THE EFFECT OF STUDENT ENGAGEMENT ON FINAL GRADES, ATTENDANCE AND STUDENT EXPERIENCES IN LARGE CLASSROOM IN AN UNDERGRADUATE BIOLOGY COURSE AT MEMORIAL UNIVERSITY

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ABSTRACT

Especially during the first year in university absenteeism can have detrimental effects on grades, and I have witnessed this while teaching large undergraduate Biology classes. According to pedagogical literature altering teaching methods from lecturing toward engaging teaching, which applies various active teaching methods in the university classroom, can enhance learning, student participation, decrease absenteeism, and improve critical thinking and problem solving skills. In this research study, I used a combination of active learning activities and engaging teaching to prevent absenteeism, in an attempt to improve grades, and to enhance interest in Biology among students in large first year Introductory Biology classes. Results show that students were less absent from the class that used engaging teaching methods. Also, the conceptual understanding test showed a significant difference in pre- and post-test grades between the classes, the engagement class having the highest improvement. The student CLASSE survey indicated more interaction between faculty and students in the section that was taught using engaging methods. According to student focus group interviews, students in the engagement class appreciated the class activities and reported benefits for learning.

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List of Abbreviations

ANOVA	Analysis of Variance
CLASSE	Classroom Survey of Student Engagement
ICEHR	Interdisciplinary Committee on Ethics in Human Research
MUN	Memorial University
STEM	Science, Technology, Engineering, Mathematics

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CHAPTER ONE: INTRODUCTION AND OVERVIEW

"Teaching is a complex art. And, like other art forms, it may suffer if the artist focuses exclusively on technique. Instructors can be more effective if they focus on the intended outcomes of their pedagogical efforts: achieving maximum student involvement and learning". Dr Alexander Astin (1984)

1.1. Background of Study

Students come to university with an enthusiastic attitude, and they truly want to learn about interesting subject matters, such as Biology. However, the first year experience can be overwhelming. A Biology first year university class that has over 600 students creates a challenge to instructors who would like to offer high quality teaching. Some of the challenges the instructors face include lack of personal communication between students and the instructor and not being able to support individual learning needs. Large classrooms often have fixed seating and these large rooms might not be the optimal environments for learning. Additionally, large class sizes are a challenge, as they tend to lead to poorer attendance. Students report that large enrolments can promote disengagement and feelings of alienation, which have a negative effect on students' sense of responsibility and lead to lack of engagement (Vanderbilt University, no date).

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 (Freeman et al., 2007, 2014; Gasiewski et al., 2012; Ruiz-Primo et al., 2011; Springer et al., 1999). 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 (Handelsman et al., 2005; Larose et al., 1998; Svanum & Bigatti, 2009).

This study was designed to increase student engagement in large classes. The hypotheses were that the engaging teaching instruction improves class attendance rates, and that engaging teaching instruction improves learning outcomes. One of the three sections in Introductory Biology class (Biology1001) 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.

There are no specific learning outcomes created for Biology 1001, however students are expected to become familiar with the following topics. This study tested conceptual understanding in these following biological topics:

- Modern scientific study of life
- Evolution and biological classification
- Basic molecules of life and genetic material
- Gene expression
- Mitosis and Meiosis
- The structure and metabolism of prokaryotes and eukaryotes (protists)
- Viruses
- Fungi

1.2. 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. Student surveys make it clear that students welcome more engaging teaching methods, and that students appreciate interactions with professor (Delaney et al., 2010). Also, lecturing tends to focus on memorization of the content, and usually does not facilitate conceptual understanding of the content (Bligh, 2000; Booth, 2001; Knight & Wood, 2005; Novak et al., 1999). 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 years (Freeman et al., 2007; 2014). In the last ten years, a significant number of classroom studies have been published in STEM fields that show the benefits of active teaching and student engagement. How is my study different than these previous studies? I will show that by adding active learning and enhancing student engagement, there is a significant increase in attendance, which hasn't clearly been shown in the pedagogical research in large undergraduate classes.

1.3. Significance of Study

The results indicated that by increasing student engagement in a large classroom a statistically significant increase in student attendance occurred in the last six weeks of the semester. In addition, it was shown that active learning significantly increased conceptual understanding in the Engaging class. Interestingly, students reported that they liked active learning and reported higher engagement in many areas in the Engaging class compared to Lecture classes.

These results are encouraging, and suggest that this type of large class instruction can be at least as effective as lecturing; and even more effective especially in enhancing student attendance, and metacognitive skills. The significance of these results is three fold. Firstly, the study showed that by modifying classroom instruction, the instructor can promote students' motivation to attend classes. Secondly, this study showed that by attending classes first year students can achieve better learning outcomes, specifically better conceptual understanding, and metacognitive skills. 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, Eagan, Garcia, Hurtado and Chang (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.

A decrease in the number of students in STEM has alarmed for example National Research Council (2003, 2012), and the President's Council of Advisors on Science and Technology in the USA by calling for ways to increase STEM majors in universities. Active learning has been shown to increase the average grades by 6%, and to decrease failing rates in STEM disciplines. Importantly, when active learning and traditional lecture models were compared, it was shown that STEM students who receive traditional lecturing are more likely to fail the course compared to the students who received active learning (Freeman et al., 2014).

Maybe university instructors can answer to the needs of these young and bright minds, and start questioning the millennia old way of "teaching" at universities by lecturing (Brockliss, 1996), which is still very common, especially at Memorial University. Currently, most PhD graduates within STEM disciplines lack pedagogical skills and knowledge. By increasing pedagogical skills of STEM instructors in higher education, we can encourage more students to pursue STEM careers. STEM instructors can learn more from pedagogical research, and hopefully adapt more of the appropriate teaching methods from the latest pedagogical studies.

CHAPTER TWO: REVIEW OF LITERATURE

2.1. The Problem of Absenteeism

Student absenteeism has been widely studied and some of the reasons behind skipping class have been found. 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 teacher (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).

A study by Arulampalam, Naylor and Smith (2008) collected administrative data from the department of economics at University of Warwick over a three-year period and investigated the association between absence from class and student performance. The observations were based on 444 students in their 2nd year undergraduate studies. There was a significant negative effect of class absence on student performance, and according to their mathematical model the adverse effect of missing class was greater for better-performing students. Arulampalam et al. (2008) write: "There was a monotonic relationship between performance and absence in the second year: while the average score across all students over their three compulsory modules is 60%, the average for students with fewer than 4% absences is 65% while that for students with more than 15% absences is 55%. We also see from the table that there is a monotonic relationship between absence and prior performance. For example, while the average 1st year math score is 68%, it was 73% for students subsequently missing less than 4% of their 2nd year classes, and 63% for those missing more than 15%. Also we find that the effect of missing classes is estimated to be significant only for high ‘ability’ students. Missing 10% of classes is estimated to be associated with around 1-2 marks for this group of students. There is a relationship between poorer marks and missing class (Durden & Ellis, 1995; Grabe et al., 2005; Neri & Meloche, 2007). Even though there can be several other factors playing a role in a student’s poor academic performance, regardless of student’s abilities, missing class regularly has been clearly shown to relate to lower grades (Marburger, 2001). When several of these contributing factors to poor grades are considered together, the most important are class attendance, the student’s ability and the perceived value of the course for the student (Park & Kerr, 1990). According to several instructors teaching first year Introductory courses at Memorial University, the attendance drops after the first few weeks by at least 30%, and keeps decreasing toward the end of the course when approximately 50% of students miss classes regularly (Rissanen, Caldwell, Goddard, personal communication 2008-2013). High level of absenteeism might have an effect on the course failure rate, as the average failing percentage is 15.4% in Biology 1001 (Registrars Office data 2010-2015). After the initial course the failure rate drops, and for example in Biology 1002 less than 10% of students fail the course (Rissanen, unpublished data 2008-2012).

Clearly promoting class attendance is important; however the discussion as to how to reduce absenteeism is ongoing. Why are students absent from class? Absence at the post-secondary level can be attributed to: socioeconomic (having to have to work), time of class (Monday/Wednesday/Friday classes preferred), availability of notes (if notes are available less student attendance), subject matter (personal interest), and the teacher. For example, if the students are likely to feel a connection with the teacher, they are less likely to miss class. Also attendance requirements (leads to 12.7% higher attendance), and teachers with teaching awards (9% higher attendance) have been shown to result in higher attendance. Interestingly, if students knew that the content is found in the textbook, they skipped classes (Devados & Foltz, 1996).

According to Knowlton (2011) students report attending more if the teacher is engaging. A student stated: "he really made class fun and engaging…I mean I really wanted to go to class!". Engaging teacher in this context specifically was utilizing non-traditional teaching formats that placed a higher emphasis on discussion, group-work, and student activities (Knowlton, 2011). Clearly, the context and the environment in which learning takes place are of importance for students.

When first-year students experienced a supportive social and learning environment they were more likely to report satisfaction with their transition to college (Kuhn et al., 2007). Also, 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). In another study in which 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. Keeping in mind that students report benefitting from friendly interactions with instructor, it seems that classroom engagement is helpful for students. In addition, interactive teaching creates opportunities to connect with other students with similar interests, which have been shown to foster successful transition to university (Baruch-Runyon et al., 2009).

