Comparison of a Traditional Teaching Model to the Scale-Up Teaching Model in Undergraduate Biology: A Mixed Method Study

by

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This project compared a SCALE-UP teaching model to a traditional teaching model. Traditional teaching is now considered a poor motivator for student performance and interests, and the SCALE-UP model was proposed to combat these problems. SCALE-UP classrooms are designed to encourage cooperative learning as well as other active learning methods. The study looked at teacher and student opinions of the two models to determine which one they preferred and why. The study also compared the students' grades between the two classes to see if there was a difference between test scores, as well as learning gains for pre-test to post-test. Student and teacher behaviors were also quantified based on categories of engagement in class. The purpose of this study was to support the literature on the idea of a viable and better option to traditional lecture in the form of the SCALE-UP model. Based on the results, students prefer and enjoy a SCALE-UP classroom more than a traditional lecture. The students also performed better and learn more when compared to the traditional lecture class.

Comparison of a Traditional Teaching Model to the Scale-Up Teaching Model in Undergraduate Biology: A Mixed Method Study

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CHAPTER 1: INTRODUCTION

There is a rising trend in education literature that supports the idea that traditional lecture classrooms are not the most effective environment for successful learning, because they are unengaging to students. These problems cause the students to become disinterested, do poorly and possibly leave the university (Tinto, 1997). This withdrawal from learning led to researchers looking at ways to increase student enrollment and decrease student dropout rates. Tinto (1997) wrote that one of the changes universities needed to make in the classroom to increase student success and retention was to increase their engagement in the classroom. All of these findings indicate that traditional lecture is no longer working in the university's favor. This dilemma has lead instructors to consider other viable options to traditional lecture when teaching students in the college classroom. Robert Beichner of North Carolina State University (NCSU) has worked on a new model called the SCALE-UP (Student-Centered Active Learning Environment for Undergraduate Programs) classroom for large enrollment physics classes (Beichner et al., 2006). Following this example, a similar model is being implemented by faculty in the biology department at East Carolina University (ECU).

Background

Traditionally, large lecture halls are the usual venue for college courses because they more easily fit the most people and, therefore, teach the largest numbers students in the least amount of time (Bligh, 2000). This makes lecture halls cost effective and proficient at saving faculty time, allowing students to attend more classes and teachers to instruct more classes and students. For the teachers, once a method of lecture (PowerPoint, speech, reading material, etc.) is developed, there is little additional work involved in prepping for that class, which saves time. From the students' point of view, there is not much work to do while in class, which could be enjoyable for some; however, this turns out not to be the case for most students. Engagement in the classroom not only helps with learning but also with graduation success (Michael, 2006; Tinto, 1997). Students who sit and passively receive information are not learning optimally (Hoellwarth, Moelter, & Knight, 2005). Studies show that active learning is a much more effective instruction method than passive lecture for students (Anderson, Mitchell, & Osgood, 2005; Michael, 2006). Active learning is defined as any learning that engages the student. This could be done with several different tools or strategies, for example, a hands-on activity or discussion group. Active learning gets students more cognitively involved in their education rather than just passively receiving lectured information from the instructor. Active learning prevents the student from getting lost in the crowd of students, giving them a chance to be accountable for their education. Although some students perform well in lecture classes, with active learning students learn more deeply and are able to think more critically. Omelicheva and Avdeyeva (2008) compared two classes, one taught using traditional lecture methods and one with active learning in the form of debates. Debates are a relatively simple form of active learning but, even so, there were differences in the students' test scores and understanding levels. The two classes showed no significant difference on multiple choice tests given at the end of the semester but, on short answer questions, the debate class showed a higher level of critical thinking and, therefore, a deeper understanding of the material. Another example of how lecture provides a good method for rote memorization is the study by Nandi et al. (2001), who compared traditional lecture classes to problem-based learning classes in pre-medical curriculum. They found medical students trained in lecture courses were not prepared for real world problems, although well versed in the terminology, and wanted to see if a more problem based curriculum would bridge this gap. Nandi et al. found that the new curricula did not result in an increase in standardized test grades but did lead to an increase in classroom performance and personal confidence (2000). This is an important side benefit of changing teaching methods as it not only increases students' grades but also improves students' interest and confidence level, factors shown to contribute to students dropping out of college (Tinto, 1997). These ideas are what led Beichner to develop a new method. Students in SCALE-UP classes should be seen taking a more active role in their education, which may better prepare them for their future in higher-level degree programs or the workplace. The methods used in SCALE-UP classrooms are designed to engage students, which also gets them practicing skills needed to succeed in the world outside of college. This is a needed step in academia to help students transition to, and be more successful in, their future endeavors. Students with improved learning will be more successful, as will the universities they attend.

Purpose

The purpose of this study was to evaluate the biology SCALE-UP classroom in comparison to a traditional lecture classroom, which is a typical freshmen biology course with large enrollment at a four-year university. This was done by observing students taking BIOL 1100 in a SCALE-UP classroom and comparing their opinions, behaviors, and test answers to BIOL 1100 students in a traditional lecture classroom. The information gained from this study can help the department and the university decide where to devote resources and time to improve enrollment as well as graduation success rate.

Research Questions

1. Do the SCALE-UP students perform better on a content test compared to those in a traditional lecture environment?
2. If a difference is seen, which class has enhanced learning and better critical thinking?

3. What are biology students' opinions of SCALE-UP, and do the opinions change over the course of the semester?
4. Which method did the instructors prefer?
5. Was the SCALE-UP classroom used as designed?

Significance

This study is significant in providing more support for a different style of teaching approach, instead of traditional lecture, in improving student learning, retention and completion rates. The study showed evidence that a SCALE-UP classroom is a viable option for replacing less-effective traditional lecture classrooms. It is a better option in terms of retaining student interest, students developing a deeper understanding of course content and learning to think more critically. The study showed that both students and teachers can adapt quickly to the different environment (SCALE-UP) and improve both attitudes and performance over lecture-based courses. This might lead to this university providing additional funding for more SCALE-UP classrooms to be installed on campus.

CHAPTER 2: LITERATURE REVIEW

Science education is an ever changing path of discovery of how students learn, and how to teach effectively. Researchers are always investigating how to teach students science in the most effective way, and recently Robert Beichner of NCSU published what he terms the SCALE-UP model. This is one alternative for use in higher education being investigated today. The following provides a brief history of science education and the opinions and theories that led up to the SCALE-UP model.

