Student Engagement in Large Classroom: The Effect on Grades, Attendance and Student Experiences in an Undergraduate Biology Course

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STUDENT ENGAGEMENT IN LARGE CLASSROOM: THE EFFECT ON GRADES, ATTENDANCE AND STUDENT EXPERIENCES IN AN UNDERGRADUATE BIOLOGY COURSE

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INTRODUCTION

Background of study

A Biology first year university class that has over 600 students creates a challenge to instructors who would like to offer high quality teaching as they tend to lead to poor student attendance. One suggested approach to increase attendance is to increase interactions by using student engagement during classes. When students are engaged in active learning exercises they achieve higher grades, and more students stay in higher education (Springer et al, 1999; Ruiz-Primo et al,, 2011; Freeman et al,, 2007; 2014; Gasiewski et al,, 2012). Student engagement by active learning includes collaborative learning among students, preparing and attending to classes, and any kind of interaction with the course content inside and outside of the classroom (Larose et al., 1998; Svanum & Bigatti, 2009; Handelsman et al., 2005).

This study was designed to increase student engagement in large classes. One of the three sections in Introductory Biology class (Biology1001, 200 students in each section) was taught using active learning and student engagement (Engaging Class), and two other sections received lectures without active learning or significant engagement (Lecture Class). This was a mixed method study with quasi-experimental design that used both quantitative and qualitative research methods, and it was conducted during the fall semester in 2013 at Memorial University, Canada.

Purpose of study

This research study focused on teaching strategies used in an undergraduate Biology course. The underlying assumption is that the traditional lecture model of teaching is outdated and new innovative teaching methods are needed to engage future science majors in a way that facilitates natural learning of scientific exploration. Researchers have argued that introductory science, technology, engineering and mathematics (STEM) courses usually promote memorization without focus on meta-cognition related to critical thinking and scientific skills (Handelsman et al., 2004; Hurd, 1997; Williams et al., 2004). This study explored active, engaging teaching methods that can be applied to large or small classes across disciplines in the hopes of providing a motivation-based learning experience that can lead to better learning outcomes and higher class attendance rates. The overall goal is to enhance student motivation to stay within STEM disciplines, as there has been a decline in student retention in STEM fields in the last decade (Freeman et al., 2007; 2014).

Significance of study

The results indicated that by increasing student engagement and active learning in a large classroom a statistically significant increase in student attendance occurred during the semester. In addition, it was shown that the Engaging class had increased conceptual understanding at the end of the course compared to the Lecture class. Interestingly, student focus group reports indicated that students liked active learning, and they reported higher engagement in many areas in the Engaging class compared to Lecture classes.

The significance of these results is three fold. Firstly, the study showed that by modifying classroom instruction, the instructor can increase students' motivation to attend classes. Even though (as we discuss later) the factors affecting the decision to attend or skip classes are complicated, it was clear in this study that the Engaging class had significantly higher attendance as counted by weekly head counts. Secondly, this study showed that first year students can achieve better conceptual understanding of biology when active learning is offered during classes. Again, there are many factors that play a role in students' learning (as we will discuss later), however this study showed that the Engaging class had a significantly higher score in a conceptual test at the end of the semester. The students in the Engaging classes experienced active learning during each 50 minute lecture according to the following design: 10-15 minutes of mini-lectures followed by either clicker questions and/or working sheets for small group activities for 5-10 minutes. These textbook based activities were available to all students as part of the publisher's online resources, however only the Engaging class students were encouraged to practice by answering clicker questions or with the help of printed worksheets that were returned at the end of the class. In addition, the instructor and two teaching assistants circulated in the room to offer guidance during the class activities. Thirdly, according to students, they welcomed the interactive classroom activities, and they appreciated the chance for deeper learning during the class time, and they self-reported being more engaged and involved in the course content. This is an encouraging study, as it suggests that university lecturers can create more engaging classroom environments by simply adding more interactions between students and the instructor. Gasiewski et al. (2012) published a quantitative survey study of STEM students in 15 different universities in the U.S, and the findings indicated that the students tend to be more engaged in courses where the instructor consistently signals openness to student questions, and recognized his/her role in helping students succeed. In another study, Leger et al. (2013) showed that incorporation of online, and in-class small group problem solving in a large first-year class in geography led to increases in Classroom Survey of Student Engagement **(**CLASSE) and National Survey of Student Engagement scores indicating higher student engagement. In addition, the students in Leger's study scored higher in deep approach to learning questions in Biggs' Study Process Questionnaire after receiving more engaging teaching.

REVIEW OF LITERATURE

The problem of absenteeism

Students provide reasons for missing class in post-secondary education due to socioeconomic issues, time of class, availability and access to notes, subject matter, and the level of engagement provided by the teacher (Park & Kerr, 1990; Devados & Foltz, 1996; Knowlton, 2011). In addition to contributing to lower marks, student absenteeism has been shown to also relate to non-academic problems, such as social alienation (Kearney, 2003). There is a relationship between poorer marks and missing class (Durden & Ellis, 1995; Marburger, 2001; Grabe et al., 2005; Neri & Meloche, 2007).

Students' own assessment of factors promoting the success in first year relate to "time management/goal setting, academic advising, stress, and institutional fit/integration" (Thompson et al., 2007). When first-year university students and teachers were interviewed about the successful transition to university, four themes emerged: the challenges of forming connections to other students with similar interests during the first few weeks on campus, the need to balance competing demands, varied experiences of connection with instructor and staff, and the need for translation of university life for minority students (Baruch-Runyon et al., 2009).

