CJLT RCAT

Canadian Journal of Learning and Technology
La Revue canadienne de l'apprentissage et de la technologie

Volume 42(1) Spring/printemps 2016

Introducing Backchannel Technology into a Large Undergraduate Course

Introduction d'une technologie d'arrière-plan dans un vaste cours de premier cycle

Ruth Neustifter*, Department of Family Relations and Applied Nutrition, University of Guelph*
Tuuli Kukkonen*, Department of Family Relations and Applied Nutrition, University of Guelph*
Claire Coulter*, Open Learning and Educational Support, University of Guelph*
Samantha Landry*, Department of Family Relations and Applied Nutrition, University of Guelph*

Abstract

Backchannel technology can be used to allow students in large lecture courses to communicate with each other and the instructor during the delivery of lecture content and class discussions. It can also be utilized by instructors to capture, summarize, and integrate student questions, ideas, and needs into course content both immediately and throughout the course. The authors integrated backchannel software in one of two sections of a course, leaving the other section as a control; combined, the two sections contained a total number of 871 students. Data was gathered comparing both groups using online surveys and semester grades; results showed that the section using backchannel software had higher class satisfaction and perception of engagement, used their mobile devices more for accessing class content, felt more comfortable participating in class discussions, and had a higher grade average than the section that did not. The authors also explore their own experiences of finding, integrating, and maintaining backchannel technology.

Résumé

La technologie d'arrière-plan peut permettre aux étudiants de grands cours magistraux de communiquer les uns avec les autres et avec l'instructeur durant le cours et les discussions en classe. Les instructeurs peuvent aussi l'utiliser pour saisir, résumer et intégrer les questions, idées et besoins des étudiants dans le contenu du cours, et ce, immédiatement et pendant toute la durée du cours. Les auteurs ont intégré un logiciel d'arrière-plan dans l'une des deux sections d'un cours, faisant de l'autre section son groupe témoin. Ensemble, les deux sections comprenaient 871 étudiants. Des données ont été recueillies pour comparer les deux groupes à l'aide de sondages en ligne et des notes du trimestre. Les résultats ont démontré que la section utilisant le logiciel d'arrière-plan avait une plus grande satisfaction et une meilleure perception de l'engagement, que ses étudiants se servaient de leurs appareils mobiles pour accéder à davantage de contenus, se sentaient plus à l'aise de prendre part aux discussions en classe et avaient une moyenne plus élevée que ceux du groupe qui n'avait pas accès au logiciel. Les auteurs explorent également leurs propres expériences pour trouver, intégrer et entretenir la technologie d'arrière-plan.

Introduction

Large courses using lecture formats are challenging for instructors who strive for active engagement across learning preferences and accessibility needs. A breadth and depth of literature is available documenting the consequences of growing class enrollments at universities. While it has been well documented that these classes create challenges, they also present unique opportunities for peer-learning resources, greater diversity, and other benefits (Wolfman, 2002). The coauthors of the paper worked together to integrate technology into a large lecture course to try to better utilize some of these resources and increase engagement, learning a great deal in the process.

The first two authors of this paper have each taught one of two sections of a large lecture-format undergraduate course at a major Canadian university located in Southern Ontario. Total enrollment between the two sections was 871 students, with approximately equal size in each section. Each section is comprised of a three hours of weekly lecture over a 12-week semester, with a large portion of the 400 to 450 students in the section attending each lecture. This class is offered regularly at this university, with the two sections regularly enrolling approximately 900 students each winter semester, with additional sections offered by other instructors and at other times of the year. In order to address some previously recognized concerns and better utilize the positive aspects of large class sizes, a grant was sought by both instructors in collaboration with the university's department of Open Learning and Educational Support. This grant was used to design and introduce a mixed-methods delivery approach to teaching a large lecture. The integration of a web-based chat tool to promote online class discussion synchronous to the lecture was hoped to increase interactivity. This "backchannel" was intended to offer every student a voice, regardless of learning preference or ability, thus facilitating a supportive community of engaged learners. Given the nature of some of the course content, the project aspired to create a safe space for student dialogue; through a provision of accountable anonymity, meaning a withholding of usernames from fellow students but not from moderators, it was hoped students would freely yet appropriately contribute to the conversation. The grant also supported the collection of data on the project's implementation from one section together with control data from the second section of the same course that was taught without technology-mediated discussions.

The process of finding, implementing, supporting, and optimizing a technology platform proved to be a far more challenging effort than was anticipated. While the data collected from students offered both considerations and support for its use, as well as insights into students' self-reported preferences for in-class technology, the research team faced substantial hurdles, some of which were sudden and unanticipated but may be avoidable in the future. As a result, the research team gathered important insights for later iterations of this project. It is the goal of this paper to explore these insights for the benefit of other instructors and teaching & learning support staff, as well as to present the results of the research analysis. Potential interpretations and applications of this information will also be discussed.

21st Century Post-Secondary Education

Canadian colleges and universities have seen a dramatic increase in enrollment of full-time and part-time students. In 2010, there were 1.2 million students on Canadian campuses. Included in this figure are 755,000 undergraduate students, 143,000 graduate students, and 275,800 part time students. Since 1980, full-time enrollment has more than doubled at Canadian universities (Association of Universities and Colleges of Canada, 2011, p. 5). The consequences of increased enrollment for teaching and learning experiences are well documented in the literature. Instructors are now responsible for facilitating large classes comprised of diverse groups of students. Incoming first year students are easily bored (Roehling, Vander Kooi, Dykema, Quisenberry, & Vandlen, 2011) and difficult to engage and also vary in terms of intelligence and drive (Mulryan-Kyne, 2010). Additionally, new students differ in age, cultural background, and socioeconomic status (Biggs, 1999). Greater class sizes have increased the opportunity for students to remain anonymous and passive in the classroom, therefore lessening student accountability and motivation (Mulryan-Kyne, 2010).

In addition, according to the Higher Education Quality Council of Ontario, 5% of all university students in the province registered with disability service offices in 2010-2011 (McCloy & DeClou, 2013). At the university where this research was conducted, approximately 1750 students were registered with Student Accessibility Services (SAS) during the 2014/2015 school year (personal communication, June 1, 2015). Based on this figure, approximately 5.5% of the student population was registered with SAS. Furthermore, approximately 15% of Canadians over the age of 15 have some level of disability (Fichten, Asuncion, Barile, Robillard, Fossey, & Lamb, 2003). Research has shown that approximately only half of students with disabilities (including mobility, auditory or communicative and learning), report their issues, and that often those who report will decline accommodations for fear of differential treatment from instructors (Blockmans, 2015; De Cesarei, 2014; Walters, 2010). While trying to instruct large numbers of students, teachers must also keep in mind the variations in needs of their students. Though disabilities must be acknowledged, focusing resources on specific areas and groups creates a risk of alienating others (Walters, 2010).