Furthermore, the quality of relationship between a student and the instructor plays a role in attrition. Wang (2012) concludes from her first-generation college student interviews that students had so called ‘turning points’ related to relationships with the instructor in their college years that were either helpful, or not helpful in learning facilitation, support, and motivation to continue in college. These turning points were a function of the communication competence and character, and management style of the teacher. These turning points were both educational, social, and personal (Wang, 2012). The problem is, that it is not clear how this type of communication could be facilitated in large classes. In large classes “engaging teaching” that uses a variety of active learning techniques in small groups combined with clickers might offer an avenue for closer communication between instructor and students. Closer communication could then help in achieving some of the outcomes found in Wang’s (2012) study, such as increased likelihood to persist at university, improved quality of relationships with instructor, and enhanced classroom experience.

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. Students are given a few minutes to think through the answers, and then share and discuss their answers with others sitting around them; the instructor urges students to try to convince each other of the correctness of their own answer by explaining the underlying reasoning (Crouch & Mazur, 2001; Wieman, 2007). Again, engaging teaching based on small groups working on scientific problems might promote a sense of belonging, and increase motivation to attend class.

2.2. Student Engagement

Student engagement is too broad to define precisely, as it can be understood at the level of who is being engaged, how they are being engaged, and what is the purpose of the engagement. The theory of student involvement by Alexander Astin gives basis for the student engagement research that has been ongoing since 1990s. The theory of student involvement focuses on what students can do to learn more efficiently, with less focus on the role of the instructors. This theory encourages the instructor to study what motivates students, and to find ways to encourage students to spend more time and energy in their own learning process. Astin writes (Astin, 1984): “The theory assumes that student learning and development will not be impressive if educators focus most of their attention on course content, teaching techniques, laboratories, books, and other resources. With this approach, student involvement—rather than the resources or techniques typically used by educators— becomes the focus of concern. Thus, the construct of student involvement in certain respects resembles a more common construct in psychology: motivation. I personally prefer the term involvement, however, because it implies more than just a psychological state; it connotes the behavioral manifestation of that state”.

Astin (1984) lists the most motivating specific factors that keep students involved, and promote students’ retention in post-secondary education. These factors include campus residence, honors program, academic involvement, student-faculty interaction, and involvement in athletic and student government activities. According to Astin (1984) “Frequent interaction with faculty is more strongly related to satisfaction with college than any other type of involvement or, indeed, any other student or institutional characteristic. Students who interact frequently with faculty members are more likely than other students to express satisfaction with all aspects of their institutional experience”. Astin (1984) continues to explain: “Teaching is a complex art. And, like other art forms, it may suffer if the artist focuses exclusively on technique. Instructors can be more effective if they focus on the intended outcomes of their pedagogical efforts: achieving maximum student involvement and learning”.

Interestingly, Kuh (2003) argues that what students bring to higher education, or where they study, matters less to their success and development than what they do during their time as a student. Students are busy, and share many responsibilities, as Trowler (2010) states: “Student engagement is concerned with the interaction between the time, effort and other relevant resources invested by both students and their institutions intended to optimise the student experience and enhance the learning outcomes and development of students and the performance, and reputation of the institution.”

It is helpful to categorize student engagement to better understand what the benefits might be in post-secondary education. Although focusing on engagement at a school level, the following categorization is useful at post-secondary level as well. Fredricks, Blumenfeld and Paris (2004), identify three dimensions to student engagement:

1. Behavioural engagement. Students who are behaviourally engaged would typically comply with behavioural norms, such as attendance and involvement, and would demonstrate the absence of disruptive or negative behaviour.

2. Emotional engagement. Students who engage emotionally would experience affective reactions such as interest, enjoyment, or a sense of belonging.

3. Cognitive engagement. Cognitively engaged students would be invested in their learning, would seek to go beyond the requirements, and would relish challenge.

Student engagement according to Kuhn, Kinzie, Buckley, Bridges and Hayek (2007) is also “participation in educationally effective practices, both inside and outside the classroom, which leads to a range of measurable outcomes”. In addition, Krause and Coates, (2008) add “the extent to which students are engaging in activities that higher education research has shown to be linked with high-quality learning outcomes”. Importantly, according to Coates (2005) student engagement is fundamental part of student learning: “The concept of student engagement is based on the constructivist assumption that learning is influenced by how an individual participates in educationally purposeful activities ... In essence, therefore, student engagement is concerned with the extent to which students are engaging in a range of educational activities that research has shown as likely to lead to high quality learning.”

As STEM disciplines have had difficulties with student attrition, it seems logical that student engagement can help in student retention. Kuh, Cruce, Shoup, Kinzie and Goneya (2008) say: “... student engagement in educationally purposeful activities is positively related to academic outcomes as represented by first-year student grades and by persistence between first and second year of college”. In addition, Krause (2005) argues:

"... we should be most concerned when students who should otherwise be receiving targeted assistance in the form of student support, course advice from academics, or peer support are not receiving this because they failed to engage when the opportunities were available. These are the students for whom inertia and failure to act may ultimately result in failure to persist and succeed ... (W)e should be concerned about the inertia apparent in some of the first year students in the national study ... because it is closely aligned with student dissatisfaction and potential withdrawal from study."

The published classroom research in STEM disciplines is often based on student engagement, and definitions of student engagement include collaborative learning among students, preparing for classes, and attending classes (Larose et al., 1998; Svanum & Bigatti, 2009). Handelsman, Briggs, Sullivan and Towler (2005) broadly define engagement in STEM as students interacting with the course content inside and outside of the classroom. In his study, student engagement was broadly referred as student activities during classes, interactions with peers in the classroom, and interactions with the lecturer.

Does student engagement in STEM disciplines facilitate learning, and can the results be quantified? One type of student engagement is active learning that is broadly defined as using teaching methodologies that require students to actively participate in their learning process (Handelsman et al., 2004, 2005) Interestingly, according to a recent meta-analysis of 225 studies in STEM undergraduate courses (Freeman et al., 2014) active learning improved test scores an average of 6% across undergraduate university STEM disciplines. In addition, students in traditional lecture classes were more likely to fail than students who were taught using active learning. Furthermore, students taught by engaging teaching methods are more likely to stay in university (Freeman et al., 2014; Nelson Laird et al., 2008; Pascarella et al., 2011). Importantly, the studies reporting the benefits of student engagement often use conceptual tests to measure deep learning instead of relying only on grades from class tests (Crouch & Mazur, 2001; Klymkowsky & Garvin-Doxas, 2008). Conceptual inventories are widely used to measure deep learning in pedagogical active classroom research. Students are given a pre-test that is based on deeper understanding of the course content, and the same test is given as a post-test at the end of the course. This approach has the benefit of testing conceptual understanding (Wieman, 2007).

Thus, what are the student behaviours that help students to achieve higher grades? Generally students who attend classes, and communicate with instructor during office hours tend get higher grades (Handelsman et al., 2005). Particularly, engaging students in learning is important in facilitating learning. 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. This is a great active learning strategy as the instructor can ask challenging questions while students get a chance to practice their understanding as a formative assessment before their exams (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, Dawe, Shuster and Shuster (2007) assessed the effects of the clicker response systems on student learning in various Biology undergraduate courses. Students' learning outcomes were compared based on exam question scores derived from lectures with low, medium, or high numbers of in-class clicker questions. Increased use of the clicker response systems in lecture had a positive influence on students' performance on exam questions across all six biology courses. Preszler et al. (2007) summarize that "students not only have favourable opinions about the use of student response systems, increased use of these systems increases student learning". Especially when the instructor asks relevant, challenging questions about the course content that help students to fix their misconceptions, student have been shown to develop higher thinking skills. According to longitudinal analyses of exam results, students perform better on analytical questions when the course is taught using clickers. However, students did not perform better on simple memorization questions when the course was taught using clickers to encourage discussion, than when the course was taught by the same instructors without clickers (Slain et al., 2004). This difference in the impact of interactive learning methods on lower- and higher-order learning is not limited to university students. Chang and Mao (1999) found that when cooperative learning was used in ninth-grade earth science students there was no improvement in students' performance on questions requiring only lower-level cognitive skills, but cooperative learning did improve student performance on higher-level questions. Thus, students seem to perform better when they receive formative assessment that promotes higher thinking skills about the course content (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).

2.3. 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, in a large undergraduate biochemistry course, students were divided into two groups, either receiving traditional lectures, or cooperative-learning tutorial classes based on problem solving with the help of teaching assistants. Students in cooperative learning classes performed better on standardized testing of content knowledge, problem-solving skills, and also had more positive opinions about the course (Anderson et al., 2005).

In an introductory biology course re-design increased academic performance and improved student engagement and satisfaction. Specifically, the course was re-designed by reordering the presentation of the course content by adding broader conceptual themes, incorporating active and problem-based learning into every lecture, and finally using strategies to create more student-centered learning environment such as learning goals, vocabularies, and increased formative assessment. The results showed that the students self-reported significant increase in interest in the course content, self-reported learning, stimulating lectures, helpfulness of lectures, and instructor quality. Students specified that most helpful teaching techniques were the learning goals, clicker questions, and weekly quizzes. Additional vocabularies and reading questions were ranked the least helpful. In addition, the course re-design resulted in better student performance in identical final exam questions (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. The students received either traditional PowerPoint based lecturing, or cooperative small group peer teaching by two different instructors. In the cooperative classes, the students worked in small groups to answer clicker question, and tackle problems with minimal instruction. Students' knowledge was tested by quizzes, midterm exams, and the final exam. To determine student satisfaction, the attendance was calculated as head counts, and student surveys. Interestingly, researchers included covariants, such as GPA and previous science credits, in the data analysis of the course grades. The results showed that there was a statistically significant difference between the instructor's effects on the grades. Even though the overall performance was better in the exams and quizzes in the cooperative groups, it was due to one instructor only. In addition, prior GPA significantly influenced the student performance on all five measures examined. Student attendance was significantly higher in the cooperative groups, and students indicated that the group activities and tests helped them in understanding the course material. More than 92% of the students indicated that the cooperative learning strategies should be used in other classes (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 the experimental group. One class received traditional lecturing; the other class received student-centered teaching via active learning in small groups, and daily feedback. Interestingly, Burrowes's course had very similar curriculum to Memorial's Biology1001 course. 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).