Similar to the motivating effects of an engaging instructor, a sense of belonging to a group of students increases the level of intention to attend class, and results in higher levels of attendance. This higher level of internal motivation of a student also promotes higher rates of attendance later in university (White et al., 2011). Importantly, peer-instruction has been shown to enhance learning experience during large classes. A large class taught with peer-instruction is divided into a series of content presentations, and each is followed by a related conceptual question, which challenges students' understanding of the lecture content (Crouch and Mazur, 2001; Wieman, 2007).

Student engagement

It is helpful to categorize student engagement to better understand what the benefits might be in higher education. Fredricks, Blumenfeld and Paris (2004), identify three dimensions to student engagement; behavioural engagement, emotional engagement and cognitive engagement. Particularly, engaging students in learning is important in facilitating learning. Generally students who attend classes, and communicate with instructor during office hours tend get higher grades (Handelsman et al., 2005). There are several ways to keep students engaged during large classes. For example, class response systems; such as clickers or online-based polling tools can be used to collect on-time student responses during the classes (MacArthur, 2010). Also, this provides a form of feedback to the instructor to better understand what students are learning, or not learning, and to adapt accordingly (Caldwell, 2007; Crossgrove & Curran, 2008). Students report that they like attending classes where clickers are used; indeed according to some studies the use of clickers may increase attendance, attentiveness and alertness during classes, and decrease course attrition (Caldwell, 2007; Nagy-Shadman & Desrochers, 2008). Indeed, some studies report that students do master course content better when the instructor uses clickers in class. Preszler et al. (2007) assessed the effects of the clicker response systems on student learning in various Biology undergraduate courses. Increased use of the clicker response systems in lecture had a positive influence on students' performance on exam questions across all six biology courses (Freeman et al., 2007; Preszler et al., 2007).

Another common engaging teaching method is small group work that is based on the social constructivist theory, which states that knowledge is actively created in the mind of the learner (as opposed to being received passively), and this knowledge creation is facilitated by interactions with others (Herron, 1996). In small groups, students can feel more comfortable sharing ideas, explaining new concepts to each other, and can learn more from other group members (Cozolino & Sprokay, 2006).

Classroom Studies in undergraduate science

Classroom research in undergraduate science courses has focused on problem-solving, small group work, and tutorials in the process of developing more effective teaching strategies. For example, cooperative-learning tutorial classes based on problem solving helped students to perform better on standardized testing in an undergraduate biochemistry course (Anderson et al., 2005). In an introductory biology course re-design increased academic performance and improved student engagement and satisfaction (Armbuster et al, 2009). Also in a first semester introductory biology large enrolment classroom study, students' opinion of cooperative learning versus lectures was highly favourable toward cooperative learning activities, and the students showed greater course content knowledge only in the collaborative teaching group compared to traditional PowerPoint based lecturing (Armstrong et al., 2007). In an undergraduate biology classroom study by Burrowes (2003), one professor taught two large classes, using one as the control class, and the other as student-centered teaching via active learning in small groups. The results indicated that the experimental group performed better in midterm and final exams, and students reported significantly higher interest in biology compared to the control class (Burrowes, 2003). Interestingly, a classroom study by Deslauriers, Schelew and Wieman (2011) compared a respected, highly experienced physics professor lecturing to a class, to another section of the same course that was taught using active teaching facilitated by novice instructors. The active learning promoted learning, and led to a significant improvement in quiz marks, attendance and student satisfaction and student engagement. Knight and Wood (2005) compared a large biology undergraduate course grades and conceptual pre- and post-test scores in two classes receiving different instruction. One class received traditional lecturing, and a year later the same curriculum was delivered using clickers, small group discussion and formative assessment during classes. Students performed significantly better in the active learning class, and showed better conceptual understanding.

The use of teaching assistants to promote student engagement

We cannot underestimate the emotional responses and feelings that especially first year students might experience when entering university. Students' class participation can be hindered by feelings of intimidation and inadequacy (Weaver & Qi, 2005). If a student does not feel adequately knowledgeable about the course content, and if there is a lack of understanding and confidence of the course content, the student might feel discouraged to participate (Fassinger, 1995; Weaver & Qi, 2005). Increased levels of engagement happen when students have a sense of belonging, and they sense that the professor cares about them (Crombie et al., 2003). Classroom climate is an important part of an encouraging experience, especially when students' feedback and questions are respected, students do engage more in classes (Crombie et al., 2003; Dallimore et al., 2004). One way to increase classroom interactions in a positive and supportive way is to use teaching assistants in large classes. Graduate students are interested in teaching, however the doctorate programs often don't focus on teaching skills or pedagogical knowledge. According to Golde and Dore (2001) over 80% of doctorate students in the major universities in the U.S were seeking faculty position because of their passion in teaching. Effective integration of pedagogical skills into graduate programs is a fairly new phenomenon in STEM disciplines, and usually includes workshops in teaching and learning (Bartlett, 2003). When teaching assistants are present in the classroom with the professor, it helps everyone in creating more inclusive and engaging learning environment (Allen & White, 1999; Platt et al., 2003). This approach helps the professor to use more innovative teaching methods in a large class, and it helps the graduate students to gain valuable teaching experience especially demonstrating how to use active learning in large classes instead of traditional lecturing (Allen & Tanner, 2007).

