and were established in their respective educational modes, leaving the possibility open that differences in the data could have been due to the type of course the students participated in. Another possible difference in the data could come from where the students resided related to one another. In both the traditional and blended courses students resided in the same geographic area, while the online course had a student population dispersed throughout the country. Also, Rovai and Jordan's study focused on established traditional, blended, and online courses. In an environment where a course transitions from traditional to blended learning, a closer examination would be required to determine what specific aspects of blended learning might promote SOC. Finally, Rovai and Jordan's work was published nearly a decade ago, and many technologies (such as video-based technologies and course management systems) have emerged and evolved to provide powerful new ways of supporting human interactions in blended learning environments. Thus, it is critical to update the work of these scholars and seek to understand the nature of supporting a SOC in today's learning environments. To this end, the purpose of this study was to carry out a design-based research agenda of producing improved interventions for teaching preservice teachers technology integration skills in a blended learning environment while simultaneously seeking to understand whether—and how—these interventions supported their sense of connectedness (an aspect of sense of community) in the course.

Method

Design-Based Research

Design-based research (DBR) is concerned with three areas of a learning environment: inputs of the system, outputs of the system, and the contribution of theory to the system (Brown, 1992). Literature has shown that DBR studies often have the following characteristics (The Design-Based Research Collective, 2003).

1. The central goals of designing learning environments and developing theories of learning are intertwined. Edelson (2002) supports this by adding that design researchers should start with a hypothesis; however, it should be less detailed and allow for adjustment while designing and developing learning environments.
2. Development and research take place through continuous iterations of design, enactment, analysis, and redesign. Cobb et al. (2003) described DBR as highly interventionist in nature.
3. Research on designs must lead to sharable theories and interventions that help communicate relevant implications to practitioners and other educational designers.
4. Research must account for how designs function in authentic settings. This account must be detailed.
5. Development of such accounts relies on methods that can document and connect processes of enactment to outcomes of interest.

These characteristics informed our DBR study's design and documentation by providing a framework to follow. In addition, Graham, Henrie, and Gibbons (2013) provided a model for performing DBR. Their model consisted of defining the core attributes in an iteration that would be affected by an intervention, measuring the outcome, then repeating the process in a new design. Figure 1 is a representation of this study in the framework of their model. Following Figure 1 is a summary of each intervention's purpose. A more thorough review of DBR is contained in Appendix B.

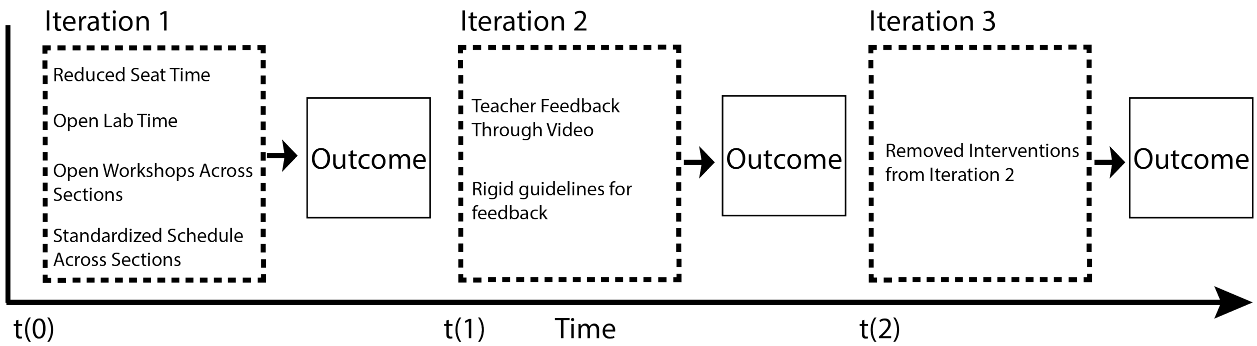

Figure 1. Visual representation of design research comparing iterations over time.

In following the model from Graham et al., (2013) we will now explain each major intervention, including the core features that were modified.