The most high profile journal in the field of natural sciences, *Science*, published the classroom study by Deslauriers, Schelew and Wieman (2011) that compared a respected, highly experienced physics professor lecturing to a class, to another section of the same course that was taught using active teaching (pre-class reading assignments, pre-class reading quizzes, in-class clicker questions with student-student discussion, small-group active learning tasks, and targeted in-class instructor feedback) 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 (Deslauriers et al., 2011).

Knight and Wood (2005) used very similar approach to my study, they 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 (Knight & Wood, 2005).

Taken together, active learning is an important factor in promoting learning in

STEM disciplines. The literature supports the usefulness and benefits of classroom activities, and currently at Memorial there are only few educators that consistently use active, engaging teaching methods.

2.4. 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).

Social interactions are also important for students. Stanton-Salazar (2011) indicates that the role of instructors in helping students to find forms of support is very important. Access to help centres and tutoring is important, especially for first year students, and instructors can act as a resource for this information. 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). Clearly, teaching assistantship is a vital part of training the future academics, as the young faculty is required to teach several courses per year. One approach in enhancing teaching skills is to use graduate students as peer-teachers in large classes. 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).

2.5. 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). Especially in STEM disciplines, the idea is to develop teaching methods that resemble a scientific experiment. The students are actively engaged and work in small groups to solve a problem, analyze data, or they create hypotheses and produce data, which they then interpret and present. The goal is to sidestep the regurgitation of information and focus on developing curious, self-motivated critical thinkers and problem-solvers. This type of instruction can succeed in large classes by instructional design and promotion of an engaging classroom environment by increasing small group work (Allen & Tanner 2007; Handelsman et al., 2007). These methods have been shown to improve student learning outcomes in undergraduate science teaching (Anderson et al., 2011; Freeman et al., 2007, 2014; Handelsman et al., 2004; National Research Council 2003, 2013; Wieman, 2007).

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).

Instead of passive lecturing in large classes, students can also work in small collaborative groups. The course content can be presented as problems to be solved, and students can work in small groups to construct hypotheses, collect and analyze data, and evaluate outcomes. During class, students actively engage in their own learning and rebuild their own conceptual framework while incorporating new information (Anderson et al., 2001; Ebert-May & Hodder, 2008). The most effective learning is taking place when learners have to realize their own misconceptions (Meyer & Land 2003). This process of active learning can increase student performance in introductory science classes (Freeman et al., 2007, 2014; Wieman, 2007).

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; Ebert-May & Hodder, 2008; Handelsman et al., 2007; MacArthur, 2010; Wieman, 2007). For example, students can be given a real life problem in which they have to come up with a recommendation, solution or a hypothesis. To encourage deep learning, students have to first map what they know about the topic, and then determine what they need to learn to be able to answer the questions, and then collaboratively develop answers to the given problems. Factual information can be provided to students in the format of a mini lecture, podcast, or readings from the textbook. Students are encouraged to use online resources of the textbook, and other resources provided by the instructor. The main focus is that the students will work actively to change their individual conceptual framework, and the outcome (learning) can be measured by in-class assessments. These activities can take one class, or can be larger projects throughout the semester (Ebert-May & Hodder, 2008). Scientific exploration is a key component in introductory biology courses, and institutions and textbook publishers already provide plenty of active learning exercises that can be incorporated into the existing curriculum (see Appendix B for an example list of links). For example, in Biology1001 the "Module 1.2. Introduction to Scientific Exploration" can be taught by using peer-to-peer teaching in small groups based on the exercise illustrated here. Students are given data, and they have to examine the data, and decide if the experiment followed the scientific method. As in this example students can be given data, or problems, case studies, scientific publications (more examples in Appendix D), or they can visit sources outside the university to tackle questions based on everyday life.

Example from Biology1001: Module 1.2. Learning Objective: Understand hypothesis testing, and describe the scientific method.

Metabo-Herb causes your tomatoes to grow faster than 'Super-Grow.' (from McGraw Hill textbook Connect online resources)

- The following experiment provides definitive, scientific proof of the superiority of 'Metabo-Herb' over 'Super-Grow.'
- Two side by side one-acre fields were planted with the same variety of tomatoes. One of the fields was fertilized with 'Metabo-Herb,' the other was not.
- At the end of the season, plants were randomly sampled from each field and compared with respect to growth (plant height).
- A statistically significant difference in plant height between the groups proves the superiority of 'Metabo-Herb" over our competitors.
- Plants fertilized with Metabo-Herb grew on average 11 inches taller than those without. These data scientifically prove the superiority of Metabo-Herb over Super Grow.

Growth (height in inches)

	'Metabo-Herb'	Without
	48	39
	52	31
	43	36
	49	29
	50	37
	37	39
	51	36
	47	34
	48	37
	42	38
	53	33
	50	43
	29	32
	48	29
	47	26
Mean	**46**	**35**

Questions for Students to work in small groups:

1.What specific claims do the manufactures make about their product?

2. The manufacturer doesn't identify a biological mechanism by which their product may promote plant growth. Explain why this information is vital for a proper evaluation of the claims.

3. Identify the following components of the study:

Control Group:

Experimental Group:

4. Is the experiment described an appropriate test of the claims made by the manufacturer? Explain.

5. What is the purpose of a control group in an investigation?

6. Is there any statistical analysis of the data? Why is it important to utilize statistical procedures to analyze data?

7. What conclusions can be drawn from the data?

8. Why are testimonials of limited value to scientific investigations?

Importantly, students are often not aware of what they are expected to learn, and they usually start with not much information on what to expect from the course (Handelsman et al., 2007). To facilitate learning, specific learning outcomes are provided to students for each module and the instructor should design assessments based on the learning outcomes to measure specific learning outcomes (Allen & Tanner, 2007). In addition, students have to decide to engage in the learning process. Students should have goals, and they should use their own strategies to achieve the goals. Lastly, they should make a decision about what methods they use to achieve the goals (Handelsman et al., 2007). This can be an iterative process; students can evaluate their own learning and determine whether or not they are reaching the learning goals based on the learning outcomes and their performance in assessments in class. This is the basis of critical thinking many universities are hoping that students learn during their undergraduate studies. Students critically evaluate their own working style and ethics, and decide whether or not they have reached the learning goals based on the assessment results. Hopefully this process will facilitate students' self-reflection skills to find strategies that will ensure success, and encourage self-motivated learning.

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 (Crouch and Mazur, 2001; Klymkowsky & Garvin-Doxas, 2008). 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 (Wieman, 2007). Conceptual inventories are tests that are designed to give students a chance to explore important concepts, rather than testing memory. Students are presented with the common difficulties with the content. When these tests are designed the incorrect answer choices should be plausible, and based on typical student misunderstandings. The goal is to expose students to common misunderstandings and to promote deeper understanding of the course content. 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. This instrument is designed to assess student understanding of the most basic concepts in Newtonian physics. This forced-choice instrument has 30 questions, and looks at six areas of understanding: kinematics, Newton's First, Second, and Third Laws, the superposition principle, and types of forces (such as gravitation, friction). Each question offers only one correct Newtonian solution, with common-sense distractors (incorrect possible answers) that are based upon student's misconceptions about that topic, gained from interviews. The Force Concept Inventory is available in twenty-seven languages as of February 2015 (Hestenes et al., 1992).

A stone dropped from the roof of a single story building to the surface of the earth:

(A) reaches a maximum speed quite soon after release and then falls at a constant speed thereafter.

(B) speeds up as it falls because the gravitational attraction gets considerably stronger as the stone gets closer to the earth.

(C) speeds up because of an almost constant force of gravity acting upon it.

(D) falls because of the natural tendency of all objects to rest on the surface of the earth.

(E) falls because of the combined effects of the force of gravity pushing it downward and the force of the air pushing it downward.

Diagram 1. An example of Force Concept Inventory question.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3. 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). I compared two types of teaching in a statistical analysis of collected grades and attendance rates, and determined if there was a statistical relationship. Qualitative methods (survey, focus group) were used to interview students about the two teaching styles.

The hypotheses were that the engaging teaching instruction improves class attendance rates, and that engaging teaching instruction improves learning outcomes. 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. 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.

At the beginning of the semester the students were told that they were part of a research study, however, the exact details were withheld. Students had an idea that the study measured teaching effectiveness, but they did not know that the study focused on the effects and outcomes of teaching methods. The students were given consent forms and any student refusing to participate was given a chance not to sign the consent form. Only the grades of those students who signed the consent form (407 out of 603) were used in the data analysis.