History of Science Education

Tracing the history of science education leaves one baffled by the back and forth movement of philosophies about how science should be taught and learned. Before those philosophies could be argued, however, scientists had to make science education a part of the classics taught in US schools at the time (Deboer, 1991). In the early 19th century, higher education was for those who wished to gain prestige or the clergy. In 1892, the Committee of Ten met to lay down rules to make college entrance requirements more uniform. This was to enhance students transition from high school to college in terms of knowledge expected when they enter college. This Committee of Ten led to more conferences and committees meeting on subject matter, specifically science content meetings to say what needed to be added to college curriculum. The Committee of Ten finally approved the addition of some of the sciences to regular college courses offered. Then, once science education secured its place on the list of courses, the question became how to teach it. Various formats were available, but the most popular at this time was rote memorization of facts. This was called the Progressivism Age. The popular thought was that students should be led from one step to the next with little room for exploration, which was slow and time consuming; everything should be focused on learning the facts and principles of science. Unpopular opinions at the time focused on laboratory science and students exploring the material on their own. As people started to reconsider how science should be taught, war came to the US, which created the need for change. The 1950's saw the technological ramifications of war and, most notably, the effects of the launch of Sputnik on education reform. Even before the launch, the US was falling behind Germany and missile building by their scientists. The launch started to influence government interest in science education and promote funding for change. War also created a more open environment for conversations to occur and different ideas to surface or be re-evaluated.

Sputnik-age

With the launch of Sputnik by the Soviet Union in 1957, a light was shined on US science, ending the debate on education reform and leading to action. The US was being challenged by the rest of the world and the government saw a gap in the resource of educated scientists to rival Sputnik technology. When the government finally called on their scientists, there were not enough to answer the call, the US had to pull scientists from other countries to fill the gaps. The US was afraid they could not compete in the arms race against the Soviet Union and any other potential enemies in the future. Effectively, Sputnik was the beacon announcing the US's failure to stay on top of the technology at that time; it was interpreted by the government and people as a failure of the education system, and indicated a need for change (Bernhaerdt, Burns, & Lombard, 2009). The US was not producing enough qualified scientists to teach the next generation or advance the current one. In 1958, Congress signed the National Defense Education Act (NDEA) in order to allocate government funds to education needs (Deboer, 2000). This bill sought to change science education to make more successful scientists as well as to encourage more people to be scientists. The threat of the Soviet Union also drew people's attention to more gifted students and a need for gifted or accelerated science education programs in schools (Jolly, 2009). The US wanted gifted individuals to combat the Soviet Union's threat over the US's perceived status in the world. This necessitated curricular reform and, subsequently, textbooks were rewritten to allow accelerated learning tracks in schools, as well as a better understanding of what was important to science (Deboer, 1991).

The National Science Foundation (NSF), which was founded in 1959, was responsible for funding education programs by the NDEA. The NSF spent millions on new textbooks written for curriculum reform. Science education was rewritten to reflect a new focus on the logical progression of themes in sciences and the process of science itself. This curriculum reform was led by scholars and teachers to restructure courses and textbooks to be in line with how they thought, at the time, the sciences should be taught. They wanted more focus on understanding themes and less on memorization of those themes. Scholars thought this would lead to better learning and enabled deeper understanding of the newly designed science material. They also wanted to teach the methods of science and how people interact with these methods to get the results seen in the real world. This was demonstrated in the project conducted by the Physical Science Study Committee (PSSC) (The Curriculum Reader, 2004). This committee's main responsibility was to write a new physics course for the high school level, focusing on understanding the principles of physics by working with concepts, not just asking students to memorize them. The laboratory played an important role in this process, as that is how the students worked with the principles to increase their understanding. Schwab (1959) brought the importance of inquiry learning as a part of the laboratory experience to the attention of the people at this time. Fundamentally, he stated that science is an inquiry-based activity and that teachers should be instructing students on how to be scientists through inquiry; however, Schwab's argument was lost in the discussion when the new curriculum reform failed to produce the results intended. One controversy that surfaced with changing a curriculum was that to increased understanding of one concept usually meant less time is spent on others, meaning less total material was covered in each course. Another concern of teachers was that new courses did not prepare students for college, which were still following old methods. The final problem was that interest flagged because the new textbooks failed to relate the courses and material to the students, or to real world problems. As seen throughout the history of education, there is a pattern of completely changing from one idea to a completely new one. This total change from one point of view to another saw the need to connect the role of science in society with science as an academic subject in the textbook (Deboer, 1991).

New Progressivism

From the late 1960's until the 1980's, science education saw a shift back to the previous ideas of progressivism. This was seen when idea of the importance of teaching science that is relevant to the everyday world reemerged (Deboer, 1991). These decades are therefore referred to as the New Progressivism. The importance of scientific literacy also was focused upon as a part of the New Progressivism; however, first the scientific and educational community needed to decide on what the phrase 'science literacy' meant for science education. This goal was clearly defined when the National Science Teacher Association (NSTA) met in 1971, releasing their official statement of *School Science Education for the 70's*. The statement's opening line focused on the need for achieving scientific literacy. The NSTA (1971) later went on to define an individual with scientific literacy as someone who "uses science concepts, process skills, and values in making everyday decisions as he interacts with other people and his environment" as well as "understands the interrelationships between science, technology, and other facets of society, including social and economic development" (pg. 78-79). Using this definition as a guide, science education was moved forward in terms of making an effort to connect science concepts with society. In connection with this, Gallagher suggested four areas to include in courses; the concepts of the course, the processes of science, technology, and society (Gallagher, 1971). The idea was that these four concepts would effectively connect and reinforce each one, creating a full picture of how scientists and science education contribute to society. This paper was the precursor to the Science-Technology-Society (STS) theme seen through the rest of the 1980's (Deboer, 1991). The NSTA also elaborated on this theme in their new statement for the 80's (National Science Teacher Association, 1982). In sum, the new statement argued that science has evolved with technology and future scientists needed to be able to evolve with the technology. It also stated that there was a need for students to understand technology's role in science and to be able to use it effectively. Technology also plays a big role in society, thus bridging the gap between science and society. The need to humanize scientists and their important roles in society led educators to use the humanistic approach made famous by psychologists Carl Rojers and Abraham Maslow (Underhill, 1989). Humanistic education in science education was tasked with making science a more human and approachable activity. It was also used as a type of teaching technique that treated students as individuals to help with learning. This opened the door for other psychology theories to be used when thinking about teaching curricula and education reform.