Iteration 1. Interventions to the course in this iteration included the following:

- Implemented a unique blended learning model in order to mitigate the traditional time and space limitations of the course while hopefully maintaining SOC and the overall student experience.
- Standardized scheduling across multiple sections, in order to augment the students' support system.

Iteration 2. Interventions to the course in this iteration included the following:

- Formalized greater instructor/student interactions using assignment feedback, in order to increase SOC in the course.

Iteration 3. Interventions to the course in this iteration included the following:

- Removed Iteration 2's intervention in order to determine whether the change in SOC was due to the intervention or the maturity of the new blended course.

Participants and Course Design

Participants consisted of 247 preservice secondary education teachers enrolled in a technology integration course. A breakdown of the participants is shown in Table 1. Two limitations in the data need clarification. Sense of community data was not collected for the Winter 2012 semester. At that time, it wasn't clear how these data would prove valuable. Once the decision to move to a blended format was made, the data became invaluable and collection continued. Also, responses for Iteration 2 and Iteration 3 were unusually low, though the enrollments in the course were on par with other semesters. We are not sure of the direct cause of this low response rate, although it is likely that the instructors for these iterations did not incentivize participation in the survey like previous instructors did. Each semester, four sections of the course participated in the study. The baseline consisted of participants' data collected from four semesters, totaling 16 sections. Each iteration consisted of participants' data collected from only one semester, totaling four sections each.

Table 1

Breakdown of Participants by Iteration

	# of Participants	Semester
Baseline	161	W2010-F2011
Iteration 1	44	Fall 2012
Iteration 2	22	Winter 2013
Iteration 3	20	Fall 2013

Students were placed into different sections of the course based on their major field of study. These fields of study included physical and biological science, social science, physical education, family and consumer education, and language arts. This way, each student shared with peers their ideas for using technologies specifically for the context of their field of study.

A faculty member trained in educational technology along with his mentored graduate students taught the course. The faculty member taught two sections each semester resulting in the majority of students being taught by him. With input from the faculty member, the graduate students were given some autonomy to design and teach their section. Graduate students typically taught for two semesters only, rotating in new graduate students every semester.

Baseline Course Description

Participants in the traditional face-to-face course were required to attend one hour each week. In order to complete their projects, they were expected to devote an additional two hours or more per week to their coursework. The course was divided into multiple units, one for each project or technological concept. Each unit typically consisted of an introductory class period with demonstration of the technology and discussion. Subsequent class sessions would be in a required lab setting where students could work on their projects and the class would have additional demonstrations in a workshop style. Some of the smaller units or units not specifically tied to learning a technology were only one week long, omitting the lab.

For example, the first unit was to learn an Internet communications technology. The first week of this unit was devoted to a teacher-led demonstration of a website-creation program followed by discussion on where and how it could be used in the classroom. The next week was devoted to students working on a project that would provide hands-on application of the program. If needed, the teacher would demonstrate additional features of the program to help better student understanding. The following week would be devoted to a new unit and the previous assignment involving the website program would be due. For units involving educational concepts such as Internet safety, where new technologies did not need to be learned, one week was taken to provide resources on the topic and discussion with the assignment for that unit being due the following week.

Measurement Instrument

For this study we chose to adapt the Classroom Community Scale (CCS), developed by Rovai, in order to collect the necessary SOC data. The original scale from Rovai consisted of 20 items split equally into two subscales: the connectedness subscale and the learning subscale (Rovai, 2002b). A factor analysis of this scale performed by Rovai confirmed that the overall results of using the scale reflected the classroom community construct.