In the informed consent form (Appendix A) the participants were told that they will be part of a research study looking to improve teaching methods, and that their identity is kept confidential and anonymous, however the results might be published in a scientific journal. 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 with the help of the Instructional Development Grant provided by the Distance Education and Learning Support, which is a department at Memorial University that organizes teaching and learning initiatives. Teaching assistants were hired to maintain a database of midterm, lab and exam grades, to facilitate learning during classes, to collect attendance data, to perform focus group interviews, to collect and maintain record of consent forms, and to help in administrative work of the course.

In the Engaging class the professor prepared in-class activities for each lecture that engaged students in the course content (see Appendix C and D for examples of activities). 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 clickers (MacArthur, 2010) to answer clicker questions (access codes were purchased by Biology Department).

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 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 learning, a 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. We used Klymkowsky's (Klymkowsky & Garvin-Doxas, 2008) Biology concept inventory questions, and modified the questions to align with the course content and learning objectives. The students are expected to become familiar with the following topics in Biology1001, and this study tested conceptual understanding in these topics:

- Modern scientific study of life
- Evolution and biological classification
- Basic molecules of life and genetic material
- Gene expression
- Mitosis and Meiosis
- The structure and metabolism of prokaryotes and eukaryotes (protists)
- Viruses
- Fungi

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 F). 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 the teaching assistants conducted them. 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 website. CLASSE measured the level of experienced engagement during the semester (see Appendix E). Again, the responses were anonymous and the professor did not know who responded.

CHAPTER FOUR: RESEARCH FINDINGS

4.1. Research Results

The data analysis was performed by SPSS software using ANOVA, and post-hoc Scheffe analysis by the researcher. The grades were obtained from the other two professors on Excel sheets, and the teaching assistants created an Excel sheet that only contained the grades, and attendance of the students that had signed the consent form (407 out of 603). That Excel sheet was converted to a data file is the SPSS software, and 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, final exam grades, and the final course grade. The three professors were compared in the analysis to study any statistically significant effects of the instruction on the learning outcomes in the course. If there was a significant statistical overall Group effect, then Scheffe post-hoc analysis was used to indicate which groups were statistically different from each other. Only the grades of those students who signed the consent form were used in the data analysis, which were 407 students out of 603.

4.1.1 Attendance

The hypothesis was that the engaging teaching instruction improves class attendance rates. If instruction style had no effect on attendance, then the hypothesis was rejected. The quantification of student attendance was recorded by once-a-week head-count in all three classes on Wednesdays. The attendance rates were compared in the three groups by using ANOVA in SPSS, and Scheffe post-hoc test.

The Engaging class had significantly higher attendance (p=0.009) in the last six weeks of the semester (Fig. 1). The average attendance in the last six weeks for Engaging class was higher (65.3%) than the other two classes (46%).

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.

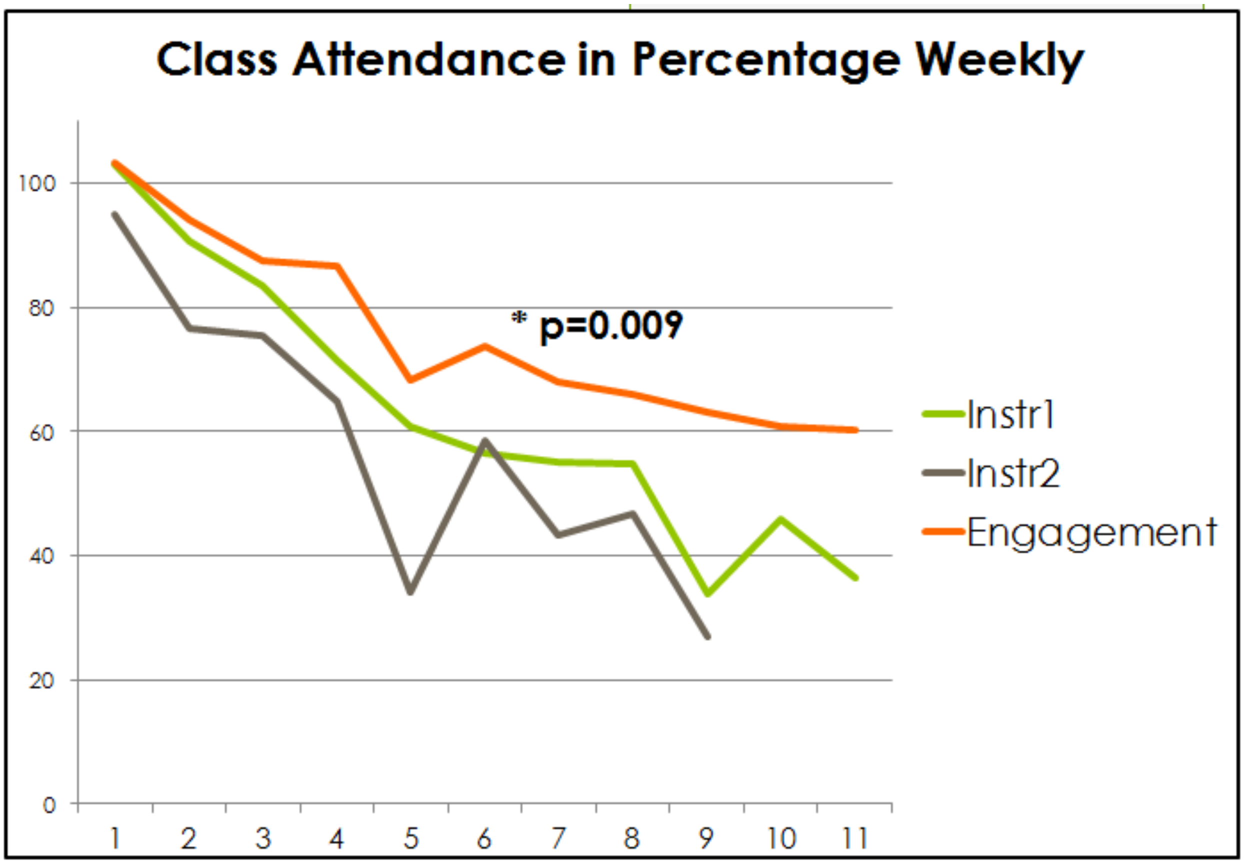

Figure 1. Engaging class had significantly higher attendance (p=0.009) in the last six weeks of the semester.

4.1.2 Learning Outcomes

The hypothesis was that engaging teaching instruction improves learning outcomes. If the instruction style had no effect on quantifiable learning outcomes, then the hypothesis was rejected. Quantification was done by comparison of exam scores of the two midterms, labs and final exam, and scores of the conceptual Pre-test and Post-test, and the final course grade. The grades were compared in the three groups by using ANOVA in SPSS, and Scheffe post-hoc test.

The final grade and the final exam grade were significantly higher in the Engaging class ($p=0.04$) compared to one Lecture class (Fig. 2). Importantly the Engaging class performed significantly better ($p=0.029$) in the Post-test compared to the other two classes (Fig. 3).

The final grade is a cumulative grade that contains all the tests from the semester; however it is heavily based on the final exam, which was valued at 50% of the total grade for the course. Thus, it is not surprising to see both the final exam, and final grade being significantly higher in the Engaging class, as the final grade is largely based on the final exam. Thus, the students performed significantly better in the final exam, and that had a significant effect on their final grades. However, it is recommended to only focus on the final exam grade, as the Engaging class students were given an additional 2 marks to their final grade if they returned all class activities. I cannot rule out the possibility that it might have had a statistical effect on the final grade.

The conceptual 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 means 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 either of the Lecture classes. This is a significant finding, because it is recommended to use conceptual testing instead of the class tests to measure deeper understanding of the course content.