Psychology of Learning

Although the science of psychology had been around for a while, and theories on education had also been a part of the literature and discussions on education, it was not until the 1980's that curriculum started to be altered based on these theories. Scientists and educators were finally listening to cognitive psychologist who specialized in the science of learning. Thinking about how students learn could help teachers shape a mind to be that of a scientist, imparting critical reasoning and an inquiry learning mindset. Jean Piaget was a psychologist interested in child development, and his theories strongly impacted learning in classrooms. Lawson (1979) was the first to propose how Piaget's theory could be used in Science Education. Lawson took Piaget's concrete operational stage and formal operational stage and put them in terms related to science education. The concrete operational stage is when something is classified or measured, whereas the formal operational stage is when deductive skills and higher reasoning are used. Piaget theorized that children learn as they mature by interacting with their environment and assimilating new information with their current knowledge. Students would then accommodate that assimilation in a meaningful way, thus learning and understanding more fully. This theory gives "discovery" teaching a place in the classroom as a good method to develop higher order thinking skills that emulate a scientist's mind.

Another learning theory popular at the same time was the Ausubelian theory. Ausubel (1966) followed the Piagetian theory, but did not subscribe to the discovery aspect of learning. He thought that a student would assimilate new knowledge most effectively by being told that new knowledge clearly. Ausubel was concerned about the transition from the concrete to formal operating stages; this is why he argued that children need to be directed from one to the next so nothing goes wrong in transition. This theory also stated that, in order for an idea to be assimilated, there needs to be something the learner can assimilate it with. This means that the learner needs to have previous knowledge to build upon. Ausubelian theory is based on the idea that more a learner knows, the more easily he/she can assimilate new knowledge (1996). Thus, an instructor's role is to teach material that directly relates to the learner's existing knowledge so that new knowledge can be more easily accepted. The undesirable part of this theory is that it leaves little for discovery and inquiry.

A theory focused on how instruction can achieve better learning was proposed by Robert Gagne. His theory is known as ‘Conditions for Learning’ or ‘Hierarchical Learning’ (Deboer, 1991). It is based on the principle that to learn something one has to have certain prerequisite knowledge, as in Piagetian Theory, which allows learning of new objectives. This also includes listing the objectives up front so students know what they are supposed to get from the lesson. This listing of objectives also helps the instructor know what students need to know before they can understand the new material. Students have to build their knowledge by acquiring new skills that lead to the ability to acquire yet additional skill.

Finally, the literature leads to Robert Karplus and his Learning Cycle theory. His concept learning theory utilizes Piagetian theory of learning and development, although he takes the concrete and formal operation stages and places them into a learning cycle (Karplus, 1977) with three stages; these are exploration concept introduction, and concept application. Students are allowed to explore a new concept with a simple activity that they may or may not be able to complete. Then the instructor introduces the concept in a logical and more meaningful way. This leads to the students using this new knowledge to form their own thoughts about the concept and apply it to other concepts. This style of instruction leaves space for different kinds of instruction; verbal, activities, discussions, labs, etc. This mixture of instructional approaches is where science education is heading today.

Student Involvement

The next step in education is to get the students involved in their own learning. Constructivism is the theory that is defined by students actively imposing the reorganization of ideas to make the connections between the ideas themselves (Reiser & Dempsey, 2012). This learning theory also takes from Ausbel the importance of building knowledge from existing knowledge. Contrary to Piagetian theory, they do not simply let the environment influence them, but also choose to take what they can from the environment. A constructivist learning environment should encourage creativity, collaboration, setting clear goals, and reflection on the content being learned. This biggest part is activities relevant to the content that lead to active learning. Active Learning is the new phrase for teaching styles that strive to do just that. Active Learning is any instruction that gets the student involved in the content from their own perspectives; this could be group work, class discussion, in class activities, etc. (Instruction at FSU Handbook, 2011). There are several pedagogies that focus on various methods of active learning. Inquiry based teaching is gaining attention again through a debate on inquiry in science; however it gets lost in definitional confusion between inquiry being taught and inquiry as the teaching method (Deboer, 1991). It may be helpful to remember that learning by inquiry is interacting with an environment freely and forming questions from that interaction. This can be more closely regulated by structuring the inquiry to target certain concepts, for example, by having activities that are about those concepts. The teacher serves as a guide or facilitator of knowledge and the student drives the learning, as well as where the class goes (Anderson, 2002). The problems with approaches like these are that textbooks and classes are not designed to be used with these pedagogies. Teachers have problems adjusting to these methods because they are not familiar with their new roles. Another important aspect of inquiry is Student driven learning, it is helpful in respect to the social aspect of science. Science is a cooperative and collaborative endeavor, which is sometimes overlooked when teaching about science. Small groups working together help show this and garner teamwork, accountability, interdependence, and group processing (Smith et al., 2005). These things all lead to a more confident and able scientist. Although there is a vast literature that argues students should take a more active role in their own learning, and not just be passive in gaining that knowledge, classrooms are still largely operating as traditional lecture style environments (Anderson, 2002). Why are classrooms so slow to change even though there is overwhelming evidence that students learn better and more deeply from active learning techniques that involved them with the material? These questions led to researchers developing new class structures to include these new learning theories, one of which is the SCALE-UP project.

Change for the future

Problems in science education have been ongoing and even though research continues to argue for it, widespread change still has not occurred. Deboer (1991) wrote "A History of Ideas in Science Education: Implications for Practice," to illustrate the changes that have been made and still need to be made. He insisted that the focus needs to be on learning and not teaching, especially not teaching that leaves the students uninvolved. College courses are largely still lecture style and teacher driven, which, based on evidence of how people learn, is not an optimal approach. Also, science courses have a problem of retaining student interest and enrollment. There need to be changes that increase interest and successful learning, which can be done by getting students involved in their own learning through active engagement, and by letting them drive the classroom to a certain extent. This style has previously been mentioned as Student-Centered Learning, a part of Active Learning. The goal of science education in the US is to teach everyone to the same standard and level of understanding; yet the US still struggles to the find productive teaching methods that permit students to successfully score at the top when compared to the rest of the world.