Kerr (2011) notes that one of the inherent teaching and learning challenges presented by large class size is the implementation of active learning strategies. The present study hoped to use active learning strategies in order to involve students in their own learning, and to appeal to the diverse group of individuals who make up large university lecture classes.

The Lecture and Active Learning Pedagogy

Instructor-led lectures are commonplace in higher education classrooms. Increased class sizes compound the frequency of lecture-based pedagogies, as growing resource demands equate to fewer instructors responsible for greater enrolments. In this format, learners are passive receivers of content as instructors transmit knowledge from the front of the room. This didactic model is most often teacher-centered and students are rarely encouraged to engage with their peers. This format is common largely because it provides a more cost-effective approach due to higher student-to-teacher ratios. While some studies have indicated that students still favour lectures when presented with digitally-mediated alternatives (Gysbers, Johnston, Hancock & Denyer, 2011), Freeman et al. (2014) report significant gains in learning outcomes in classes where active learning strategies are employed when compared to traditional lecture formats. Lecture formats may lack effectiveness as emphasis is on what is taught rather than what is learned (Berry, 2008), and as noted by Angelo and Cross (1993) "teaching without learning is just talking" (p. 3).

A great number of instructors are increasingly seeking ways to facilitate active learning experiences and increased engagement, and there is evidence to support these strategies as overcoming some challenges presented by a large class format (Mulryane-Kyne, 2010). By asking students to contribute beyond the role of passive listener, instructors seek to facilitate a learner-centered classroom where the balance of power shifts and students are encouraged to participate in the co-construction of knowledge (Roehling, Vander Kooi, Dykema, Quisenberry, & Vandlen, 2010).

Bonwell and Eison (1991) define active learning as any instructional strategy that has "students doing things and thinking about what they are doing" (p. 2). Research finds the benefits of active learning to include: increased conceptual understanding and retention; gains in motivation; and improved overall outcomes (Cherney, 2008; Crouch & Mazur, 2001; Freeman et al., 2014; Nilson, 1998; Prince, 2004; Smith & Cardaciotto, 2012). Additionally, higher order critical thinking is promoted when students are encouraged to share their own ideas and respond to the ideas of others through social and collaborative learning activities (Chickering & Gamson, 1987).

Discussion as Active Learning Strategy

Active learning implies a number of possible instructional strategies designed to invite engaged participation. Classroom discussion activities, which are one such strategy, promote long term retention of materials, increased motivation and the development of higher order thinking skills when compared to traditional lecture presentations (McKeachie et. al, 1986). Though again, it is not enough to simply have students "doing"; they must be encouraged to think beyond behavioural activity (discussion) through a guided process of selecting, organizing, and integrating knowledge (Mayer, 2004). Well-facilitated discussions are democratic and inclusive; they incorporate learner knowledge and experiences, and include feedback to support the development of well-constructed arguments (Dallimore, 2004; Sautter, 2007).

Research suggests, however, that even when students are asked to participate in lecture, they often do not. A recent survey of medical students found an aversion to public speaking as a primary deterrent (Moffett, Berezowski, Spencer, & Lanning, 2014). Similar results were found by Yoon, Kensington-Miller, Sneddon, & Bartholomew's (2011) study of participation in undergraduate mathematics lectures. Student interviews revealed several themes including: a reduction in student learning expectations in transmission-mode lectures; a reduction in student questions when material is not understood; and an overall reluctance to answer questions during lecture. Students expressed a fear of "looking stupid" while expressing admiration for those students who were confident enough to ask questions. Social norms govern how students can and should use their voices in the classroom and many feel uncomfortable challenging these boundaries (Yoon et al., 2011). This is particularly true if controversial topics are to be discussed, especially in a large class format (Ezzedeen, 2008). So it would seem that while discussions add value in lecture, they are often not easily facilitated given student reluctance to participate. This may also be partially due to the fact that lecture formats place pressure on the instructor to push the discussion forward in order to cover the necessary material. Research has demonstrated that instructors often wait, on average, only 1 second or less to elicit student responses following question prompts, and more, that the response time of instructors to student answers is similarly often less than 1 second (Rowe, 1986). With such brief intervals between discussion elements, it would seem that elicitation of new ideas would be improved with increased wait times. Indeed, Rowe notes several benefits resulting from increased wait times, including increases in student responses, increases in student-generated questions, and greater student confidence overall. The value of student-generated questions is of particular significance; when students ask questions in class, both instructors and other students benefit. Chin and Osborne (2008) argue that students experience four fundamental benefits from posing questions. First, asking questions helps students rearrange information in order to better understand it. Second, student questions allow learners to embark on a journey of co-constructed knowledge; peers are often stimulated by each other's questions. Third, active inquiry allows students to gauge the scope of their understanding by engaging in an internal inquiry. Finally, posing questions can spark interest—particularly when students are able to satisfy their queries with answers.

Digital Ubiquity

Incoming university students are prepared for working and creating in a space informed by technology (Gabriel, Campbell, Wiebe, MacDonald, & McAuley, 2012) and nearly all students in North American universities have access to computers (Kay & Lauricella, 2014). Research also indicates that a large majority of students report bringing mobile devices to the classroom. A recent study at the University of Guelph found that 93% of students bring at least one mobile device to lecture (Witecki & Nonnecke, 2015). Kay and Lauricella (2011) report increases in course interest and student participation when the use of mobile devices is purposefully integrated in lecture or other learning activity. Social web-based technologies, described as "second generation... more personalised, communicative form[s] of the... Web that emphasi[ze] active participation, connectivity, collaboration and sharing of knowledge and ideas among users" (McLoughlin & Lee, 2011, p. 665) are commonplace. This study hypothesized that there exists an opportunity to meet some of the challenges of facilitating active participation in a large lecture through the implementation of emerging educational technologies (Mayer, 2004).