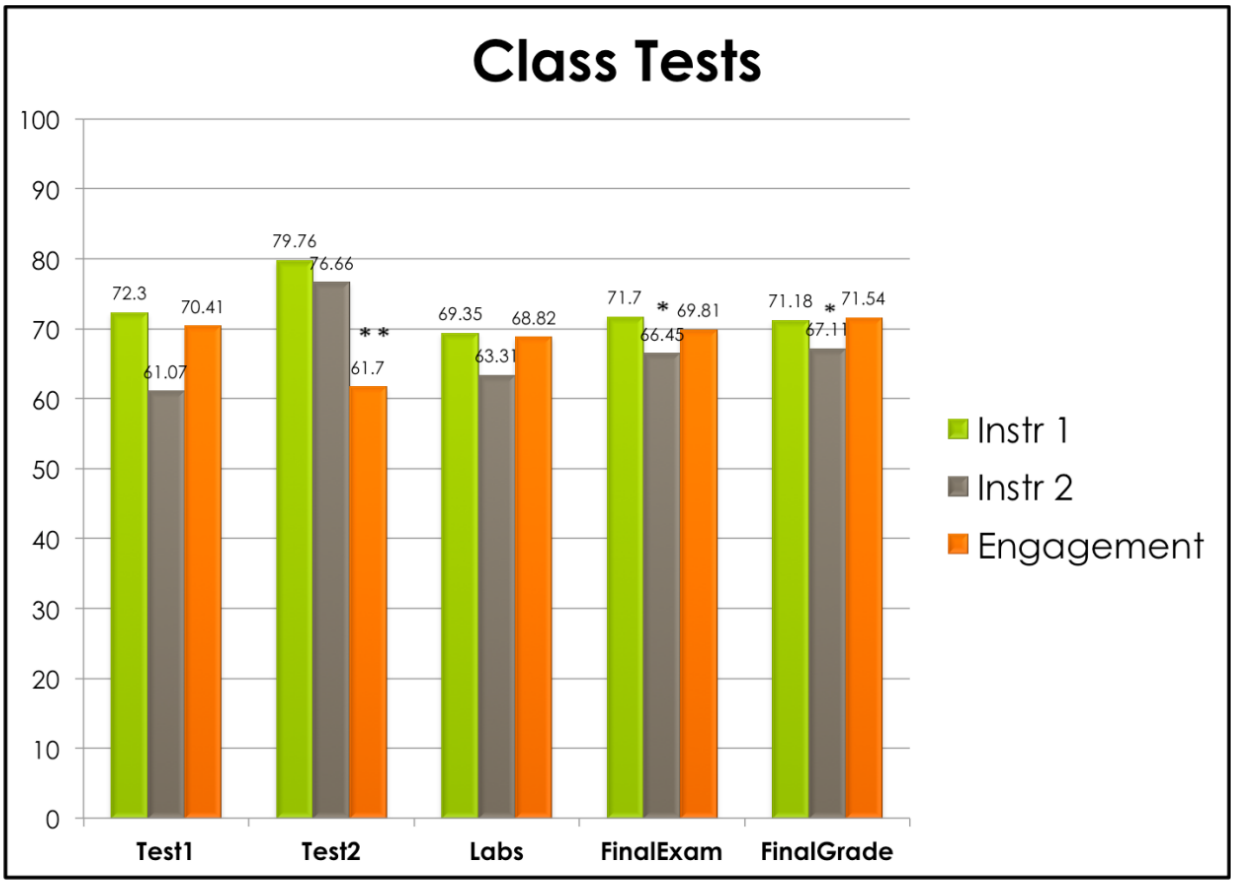

Figure 2. The final exam score, and final grade (p=0.04) were significantly higher in the Engaging class compared to one Lecture class (n=407).

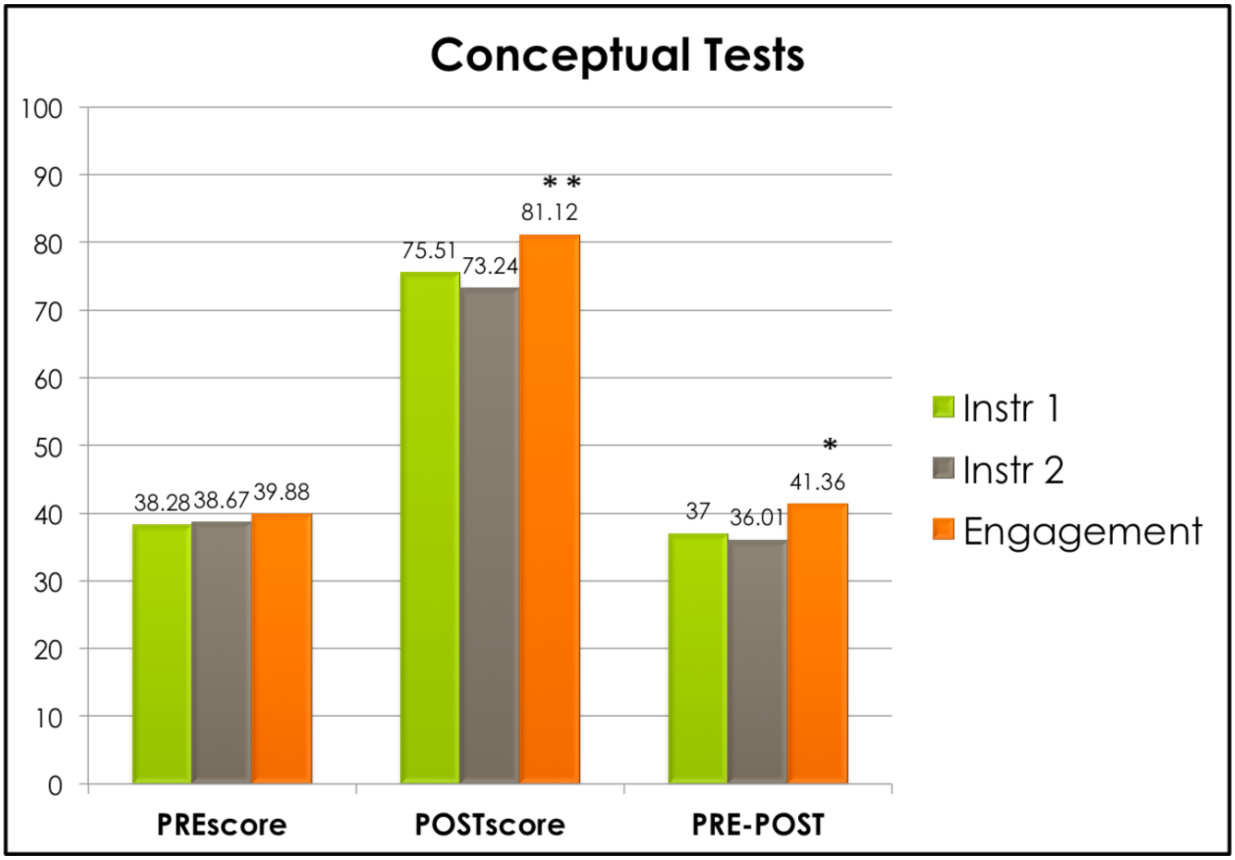

Figure 3. Engaging class performed significantly better (p=0.029) in Post-test compared to the other two classes (n=354).

4.1.3 The level of engagement experienced by students

The level of engagement was measured by an online CLASSE survey filled by anonymous student volunteers (n=60) in all three classes. CLASSE survey indicated (Fig. 4) that students in the Engaging class were significantly more active according to Section 1 “Engagement Activities” questions (p=0.042). 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 statistical difference between the classes.

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.

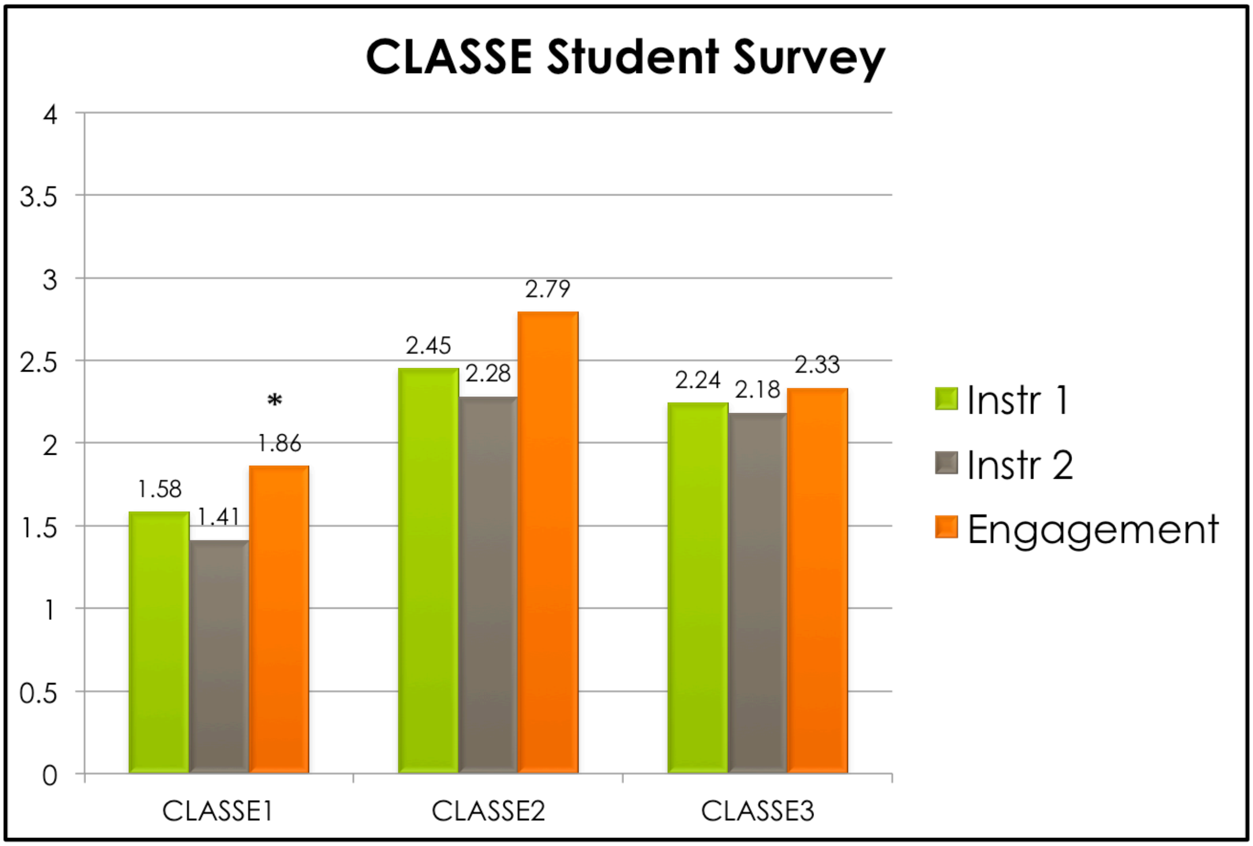

Figure 4. CLASSE survey indicated that students in Engaging Class were significantly more active according to Section 1 "Engagement Activities" questions ($p=0.042$). Section 2 "Cognitive skills", and Section 3 "Other educational activities" showed no statistical difference between the classes.