In order to better fit our specific objectives on measuring connections and trust, we only used the connectedness subscale, and altered some of the items to better reflect the context of our course. For example, the item “I feel uncertain about others in this course” was too broad and vague for our context. It was altered to “I could share ideas on projects with others without being criticized” in order to measure a specific example of trust and connectedness with others. A seven-point response scale was used to allow for greater variance and to match other formative evaluation items asked of the students, instead of the five-point scale originally proposed by Rovai. One item was added to the survey that directly addressed the learner’s opinion on how important SOC is in the class. This item was not designed to measure the participants’ sense of connectedness and is thus not included in our connectedness score; however, responses to this item are included below to provide additional context within each iteration. These modifications were made prior to collecting data and were consistent throughout this study. Our adapted CCS has been included in Appendix A.

Data Collection and Analysis

Participants in each iteration completed the adapted CCS as part of an end-of-course online survey each semester. Responses were then compiled and missing values were removed from the data. If one participant submitted two surveys, the most recent survey was kept while the other was discarded. Only responses in which the participant provided permission were used.

To obtain the connectedness score, the weights of each item were added. Total scores ranged from a maximum of 66 to a minimum of 0. For all items except No. 9, the following scoring scale was used: strongly agree = 6, agree = 5, somewhat agree = 4, neutral = 3, somewhat disagree = 2, disagree = 1, strongly disagree = 0. For item No. 9, "I felt isolated," the scoring scale was reversed to ensure the most favorable choice was assigned the higher value in order to be similar to the other items: strongly agree = 0, agree = 1, somewhat agree = 2, neutral = 3, somewhat disagree = 4, disagree = 5, strongly disagree = 6. A one-way ANOVA was performed on the connectedness scores to look for SOC differences between iterations.

Similarly, student ratings were obtained through a separate end-of-course survey provided by the institution. Students were asked to rate their experience in the course. The following scoring scale was used: Exceptionally Good = 7, Very Good = 6, Good = 5, Somewhat Good = 4, Somewhat Poor = 3, Poor = 2, Very Poor = 1, Exceptionally Poor = 0.

Iterative Findings

In order to understand the findings in this study, we will begin by thoroughly explaining the different design iterations of the course, followed by the findings related to the sense of connectedness felt by students in each iteration. We will then discuss overall findings.

Baseline SOC Findings

There was one outlier in the data for the baseline version of the course, as assessed by inspection of a boxplot for extreme values. Upon further examination it appeared that the participant selected the lowest score for all but two survey items, totaling a connectedness score of five. The next lowest score in this iteration was 25. Due to the large disparity between these two low scores, the outlier was removed from the dataset. The mean and standard deviation for the connectedness score and perception of SOC importance are reported in Table 2. The connectedness score mean was 50.80 out of a possible 66. The SOC importance mean was 4.12 out of a possible 6. The student ratings mean was 6.60 out of a possible 8.

Table 2

Descriptive Statistics for the Baseline

	n	Min	Max	*Mean*	*SD*
Connectedness Score	161	25	66	50.80	9.433
SOC Importance	161	0	6	4.12	1.341
Student Ratings	215	1	8	6.60	-

Iteration 1 Findings

Several challenges were present in the traditional face-to-face model of this course. Inherently in an F2F course, time and space restrictions exist. The course was allotted only one credit hour, which left little time for demonstration, discussion, and application of the technologies students would most likely encounter in the classroom. Students' technical abilities also varied greatly, which made it more difficult to pace the course according to need. With limited time and resources, instructors were typically forced to pace the class in line with the average technical ability of the students leaving lower and higher ability students either frustrated or bored.

In order to address the challenges in the baseline version of the course, we implemented a blended model that would increase flexibility in the course without adversely affecting SOC or the overall student experience. No current blended model existed that exactly fit our context, so our first intervention was to design a unique model for our course.

Our design removed the requirement to come to each class period, opting instead to require only introductory days for new units. This meant that roughly 60% of the course could be accomplished outside of class. For the required in-class days, instructors typically utilized that time for more discussion on the impact of technology or technology-related concepts. Demonstrations of the specific technologies were moved online in the form of video tutorials.

Our design also consisted of turning the remaining class periods into labs that were open to all sections of the course. That increased the possibility for students to come and receive help from one day each week to four. Since it was optional, we only encouraged or required the lab days for students who were struggling in the course. Instructors were then able to devote more of their time in assisting struggling students while the more capable students did their work off-campus.