How to increase student engagement and reduce absenteeism

Mann and Robinson (2009) found that students who reported being bored more often in class reported lower levels of engagement. One approach to better engage science students in larger classes is called “engaging teaching”. According to this teaching methodology, educators include teaching methods in the curriculum that encourage scientific exploration by using for example: Group Problem Based Learning, Peer-teaching, Clickers, Think-Pair-Share, Small Group Work, Invention Activities, Brainstorming, Concept Mapping, Decision Making, Real-World Examples, and Hypothesis Forming (Allen & Tanner 2007; Wieman, 2007). These methods have been shown to improve student learning outcomes in undergraduate science teaching (US National Research Council 2003; 2013; Handelsman et al., 2004; Wieman, 2007; Anderson et al., 2011; Freeman et al., 2007 & 2014).

The peer-to-peer learning in small groups has been shown success, and one reason is that instruction targeting the student diversity leads to increased success and creativity (Crouch and Mazur, 2001; Handelsman et al., 2007; MacArthur, 2010). In addition, maintaining a moderate level of arousal, activation of thinking and feeling combined with social interaction during a learning situation promotes the learning process (Cozolino & Sprokay, 2006). The traditional lecture format is not usually engaging, and often students are just passively listening, which is not the optimal situation for learning (Wieman, 2007; 2011). There are many peer-learning classroom activities that have been used successfully to engage students in scientific learning (Anderson et al., 2001; Allen & Tanner 2007; Handelsman et al., 2007; Wieman, 2007; Ebert-May & Hodder, 2008; MacArthur, 2010). These activities can take one class, or can be larger projects throughout the semester (Ebert-May & Hodder, 2008).

The instructors should be aware that measuring deep learning and conceptual understanding by using class tests might not be sufficient measure of learning; instead it is important to use conceptual inventories (Klymkowsky, 2009; Crouch and Mazur, 2001). Conceptual inventories can be used as a pre-test, and the same test is given as a post-test at the end of the course to measure learning gains (Wieman, 2007; 2011). Conceptual inventories are tests that are designed to give students a chance to explore important concepts, rather than testing memory. The instructor can investigate homework or class test results to find the common misconceptions, or search the education research literature. These questions should be challenging but not excessively difficult, nor too easy (Crouch and Mazur, 2001). For example, Force Concept Inventory in Physics has been widely used to standardize the measurement of the learning outcomes in classroom research across different universities. The Force Concept Inventory is available in twenty-seven languages as of February 2015 (Hestenes et al., 1992).

RESEARCH DESIGN AND METHODOLOGY

Research design and methodology

This was a mixed method study that used both quantitative and qualitative research methods. The study used quasi-experimental design to compare engaging teaching and lecturing (Cohen et al., 2011). Qualitative methods (survey, focus group) were used to interview students about the two teaching styles.

Three professors were assigned a separate section of the course, each with 200-230 non-major students participating in a first year course Principles of Biology (Biology1001) in fall semester, 2013. These professors already had experience in teaching that particular course, and they all used the same course curriculum and textbook. The groups receiving traditional lectures (Lecture class) were delivered traditional lectures, and the engaging teaching group (Engaging class) received active teaching that used clickers (MacArthur, 2010) and small group activities during classes. The students in the Engaging classes experienced active learning during each 50 minute lecture according to the following design: 10-15 minutes of mini-lectures followed by either clicker questions and/or working sheets for small group activities for 5-10 minutes. These textbook based activities were available to all students as part of the publisher's online resources, however only the Engaging class students were encouraged to practice by answering clicker questions or with the help of printed worksheets that were returned at the end of the class. In addition, the instructor and two teaching assistants circulated in the room to offer guidance during the class activities.

At the beginning of the semester the students were told that they were part of a research study, however, the exact details were withheld. The students were given consent forms and any student refusing to participate was given a chance not to sign the consent form (Appendix A). Only the grades of those students who signed the consent form (407 out of 603) were used in the data analysis. The permission to conduct this study was obtained beforehand from the institution's ethical board ICEHR (Interdisciplinary Committee on Ethics in Human Research), and from the Head of Biology Department (Cohen et al., 2011). To increase engagement and to provide supported learning experiences, two teaching assistants were hired to facilitate learning during classes. In the Engaging class the professor prepared in-class activities for each lecture that engaged students in the course content. Students were given work sheets, and they were assigned to their regular in-class working groups (Handelsman et al., 2005) at the beginning of each class. The students in the Engaging class were notified at the beginning of the semester that they will receive additional 2 marks out of 100 if they return all fully filled group activities at the end of each class. This additional 2% was a minimal reward, and was only given if the student was present and returned all the 36 activity sheets on time at the end of each class. The Lecture classes did not receive any additional marks for participation, as they did not offer activities during classes. The instructor in the Engaging class also asked students clicker questions in every class. The class-response clicker system used was by Turning Technologies Inc, and students used mobile devices or personal clickers (MacArthur, 2010). Student groups worked through their assigned scientific problems or assignments after a brief introductory lecture into the topic. The professor and two teaching assistants circulated in the classroom to discuss with students. At the end of 50-minute class each group (5 students in each) handed their assignments back for check up by the teaching assistants. The assignments were briefly covered in the next class for review. Attendance in all classes was recorded by head count every Wednesday by teaching assistants.