Table 1. Increased behaviours according to CLASSE online survey.

Student behaviours that increased in the Engaging class (1-2 times) compared to the Lecture class (never).	**Student behaviours that increased in the Engaging class (3-5 times frequently) compared to the Lecture class (1-2 times).**	**Student behaviours that increased in the Engaging class (more than 5 times, very frequently) compared to the Lecture class (1-2 times).**	**Student behaviour that decreased 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?		

4.1.4 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. This is problematic, as the lecture instructors do not teach at labs. We have tried to better align the lecture content with the lab content, however as the lecture component of the course has more content, it is difficult to perfectly cover the same content at the same time. This is a topic that can be given thought to, and possibly can support comprehension and learning amongst students. 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.

CHAPTER FIVE: DISCUSSION

5.1. Overview of Results

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 et al. 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. This is significant because in the K-12 educational innovations research any applications that lead to as low as 0.2 increases in effect size are considered of policy interest (Freeman et al., 2014; Springer et al., 1999; Ruiz-Primo et al., 2011).

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. According to educational research clicker questions and peer teaching during classes promote deep learning (Crouch and Mazur, 2001; Klymkowsky & Garvin-Doxas, 2008), thus it was interesting that students themselves suggested this approach. This study also used an online survey CLASSE, which measures the level of classroom engagement to ensure that students were engaged during classes. Students in the Engaging class self-reported higher levels of engagement, and activity compared to students that only received lecturing. Especially during the first semester in university students might feel intimidated, and they might miss an opportunity to ask questions in a large classroom that can hinder their learning (Fassinger, 1995; Weaver & Qi, 2005). Interestingly, peer-instruction has been shown to enhance learning experience in STEM undergraduate large classrooms (Crouch & Mazur, 2001; Wieman, 2007). According to the students in the Engaging class they experienced benefits that are indicative of deeper learning, and higher metacognitive skills. 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"*. Furthermore, students in the Engaging class showed increased metacognitive skills as when they 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"*. The metacognition, deeper learning and inspiration toward biology were evident based on those previous answers. There was a striking difference compared to the Lecture classes, in which students reported feelings of just memorizing course content, and habit of missing classes. For example, when students in the Lecture class were asked "*Which type of instruction do you prefer- lecture or engagement?"* a student responded *"...Lectures – "in Biology where it's just like the way it is, is not so much the understanding, it's like memorizing",* and added that *"...life stories and slides were good, but as said it's all online and I have missed a few classes, and I haven't gotten too far behind"*.

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). According to my data analysis (unpublished, Rissanen 2014) there was a correlation between higher attendance and higher final grades, which might have been because of the additional 2 marks given to those who participated, or it could have been because those who attended classes actually learned more, and performed better in the final exam.

5.2. Scope and Limitations

The scope was to better understand what type of instruction works for large introductory Biology classes, and what type of instruction brings out the most interesting aspects of biology to students. The aim was to better understand what type of instruction motivates students, and also to test if the engaging teaching methods lead to better learning outcomes reflected by higher grades.

I expected some challenges in avoiding students from communicating across the three different classes. Even though the classrooms were at different locations and times, the students might have communicated at their lab groups. It is common for students to share experiences about teaching (personal communication with students), and some of them do compare their instruction, and discuss the details. However, as the number of participants was large, this was not problematic. Indeed, in teaching education research, student communication about instruction has not affected the results (Anderson et al., 2001; Allen & Tanner 2007; Ebert-May & Hodder, 2008; Handelsman et al., 2007; Wieman, 2007).

In addition, as 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”. However, it might be that poorly prepared students can benefit from attending classes. Also, frequent attendance may affect achievement of students with learning styles that require the interactions, auditory emphasis, or communication with others for better performance. To find out whether attendance truly supports learning, and academic achievement, the many variables affecting academic achievement would have to be controlled. Measuring academic performance with and without absenteeism is indeed a challenging task.

Further research might focus on what leads students to voluntarily come to class, and to participate in the active learning. Often being academically motivated means that students have a desire to learn, and to understand the course content better. 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).

Paul Pintrich (1994) explained academic motivation in the classroom “in terms of reciprocal interactions among these components: the classroom context, the students’ emotions and beliefs about their own motivation, and the students’ observable behaviors”. Thus, when students do not believe there is any value in attending class, they may be unlikely to attend. Therefore, it can be implied that it is the educator’s responsibility to provide a valuable classroom environment to encourage attendance (St Clair, 1999). Taken together, if a class is enjoyable because of the engagement (lively discussions, the instructor is effective), students may be more likely to attend. Some students who purchase class notes from note-taking services admit that they do not miss much by not going to class if the professor is “dry” and “mechanical” (Collison, 1992). My study reflected very similar results; students attending the Engaging class reported benefits, whereas the

Lecture class students skipped classes. An enjoyable, engaging class does not guarantee high academic achievement, or better learning. Some reasons might be that students may not feel capable of being successful. In addition, enjoyable does not necessarily mean the same as valuable (St Clair, 1999). However, overall classroom environments that engage students, emphasize the importance of students' contributions, and have content directly related to knowledge assessed, will undoubtedly provide encouragement to students to attend regularly (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). Teacher efficacy not only affects the types of interactions that a teacher will have with their colleagues but it also affects interactions with their students. Importantly, teacher efficacy has been shown to effect the student achievement in elementary school education, so we can assume that higher teacher efficacy is related to higher student achievement also in post-secondary education (Goddard et al., 2000).

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.

The professor providing the engaging classes was familiar with the proposed engaging teaching methods. She was able to provide constant engaging teaching, and planned the activities within each class carefully to follow the experimental set-up. However, according to the course evaluation questionnaire feedback, some students would have preferred less time for activities and more time for lecturing. Also students asked for more detailed feedback about their classroom activities immediately after they were completed. This feedback will be taken into consideration when designing further classroom activities.

There were no statistical differences in the course failure rates between the Engaging and Lecture classes. According to the MUN Registrars Office, the average failure rate for Biology1001 varied from 13-19% between years 2011-2015. The average failure rate in Biology1001 was 13% in Fall 2013, and the Engaging Class had failure rate of 11.9% (25 students out of 210).

Students in the Engaging class were given a minimal 2% additional mark for attending classes, and returning their small group activities on time. The professor in the Engaging class had been using this method previously to reward students for class attendance, and in order to have a consistent data set to previous semesters, she decided to keep the reward for students. The 2% addition to the grade was not a factor in the conceptual tests as those were independent of the final grade, however the additional 2%

might have affected the final grades in the Engaging class (not final exam, and not pre- and post-tests). Whether or not those additional two marks out of 100 were a significant motivator to attend the Engaging classes is unclear, and another study would have to be conducted to test the hypothesis. According to Freeman et al. (2014) active learning reached a statistically significance at 6% increase in the grades, which is an indication of a small likelihood of the extra 2 marks having an effect on the final grade.

According to this study it is recommended for university lecturers to adapt at least some type of engaging teaching to their teaching methods. According to this study, and other studies about teaching natural sciences in universities (Freeman et al., 2007: 2014), the engaging teaching provides benefits that are measurable, and quantifiable such as decreased drop rates, and increased learning outcomes. Even though the learning outcome benefits are relatively small in statistical analysis, active learning still makes a financial difference, as decreased dropout rates have been shown to save a significant amount of money for the universities. Students in STEM disciplines taught by engaging teaching methods are more likely to stay in the university (Freeman et al., 2014; Nelson Laird et al., 2008; Pascarella et al., 2011).

CHAPTER SIX: SUMMARY AND CONCLUSION

6.1. Conclusion

This study was conducted in order to test two hypotheses. The first one was, that the engaging teaching instruction improves class attendance rates. The Engaging class attended classes more frequently as measured by weekly head counts, and this difference was statistically significant compared to both Lecture classes. Thus we can accept the hypothesis that engaging teaching can lead to higher attendance in first year large enrolment courses. The second hypothesis was, that engaging teaching instruction improves learning outcomes, as measured by test grades, final grades, and conceptual pre- and post biology multiple-choice tests. Students in the Engaging class performed significantly better in a conceptual post-test, and they had higher marks in the final exam. Thus, we can accept the hypothesis that engaging teaching can improve learning outcomes; specifically engaging students can improve their conceptual understanding of the subject matter. There are no specific learning outcomes created for Biology1001, however students were expected to become familiar with the following topics in Biology1001, and the conceptual pre- and post-tests measured understanding in these topics:

- Modern scientific study of life
- Evolution and biological classification
- Basic molecules of life and genetic material
- Gene expression
- Mitosis and Meiosis
- The structure and metabolism of prokaryotes and eukaryotes (protists)

- Viruses
- Fungi

In addition, the students in the Engaging class reported more frequently asking questions during the lecture, contributing to a class discussion, teaching other students in the class, and using email to communicate with the instructor. Thus, we showed that students in the Engaging class were truly involved during the course, as there was a statistically significant increase in the engagement reported by students themselves in the Engaging class compared to the Lecture classes.

As a summary, This study shows that by increasing student engagement by active learning in large first year classes we can enhance conceptual understanding, and even promote higher metacognitive skills in students. 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".* Furthermore, 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".* These answers reflect better metacognitive skills, which can be beneficial in later years of studying in university. In contrast, the students in the Lecture classes when asked "*Which type of instruction do you prefer- lecture or engagement?,* reported the following: *"—I prefer lectures – "in Biology where it's just like the way it is, is not so much the understanding, it's like memorizing",* additionally students responded*: "I liked the 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*".