Taking the Discussion Online

The first consideration when implementing educational technology in the classroom is the instructional design; the pedagogy should always precede the technology (Tamim et. al., 2011). Ross et al. (2010) define educational technology as "a broad variety of modalities, tools, and strategies for learning, [the] effectiveness... depend[ing] on how well [the technologies] help teachers and students achieve the desired instructional goals" (p. 19). The Higher Education Funding Council for England (HEFCE) (2009) identified several benefits of educational technology interventions in the support of teaching and learning, including the enhancement of existing practices toward improved process and outcomes. With increased engagement through active inquiry as the goal, the question then is whether there exists an opportunity to enhance classroom discussion using technology.

This hypothesis is not new; for many years, university instructors have integrated Classroom Response Systems (CRSs), also known as Audience Response Systems, into their teaching practice. More recently, web-based CRSs designed to meet a variety of needs have been developed to provide instructors with further tools to enhance the physical classroom and encourage student participation. CRSs have been used to track attendance, to produce class notes (Simon, Davis, Griswold, Kelly, & Malani, 2008), to promote interactivity (Wessels, Fries, Horz, Scheele & Effelsberg, 2007) and as a tool for reinforcing and assessing student knowledge (Boyle & Nicol, 2003) and maintaining focus in the classroom (Fies & Marshall, 2006). Though web-based classroom assessment tools such as electronic voting systems have been supported for their positive outcomes on standardized test results (Crouch & Mazur, 2001) and for providing formative feedback (Draper & Brown, 2004), they are not without limitations. While classroom clicker systems and online polling platforms allow instructors to gauge learner understanding, their closed-ended nature does not encourage students to introduce new ideas, thoughts and opinions. Hainz et al. (2014), in their development of a web-based CRS, suggested that a new system should be kept as basic as possible and that features should be prioritized in order to emphasize practicality.

Introducing the Backchannel

In the lecture format, the presentation at the front of the room can be described as a "front channel" where the flow of information is typically unidirectional from instructor to learners. In this model, the professor or instructor is the bearer of knowledge, and students are passive receptacles. In contrast, a "backchannel," a term coined by Yngve (1970), refers to a parallel channel for communication that takes place simultaneously to the front channel. In the past, the backchannel was characterized by listener-produced sounds and signals such as "mm-hmm," "yeah," and nodding (Yngve, 1970). In the context of the classroom, this may extend to the passing of notes or whispering amongst students. Contemporary understandings of backchannel exchanges have expanded beyond "response tokens" such as "mm" and "yeah" to include short phrases and substantive responses which may redirect the dominant discussion (Lambertz, 2011). More recently, technology has mediated these side conversations in classrooms, museums (Ebner, 2009; Langa, 2014) and academic conferences (Ross, Terras, Warwick & Welsh, 2011). In the context of university lectures in particular, technology-enhanced backchannels have been documented and represent a range of instructional designs and outcomes (Dufresne, Gerace, Leonard, Mestre & Wenk, 1996; Ratto, Shapiro, Truong & Griswald, 2003; Yardi, 2008). Today, therefore, the term backchannel is used to describe a technology-mediated communication tool facilitating "a secondary electronic conversation that takes place at the same time as a conference session, lecture, or instructor-led learning activity" (Educause, 2010, para. 5).

A technology-mediated backchannel improves communication by facilitating a new flow of information as the learners, traditionally the receivers of information, become active senders. When implemented with purpose, a backchannel can effectively provide a means to make the whispers in the room explicit. Students are offered equal opportunity to participate in the conversation, both with the instructor and with each other, and thus interactions become multidirectional. Sandstrom and Rawn (2015) note that social interaction in the classroom contributes to an increased sense of belonging and positive perceptions of a class. Mason and Rennie (2008) note that participation in a community of learning increases the effectiveness of the learning experience (in Saunders and Gale, 2012). A backchannel, then, offers increased opportunity for social interaction through a web-enabled community of learners all contributing to the construction of knowledge. Yardi (2008) notes that backchannel conversations provide a means by which

> students can create their own knowledge by having the freedom to direct the discussion in ways that are relevant, contextual, and instructional for their own learning purposes. The ways in which students use chat rooms emulate their culture of learning, communicating, and interacting. Peer-to-peer interactions support flexible, learner-centered designs in which learning is active and organic rather than static. (p. 149)

Moreover, Wieman (2007) reports that by implementing interactive technologies, student questions represent a greater diversity of learners across gender and ethnicity. Rose, Meyer, Strangman, and Rappolt (2002) support this notion by underlining that digital technologies are often able to flexibly respond to learner differences.

While the concept of backchannel communication began with body language and uttered affirmations and dissents, it has since come to encompass technological communication, as well. This is particularly relevant in large lectures where traditional backchannel communication is difficult to elicit and receive due to the number of students. Mindful integration of backchannel opportunities in the classroom creates options for students who would otherwise avoid interacting during group discussions. It also offers additional avenues for students who struggle to interact during class due to disabilities or other concerns. Finally, it allows students to more actively participate in the lecture, so that information and communication can flow in multiple directions.

Methods

Participants

Potential participants were recruited through an introductory undergraduate course on couple and family relationships. A total of 871 students were registered in the two sections of the course, and 638 completed the online survey. Participants ranged in age from 17-68 years (mean age = 19.41 years, $sd = 3.31$) and predominantly identified as female ($n = 540$; male $n = 82$; transgender $n = 1$; prefer not to answer or missing $n = 15$), and in their first year of undergraduate studies ($n = 416$; second year $n = 124$; third year $n = 40$; fourth year or higher $n = 43$; prefer not to answer or missing $n = 15$). This study was approved by the University of Guelph Research Ethics Board.

Measures

An online questionnaire was created for this study by using survey questions from previous research that pertained to our main research goals (Eastman & Eastman, 2011). Using

Likert-style questions (1= strongly agree to 5 = strongly disagree) the questionnaire evaluated 1) general course satisfaction (4 questions), 2) course interaction and interest (6 questions), 3) use of technology in the class (14 questions), and 4) attitudes towards interactive technology (6 questions; section using backchannel only). Additional questions gathering basic demographic information (sex, age, year of study and GPA) were also included.

Procedure

To determine whether an active backchannel significantly improved student outcomes and perceptions of class enjoyment and engagement, two sections of an introductory first year course on family and couple relationships were selected for the study. Two different course instructors were assigned, one for each section. Course content, lecture material, slides, in-class discussion questions and evaluation activities were shared for both sections; however, one section included an active backchannel chat during lecture time, while the other section did not.