In the traditional lecture class, the professor who was familiar with the content provided a traditional lecture with no student engagement. Each professor covered the same content, and the all students were given the same lab exams and final exams. The midterm exams were different as each professor prepared them individually. The common final exam was designed in a way that it assessed the content and did not offer benefits to either group of students.

To measure conceptual understanding, a multiple choice pre-test that contained conceptual questions from all the 13 Units of the course was given during the first week of classes to all students, in all three classes with the help of Scantron scanning exam sheets. The same questions (after slight modification) were given in the final exam as a post-test to measure learning gains. We used Klymkowsky's (2009) Biology concept inventory questions, and modified the questions to align with the course content and learning objectives.

For each of the three sections of the course, an e-mail invitation was sent to students to participate in a focus group interview concerning the teaching they received during the course at the end of the semester. The questions were open-ended questions (see Appendix B). Questions included details about the quality of the instruction, whether or not the instruction motivated the student, and if the student is planning on majoring in Biology based on the course experience. The focus group interviews were conducted separately for each three classes, and they were conducted by the teaching assistants. The professor did not know which students participated in the interviews. The teaching assistants recorded what students said, and later wrote transcripts with specific quotes. The professor received the written transcripts, but not any recordings, as the responses were anonymous.

In addition, an e-mail invitation was sent to all students to participate in an online CLASSE survey at D2L learning management website. CLASSE measured the level of students' experienced engagement during the semester. Again, the responses were anonymous and the professor did not know who responded.

RESEARCH FINDINGS

Results

The data analysis was performed by SPSS software using two-way ANOVA by the researcher. The researcher conducted an anonymous data analysis using SPSS Analysis of Variance for attendance, first midterm grades, second midterm grades, lab grades, pre- and post-test grades, and the final course grade. The Engaging class was compared to pooled data from the two Lecture classes in the analysis to study any statistically significant effects of the instruction on the learning outcomes in the course. Only the grades of those students who signed the consent form were used in the data analysis, which were 407 students out of 603.

Attendance

The hypothesis was that the engaging teaching instruction improves class attendance rates. The quantification of student attendance was recorded by once-a-week head-count in all three classes on Wednesdays. The Engaging class had significantly higher attendance (p=0.037, $F_{(1,30)}$= 4.74) during the semester (Fig. 1). The average attendance in the Engaging class was higher (75.6%) than in the Lecture classes (59.7%). The results are interesting as this is an indication that the students found more value in attending the Engaging classes compared to the Lecture classes.

Place Figure 1 here.

Learning Outcomes

The hypothesis was that engaging teaching instruction improves learning outcomes. Quantification was done by comparison of exam scores of the two midterms, lab grade, and scores of the conceptual Pre-test and Post-test, and the final course grade. There was no difference in pre-test, first midterm, lab grade or the final grade between the classes. However, the Engaging class performed significantly better (p=0.0005, $F_{(df\ 1,\ 404)}$ = 16.87) in the Post-test compared to the Lecture classes (Fig. 2). The conceptual pre- and post-tests tests were designed to test the most important conceptual understanding of the course core content. The students did not differ in the pre-test scores, which indicated that all students started at the same level of knowledge. However, when the same (or very similar) questions were given as post-test questions in the final exam, there was a statistically significant improvement in the Engaging class, as they performed better than the Lecture classes. Interestingly, as the midterm exams were designed by each professor separately, the Engaging class scored significantly lower in the second midterm (p<0.00001, $F_{(df\ 1,\ 406)}$= 113.65) which indicates that the exam was more challenging compared to the Lecture Class midterms. The midterm exams were the only ones that were designed separately by each Professor, and that explains why students had different grades. The final exam, pre-and post-tests and lab exams were either identical or very similar.

Place Figure 2 here.

The level of engagement experienced by students

The students' experienced level of engagement was measured by an online CLASSE survey filled by anonymous student volunteers (n=60) in all three classes. CLASSE survey indicated that students reported being more active according to Section 1 "Engagement Activities" questions in the Engaging class. According to CLASSE, students communicated with each other, and with the professor more when engaging activities were used instead of lecturing (Appendix E). The other two sections in the CLASSE measuring cognitive skills and other educational activities showed no difference between the classes. Indeed, CLASSE survey doesn't provide a clear measurable result; it is rather a self-reported indicated level of experienced engagement by each individual student.

In the Table 1 below are the student behaviours that increased in frequency in the Engaging class compared to the Lecture class according to CLASSE online student survey. For example, students in the Engaging class self-reported asking questions more frequently, contributing to a class discussion, tutoring or teaching other students in the class, working on a problem in the class that required integrating ideas or information from various sources, synthesizing and organizing information into new, more complex interpretations and relationships, and using an electronic medium more frequently. These behaviours that students reported are the goals of engaging and active teaching, thus this study succeeded in engaging and involving the students in the course content.

Interestingly, students reported skipping class more frequently in the Lecture classes than in the Engaging class. This further supports the attendance data, and illuminates one clear reason why absenteeism can be a problem. Students prefer attending more engaging classes.

When students were asked to score (on a scale 1-4) how much they enjoyed group work that happened during classes, they responded that they liked the group work (the average was 2.6 out of 4 which corresponds to the answer choice “quite a bit”).