Where Does America Stand?

The US kick-started education reform because of the launch of Sputnik by the Soviet Union, and the eventual realization that the US might not be on top anymore (Deboer, 1991). Since then, some have questioned whether the US has improved the education system and science understanding. The Trends in International Mathematics and Science Study (TIMSS) was first performed in 1995 (National Center for Education Statistics, 2003). This study accesses the knowledge and understanding of mathematics and science in participating countries in 4^{th} and 8^{th} graders. This allows countries to access their education systems and make changes to improve. The US has never been in the top 5 countries and often is not in the top 10. It would appear that the US has not reformed our education system effectively and still cannot compete effectively with other countries. In fact, from 1995 to 2003 performance in the US was not improving, while other countries were showing improvement in mathematics and science. If the US' 4^{th} and 8^{th} graders were falling behind, then those at the college level were already at a disadvantage from the start, as the base upon which to build advanced knowledge was not well formed. The OECD (Organization for Economic Co-operation and Development) discovered that the US was behind in graduation rates from college when compared to other countries (2013). This follows the pattern that students drop out of science programs or even college itself (Seymour, 2000). It appears that, overall, US educators have failed to teach effectively and keep students interested in science. This has been demonstrated by weak interest in STEM (Science, technology, Engineering, and Mathematics) programs, with enrollment of high school seniors to college freshmen dropping by 40%. Educators clearly need to change; however, what that change will be is the challenge for the US right now.

Active Learning vs. Traditional Lecture

Teachers shifting from traditional lecture to new teaching styles are focusing on finding methods that help students to learn and understand, and less on teaching students simple bodies of knowledge. This is the foundation of reasoning backing the idea of leaving behind traditional lecture style and moving towards active learning, more specifically toward student centered learning. One of the main goals of active learning is to get students to think like scientists; that is, to use higher levels of cognitive functioning, problem solving skills, critical thinking, make inferences, and build upon previous knowledge (Smith et al, 2005). So does active learning actually increase these skills?

There have been countless studies on active learning in the college classroom and many reviews of this literature. One such review was done by Prince (2004) on whether or not active learning does work. He surveyed current literature and found that yes active learning is an asset to the classroom and does improve student performance, in most cases. He does not come to a conclusion based on the literature he studied on which method of active learning is best, however. Some examples of active learning used in college classrooms in the last thirty years will be looked at. In 1989, professors hosted two classes of Biology level 1 and Biology level 2, one using lecture (the basic didactic teaching) and the other an active learning environment (Goodwin, Miller, & Cheetham, 1991). The goal was to see which style produced the better results (e.g. greater learning gains) by looking at results of test questions. Both sets of students were concluded to be about the same level of prepared for later biology courses based on test scores over the semester, but opinions were mixed on the new nontraditional courses. Students in the 1989 course felt they did not learn as much biology as if they had been in a traditional lecture class, but they still performed the same if not better, than students in the lecture class. In the

1990 course year, however, students felt prepared and more favorable towards the active learning approach than a lecture class. Goodwin, Miller, and Cheetham (1991) showed an alternate way to teach that could move classrooms away from solely lecture style, towards active learning, but questions remained as to improvements in critical thinking and problem solving skills.

One type of active learning is teaching through debate; students are given a subject and asked to debate both sides. Theoretically, debates should encourage higher learning and deeper understanding compared to traditional lecture (Smith et al. 2005). Research by Omelicheva and Avdeyeva (2008) compared the two styles (debate vs. lecture), hypothesizing that debate would have these stated benefits, but that traditional lecture would be better for learning factual knowledge. They found a trend indicating that students learned factual knowledge better in lecture, but overall comprehension and application was more highly developed in the debate setting. The debates allowed students to examine information from different perspectives, leading them to take further steps and form their own opinions, an example of higher level scientific thinking. This improvement was measured by asking the students hypothetical situation questions wherein they applied the class-derived information to devise a solution. Students in the debate class were better able to come to clear solutions than were the lecture students. This research also looked at student opinions and found that students had more negative than positive feelings towards both classes.

Another student-centered approach of active learning is cooperative learning (Smith et al., 2005). Cooperative learning occurs in small groups of students working on an activity of some sort together. This should encourage students to work together, gain confidence in the material, and share ideas. Smith et al. (2005) stated that working in groups should cause more links to form among classroom concepts to better accommodate and incorporate the knowledge.

It also allows students to voice their knowledge on a subject and to teach other students in the group, which leads to a more meaningful understanding. A study was conducted in a college level biochemistry class comparing traditional lecture and cooperative learning (Anderson, Mitchell, & Osgood, 2005). The researchers examined two different classes, one using standard lecture delivery and the other employing cooperative learning, featuring problem based work, inquiry based learning, discussions, and other student centered techniques. They gave an exam after each section of the course to both classes (4 exams total). The cooperative learning class did significantly better on the tests than the lecture based class, although both classes showed increases in knowledge. Most interesting, the cooperative learning class performed significantly better on questions designed to assess problem-solving skills. These results are in agreement with the literature presented previously, all indicating that active learning appears to be more effective than traditional lecture, particularly with respect to improved critical-thinking skills. Student opinions also were assessed and the cooperative learners commented that they found the course harder, but at the end enjoyed it more once they became used to the non-lecture style class. Enrollment also increased for the cooperative learning class over the lecture class. This brought into the conversation the idea that active learning environments could lead to higher enrollments and more diplomas in the sciences, a problem in science education that had not yet been addressed.

The evidence presented is just some of the studies that shows that active learning strategies work as well as or better than traditional lecture in all measurable areas, demonstrating that they are a reliable alternative to the standard college lecture style of teaching. There is an increase in learning, better critical thinking, and an important role for cooperative learning, as shown in the few studies highlighted previously. This is not to say that there is no place for traditional lecture, as it is useful when there are time constraints and a lot of factual material to be covered. As illustrated in this discussion, research suggests that there should be at least a mix of approaches so that students get involved in, and excited about, their own learning. This should lead to increased interest in science and greater enrollments in the STEM fields. That is why the SCALE UP model is an important model to explore and implement in classrooms today (Beichner, 2009).