It was the goal of the researchers to add a combination of multiple functionalities: private chat between instructors and students; moderated group chat between all students and the instructor; polling facilitated by the instructor and moderators; and the option to keep transcripts of each of these. It was also important that the software comply with accessibility requirements, and be restricted to students who were logged in with official university accounts. Finally, it was necessary that the software support on-going classroom interaction for hundreds of students at once while still being cheap or free without forcing advertising on students.

This proved to be a challenging set of criteria to meet in a single piece of software. The initial low-cost software chosen was not able to sustain the load placed upon it, in spite of careful planning with the creators, and had to be quickly replaced with other backchannel software. The second backchannel program lasted through the semester, but was then scheduled to be discontinued shortly after the end of the course.

Class integration of the backchannel software was consistent across both platforms. The instructor inserted specially marked discussion starter slides into the slide deck, each marked with a uniform question mark image and containing text encouraging and directing students to respond via the backchannel. The control class, which did not have backchannel technology, had the same discussion starters for in-class conversation but no mention of technology. Initially the instructor projected the ongoing, moderated class conversation on one of two front screens at the front of class. However some students found this distracting (most notably adult learners) and this was replaced with the suggestion that interested students check the chat screen on their own devices. The online chat room also had designated areas for asking general class questions, as well as questions about assignments and assessments. Students using the backchannel also received slides encouraging the use of poll voting, with directions on how to log in and utilize the poll. Results were incorporated into class discussion and lecture. Finally, online office hours were offered using the backchannel at the same time as live office hours The online hours were offered to all students in the backchannel section of the course; this allowed students to ask questions of the instructor either verbally or via software both inside and outside of class, making office hours consistent with classes in terms of the instructor's digital accessibility. Although all class-wide communication was moderated, students could effectively contribute anything to inform the discussion of content. Polls were used to gauge understanding/values. The instructor would often synthesize these contributions and relate them back to the lecture, thereby allowing students to see their contributions in the lecture and discussion content.

Toward the end of semester, all registered students were invited to take part in an anonymous online survey regarding their perceptions of technology use in the classroom and their perceived satisfaction with the course. Upon completion, participants were offered the opportunity to separately enter their names in a random draw for a number of $25 gift cards (one card for every one hundred participants) and to receive course credit for their participation.

Data Analysis

All data analyses were conducted using SPSS 23. To evaluate whether differences existed in question responses between the two sections, MANOVA analyses were conducted with individual question responses regarding course satisfaction, course interaction and interest, and the use of technology in the class as the dependent variables and course section (backchannel class vs. traditional lecture) as the independent variable. It was hypothesized that participants in the backchannel chat condition would demonstrate significantly higher course satisfaction, interaction and interest than those in the traditional lecture condition. Furthermore, it was hypothesized that the participants in the backchannel chat condition would use their mobile devices significantly more for accessing course content and lecture material in class than students in the traditional lecture condition, who would use theirs primarily for social/personal browsing during lecture time.

Results

When asked whether participants regularly use mobile technology in class (defined as a cell phone, laptop, tablet or other similar electronic device), 88% of the sample indicated that they do (n=548), while 10% indicated that they did not ($n = 64$; 16 participants did not answer this question). A MANOVA analysis on the use of mobile devices for personal and class content demonstrated significant differences between the sections with students in the backchannel class using their devices significantly more for course content than those in the traditional lecture (F (1, 614) = 5.80, $p = .02$). There were no differences between sections for use of technology for personal content ($p = .26$). When asked if others around them use technology for personal use and/or class content, 61% of participants indicated that other students in the class used technology for both personal and class content ($n = 392$), 30% indicated that other students use technology for accessing personal/social content only ($n = 188$), and 6% indicated that others around them use technology to access course content only ($n = 37$). For the students in the backchannel chat class, the students indicated overall positive ratings of use, with the majority of respondents enjoying their experiences with the software (see Table 1 for frequencies). Out of respondents from the backchannel section ($n = 358$), 20% indicated that they had not used the technology at all in the classroom ($n = 69$).

Table 1

Distribution of Responses Regarding Use of the Interactive Technology from Respondents in the Backchannel Chat Class (n = 358)

Item	Strongly Agree or Agree	Neutral	Strongly Disagree or Disagree
I though the lecture and technology usage were effectively integrated	75% (*n* = 259)	16% (*n* =56)	9% (*n* = 31)
I enjoyed using the software to ask and answer questions in the classroom[a]	52% (*n* = 179)	16.5% (*n* = 57)	12% (*n* = 41)
I think the advantages of using the software outweighed the disadvantages in this course	63% (*n* = 217)	26% (*n* = 89)	11% (*n* = 40)
I think this course should continue to use the software	72% (*n* = 192)	18% (*n* = 63)	10% (*n* = 33)
I think other professors should use this software in their classes	58% (*n* = 200)	27% (*n* = 94)	15% (*n* = 52)

[a]20% indicated that they did not use the technology at all for questions

Course Satisfaction

A MANOVA analysis on general course satisfaction revealed significant differences for all questions between sections, with the participants in the backchannel chat section rating their course experience as significantly more positive than those in the section without it (F (1, 622) range = 7.41, all *ps* =.000; see Table 2 for means).

Table 2

Comparison of Question Response[a] Means (Standard Deviation) for Respondents in the Backchannel Class (n =348) and Traditional Lecture Class (n = 276)

Question	Backchannel Class	Traditional Lecture	*p*	Partial Eta squared
Course Enjoyment				
I enjoyed taking this course	*m* = 1.95 (.83)	*m* = 2.51 (.92)	.000	.09
The course material was presented effectively	*m* = 1.84 (.81)	*m* = 2.42 (.91)	.000	.10
This course was more interesting than I thought it would be	*m* = 2.22 (1.01)	*m* = 2.78 (1.08)	.000	.07
The weekly classes helped me master the	*m* = 2.26	*m* = 2.47	.01	.01