In summary, these results are interesting as they reflect that students were engaged in the Engaging class, and that they reported more frequent interactions with each other during classes, and with the instructor via e-mail. Also the students in the Engaging class reported using higher thinking skills frequently, such as integrating information from other classes, synthesizing and organizing ideas, and working harder than they thought they could to meet instructor’s expectations. The higher attendance rates are reflected in the CLASSE survey as well as students in the Engaging class report missing fewer classes than the students in Lecture classes.

Place Table 1 here.

Qualitative data from focus group interviews

Focus group interviews with student volunteers (n=10) were conducted to assess motivational reasons to attend classes, and to better understand the research study outcomes. Collected answers reflected that students preferred active learning; however, they still asked for lectures and guided teaching with embedded interactive components. Students enjoyed clicker questions, and they asked for more challenging clicker questions. Students also would prefer receiving more feedback about their learning during the semester. Even though students reported enjoying interactive learning, some also thought that there should have been more time allocated to lecturing as well. There were several themes that emerged from the data, and the student quotes are organized in to the following four themes: Interactive lecturing, Preference for a type of instruction, Motivating activities, and Improvements suggested by students.

Theme 1: Interactive lecturing

According to students in the Engaging class, they enjoyed interactive lecture because they had a chance to think through the content. Also group work provided them opportunities to discuss, and reflect on their own level of understanding with their peers. Students also believed that the interactive learning helped them in preparation to exams, as they were able to test their knowledge and understanding already during classes. When students in the Engaging class were asked *"Did interactive lecturing help you with exams?"* a common answer was "*Yes -"it helps me to realize what I know and don't know"*.

However, when the same question was asked from students in the Lecture class, students reported that they could have just studied the content at home. When students in the Lecture class were asked *"Did lecturing help you with exams?"* a common response was "*Yes – "but I feel that sometimes I technically could have not come to class and studied at home and it would have been just as good"*. This answer reflects that the lecture class did not add to the students' learning experience, and lecturing did not help them to understand the content better. However, students in the Lecture class reported liking the instructor, and they were pleased with the instructor's teaching skills.

Theme 2: Preference for a type of instruction

When students were asked about their preference for a type of instruction, they answered similarly in both classes; they prefer a combination of lecturing and active learning. In the Engaging class students reported having an appreciation for the opportunity to discuss the content with their peers in small groups. When students in the Lecture class were asked "*Which type of* *instruction do you prefer- lecture or engagement?,* a common answer was "…*Combination – "quiz questions and polling would be helpful in biology too like in chemistry".*

In the Engaging class, students reported experiencing benefits from being provided with a question that they tackled together. Specifically, a student mentioned that by hearing how peers understood the content was helpful in deeper understanding. When students in the Engaging class were asked "*Which type of instruction do you prefer- lecture or engagement?"* a common answer was *"Mix of both - "you're just taking notes and having basic understanding, but with a group you can discuss and get more in depth with the topics".*

Students in both classes stated that they experience having a break to absorb the content being beneficial to their learning. When students in the Lecture class were asked "*Which type of instruction do you prefer- lecture or engagement?"* students responded saying *"…class engagement is necessary for every class because people won't absorb content properly if you don't have something every 20 min or so…".*

However, there was an interesting comment given by a student in the Lecture class about how he/she experienced Biology as "just memorizing, and not understanding". When asked "*Which type of instruction do you prefer- lecture or engagement?",* this student responded *"…Lectures – "in Biology where it's just like the way it is, is not so much the understanding, it's like memorizing".*

This highlights a possible drawback of lecturing. It is possible that lecturing can lead to students experiencing that the content is not inspiring. Importantly, this thinking leads to a lack of deeper understanding of the importance of the content they are learning.

Theme 3: Motivating activities

When students were asked what activities they found motivating and beneficial for learning, the students in the Engaging class listed all activities being beneficial. Student quotes in the Engaging class to the question "*Which class activities were motivating/enhance learning?"* students mentioned *"Clicker questions", "Class activities", "Interactive lectures", "Videos", "Pictures on slides",*

However, in the Lecture class the students responded experiencing again no benefits for attending the classes, because they felt that they could have studied at home. Also, the students in the Lecture class complemented the stories and videos provided by the instructor, indicating that they enjoyed the interactivity as well. Interestingly, the Lecture class students also reported that the lecturer covered a lot of content, and they felt rushed. This is an interesting comment as engaging teaching often is criticized for taking too much time and causing lecturers having to cut down course content. Biology1001 course has a detailed course outline, and all three classes covered the same amount of content. Student quotes in the Lecture class when asked "*Which class activities were motivating/enhance learning?"* were "*…Stories, videos*", and "*at times it was rushed as she tried to cover so much content"*, and "*life stories and slides but as said it's all online and I have missed a few classes, and I haven't gotten too far behind*".

Theme 4: Improvements suggested by students

When asked what improvements this course could have in the future and what the students would like to experience more, the students requested more interactivity during classes in all three classes. They asked for demonstrations during classes, but also homework online quizzes. Students preferred having marks added to their activities to enhance motivation to participate. In the Lecture class students suggested adding clickers to classroom instruction. Importantly, students in all three classes also suggested that the labs should be aligned with lecture content. Interestingly, students in the Engaging class also requested to have more challenging clicker questions. This indicates that the students found the clicker questions beneficial, and they experienced clickers helping comprehension, and learning of the course content. The students do learn during large classes when they are given the right tools, such as challenging questions that help them to prepare for exams.