SCALE-UP Movement

Robert Beichner (2006) saw the trend in the literature calling for a change in the way classes were taught, and developed the SCALE-UP (Student-Centered Activities for Large Enrollment Undergraduate Programs) classroom. This method utilizes peer groups that work together on problem-solving activities, with a teacher guiding instead of leading. This type of teaching encourages student-driven inquiry and a better ability to work with others.

Beichner is a physics professor at North Carolina State University. He was impressed with NCSU's IMPEC (Integrated Math, Physics, Engineering, and Chemistry) curriculum, a project designed to utilize active learning methodologies such as collaborative learning, problem-solving activities, and a technology rich environment (Beichner et al., 1999). Even though the curriculum reported the students had higher success rates, the program was not continued because the classrooms were too small to be practical. Beichner wanted to continue this work so he devised a way to scale up active learning courses from small to large classrooms (100 plus students).

The IMPEC curricula and, therefore, SCALE-UP project were inspired by new guidelines for accreditation set by Accreditation Board for Engineering and Technology (ABET). ABET is non-governmental organization responsible for providing accreditation to post-secondary education programs such as engineering and applied science since 1996 (Felder & Brent, 2003). These guidelines focus on performance of certain objectives at graduation instead of on repetitive knowledge. This led professors to think about how best to address fulfilling these accreditation objectives; school and programs would have to detail the specific objectives desired for the degree and for each course. Then instructors would write the learning objectives for each course and how they would be achieved. Thus, professors needed to address how to teach their students with these goals in mind, leading them towards a more active classroom environment. Choosing correct assessments for these new activities became an important factor when designing a class as well. This problem further encouraged the use of activities and peer review assessment in the active learning classrooms. These criteria led to a model that other programs could build upon laying out the guidelines for planning a successful program by planning the successful classes it contained.

The IMPEC curricula and SCALE-UP project both designed their problem-based, technology-rich activities following Lillian McDermott's *Physics By Inquiry*, a handbook of activities showing how inquiry learning can be used in the classroom (Beichner et al., 2006). McDermott's goal is to show how a classroom can be improved by and successful use of inquiry based teaching (McDermott, Shaffer, &Vokos, 1997). *Physics By Inquiry* was written for "courses in which the primary emphasis is on discovering rather than on memorizing and in which teaching is by questioning rather than by telling,"(McDermott et al., 1997, pg. 990). This is what Beichner envisioned for his SCALE-UP classrooms (Beichner et al., 2006).

Why SCALE-UP?

SCALE-UP classrooms based their program on studio/workshop style curricula, cooperative learning, and inquiry learning (Beichner et al., 2006). Studio or workshop style curricula are classroom courses loosely structured, but they feature a facilitator-type teacher and student-driven, hands on activities (Little & Cardenas, 2001). In 1999-2000, a freshmen engineering course was restructured to fit the studio style of teaching. The course was designed to meet ABET criteria, and assessed based on those objectives: 1) An ability to design a system, component, or process to meet desired needs, 2) an ability to function on multi-disciplinary teams, 3) an understanding of professional and ethical responsibility, and 4) an ability to communicate effectively (Little & Cardenas, 2001). Student work was compared to previous semesters to see if there was an increase in success in completing those objectives. The researchers found that skills increased. Another study paired a lecture based course with a studio style course, both teaching physics (Hoellworth, Moelter, & Knight, 2005). The studio course utilized computers for assignments as well as small group collaborations on projects. The goal was to see the different effects on conceptual understand and problem solving. The researchers measured this using Force Concept Theory or Force and Motion Conceptual Evaluation. These tests are common measures of physics concepts and used to assess success in the classroom. Like other studies, the results showed higher conceptual understanding and problem solving skills in the active learning environment. This showed evidence that studio style teaching is a viable active learning teaching model. Cooperative and Inquiry Learning had already been laid out as a favorable approach to teaching (Anderson, 2002; Smith et al, 2005; McDermott et al., 1997).

Beichner implemented his SCALE-UP classroom at NCSU and collected data on its success (Beichner et al., 2006). The style of classroom since has been adopted by several universities around the world, all with data showing improved conceptual understanding, increased problem solving skills, higher attendance, reduced failure rates, and improved attitudes toward the class. Beichner has also shown that students taught with SCALE-UP curriculum performed better than those who were not in the next semester of physics.

Challenges

Challenges have been seen through history with changing to a new style of teaching (Deboer, 1999). Change is often met with reluctance and resistance. In this case, the challenges include getting faculty on board and, once on board, getting them properly educated in how to use the classroom space correctly. Students' perceptions about a new style of learning during the new classes tend to be low, as students are concerned whether learning is occurring and could affect their grade negatively(Goodwin et al., 1991). Although, at the end of the semester students express more favorable opinions towards the active learning environment, new students still must choose the non-traditional class over a known quantity (lecture) that they are used to. Even before the students and teachers are on board, the school has to allocate the resources to create a SCALE-UP space. The unique cafe style seating does not match already installed lecture halls (Beichner et al., 2006). This means that the universities have to pay to remodel classrooms, which also takes time and reduces classroom access during the remodel. Once the curriculum is in place, instructors need to know how to use the space as it is designed. They have to keep from resorting to lecturing and accept the role of facilitator rather than "dictator". Some teachers did not want to change from the methods they were used to, switching to this new one (Beichner, 2009). Teachers have to be educated on how to use the space and teach in an active learning environment, although they can ease the transition by employing approaches in a stepwise manner (Salter, Thomson, Fox, & Lam, 2013). The students have to accept their new roles as well, as intellectual drivers rather than as passive listeners in traditional lecture courses. Once this is accepted students have to learn to work in groups successfully. Group work, however, generally is not assessed for group dynamics, just the quality of overall product of the group. This leaves a question about whether all students are getting the desired collaboration when working in a group (Beichner, 2009). Although there clearly are many challenges to science education, these emphasize the important role of the teachers, who can continually step in and adjust the activities of the students. Although most of the pressure of successful implementation falls on the teachers, there is also a need for the education system and college administrations to empower teachers who take the initiative to innovate the classroom (Kober, 2015). They also need to develop incentives so that teachers want to try new things and improve infrastructure for teacher training, not simply continue things as they are now.