Even though teaching large classes can be a daunting task, especially when trying to add active learning to teaching, it seems that by adding engaging teaching the instructor can encourage interactions, and provide more opportunities to deeper learning for the students. Instructors are able to create welcoming and engaging learning environments, even in large classrooms, by adding clicker questions and small group activities to large classroom teaching. Interactive and active teaching can help, especially first year students, to feel more comfortable in large classes, and facilitate deep learning and conceptual understanding.

6.2. Future Research

It would be interesting to follow up with the students who were in the Engaging class and find out how many of them chose to major in Biology. Also it would be interesting to see if there were any differences in attrition rates between the different classes. As this study confirms, the instructor can promote deep learning, conceptual understanding and metacognition by adding active learning and student engagement in the course. It would be interesting to follow these students in their upper level courses to see if they developed study skills, and metacognitive skills from their first semester biology course. The aim of using active learning in student engagement is to help the students to become more self-oriented. Maybe these students performed better later in university, however a different study would have to be set up to follow these students' success.

Other aspects of student engagement could be studied as well, such as homework quizzes, tutorials, and semester long projects. Students in the first year might also benefit from career guidance from faculty members, as they are often unclear about future career options in Biology. Other beneficial attempts might include first-year teaching committee, or a hired teaching specialist, that could help faculty members in the process of adapting more engaging teaching methods.

Also we need to better understand which type of active learning (clickers, small group activities, group projects) provides the best benefits for students, and especially what helps in specific disciplines, or which approach helps specific sub-groups of students. There are several pedagogical measuring tools (protocols) that can be used to measure the level of engagement in classrooms, such as Reformed Teaching Observation Protocol and Behavioral Engagement Related to Instruction. These protocols can be combined with classroom research, and they provide data that can help instructors to better understand student engagement, and how students respond to different activities (Lane & Harris, 2015; Sawada et al., 2002).

The instructor can have an effect on the learning process, and it would be important to know in detail what aspects of the instructor behavior enhance student learning, and to find out which sub-groups of students benefit from which type of support provided by the instructor. However, we do not want to exhaust the students with a variety of activities, and it would be important to better understand how the frequency of engagement affects learning, what helps and when does it become too much for the students.

Furthermore, in higher education artificial intelligence systems are increasingly utilized in support of personalized learning and adaptive learning systems. Personalized and adaptive learning are defined as pedagogical approaches that focus on personalization of the learning experience. Each learner is unique, differing for example in skills, knowledge, adaptability, and learning styles. Therefore, personalized learning systems will be able to support the learner in the areas where they lack specific knowledge, skills and abilities (Graf, 2009). These online-based systems will be able to automatically guide learners to specific learning materials and tutorials based on quizzes or other form of assessments. McDaniel, Lister, Hanna and Roy (2007) observed a significant increase in learning gain, measured by using conceptual learning inventories, with web-enhanced, interactive pedagogy in Introduction to Biology course compared to a standard instructor-centered pedagogy. In a similar study, Moravec, Williams, Aguilar-Roca and O'Dowd (2010) used online learn-before-lecture material in a large introductory biology class, and showed that students performed better in the content quizzes in the class that had in-class interactive teaching, and online learning resources.

6.3. Dissemination of Research Results

This research study was presented in Graduate Students Aldrich Conference at Memorial University in April 2014, and it won the 1st Prize in Teaching and Learning presentation category. Also these results were shared with Biology department faculty and staff in a departmental Journal Club meeting in Fall 2014. Research results were presented also in an international STEM teaching and learning conference as a poster (STEM Conference, University of British Columbia, July 2014). In addition, a manuscript will be written, and offered to a peer-review journal during Summer 2016.

This study adds to the current literature because firstly, it shows that by increasing student engagement, a significant increase in attendance happens in first year large classes.

Secondly, the active learning happening during interactive classes promotes deeper understanding of the course content, and promotes metacognitive skills in students. Thirdly, these results encourage further studies into the mechanisms of learning that take place during interactive large classes. Memorial University has an increasing amount of teaching and learning related activities, however the typical PhD graduates have very little knowledge in pedagogy. That is why this study is new and different locally at MUN. I might be the only STEM academic that has taken pedagogical research into the classroom at MUN. I had no previous exposure to teaching and learning literature when I started, and now some years later I am conducting classroom research to ensure that students have an inspiring, and beneficial learning experience. Why isn’t this more common? Why aren’t the academics learning more about pedagogy? Student engagement is important at institutional level, as Kuh states (2009): “What the institution does to foster student engagement can be thought of as a margin of educational quality – sometimes called value added – and something a college or university can directly influence to some degree.”

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APPENDIX A Informed Consent Form.

Informed Consent Form

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

Researcher(s): Anna Hicks, PhD
Teaching Consultant
Distance Education, Learning and Teaching Support
Memorial University
St. John's, NL A1B 3XB
Tel: 709 864 4503

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, please contact:

Anna Hicks, PhD	Dr Trudi Johnson
Teaching Consultant	Associate Professor

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e-mail: anna.hicks@mun.ca

Faculty of Education
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Tel: (709) 864-8622
E-mail: trudij@mun.ca

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 709-864-2861.

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.

__________________________________ __________________________________

Signature of Principal Investigator Date

APPENDIX B

Active Learning Exercises Resources

The Active Learning Resources at University of Wisconsin-Madison

https://tle.wisc.edu/category/solutions/active-learning

The Carl Wieman Science Education Inititative, University of British Columbia

http://www.cwsei.ubc.ca/resources/other.htm#Other

National Center for Case Study Teaching in Science

http://sciencecases.lib.buffalo.edu/cs/teaching/

Transforming Science Education at Large Research Universities: A Case Study in Progress

http://www.changemag.org/Archives/Back%20Issues/March-April%202010/transforming-science-full.html

Teaching with Clickers

http://derekbruff.org/teachingwithcrs/

Indiana University-Active Learning

http://www.iupui.edu/~webtrain/active_learning.html

California State University- Large Class Activities

http://www.calstatela.edu/dept/chem/chem2/Active/main.htm

Biology textbook Connect website with Activities

http://connect.mcgrawhill.ca/

APPENDIX C Examples of Class Activities.

Module 1.2. Learning Objective: Understand hypothesis testing, and describe the scientific method.

Metabo-Herb causes your tomatoes to grow faster than 'Super-Grow.' (from McGraw Hill textbook Connect online resources)

- The following experiment provides definitive, scientific proof of the superiority of 'Metabo-Herb' over 'Super-Grow.'
- Two side by side one-acre fields were planted with the same variety of tomatoes. One of the fields was fertilized with 'Metabo-Herb,' the other was not.
- At the end of the season, plants were randomly sampled from each field and compared with respect to growth (plant height).

Growth (height in inches)

	'Metabo-Herb'	Without
	48	39
	52	31
	43	36
	49	29
	50	37
	37	39
	51	36
	47	34
	48	37
	42	38
	53	33
	50	43
	29	32
	48	29
	47	26
Mean	**46**	**35**

- A statistically significant difference in plant height between the groups proves the superiority of 'Metabo-Herb" over our competitors.
- Plants fertilized with Metabo-Herb grew on average 11 inches taller than those without. These data scientifically prove the superiority of Metabo-Herb over Super Grow

Questions for Students to work in small groups:

1.What specific claims do the manufactures make about their product?

2. The manufacturer doesn't identify a biological mechanism by which their product may promote plant growth.

Explain why this information is vital for a proper evaluation of the claims.

3. Identify the following components of the study:

Control Group:

Experimental Group:

4. Is the experiment described an appropriate test of the claims made by the manufacturer? Explain.

5. What is the purpose of a control group in an investigation?

6. Is there any statistical analysis of the data?—Why is it important to utilize statistical procedures to analyze data?

7. What conclusions can be drawn from the data?

8. Why are testimonials of limited value to scientific investigations?

Module 4.2 Learning Objective: Understand equilibrium across a semipermeable membrane, and how osmosis and diffusion relate to equilibrium.

---

1 out of 3 attempts

Be sure to answer all parts.

Part 1 out of 2

Two solutions, A and B, are separated by a selectively permeable membrane. The membrane is permeable to glucose and impermeable to NaCl. Solution A is a 300 mL solution composed of 400 mM glucose and 100 mM NaCl. Solution B is a 300 mL solution on the opposite side of the membrane, composed of 200 mM glucose and 300 mM NaCl. Enter the concentrations of glucose and NaCl in each solution after the system is allowed to reach equilibrium.