When students in the Engaging Class were asked, "*What can be improved?",* they listed the following; "*Add demonstrations*", "*More clicker questions (more challenging*)", "*Align Labs with lectures"*, "*Add marks to participation or online quizzes*". When student in Lecture Class were asked, "*What can be improved?",* they responded; *"Add clickers*", *"Add quizzes to lectures"*, "*Align Labs with lectures*", "*Add marks to participation or online quizzes*". The list of student recommendations in all classes was very similar, which indicates that there are ways the instructors can enhance the learning experience for the students

DISCUSSION

This study used active learning in large classes by small group activities, and clicker questions in an undergraduate biology course. A comparison of data including grades, attendance, and student feedback was made to two other classes of the same course in which students received traditional lecturing without classroom activities. According to this study, engaged students can perform better in tests that measure conceptual understanding, however the overall performance in the course exams might not improve. Freeman reported similar results (2014) in an international meta-analysis of 225 studies in undergraduate STEM disciplines. Indeed, studies have indicated an average of a shift of 0.5 standard deviations in examination and concept inventory scores, when STEM undergraduates are taught with active learning methods, which would produce 6% increase in average grades (Springer et al., 1999; Ruiz-Primo et al., 2011; Freeman et al., 2014).

Also, students in this study who were engaged during the large classes, reported appreciation for having the opportunity for active learning during the class time, and interestingly requested more challenging classroom activities and clicker questions. In addition, the engaging activities motivated students to attend classes more frequently compared to the students in other classes of the same course. This is encouraging because the results indicate that the instruction can make a difference in the motivation of the students when they decide to attend classes, even in the large classroom settings. This illuminates one clear reason why absenteeism can be an indicator of possible problems. Students prefer attending more engaging classes. According to some pedagogical research there is a relationship between poorer marks and missing class (Durden & Ellis, 1995; Grabe et al., 2005; Neri & Meloche, 2007).

This study focused on first year large classes, the majority of the students were first semester students, with little experience of university teaching. Thus, the results cannot be generalized into higher year courses; another separate study would have to be performed to find out if the effect is the same with more experienced students. Also, students have a varied background, capabilities and skills both academically, and as individuals. In such large classes it is impossible to control for example the study skills, or the level of independence of students, or how strong background they might have in biology.

Even though this study showed increased attendance, I cannot argue that the attendance was the reason why students in the Engaging class showed higher level of conceptual understanding in biology. Indeed, the empirical research evidence on the relationship between attendance rates and academic achievement is inconclusive. The factors that lead to higher academic success are indeed complex, and certain student populations might benefit from attending classes, whereas more independent learners might not receive any additional benefits. As Slem (1993) points out, academic achievement is related to a number of psychological variables. These variables include “the student's intelligence, persistence, or personal circumstances; the instructor's style or ability to teach; or course difficulty and requirements”. Attendance, when being voluntary behavior, can eventually lead to measurable academic achievement. Class attendance is a voluntary behavior currently in higher education, and when combined with active learning can reflect the degree of academic motivation (St Clair, 1999).

Instructor efficiency might have played a role in the results as well. Even though all the instructors had previous experience teaching this course, we can’t exclude any additional factors that were not controlled for, such as instructor efficacy. Teacher efficacy has been defined as “the extent to which the teacher believes he or she has the capacity to affect student performance” (Berman et al., 1977), or as a “teachers belief or conviction that they can influence how well students learn, even those who may be difficult or unmotivated” (Guskey & Passaro, 1994). In addition, this study wasn’t designed to measure exactly how the learning happened. There are several possible reasons why students learned more effectively in the Engaging class. These factors include possibly: increased student engagement associated with individual clicker questions; less passively waiting for answers during classes; discussion amongst students; students answering verbal questions and writing answers down; higher attention levels due breaks from lecture; immediate formative assessments; communication between students, and the instruction of concepts that students find challenging.

Figure 1. The Engaging class had significantly higher attendance ($p=0.037$, $F_{(1,30)}= 4.74$) during the semester. The average attendance in the Engaging class was higher (75.6%) than in the Lecture classes (59.7%).