The final design consideration affected the last few weeks of class. Instead of demonstrating one technology each week for students in our individual sections, we developed open workshops that any student from any section could attend. We required that each student attend at least two of these workshops. Now, instead of only 3-5 technology workshops available to our students, they would have 12-15. These interventions not only increased flexibility in time and space for our students, but in choice as well.

In order for our design to work, we needed to limit the autonomy instructors had in scheduling their own sections. Our second intervention in this first iteration was to standardize the schedule across all six sections each semester. For example, each section would start unit three on the same week. This intervention made our design possible since our design demanded sharing of class time and instructors across sections.

There were no outliers in the data for Iteration 1, as assessed by inspection of a boxplot for extreme values. The mean and standard deviation of the connectedness score and perception of SOC importance are reported in Table 3. The connectedness score mean was 39.68 out of a possible 66. The perception of SOC importance mean was 3.09 out of a possible 6. The student ratings mean was 6.53 out of a possible 8.

Table 3

Descriptive Statistics for Iteration 1

	n	Min	Max	*M*	*SD*
Connectedness	44	15	63	39.68	11.334
SOC Importance	44	0	6	3.09	1.378
Student Ratings	39	1	8	6.53	-

Iteration 2 Findings

One intervention was added in the second iteration of the course. After the design and development of the blended environment, attention was turned to increasing relationships between the instructor and the students. As instructors, we felt less connected with our students. Our concern was that this feeling was reciprocated and a loss of SOC had occurred. An increased effort to use video recordings for assignment feedback was introduced. Along with more video feedback, an increased emphasis on developing a stronger relationship with the student was required through text feedback as well. Specifically, each instructor followed the guidelines below when providing both video and text feedback:

- Address the student by name;
- Identify things in common that you have with the student;
- Welcome the student into the class when giving feedback on the first assignment, e.g., “Glad to have you in class”;
- Offer help, “Let me know if there is anything that I can do to help you this semester”;
- Look in the webcam if you are giving video feedback;
- All feedback should be timely—within a week of the due date; and
- Send an email to the class reminding them to view their feedback.

There was one outlier in the data for Iteration 2, as assessed by inspection of a boxplot for extreme values. Upon further examination it appeared that the participant selected the highest score for nearly all but one survey item, totaling a connectedness score of 65. The next highest score in this iteration was 58. Due to the disparity between these two high scores, the outlier was removed from the dataset. The mean and standard deviation of the connectedness score and perception of SOC importance are reported in Table 4. The connectedness score mean was 42.95 out of a possible 66. The perception of SOC importance mean was 3.18 out of a possible 6. The student ratings mean was 6.58 out of a possible 8.

Table 4

Descriptive Statistics for Iteration 2

	n	Min	Max	*Mean*	*SD*
Connectedness	22	32	58	42.95	7.718
SOC Importance	22	1	5	3.18	1.053
Student Ratings	43	5	8	6.58	-

Iteration 3 Findings

Though our increased attentiveness when providing feedback and our introduction of video feedback may have had a positive impact on SOC, the improvement shown did not seem to justify the increased time and effort required to provide that type of feedback. At the same time, our blended learning model had matured, which we felt may be a cause of the improved SOC. For this third iteration, we removed the requirement for instructors to follow the rigid guidelines for providing feedback described in Iteration 2 and feedback through video technology. Since following these guidelines and providing video feedback was time-consuming with little added benefit to students, instructors did not continue with these interventions in Iteration 3 once the requirement was removed. No other interventions were purposefully made to the course. There were minor changes to instructors and updates to course content; however, these changes are common in this course and were in each previous iteration.

There were no outliers in the data for Iteration 3, as assessed by inspection of a boxplot for extreme values. The mean and standard deviation of the connectedness score and perception of SOC importance are reported in Table 5. The connectedness score mean was 50.65 out of a possible 66. The perception of SOC importance mean was 3.90 out of a possible 6. The student ratings mean was 6.08 out of a possible 8.