Glucose, Solution A: ______ **mM**

NaCl, Solution A: ______ **mM**

Glucose, Solution B: ______ **mM**

NaCl, Solution B: ______ **mM**

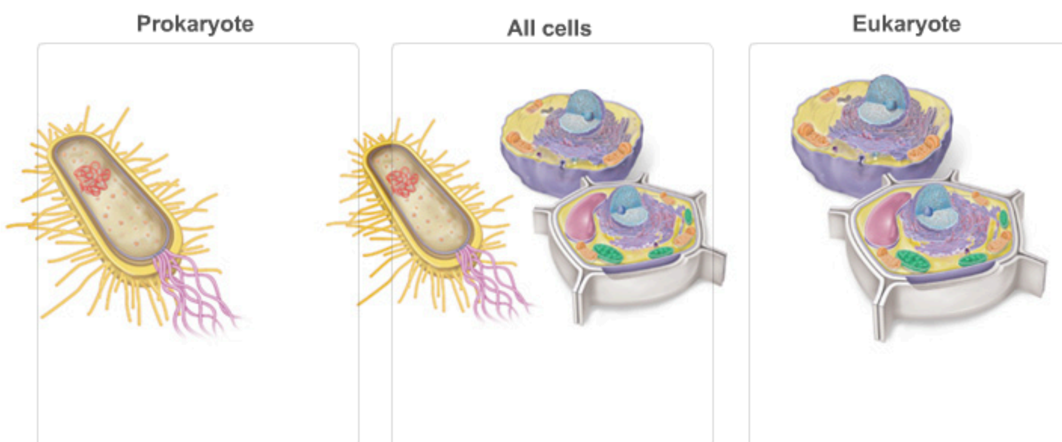
next

APPENDIX D Example of a Class Activity and Conceptual Exam Question

Class Activity Sheet:

For each characteristic, identify if the charactertistic is present in prokaryotes, eukaryotes, or all cells.

Secretes a glycocalyx	Has a cytoskeleton	Has a proteome
Has a cell wall containing peptides and carbohydrates	Has a plasma membrane	Contains ribosomes
Has DNA	Has a nucleoid region	Has mitochondria



Pre-test and Post-test Question example:

Q12. Protists are alike in that all are

A. autotrophic.

B. unicellular.

C. monophyletic.

D. eukaryotic.

APPENDIX E Online CLASSE questions.

CLASSE Student Survey

____

[FILL IN APPROPRIATE COURSE NAME/NUMBER]

PART I: ENGAGEMENT ACTIVITIES *<u>DURING LECTURES</u>*

So far this semester, how often have you done each of the following in your course LECTURES?

Note: Answer these questions based only on the class lectures, NOT the lab sessions.

1. Asked questions during your lecture
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

2. Contributed to a class discussion that occurred during your lecture
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

3. Prepared two or more drafts of an assignment in your class before turning it in
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

4. Worked on a problem in your class that required integrating ideas or information from various sources
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

5. Included diverse perspectives (practical application, religions, genders, politics, beliefs, etc.) in class discussions or assignments in your class
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

6. Came to your lectures without having completed readings or assignments
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

7. Worked with classmates outside of your class to prepare class assignments
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

8. Put together ideas or concepts from different courses when completing assignments in your class

a. Never
b. 1 or 2 times
c. 3 to 5 times
d. More than 5 times

9. Tutored or taught other students in your class
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

10. Used an electronic medium (clickers, listserv, chat group, Internet, instant messaging, etc.) to discuss or complete an assignment in your class
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

11. Used email to communicate with the instructor or your class
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

12. Discussed grades or assignments with the instructor of your class
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

13. Discussed ideas from your class with others outside of class (students, family members, coworkers, etc.)
    a. Never
    b. 1 or 2 times
    c. 3 to 5 times
    d. More than 5 times

14. Made a presentation in your class
    a. Never
    b. Once
    c. 2 times
    d. More than 2 times

15. Participated in a community-based project (i.e. service learning) as part of your class
    a. Never
    b. Once
    c. 2 times
    d. More than 2 times

16. Discussed ideas from your readings or classes with your instructor outside of class
    a. Never
    b. Once
    c. 2 times
    d. More than 2 times

17. Received prompt written or oral feedback on your academic performance from your instructor
    a. Never/rarely
    b. Sometimes
    c. Often

d. Very often

18. Worked harder than you thought you could to meet your instructor's standards or expectations
    a. Never/rarely
    b. Sometimes
    c. Often
    d. Very often

PART II: COGNITIVE SKILLS

So far this semester, how much of your coursework in your LECTURE class emphasized the following mental activities?

19. Memorizing facts, ideas, or methods from your courses and readings so you can repeat them in pretty much the same form
    a. Very little
    b. Some
    c. Quite a bit
    d. Very much

20. Analysing the basic elements of an idea, experience, or theory, such as examining a particular case or situation in depth and considering its components
    a. Very little
    b. Some
    c. Quite a bit
    d. Very much

21. Synthesizing and organizing ideas, information, or experiences into new, more complex interpretations and relationships
    a. Very little

b. Some
c. Quite a bit
d. Very much

22. Making judgements about the value of information, arguments, or methods, such as examining how others gathered and interpreted data, and assessing the soundness of their conclusions
    a. Very little
    b. Some
    c. Quite a bit
    d. Very much

23. Applying theories or concepts to practical problems, or in new situations
    a. Very little
    b. Some
    c. Quite a bit
    d. Very much

PART III: OTHER EDUCATIONAL PRACTICES

So far this semester

24. To what extent do the examinations in your class challenge you to do your best work?
    a. Very little
    b. Some
    c. Quite a bit
    d. Very much

25. In a typical week in your class, how many homework assignments take you more than one hour each to complete?

a. Never
b. 1 or 2 times
c. 3 to 5 times
d. More than 5 times

26. In a typical week, how often do you spend more than 3 hours preparing for your class (studying, reading, doing homework or lab work, analysing data, rehearsing, and other academic matters)?
    a. Never/rarely
    b. Sometimes
    c. Often
    d. Very often

27. How many times have you been absent so far this semester in your lectures?
    a. None
    b. 1 or 2 absences
    c. 3 or 4 absences
    d. 5 or more absences

28. How frequently do you take notes in your class?
    a. Never/rarely
    b. Sometimes
    c. Often
    d. Very often

29. How often do you review your notes prior to the next scheduled meeting in your class?
    a. Never/rarely
    b. Sometimes
    c. Often

d. Very often

30. How often have you participated in a study partnership with a classmate in your class to prepare for a quiz or a test?
    a. Never
    b. Once
    c. 2 times
    d. 3 or more times

31. How interested are you in learning the course material from lectures?
    a. Very uninterested
    b. uninterested
    c. interested
    d. very interested

32. How much do you enjoy group work with your classmates during your lectures?
    a. Very little
    b. some
    c. quite a bit
    d. very much
    e. I didn't do any group work during lectures

33. How difficult is the course material in the lectures?
    a. easy
    b. somewhat difficult
    c. difficult
    d. very difficult

34. How easy is it to follow the lectures?

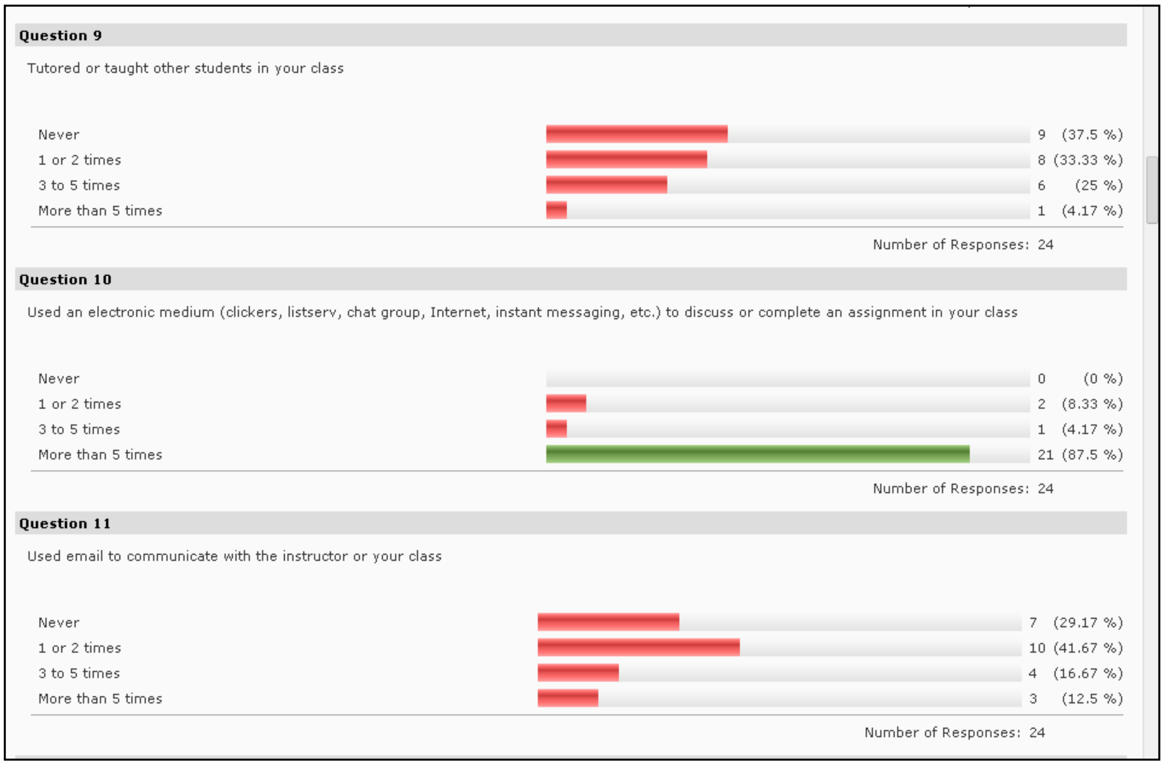
a. easy

b. somewhat difficult

c. difficult

d. very difficult

Examples of CLASSE Responses in the Engaging class:



APPENDIX F 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