Question	Backchannel Class	Traditional Lecture	*p*	Partial Eta squared
course material	(.93)	(.93)		
The lectures held my attention	*m* = 2.34 (.98)	*m* = 2.73 (.97)	.000	.04
Course Interaction				
The professor encouraged class participation during lecture	*m* = 1.36 (.54)	*m* = 1.69 (.65)	.000	.07
I actively participated in class discussion	*m* = 3.40 (1.09)	*m* = 3.33 (1.02)	.43	.00
I felt comfortable participating in class discussions	*m* = 2.88 (1.03)	*m* = 3.06 (1.01)	.03	.01
I felt comfortable asking questions in class	*m* = 2.90 (1.04)	*m* = 3.04 (.98)	.08	.01
Use of Technology in Class				
In class, I primarily use my mobile device for social/personal browsing and communication	*m* = 3.08 (1.25)	*m* = 3.20	.26	.00
In class, I primarily use my mobile device for accessing course content/lecture material	*m* = 2.48 (1.33)	*m* = 2.75	.02	.01
I find the use of mobile devices in the classroom distracting to my learning	*m* = 3.51 (1.12)	*m* = 3.45 (1.06)	.49	.00
I think professors should use more interactive technology (we should define interactive technology) to make their courses more interesting	*m* = 2.47 (.99)	*m* = 2.37 (.82)	.18	.00
I believe that I learn more in courses using interactive technology than I do in traditional lectures	*m* = 2.50 (1.05)	*m* = 2.52 (.93)	.87	.00
I believe the use of interactive technology can facilitate learning and interaction for students with disabilities	*m* = 1.98 (.75)	*m* = 2.04 (.69)	.33	.00
The use of interactive technology (would have) increased my understanding of course material	*m* = 2.61 (.95)	*m* = 2.44 (.81)	.02	.01
The use of interactive technology (would have) helped me learn factual material	*m* = 2.61 (.98)	*m* = 2.45 (.86)	.03	.01
The use of interactive technology (would have) helped me identify issues central to this course	*m* = 2.42 (.91)	*m* = 2.46 (.83)	.60	.00

Question	Backchannel Class	Traditional Lecture	*p*	Partial Eta squared
I find the use of interactive technology to be distracting in class	*m* = 3.34 (1.05)	*m* = 3.45 (.90)	.17	.00
I believe that the use of interactive technology puts students at a disadvantage if they don't have access	*m* = 2.43 (1.02)	*m* = 2.40 (.97)	.68	.00
If I had the choice between a course taught with interactive technology or taught in a traditional manner, I would choose the interactive course	*m* = 2.51 (1.10)	*m* = 2.54 (.97)	.78	.00

[a] Question responses 1= strongly agree, 2= agree, 3= neutral, 4= disagree, 5= strongly disagree.

Course Interaction and Interest

A MANOVA analysis on course interaction and interest revealed significant differences between the sections for perceived comfort in participating in class discussions (F (1, 619) = 4.62, p = .03) and professor encouraging students to participate in lecture (F (1, 619) = 48.25, p = .000); see Table 2 for means) with participants in the backchannel class indicating stronger agreement with these statements than those in the traditional lecture.

Attitudes towards Technology

A MANOVA analysis was conducted on questions pertaining to attitudes towards technology (see Table 2 for questions and means). The only significant differences between the sections were regarding understanding of course material, where students in the traditional lecture section indicated that they thought the technology would significantly improve their understanding of course content as compared to the section that actually used the technology (F (1, 603) = 5.39, p = .02) and thought that the use of technology would have significantly improved their learning of factual material as compared to the class that actually used the technology (F (1, 603) = 4.87, p = .03).

Course Performance

A one way ANOVA conducted on the overall class grade average for both sections demonstrated significant differences between the sections with the class using backchannel chat having a significantly higher average (m = 82.24%, sd = 11.26) than the class without the technology (m = 74.28%, sd = 12.54; F(1, 870) = 97.31, p = .000, partial eta-squared = .10).

Discussion

The purpose of this research was to examine the feasibility of using a backchannel in a large university lecture and to determine whether its use significantly improved student perceptions of engagement and enjoyment in class. Overall, the results supported these hypotheses, with students in the backchannel class indicating greater overall satisfaction with the course and increased comfort with participating in class discussions than students in the traditional class setting. Additionally, students in the backchannel class indicated paying greater attention in class and used their mobile devices significantly more for accessing course content than the class without the backchannel. This suggests that the backchannel chat was successful in engaging students and encouraged increased attention towards class content. Although these results were significant, it should be noted that the effect sizes were small, which suggests that the actual impact of interactive technology on the class as a whole might be small. Given the technical difficulties with software at the outset of the course, and the exploratory nature of this study, it could be that these results are an underestimate of the potential that interactive technologies can have on the classroom. Additionally, it may be that interactive technology has a differential impact on students, and that exploration of different subsets of student groups, such as those who feel inhibited in participating in class discussions, would reveal greater differences. Given the basic demographic information gathered, it was beyond the scope of this study to examine subsets of students. Despite the small effect sizes, the backchannel class earned an overall average of A-, which was significantly higher than the B average earned by students in the traditional lecture, providing further support for the benefits of incorporating interactive technologies. While it is possible that this significant difference could be attributable to a number of factors including the professor and teaching assistants, both classes had the same level of teaching support, lecture materials, identical assignments, grading schemes and exam questions. Although student perceptions of integrative technology demonstrated that the class without a backchannel thought it would facilitate learning to a greater extent than the class that actually had it, the difference in grades suggests that further examination of the contribution of a concurrent backchannel to student learning outcomes is warranted.

Every research project and technological effort runs the risk of running into challenges, anticipated and not, and this effort was no different. Even so, the research team was surprised by the nature of some of the hurdles that we faced. Most notably, the team struggled to find software that met our specific needs for this project. With the recent growth in cloud-based teaching and learning software, we anticipated that there would be a variety of suitable options from which to choose. Instead, the team found that few programs with the desired functionality were available for larger lecture classes, especially without leveraging additional fees to students or an investment of thousands of dollars by the instructor or university. An initial low-cost software package was chosen that offered to support an unlimited number of students, which was confirmed in conversation with the software designers. However, upon its first use we quickly discovered that it was not able to support interaction from a class of the size used in this study. The designers responded quickly but were unable to alleviate the problem and after three weeks, the team was informed that the software had been capped at fifty users, instead of an unlimited number.

At this point, it was necessary to quickly find a new software alternative and then educate and encourage the class to use the new software. This proved difficult for several reasons. First, the students had become disheartened after many experiences with crashing the prior platform during class. Second, the students were now being asked to register accounts with another software company and learn how to use the new platform. Third, the team had to learn to implement, integrate, and support the new software with very little preparation and practice time. The team responded to this shift by offering live assistance in class to help students sign in for the software, and were able to find an alternative that integrated with their existing university log-ins.