CHAPTER 3: METHODS

This study looked at the relative effects of a SCALE-UP designed classroom on student performance, teacher and student opinions, as well as general behaviors of students. This was evaluated by comparing student performance and opinions in a SCALE-UP classroom to a traditional lecture hall classroom; specifically, classes of BIOL 1100 students in the spring semester in 2015, one in each of the two environments. Three tools including both qualitative and quantitative measures were used to triangulate the comparative results between the two courses, thereby making this research what is termed a triangulation mixed methods study (Morse, 1991).

Mixed Methods

Mixed methods research involves collecting and analyzing both quantitative and qualitative data (Creswell & Plano Clark, 2007). Quantitative data are closed-ended data whereas qualitative approaches ask open-ended questions. For this study using only quantitative or only qualitative data would be inadequate to address the major questions regarding the SCALE-UP classroom as a viable option for colleges over traditional lecture. Moreover, using both qualitative and quantitative data adds strength to the research design. Quantitative data included pre- and post-tests comparing class means using independent and paired sample t-tests. Student opinion surveys were used to assess opinion quantitatively using both paired and independent sample t-tests. Qualitative data included an open-ended portion of a student survey, instructor surveys that were compared directly as there were only two teachers, as well as observational data on classroom activities. These are among the key factors affecting the viability of a new type of classroom; simply assessing test scores would not be enough to form a clear picture of how SCALE-UP affects the educational experience. Simultaneous evaluation of quantitative and qualitative data can provide a more a fully formed answer to the basic research questions addressed in this study.

Sample Population

The Scale-Up classroom used was a section of a BIOL 1100 (Principles to Biology, part 1). There was one section with an instructor 'experienced' in implementing active learning methods. This meant the instructor could be counted on to utilize the space as it was designed, not as if the classroom was a typical lecture hall. Registration for these classes was done by the students based on their personal preference and schedule availability. The active learning classroom used for this study can hold at most 56 students.

The lecture hall class was taught by a different single instructor. These students also registered for the class in the same way, choosing a class and section that best fit their needs. The lecture hall holds 245 students.

Data Collection

Pre/Post-Test

Data on the students were collected using pre and post content tests, opinion questionnaires, and by in-class observations. The pre-test was given to students in each class on the first day, at the beginning of the semester. The pre-test determined what students already knew coming into the class, to get a baseline of their pre-existing knowledge. The pre-test results were compared to results of a post-test given at the end of the semester, embedded in the final exam. The pre-test and post-test contained the same questions. The tests were designed to determine what students learned and retained in terms of the content of the course over the semester. The questions were written based on the learning objectives of the BIOL 1100 course for the semester. There were 19 multiple choice questions spanning the semester's course content, starting with the first chapter and continuing to the last chapter covered, as well as two short answer questions. The short answer questions were designed to test for a higher level of critical thinking than can be judged from the multiple-choice questions.

Student Opinion Surveys

Student opinions on the classes were collected by questionnaire. The questionnaire was given at the beginning of the semester and at the end of the semester, similar to the pre/post-test on subject matter. The opinions were used to determine how the students react to an active learning environment versus the traditional lecture environment. The students were also asked if they think this environment is more conducive to learning or if they think the traditional lecture room would be better. The questionnaire used a Likert scale from 1-5, as well as some open-ended questions. The opinion surveys also were used to collect demographic data on the students participating in the research. This included information regarding age, sex, and ethnicity. The survey was offered online via the Blackboard website (Appendix B).

Teacher Opinion Surveys

The teacher opinion surveys were very similar to the student version. They asked the teachers' opinions on whether the SCALE-UP classroom facilitates student learning more than a traditional lecture. The survey also asked how the instructor enjoys teaching in this type of classroom versus a traditional lecture, as both instructors had experience in each venue. The survey featured a questionnaire using a Likert scale of 1-5, as well as some information about how long the instructors have been teaching. Each question also had the option of providing additional feedback and comments. This survey was presented as a printed handout the teacher filled out only at the end of the semester (Appendix C).

Classroom Observations

Both classes were observed using an observation checklist designed to rate behaviors associated with the active learning environment of a SCALE-UP classroom, as well general behaviors that could be compared between classes (Appendix D). This included student-student interactions, student-teacher interactions, student engagement, and general classroom management. The observations were used to determine whether the SCALE-UP classroom was being used in the way it was designed. This meant that the teacher is not simply lecturing the whole time, and that students were not just sitting around but, rather, were working on in-class activities, participating in groups, and talking about the subject matter with their peers. Observations were made four times over the semester in each class. Observation dates were picked to be spread out over the semester; one toward the beginning, two in the middle, and one toward the end of the semester. Dates were also chosen so that observations could happen in both classes on the same day, and activities reflected a normal day of class.

Data Analysis

Pre/Post-Test

The pre/post-tests were analyzed by comparing pre-test with the post-test answers within and between the two types of classroom environments, and changes in scores from the pre- to the post-test in both environments. These statistical analyses involved simple t-tests, run on the program SPSS. For the pre/pre-test and post/post-test comparisons an independent sample t-test was used and for the pre/post-test comparisons a paired sample t-test was used (Slater, Slater, & Bailey, 2010 pg. 29). An independent sample t-test looks for the difference in means between two samples, not dependent on each other, of the two different environment types (SCALE-UP vs. Lecture). The paired sample t-tests compared the pre and post test score of dependent samples, in this case comparing the same student's score from the pre-test to the post-test for every student in both class environments. For the purpose of this study a *p* value of 0.05 was considered significant. As a way of assessing learning gains, a Gain score was calculated for each class using the following formula: % student gain = (post-pre/100-pre)*100. The mean of these scores was taken and compared using an independent sample t-test. All of this was done for both the multiple-choice section and then, independently, for the short answers.