Table 5

Descriptive Statistics for Iteration 3

	n	Min	Max	*M*	*SD*
Connectedness	20	33	68	50.65	9.422
SOC Importance	20	2	6	3.90	1.210
Student Ratings	41	3	8	6.08	-

Overall SOC Findings

The data were not normally distributed for the Baseline, while the three iterations had normally distributed data, as assessed by Shapiro-Wilk test ($p > .05$) reported in Table 6. There was homogeneity of variances, as assessed by Levene's test of homogeneity of variances ($p = .336$) reported in Table 7.

Table 6

Shapiro-Wilk Test of Normality

	Statistic	df	Sig.
Baseline	.965	161	.000
Iteration 1	.982	44	.708
Iteration 2	.938	22	.177
Iteration 3	.978	20	.909

Table 7

Levene's Test for Homogeneity of Variances

Statistic	df1	df2	*p*
1.133	3	243	.336

Overall the SOC (connectedness score) decreased from the Baseline (M = 50.80, SD = 9.4), to Iteration 1 (M = 39.68, SD = 11.3), with a slight increase in Iteration 2 (M = 42.95, SD = 7.7). From Iteration 2 to Iteration 3, there was a considerable increase in SOC (M = 50.65, SD = 9.4) as reported in Table 8.

Table 8

Descriptive Statistics for SOC in Each Iteration

					95% CI			
	N	*M*	*SD*	*SE*	Lower	Upper	Min	Max
Baseline	161	50.80	9.433	.743	49.33	52.26	25	66
Iteration 1	44	39.68	11.334	1.709	36.24	43.13	15	63
Iteration 2	22	42.95	7.718	1.646	39.53	46.38	32	58
Iteration 3	20	50.65	9.422	2.107	46.24	55.06	33	68
Total	227	47.88	10.699	.710	46.48	49.28	15	66

Since the connectedness score was not normally distributed for all iterations, both a one-way ANOVA and a Kruskal-Wallis test were conducted. Results from the Kruskal-Wallis test lead to the same conclusion as the one-way ANOVA. Therefore, only the analysis of the one-way ANOVA between iterations is provided. There was a statistically significant difference among the iterations, $F(2,224) = 25.9$, $p < .001$.

Table 9

One-way Analysis of Variance for SOC

	Sum of Squares	df	Mean Square	F	p
Between Groups	4999.977	3	1666.659	17.843	< .001
Within Groups	22697.286	243	93.404		
Total	27697.263	246			

Tukey post-hoc analysis revealed that the mean decrease from the Baseline to Iteration 1 (11.1, 95% CI [6.9, 15.4]) was statistically significant ($p < .001$) while the mean increase from Iteration 1 to Iteration 2 (-3.3, 95% CI [-9.8, 3.3]) was not significant ($p = .566$). The mean increase from Iteration 2 to Iteration 3 (7.7, 95% CI [-15.42, .03]) was not significant, though just barely ($p = .051$). Also, the mean increase from Baseline to Iteration 3 (.1, 95% CI [-5.8, 6.1]) was not statistically significant ($p = 1.000$).

Table 10

Tukey Post-Hoc Analysis of SOC in Each Iteration

		Mean Difference	*SE*	*p*	95% CI Lower	95% CI Upper
Baseline	Iteration 1	11.1	1.6	< .001	6.86	15.37
Iteration 1	Iteration 2	-3.3	2.5	.566	-9.80	3.26
Iteration 2	Iteration 3	7.7	3.0	.051	-15.42	.03
Iteration 1	Iteration 3	-11.0	2.6	< .001	-17.71	-4.23
Baseline	Iteration 3	.1	2.3	1.000	-5.78	6.07

Report of Student Ratings

There was little difference in student ratings between iterations. The Baseline showed the highest mean rating of 6.60 followed by Iteration 2 at 6.58, Iteration 1 at 6.53, and finally Iteration 3 at 6.08.