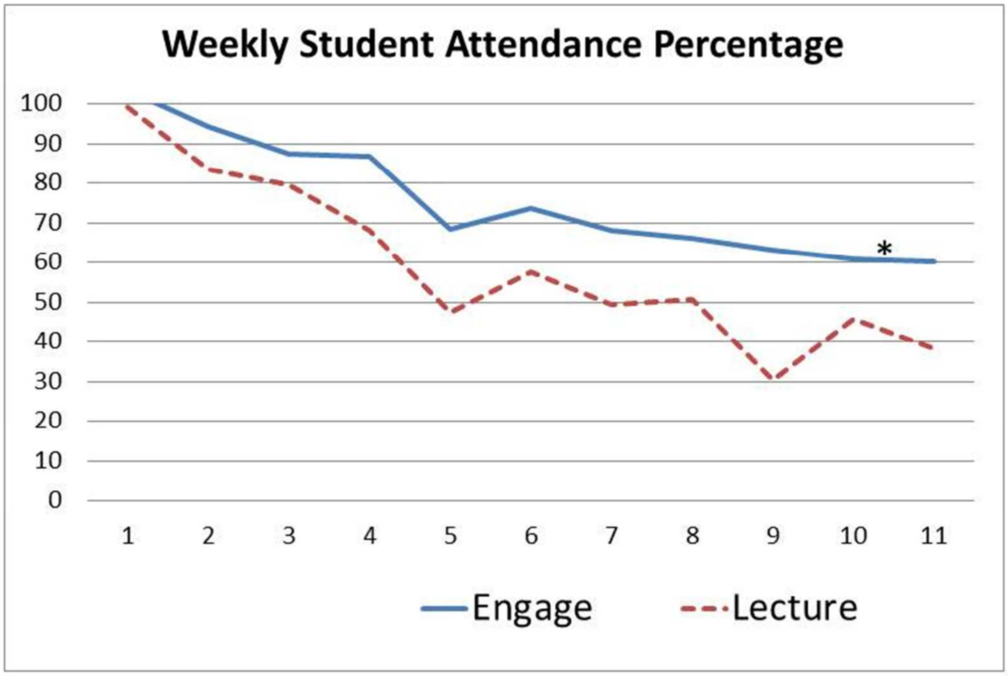
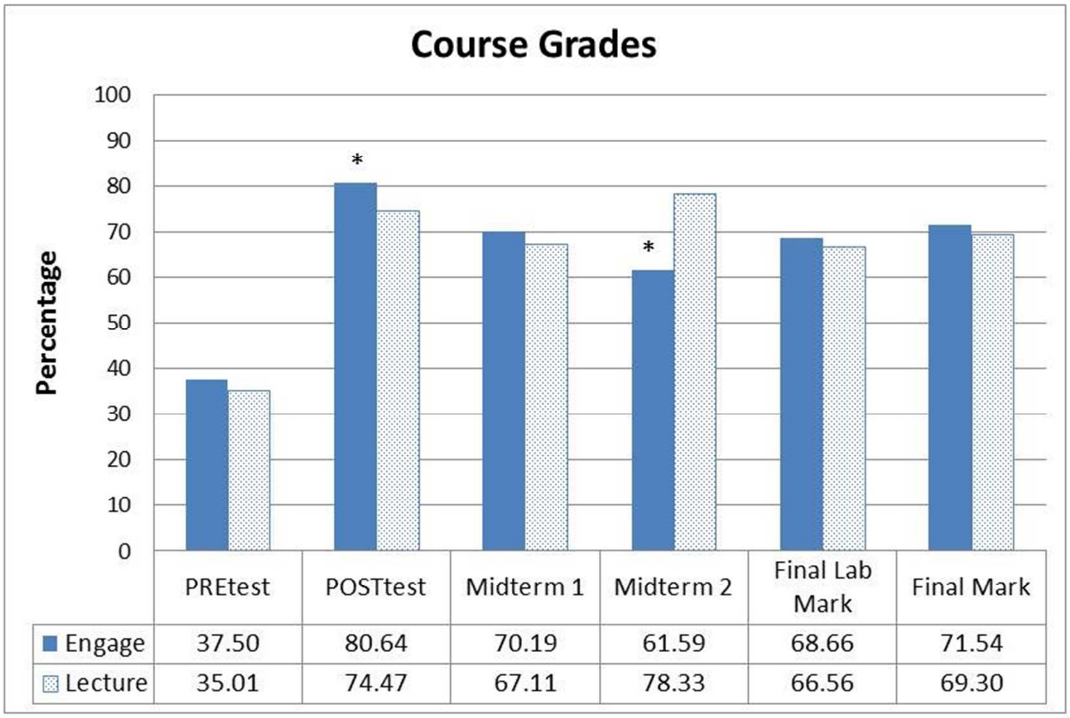


Figure 2. The Engaging class performed significantly better in the conceptual Post-test compared to the Lecture class (p=0.0005, $F_{(df\ 1,\ 404)} = 16.87$). However as the midterm exams were designed by each Professor there was a significant difference in difficulty causing the Engaging Class score lower in the second midterm ($p<0.00001$, $F_{(df\ 1,\ 406)} = 113.65$).



Student behaviours that <u>increased</u> in the Engaging class (1-2 times) compared to the Lecture class (never).	**Student behaviours that <u>increased</u> in the Engaging class (3-5 times frequently) compared to the Lecture class (1-2 times).**	**Student behaviours that <u>increased</u> in the Engaging class (more than 5 times, very frequently) compared to the Lecture class (1-2 times).**	**Student behaviour that <u>decreased</u> in the Engaging class (1-2 times) compared to the Lecture class (3-5 times frequently).**
Asked questions during your lecture	Worked on a problem in your class that required integrating ideas or information from various sources	Used an electronic medium (clickers, listserv, chat group, Internet, instant messaging, etc.) to discuss or complete an assignment in your class	How many times have you been absent so far this semester in your lectures?
Contributed to a class discussion that occurred during your lecture	Came to your lectures without having completed readings or assignments		
Tutored or taught other students in your class	Worked harder than you thought you could to meet your instructor's standards or expectations		
Used email to communicate with the instructor or your class	Synthesizing and organizing ideas, information, or experiences into new, more complex interpretations and relationships		
In a typical week in your class, how many homework assignments take you more than one hour each to complete?	How frequently do you take notes in your class?		

Table 1. Increased behaviours according to CLASSE online survey.