Student Opinion Surveys

The student opinion questionnaires had qualitative and quantitative aspects. The Likert scaled questions were coded and run through a statistical program (SPSS) to compare responses and to see whether there were trends for each of the classes, much like the pre/post-test data; that is, both independent and paired sample t-tests were performed. Independent sample t-tests compared the mean score for each Likert scaled question for the pre-survey (SCALE-UP vs. Lecture) and the post-survey (SCALE-UP vs. Lecture). Paired sample t-tests compared the difference of opinion from pre-survey to post- survey in each class (SCALE-UP vs SCALE-UP and Lecture vs. Lecture). Student names were used to create the pairings, which meant that the same student was compared in the pre-survey to post-survey results. Likert scale questions were from 1 (Strongly Disagree) to 5 (Strongly Agree). These were the quantitative data. The open ended questions that followed the Likert scaled questions asked students to expound on points covered in the qualitative data to give added context to the numbers and to help understand why the students answered the way they did. This helped to triangulate the results with the pre/post-test findings and what was seen with the classroom observations. The open-ended questions demonstrated the opinions and feelings of students in their own words.

Teacher Opinion Surveys

The two teachers were given a similar survey as the students, but since there were only two teachers surveyed their answers were not analyzed statistically, but were directly compared by the researcher. This placed most of the focus on the teachers' open-ended portion of the survey.

Classroom Observations

The classroom observation sheet was used to look for trends within and between the two classrooms, and to determine whether the SCALE-UP room was being used differently than the lecture room. The observations made were grouped into categories and, where appropriate, were averaged over the four observations in each class. These trends showed the differences in activities of students and teachers between the classes and environments.

Limitations

The biggest limitation of the study was in the comparison groups. Although the data collected on the active learning classroom were meaningful in themselves, the most important conclusions are best drawn from a comparison between traditional lecture and the active learning classroom. The ultimate question was "does this SCALE-UP classroom provides a more effective learning environment compared to a traditional lecture classroom?" Therefore the two classes needed to be compared. The limitations were in differences in the sample populations, foremost of all was the different class sizes (SCALE-UP = 54, Lecture = 245). The classes themselves met at different times, potentially affecting student performance. Another problem was that different instructors taught in the lecture hall and SCALE-UP classrooms. Therefore teacher influence could have affected the data results. However, students were asked in the opinion survey on the different teaching methods in reference to the teacher teaching it accommodating this bias. Bias could have also arisen from excluding students younger than 18 as 17 year olds need special permission from a guardian to consent to the study. This excluded only two of the participants in the traditional lecture classroom, and therefore did not have a major impact on the results. The loss of the short answer data and students running out of time when taking the post-test required some data to be excluded as well. This was addressed by dropping zero scores which would actually have a favorable bias towards the lecture method and not the SCALE-UP method. The instructor in the SCALE-UP classroom could have motivational bias towards what he considers to work better, SCALE-UP over traditional lecture, which is why he already changed to this new method. The same could be said for the lecture classroom teacher preferring the old ways of doing things. This was looked at by collecting the teacher opinions on the two different methods. The researcher (myself) had bias in preferring the new method over the traditional ways of doing things, which is why this project was chosen.

CHAPTER 4: RESULTS

Mixed methods research requires that both qualitative and quantitative data be triangulated in an effort to find support for the research findings. Quantitative results on knowledge and learning gains will be presented first in the form of pre/post-tests results. Mean scores of the pre/post-test were compared, as well as mean scores of the coded student opinion survey. The open-ended questions were summed into categories and cataloged based on them. The observation sheets were also summed up for behaviors and trends and presented in a table.

Pre/Post-Test

Independent sample t-tests were used to compare the mean scores of the pre-test taken by the SCALE-UP students and the pre-test score for the traditional lecture students. The multiple choice (MC) and short answer (SA) sections were compared separately for each condition. First, the pre-tests were compared between the two classes to see if there was any significant difference in starting knowledge. For the multiple-choice section there was no significant difference ($p = 0.470$) between classes; however, there already was a statistically significant difference on the short answer section ($p < 0.001$) with the SCALE-UP classroom scoring much higher (Figures 1 and 2). Next, the post-tests were compared within and between classes. The multiple-choice scores for the post-test were significantly different between classes ($p < 0.001$), as were the short answer results ($p < 0.001$). In each case the SCALE-UP classroom scored on average higher. Post-test scores were removed from the data if they were left blank (MC and SA) or incompletely filled out (MC only). The pre-test was testing for prior knowledge so non-answers were expected. The short answer sample size is much smaller than the MC sample because many students did not report their name on the answer sheet and could not be paired with the pre-test answers; consequently 87 in total were left out. Interestingly, no such problems existed in data from the SCALE-UP class.

To assess the amount of knowledge gained over the course of the semester, not just differences in mean scores, learning gain percentages were calculated for the SCALE-UP and traditional lecture learning methods. This analysis shows how much the student could potentially learn from pre-test to post-test, given his/her pre-existing level of knowledge. The mean learning gain percentage for the SCALE-UP classroom was 22.0133% (MC) and 24.781% (SA) compared to the lecture mean gain percent of -1.300% (MC) and 7.809% (SA) (Figure 3). These were statistically significant differences between the two classes for both multiple choice and short answer questions (both $p < 0.001$) (Table 1). Table 1 shows the results of the independent sample t-test discussed here featuring the number of students in each sample that is compared, the mean score for the test, mean learning gain percentage, the standard deviations describing these means, and the p-values associated with the comparisons. This shows the overall change from pre-test to post-test in knowledge gained and whether it was significant between the two classes. It also shows the results of the analysis between MC and SA mean scores of the pre/pre-test and the post/post-test between the two environments.

Along with the learning gains, the mean scores for multiple choice and the short answer questions were compared from pre-test to post-test within environments to see whether they were significantly different from one to the next. There was no significant difference from pre to post-test for MC questions in the lecture classroom ($p = 0.079$), but there was in the SCALE-UP classroom ($p < 0.001$) (Table 2). However, both classes differed significantly for the short answer questions ($p < 0.001$ and $p < 0.001$ respectively). Table 2 shows the number of students in the sample, mean score (with standard deviation), and associated p-value for the MC and SA scores, for the pre-test to the post-test change in both the lecture and the SCALE-UP classes.