Report of SOC Importance

An independent-sample t-test was run to determine if there was a connection between participants' view on the importance of SOC and the SOC score they provided. Participants were divided into two groups. Group A consisted of participants who agreed that SOC was important and scored that item with a 4 or higher. Group B consisted of participants who disagreed that SOC was important and scored that item with a 2 or lower. Those participants who chose to remain neutral were not included in the comparison.

There were 131 participants in Group A and 30 participants in Group B. Those in Group A had a higher SOC score ($M = 54.99$, $SD = 6.73$) than those in Group B ($M = 35.40$, $SD = 10.34$). The difference between the two groups was statistically significant, $M = 19.59$, 95% CI [15.58 to 23.61], $t(34.82) = 9.91$, $p < .001$.

Discussion

By moving to a blended environment, we were able to increase flexibility in the course for both students and instructors without negatively impacting student ratings. The students were no longer required to attend each week, giving them more flexibility in the time and space where they would complete their schoolwork. Also, by opening up our lab days to every section, the students were able to choose which day of the week they could attend lab for support. Instructors also had more flexibility. Instead of teaching to the middle demographics, those students with average technical abilities, instructors were able to devote more of their time on lab days to only the students who came in for help, typically those struggling in the course. By sharing resources between sections, instructors could now offer multiple technologies and projects that they individually couldn't support. Instructors were no longer limited to the technologies that they personally knew. Students benefited from this sharing of resources with a much larger selection of technologies to select from for projects. Feedback from student ratings revealed no negative impact from our interventions with an average course rating of "Good" for each iteration.

SOC, however, was more volatile. Though we saw a significant drop in students' sense of connectedness to each other from our baseline to our first iteration, there was no significant difference between our baseline (M = 50.80) and our final iteration (M = 50.65). The students' opinion of the importance of SOC seemed to also follow this trend, dropping in the first iteration then gradually rising. These results make our findings on rigorous and personalized feedback inconclusive. We cannot know for sure whether the feedback was the cause for the rise of SOC in Iteration 2 or whether the increase was due to the maturity of our blended learning model.

Thus, our main conclusions from this design-based study is that it seems that SOC can decrease when moving to a blended environment; however, in this case, it rebounded with the continued evolution of skills and materials used to teach the course. This leads us to conclude and recommend that blended learning can be a suitable option for project-based technology courses such as this one as a good compromise between the flexibility of online learning and the sense of connection and community that students need to feel in order to have a satisfactory learning experience.

Limitations and Future Research

In order to identify the specific cause of the decrease in SOC from the Baseline to Iteration 1, further research should be done regarding the maturation of the model. Some of the adjustments to the course that occurred in each iteration over time included the following:

- Content updates and additions;
- Turnover rate of graduate student instructors;
- Introduction of new technologies;

- Minor tweaks to scheduling;
- Better grasp of the structure of the course; and
- Maturity of materials used in the course.

Research into these aspects could provide more insight into what specifically caused the drop and subsequent rise in SOC across the iterations.

Further research is also needed in determining how the importance of SOC to participants affects the SOC felt in a course. Our findings indicate that there was a connection between participants' perception of SOC importance and the overall SOC felt, with those who agreed SOC was important giving a higher SOC score than those who disagreed. Research into whether this perception influences or is influenced by SOC in a classroom could provide additional insight into course design.

Age of participants is another factor that requires further research. Moore (1989) mentioned that the interaction between students was more important for younger learners. Since the learners in our study were adult learners and more self-motivated, a study of SOC at different age levels would provide insight into what designs prove best for transitioning to a blended format for younger students.

Finally, as with all research into SOC, further research is required in different contexts. SOC may not have been as important in our course due to its design, which emphasized more individual projects and that required technical skills and not necessarily collaborative and discursive ones. Other blended courses that require more interaction among peers and the instructor may provide additional insights into context-specific blended design pedagogies.