At the end of the semester, the team was made aware that the new platform was also going to be discontinued, and would not be available for future use. Future instructors and educational support staff teams should carefully consider the long-term viability of chosen platforms, and not assume that they will be able to work with larger courses unless they can demonstrate an existing history of doing so. Unfortunately the cost of major, established programs like this is prohibitive for instructors without larger-level financial support from their institutions. Institutions may wish to consider the value of offering such interactive large classroom software to their instructors through bulk licenses, or of developing and supporting robust options themselves. The second software chosen was offered from a very large international software company, and it will still not be available for future semesters. It may not be possible to fully avoid the loss of a software program after it has been adopted.

The team member who taught the course in which the software was used also faced a more readily avoidable concern: managing the distraction caused by the software while still promoting its use with students. Initially the instructor projected the software feed on one of two large screens at the front of the class. This did encourage students to submit more comments, and helped to integrate the online conversation more fully into class. While some students reported that this was a positive addition to the class, others were quite firm that this was a major distraction for their learning. The students who asked that the feed no longer be projected were largely adult learners, but it cannot be assumed that younger students were not also in agreement. Those learners that voiced concerns in person both found the display distracting and also thought that it distracted the instructor. They pointed out that the instructor would sometimes stop in mid-thought or change topics quickly in order to respond to the live feed, and this made it difficult for them to follow the lecture content. To address these concerns the instructor stopped broadcasting the live feed in front of the class, and instead inserted “backchannel breaks”—specially designated times during the class to interact with the live feed. If more urgent questions or comments were posted, the moderator would motion to the instructor to quickly pause and more discretely check the feed. Designated backchannel times were signaled by a special graphic and log-in directions that were inserted at key discussion points in the lecture slides. The instructor noted that they felt less distracted and more organized this way. No students approached the instructor with concerns about this method, although there was less active online discussion this way. However, this may be due to a variety of factors, including the change in software that was discussed above.

Finally, the instructor also commented on their personal experience of shifting class discussion to an online format while students were physically seated in the class. Their past experience included teaching online-only courses as well as traditional courses without interactivity software, but not combining key elements of both for class discussions. As students became more accustomed to online discussion, they were less likely to raise their hands. The instructor was still obligated to invite students to comment by voice, since students were not required to have a mobile device or utilize the software. However, it was no longer necessary to wait for someone to raise their hand. Instead, after waiting and seeing no hands, the instructor would switch their attention to the software.

Initially, the instructor felt as though the class was bored or unengaged because they were not speaking out loud and the instructor was accustomed to gauging class engagement and understanding by verbal comments and body language. For the instructor, it took some practice to feel comfortable with a large room that was both audibly silent and simultaneously interactive. The instructor perceived there to be less body language feedback, especially around eye contact and facial expressions, through this form of classroom communication. However, they also appreciated the diversity and consistent levels of class interaction. Student comments were often perceived to be longer, more nuanced, and more likely to include thoughtful, original content instead of brief summaries of the text or lecture content. It seemed to the instructor that students were also more likely to share personal experiences in order to illustrate their comments and link them to the class content. While it took some getting used to, the instructor (first author) felt that they would prefer to continue with well integrated and stable interactivity software for future courses of all sizes.

Conclusion

The integration of backchannel technologies for large classrooms can offer important opportunities for greater student engagement across accessibility needs and communication preferences. However, in spite of broad encouragement for such practices in the literature and at many institutions, integrating such technology can prove to be a considerable challenge. Collaboration between instructors, university teaching and technology support services, and backchannel software providers is necessary to provide students with a smooth, well integrated, accessible, and engaging experience.

When backchannel software is successfully integrated, students respond positively. Students in this study felt positively about technology in the classroom, and those in the backchannel class achieved a significantly higher average score for the course. These students also felt more positive about classroom discussions.

Universities may wish to further investigate well-supported commercial and in-house options to offer backchannel options to faculty and students. Without that, instructors and teaching and technology support staff are left scrambling to find, learn, and support a limited range of affordable, accessible options. This process can prove more difficult than learning to integrate the software into the classroom, and require considerable support resources to make work. However, the authors anticipate that more robust options will become available as technology progresses and more large classrooms explore the potential of using backchannel software.

Acknowledgements:

The authors wish to thank the University of Guelph Learning Enhancement Fund for their generous support. This study would not have been possible without their grant funding.

References

Angelo, T. A., & Cross, K. P. (1993). *Classroom assessment techniques* (2nd ed.). San Francisco, CA: Jossey-Bass.

Association of Universities and Colleges of Canada. (2011). *Trends in higher education: Volume 1 – Enrolment*. Retrieved from http://www.aucc.ca/wp-content/uploads/2011/05/trends-2011-vol1-enrolment-e.pdf

Bannink, A., & Van Dam, J. (2013). Voices, grins and laughter in the lecture room. *Linguistics and Education*, *24*(4), 572-584. doi:10.1016/j.linged.2013.06.003

Berry, W. (2008). Surviving lecture: A pedagogical alternative. *College Teaching*, *56*(3), 149-153. doi:10.3200/CTCH.56.3.149-153

Biggs, J. (1999). What the student does: Teaching for enhanced learning. *Higher Education Research & Development*, *18*(1), 57-75. doi:10.1080/0729436990180105

Blockmans, I. G. E. (2015). "Not wishing to be the white rhino in the crowd": Disability-disclosure at university. *Journal of Language and Social Psychology*, *34*(2), 158-180. doi:10.1177/0261927X14548071

Bonwell, C., & Eison, J. (1991). Active learning: Creating excitement in the classroom (*AEHE-ERIC Higher Education Report No. 1).* Washington, DC: The George Washington University. Retrieved from http://eric.ed.gov/?id=ED340272

Boyle, J. T. & Nicol, D. J. (2003). Using classroom communication systems to support interaction and discussion in large class settings. *Association for Learning Technology Journal*, *11*(3), 43–57. Retrieved from http://www.researchinlearningtechnology.net/index.php/rlt/article/view/11284

Cherney, I. D. (2008). The effects of active learning on students' memories for course content. *Active Learning in Higher Education*, *9*(2), 152-171. doi:10.1177/1469787408090841

Chickering, A. W., & Gamson, Z. F. (1987). Seven principles for good practice in undergraduate education. *AAHE Bulletin*, *39*(7), 3-7. Retrieved from http://eric.ed.gov/?id=ED282491

Chin, C. & Osborne, J. (2008). Students' questions: A potential resource for teaching and learning science. *Studies in Science Education*, *44*(1), 1-39. doi:10.1080/03057260701828101

Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics, 69*, 970-977. doi:10.1119/1.1374249

Dallimore, E. J., Hertenstein, J. H., & Platt, M. B. (2004). Classroom participation and discussion effectiveness: Student-generated strategies. *Communication Education*, *53*(1), 103-115. doi:10.1080/0363452032000135805

De Cesarei, A. (2014). Disclosure of disability by university students: Development of a study protocol. *Open Journal of Social Sciences*, *2*(8), 71-76. doi:10.4236/jss.2014.28012

Draper, S. W., & Brown, M. I. (2004). Increasing interactivity in lectures using an electronic voting system. *Journal of Computer Assisted Learning*, *20*(2), 81-94. doi:10.1111/j.1365-2729.2004.00074.x

Dufresne, R. J., Gerace, W. J., Leonard, W. J., Mestre, J. P., & Wenk, L. (1996). Classtalk: A classroom communication system for active learning. *Journal of Computing in Higher Education*, *7*(2), 3–47. doi:10.1007/BF02948592

Eastman, J. K., Iyer, R., Eastman, K. L. (2011). Improving undergraduate student satisfaction with the consumer behavior course: Will interactive technology help? *Marketing Education Reviews*, *21*(2), 139-149. doi:10.2753/MER1052-8008210204

Ebner, M. (2009). Introducing Live Microblogging: How Single Presentations can be Enhanced by the Mass. *Journal of Research in Innovative Teaching*, *2*(1), 108-111. Retrieved from http://www.nu.edu/assets/resources/pageResources/7638_JournalofResearch09.pdf

Educause (2010). *7 Things you should know about backchannel communication*. Retrieved from https://net.educause.edu/ir/library/pdf/ELI7057.pdf

Ezzedeen, S. R. (2008). Facilitating class discussions around current and controversial issues: Ten recommendations for teachers. *College Teaching*, *56*(4), 230-236. doi:10.3200/CTCH.56.4.230-236

Fichten, C. S., Asuncion, J. V., Barile, M., Robillard, C., Fossey, M. E., & Lamb, D. (2003). Canadian postsecondary students with disabilities: Where are they? *The Canadian Journal of Higher Education*, *33*(3), 71-114. Retrieved from http://ojs.library.ubc.ca/index.php/cjhe/article/view/183441

Fies, C., & Marshall, J. (2006). Classroom response systems: A review of the literature. *Journal of Science Education and Technology*, *15*(1), 101-109. doi:10.1007/s10956-006-0360-1

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410-8415. doi:10.1073/pnas.1319030111

Gabriel, M. A., Campbell, B., Wiebe, S., MacDonald, R. J., & McAuley, A. (2012). The role of digital technologies in learning: Expectations of first year university students. *Canadian Journal of Learning and Technology*, *38*(1), 1-18. Retrieved from http://www.cjlt.ca/index.php/cjlt/article/view/637

Gysbers, V., Johnston, J., Hancock, D., & Denyer, G. (2011). Why do students still bother coming to lectures, when everything is available online? *International Journal of Innovation in Science and Mathematics Education*, *19*(2), 20-36. Retrieved from http://openjournals.library.usyd.edu.au/index.php/CAL/article/view/4887/5979

Haintz, C., Pichler, K., & Ebner, M. (2014). Developing a web-based question-driven response system supporting BYOD. *Journal of Universal Computer Science, 20*(1), 39-56. doi:10.3217/jucs-020-01-0039

Higher Education Funding Council for England. (2009). *Enhancing learning and teaching through the use of technology: A revised approach to HEFCE's strategy for e-learning.* Retrieved from http://www.hefce.ac.uk/pubs/hefce/2009/09_12/09_12.pdf

Kay, R. H., & Lauricella, S. (2011). Unstructured vs. structured use of laptops in higher education. *Journal of Information Technology Education*, *10*(1), 33-42. Retrieved from http://www.informingscience.org/Journals/JITEIIP/Articles?Volume=10-2011

Kay, R. H., & Lauricella, S. (2014). Investigating the benefits and challenges of using laptop computers in higher education classrooms. *Canadian Journal of Learning and Technology*, *40*(2), 1-12. Retrieved from http://www.cjlt.ca/index.php/cjlt/article/view/831

Kerr, A. (2011). *Teaching and Learning in Large Classes at Ontario Universities: An Exploratory Study.* Toronto, Canada: Higher Education Quality Council of Ontario. Retrieved from http://www.heqco.ca/en-ca/Research/ResPub/Pages/Teaching-and-Learning-in-Large-Classes-at-Ontario-Universities-An-Exploratory-Study.aspx

Lambertz, K. (2011). Back-channelling: The use of yeah and mm to portray engaged listenership. *Griffiths Working Papers in Pragmatics and Intercultural Communication, 4*(1/2), 11-18. Retrieved from https://www.griffith.edu.au/__data/assets/pdf_file/0005/384017/Lambertz-backchannelling.pdf

Langa, L. A. (2014). Does Twitter help museums engage with visitors? *iConference 2014 Proceedings*, 484-495. doi:10.9776/14130

Mason, R. & Rennie, F. (2008). *E-learning and social networking handbook: Resources for higher education*. London, United Kingdom: Routledge.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist*, *59*(1), 14-19. doi:10.1037/0003-066X.59.1.14

McCloy, U. and DeClou, L. (2013). *Disability in Ontario: Postsecondary education participation rates, student experience and labour market outcomes*. Toronto, Canada: Higher Education Quality Council of Ontario. Retrieved from http://www.heqco.ca/en-ca/Research/ResPub/Pages/Issue-Paper-No-14-Informing-policy-through-analysis-of-current-research.aspx

McKeachie, W. J. (1986). *Teaching and learning in the college classroom: A review of the research literature* (Report No. OERI-86-0010). Ann Arbor, MI: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning. Retrieved from http://eric.ed.gov/?id=ED314999

McLoughlin, C., & Lee, M. J. (2010). Personalised and self regulated learning in the Web 2.0 era: International exemplars of innovative pedagogy using social software. *Australasian Journal of Educational Technology*, *26*(1), 28-43. doi:10.14742/ajet.v26i1.1100

Moffett, J., Berezowski, J., Spencer, D., & Lanning, S. (2014). An investigation into the factors that encourage learner participation in a large group medical classroom. *Advances in Medical Education and Practice, 5*, 65-71. doi:10.2147/AMEP.S55323