APPENDIX A Informed Consent Form.

Informed Consent Form

Title: The Effect of Teaching Methods in an Undergraduate Biology Course

You are invited to take part in a research project entitled The Effect of Teaching Methods in an Undergraduate Biology Course

This form is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. It also describes your right to withdraw from the study at any time. In order to decide whether you wish to participate in this research study, you should understand enough about its risks and benefits to be able to make an informed decision. This is the informed consent process. Take time to read this carefully and to understand the information given to you. Please contact the researcher, Dr Anna Hicks, if you have any questions about the study or for more information not included here before you consent.

It is entirely up to you to decide whether to take part in this research. If you choose not to take part in this research or if you decide to withdraw from the research once it has started, there will be no negative consequences for you, now or in the future. Just let your instructor know that your grades should not be used in this study.

Introduction
I am the Principal Investigator, Dr Anna Hicks. I have been teaching Biology since 2008, and I am interested in collecting data about grades and student experiences in first year Biology classes. This research project is part of my Masters thesis in Education.

Purpose of study:
This study simply collects exam grades, and compares teaching styles of lecturing and active student engagement. Students do not have to do anything, we will just store the grades for further analysis.

What you will do in this study:
You will participate in the lectures/course/labs as usual, and there are no actions required from your part. If you wish to participate in a voluntary interview at the end of the semester, your instructor will inform you about such opportunity. Also you will receive an e-mail that invites you to the voluntary interview in December 2013. We will not use your name at any point, all data is collected anonymously. Your CEQ forms at the end of the semester will also contain questions about your experiences of teaching in Biology1001.

Possible benefits:
From this data we will find out which teaching style students might like, lecturing or active engagement, and whether or not teaching style has an effect on grades.

Possible risks:

There are no known or foreseeable risks involved in this study.

Confidentiality vs. Anonymity
All data will be confidential, and all interviews are performed anonymously. The instructors will not know which students participate in the interviews.

Confidentiality and Storage of Data:
All data will be confidential, and all interviews are performed anonymously. All grades are stored electronically in password-protected files. All paper files are kept in a locked filing cabinet.
Data will be kept for a minimum of five years, as per Memorial University policy on Integrity in Scholarly Research.

Anonymity:
Interviews are arranged via graduate students, and data is collected anonymously, no data is matched with student identification. The instructors will not know the names of the participants, and cannot match individuals to their interview responses.

Reporting of Results:
Results will be reported in a Master thesis in Education, possibly in a scientific publication, and presented within Memorial University, and possibly in conferences outside Memorial University. All data are mean values of grades of the whole class, no individual student data is used or reported. If interview quotes are used, they are anonymous.

Sharing of Results with Participants:
Report will be provided to the participants on their wish. You can provide your e-mail at the end of this document to obtain a copy of the research report.

Questions:
You are welcome to ask questions at any time during your participation in this research. If you would like more information about this study.

The proposal for this research has been reviewed by the Interdisciplinary Committee on Ethics in Human Research and found to be in compliance with Memorial University's ethics policy. If you have ethical concerns about the research (such as the way you have been treated or your rights as a participant), you may contact the Chairperson of the ICEHR at icehr@mun.ca or by telephone at XXX.

Consent:
Your signature on this form means that:

- You have read the information about the research.
- You have been able to ask questions about this study.
- You are satisfied with the answers to all your questions.
- You understand what the study is about and what you will be doing.
- You understand that you are free to withdraw from the study at any time, without having to give a reason, and that doing so will not affect you now or in the future.

If you sign this form, you do not give up your legal rights and do not release the researchers from their professional responsibilities.

Your signature:
I have read what this study is about and understood the risks and benefits. I have had adequate time to think about this and had the opportunity to ask questions and my questions have been answered.

☐ I agree to participate in the research project understanding the risks and contributions of my participation, that my participation is voluntary, and that I may end my participation at any time.

☐ I agree to the use of quotations but do not want my name to be identified in any publications resulting from this study.

☐ I do not agree to the use of quotations.

☐ I wish to obtain a copy of the Research Report, my e-mail is ______________________________

A copy of this Informed Consent Form has been given to me for my records.

______________________________________ ______________________________

Signature of participant Date

Name of the participant ____________________________

Researcher's Signature:
I have explained this study to the best of my ability. I invited questions and gave answers. I believe that the participant fully understands what is involved in being in the study, any potential risks of the study and that he or she has freely chosen to be in the study.

______________________________________ ______________________________

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APPENDIX B Focus Interview Questions.

Questions included details about the quality of the instruction, whether or not the instruction motivated the student, and if the student is planning on majoring in Biology based on the course experience.

Open-ended questions:
1. Which class activities did you experience motivating (list of activities provided)?
2. Which class activities enhanced your understanding of the concept?
3. Which type of instruction would you prefer, lectures or student engagement?
4. Can you recommend any class activities that you believe can enhance learning?
5. What is one thing you would recommend to improve in the lecture part of the course?
6. What was one thing that you really liked in the lecture part of the course?
7. What is one thing you would recommend improving in the instruction in the class?

Scaling questions:
8. I believe class instruction helped me in learning Agree-Disagree
9. I am satisfied with my performance in this course Agree-Disagree
10. I would recommend the type of instruction I received Agree-Disagree
11. I am planning on majoring in Biology Agree-Disagree