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APPENDIX A: Adapted Classroom Community Scale

Adapted Connectedness Subscale	Original Connectedness Subscale
1. We cared about each other	I feel that students in this course care about each other
2. I felt connected to the other class members	I feel connected to others in this course
3. There was a feeling of trust	I trust others in this course
4. I felt that this course was like a family or community	I feel that this course is like a family
5. I could share ideas on projects with others without being criticized	I feel uncertain about others in this course
6. I was confident that my class members would support or assist me	I feel confident that others will support me
7. I had a sense of belonging	I do not feel a spirit of community
8. My class members could depend on me	I feel that members of this course depend on me
9. I felt isolated	I feel isolated in this course
10. I had friends that I could talk to outside of class	I feel like I could rely on others in this course
11. I received timely feedback from others	I feel that I receive timely feedback (originally from the learning subscale)
12. The "sense of community" we felt was important	(Not Included)

APPENDIX B: Extended Review of DBR Literature

Design-based research (DBR), unlike other traditional research methods, seeks to develop educational theory through continual intervention in an authentic learning environment (Edelson, 2002). Design researchers do not focus on one independent variable of a situation but rather attempt to design interventions for more general use in complex and multivariate environments. This research methodology arose from the realization that aspects of a classroom are inseparably connected and that it is impossible to affect change on one aspect without the effects reverberating throughout the system. Design researchers are, therefore, “responsible for simultaneous changes in the system” (Brown, 1992).

Design has traditionally been used in educational research to apply theories in authentic situations. Literature on DBR has shown, however, that design plays a critical role in the development of theory, not simply the evaluation of theory in authentic situations (Edelson, 2002). DBR eliminates the boundaries between design and research and “exploits the design process as an opportunity to advance the researcher’s understanding of teaching, learning, and educational systems.”

Cobb, Confrey, diSessa, Lehrer, and Schauble (2003) defined DBR as entailing “both the engineering of a learning environment and the systematic study of the forms of learning within that context defined by the means of supporting them.” It is important to note that DBR does not attempt to control for the context of the study, but rather embraces it as a vital characteristic of any outcome. Since the interventions themselves are designed based on the context they are found, interventions are outcomes of the research itself (The Design-Based Research Collective, 2003). The resulting theory built by DBR is informed by the context it was created.

Though context is embraced in DBR, an important characteristic of interventions vetted through design research is the ability for that intervention to be used in other practical situations. Bannan-Ritland's (2003) Integrative Learning Design framework was designed to “position design research as a socially constructed, contextualized process for producing educationally effective interventions with a high likelihood of being used in practice.” Practical application is central to DBR. The goal of DBR is to not only build effective designs in a single situation, but to go further by explaining why the designs work and how a particular design can be used in another situation (Brown, 1992; Cobb et al., 2003; The Design-Based Research Collective, 2003).

DBR is often found in newer, less defined interventions (Welch, 2000). Due to ambiguity and the volatile nature of an authentic learning environment, errors may be introduced into the work. Sloane and Gorard (2003) stated “drawing valid single-level or cross-level inferences from aggregated data requires that design experiment (DE) researchers begin to deal more explicitly with the possibilities for error in their work.” In response to this, a goal of design researchers is to understand failure, not control for it (Sloane & Gorard, 2003). In so doing, the hope is that a better practical theory will be built. These practical theories can then inform traditional research.

One area where DBR may inform traditional research is by studying how the gains in proximal measures translate to gains in distal measures. As McCandliss, Kalchman, and Bryant (2002) stated, “operational definitions hold the distinct advantage of being highly transportable from the context of the design experiment to other contexts, such as laboratory investigations.” Another area where DBR may benefit educational research is by offering a better understanding of interacting systems as opposed to separate factors that may influence learning (Cobb et al., 2003).

DBR also provides benefits to the researchers. Edelson (2002) offered three suggested benefits of DBR: (1) design researchers have opportunities to learn unique lessons when intervening in authentic situations, (2) DBR yields practical lessons that can be directly applied, (3) design researchers are engaged in direct improvement of educational practices.

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