Mulryan-Kyne, C. (2010). Teaching large classes at college and university level: Challenges and opportunities. *Teaching in Higher Education*, *15*(2), 175-185. doi:10.1080/13562511003620001

Nilsson, J. (1998). *Real-time control systems with delays* (Doctoral dissertation, Lund institute of Technology). Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.30.1570

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*(3), 223-231. doi:10.1002/j.2168-9830.2004.tb00809.x

Ratto, M., Shapiro, R. B., Truong, M. T., & Griswold, W. G. (2003). The ActiveClass project: Experiments in encouraging classroom participation. *Proceedings of the Fifth International Conference on Computer Supported Collaborative Learning, Bergen, Norway,* 477-486.. doi:10.1007/978-94-017-0195-2_57

Roehling, P. V., Vander Kooi, T. L., Dykema, S., Quisenberry, B., & Vandlen, C. (2010). Engaging the millennial generation in class discussions. *College Teaching*, *59*(1), 1-6. doi:10.1080/87567555.2010.484035

Rose, D. H., Meyer, A., Strangman, N., & Rappolt, G. (2002). *Teaching every student in the digital age: Universal design for learning*. Alexandria, VA: Association of Supervision & Curriculum Development.

Ross, C., Terras, M., Warwick, C., & Welsh, A. (2011). Enabled backchannel: Conference Twitter use by digital humanists. *Journal of Documentation*, *67*(2), 214-237. doi:10.1108/00220411111109449

Ross, S. M., Morrison, G. R., & Lowther, D. L. (2010). Educational technology research past and present: Balancing rigor and relevance to impact school learning. *Contemporary Educational Technology*, *1*(1), 17-35. Retrieved from http://www.cedtech.net/past2.asp?numara=11

Rowe, M. (1986). Wait time: Slowing down may be a way of speeding up! *Journal of Teacher Education*, *37*(1), 43-50. doi:10.1177/002248718603700110

Sandstrom, G. M., & Rawn, C. D. (2015). Embrace chattering students: They may be building community and interest in your class. *Teaching of Psychology*, *42*(3), 227-333. doi:10.1177/0098628315587620

Saunders, F. C., & Gale, A. W. (2012). Digital or didactic: Using learning technology to confront the challenge of large cohort teaching. *British Journal of Educational Technology*, *43*(6), 847-858. doi:10.1111/j.1467-8535.2011.01250.x

Sautter, P. (2007). Designing discussion activities to achieve desired learning outcomes: Choices using mode of delivery and structure. *Journal of Marketing Education*, *29*(2), 122-131. doi:10.1177/0273475307302014

Simon, B., Davis, K., Griswold, W. G., Kelly, M., & Malani, R. (2008). Noteblogging: Taking note taking public. *ACM SIGCSE Bulletin*, *40*(1), 417-421. doi:10.1145/1352322.1352278

Smith, C. V., & Cardaciotto, L. (2012). Is active learning like broccoli? Student perceptions of active learning in large lecture classes. *Journal of the Scholarship of Teaching and Learning*, *11*(1), 53-61. Retrieved from http://josotl.indiana.edu/article/view/1808

Tamim, R. M., Lowerison, G., Schmid, R. F., Bernard, R. M., & Abrami, P. C. (2011). A multi-year investigation of the relationship between pedagogy, computer use and course effectiveness in postsecondary education. *Journal of Computing in Higher Education*, *23*(1), 1-14. doi:10.1007/s12528-010-9041-4

Walters, S. (2010). Toward and accessible pedagogy: Dis/ability, multimodality, and universal design in the technical communication classroom. *Technical Communication Quarterly*, *19*(4), 427-454. doi:10.1080/10572252.2010.502090

Wessels, A., Fries, S., Horz, H., Scheele, N., & Effelsberg, W. (2007). Interactive lectures: Effective teaching and learning in lectures using wireless networks. *Computers in Human Behavior*, *23*(5), 2524-2537. doi:10.1016/j.chb.2006.05.001

Wieman, C. (2007). Why not try a scientific approach to science education? *Change: The Magazine of Higher Learning*, *39*(5), 9-15. Retrieved from http://www.changemag.org/Archives/Back%20Issues/September-October%202007/full-scientific-approach.html

Witecki, G., & Nonnecke, B. (2015). Engagement in digital lecture halls: A study of student course engagement and mobile device use during lecture. *Journal of Information Technology Education: Research*, *14*, 73-90. Retrieved from http://www.informingscience.org/Journals/JITEResearch/Articles?Volume=14-2015

Wolfman, S. A. (2002). Making lemonade: Exploring the bright side of large lecture classes. *ACM SIGCSE Bulletin*, *34*(1), 257-261. doi:10.1145/563517.563441

Yardi, S. (2008). Whispers in the classroom. In T. McPherson (Ed.), *Digital youth, innovation, and the unexpected* (pp. 143-164). Cambridge, MA: Massachusetts Institute of Technology Press. Retrieved from https://mitpress.mit.edu/books/digital-youth-innovation-and-unexpected

Yngve, V. (1970). On getting a word in edgewise. In M. A. Campbell (Ed.), *Papers from the Sixth Regional Meeting of the Chicago Linguistic Society*, (567-578). Chicago, IL: Chicago Linguistic Society

Yoon, C., Kensington-Miller, B., Sneddon, J., & Bartholomew, H. (2011). It's not the done thing: Social norms governing students' passive behaviour in undergraduate mathematics lectures. *International Journal of Mathematical Education in Science and Technology*, *42*(8), 1107-1122. doi:10.1080/0020739X.2011.573877

Authors

Ruth Neustifter, Ph.D., RMFT is an assistant professor of Couple & Family Therapy in the Department of Family Relations and Applied Nutrition at the University of Guelph, Ontario, Canada. Email: rneustif@uoguelph.ca

Tuuli M. Kukkonen, Ph.D., C.Psych, is an assistant professor in the Department of Family Relations and Applied Nutrition and Director of the Psychophysiology of Sexual Health Laboratory at the University of Guelph, Ontario, Canada. Email: kukkonen@uoguelph.ca

Claire Coulter, B.A., is an Instructional Technologist at the University of Guelph, Ontario, Canada. Email: ccoulter@uoguelph.ca

Samantha Landry, B. Soc. Sci., is completing her M.Sc. in Family Relations and Human Development at the University of Guelph, Ontario, Canada. Email: slandry@uoguelph.ca