Student Opinion Survey

The student opinion survey was compared much like the content tests. The mean score for each Likert Scale question was calculated for the pre- and post-opinion surveys for each class. These values were then used to compare opinions between classes (pre and post-surveys) using independent sample t-tests. The mean scores were also used to determine whether there was a change in mean opinion from pre- to post-survey within classes using a paired sample t-test. As the survey was voluntary, unlike the pre and post-test, there was a smaller sample size for both classes. Comparing pre-opinion to pre-opinion of both classes, only questions #11 and #12 were significant ($p = 0.011$ and $p = 0.006$ respectively) (Table 3). The post/post-survey comparisons showed significant changes for questions #8 ($p = 0.001$), #9 ($p = 0.002$), #10 ($p < 0.001$), #11 ($p < 0.001$), #12 ($p < 0.001$), and #13 ($p = 0.003$). In all cases the student opinion increased more favorably for the SCALE-UP style classroom. Table 3 shows the summed results of the independent sample t-test comparing the student responses from the pre/pre-survey and post/post-survey between the two classes. Following this, student opinions were compared for each class from pre- to post-survey mean responses (Table 4). For the SCALE-UP class, questions #9 ($p = 0.029$), #10 ($p = 0.011$), #11 ($p = 0.027$), #12 ($p = 0.013$), and #13 ($p = 0.017$) were significantly different from pre- to post-survey. For the lecture class, there was no significant difference in mean score opinion from the pre to post-opinion survey. Table 4 displays the summed results of the paired sample t-test analyses of the pre/post-survey responses within each class. The open ended survey questions were placed into groups to sum the responses of what the students most liked, least liked, whether they thought the environment or teacher affected their experience, and for more general comments (Table 5 and 6).

Teacher Opinion Survey

The two teachers who taught this semester, one for SCALE-UP and one for Lecture, both filled out an opinion survey at the end of the semester. Although one taught the lecture class this semester, he had experience with the SCALE-UP classroom in the past. Both instructors had the same opinion on SCALE-UP versus traditional lecture class environments. They both preferred SCALE-UP as they felt it offers a better, more effective learning environment. Furthermore they agreed that more time is required to develop SCALE-UP instruction, but after teaching once this time is decreased in subsequent iterations of the class.

Observations

Observations of how the classrooms ran and how the students behaved during class were taken four different times for each classroom environment. Those observations were then grouped into categories and summarized (Table 6). Examples of completed observation sheets can be found in Appendix D. The classrooms were observed as a whole at about 30 and 60 minutes into the class. These observations were to gauge the atmosphere of the classroom and whether or not the class appeared on task and/or actively listening. As a part of the observations, groups of students were observed for specific behaviors (phone use, on/off topic conversation between peers and the teacher, paying attention to the teacher during lecture, etc.) about 15 and 40 minutes into the class time. In the lecture class, samples of the front, middle, and back of the room were observed twice during class for about 5 minutes each time each sample. In the SCALE-UP classroom, each group was observed twice for about five minutes, and then activities were summed for behaviors at the 15 and 40 minutes into the class time shown in Table 6. On average, as the lecture class progressed, more students became uninterested and engaged in other activities un-related to school. This can be seen in Table 6 (Students on task); from 20 minutes into class to 60 minutes, the number of students on task drop from 76% to 48.75%. This was observed less in the SCALE-UP classroom (87.5% to 85%) and attendance per class was much higher than in the traditional lecture class (Avg. 91.5% vs. 60%). The teacher spent more time engaging with the students rather than lecturing in the SCALE-UP classroom; this included checking in with students or guiding them through questions they had on the activity. In contrast, the lecture room teacher spent almost the entire time lecturing and no time working one-on-one with the students. The observations were taken on the same day for both classes, expect for observation Day #2; the lecture teacher cancelled class and the SCALE-UP class had already been observed. The final observation was not a regular day for the SCALE-UP class but a mix of review, going over the last test and preparing for the final.

Table 1. Independent Sample *t*-tests of SCALE-UP vs. Lecture

Test	Class Type	n	Mean (Std. Dev.)	*t*-test *p* Value
MC pretest-pretest	Lecture	214	35.195(10.352)	0.47
	Scale-Up	52	36.337(9.624)	
MC posttest-posttest	Lecture	194	35.649(13.069)	<0.001*
	Scale-Up	46	50.638(15.052)	
SA pretest-pretest	Lecture	214	6.828(10.832)	<0.001*
	Scale-Up	52	34.519(9.143)	
SA posttest-posttest	Lecture	95	14.094(13.676)	<0.001*
	Scale-Up	46	50.000(13.801)	
Learning Gains-MC	Lecture	179	-1.296(27.653)	<0.001*
	Scale-Up	44	22.013(23.484)	
Learning Gains-SA	Lecture	92	7.809(16.894)	<0.001*
	Scale-Up	46	24.781(21.497)	

Notes. Independent Sample t-test results comparing learning gains and mean scores of pre- and post-tests between two environments
* are marked on statistically significant values $p < 0.05$

Table 2. Paired Sample *t*-tests of Pre vs. Post Test Scores in SCALE-UP and Lecture

Test	Class Type	Test	n	Mean (Std. Dev.)	*t* test *p*-value
MC Pretest-Posttest	Lecture	Pre-Test	176	35.288(10.665)	0.729
		Post-Test	176	35.707(12.792)	
	Scale-Up	Pre-Test	44	35.646(9.419)	<0.001*
		Post-Test	44	50.428(14.328)	
SA Pretest-Posttest	Lecture	Pre-Test	87	7.854(10.600)	<0.001*
		Post-Test	87	14.559(13.588)	
	Scale-Up	Pre-Test	44	33.863(8.948)	<0.001*
		Post-Test	44	49.886(13.359)	

Notes. Paired sample t test results comparing pre and post test results for each environment

* are marked on statistically significant values $p < 0.05$

Table 3

Likert Questions	Class Style	N in Pre-Survey/Post-Survey	Mean Score pre-survey (Std. Dev.)	Mean Score post-survey (Std. Dev.)	t test p-value Pre-Pre	t test p-value Post-Post
8. I will like a SCALE-UP class style better than a traditional lecture class style.	Lecture	104/42	3.29(.900)	3.26(1.083)	0.095	0.001*
	Scale-Up	27/27	3.63(1.079)	4.15(1.027)		
9. I will learn more with a SCALE-UP class style than in a traditional lecture class style.	Lecture	104/42	3.41(.888)	3.31(1.070)	0.589	0.002*
	Scale-Up	27/27	3.52(.935)	4.15(.989)		
10. I will be more interested in the content of this course in a SCALE-UP class style than in a traditional lecture.	Lecture	104/42	3.35(.953	3.26(1.037)	0.305	.000*
	Scale-Up	27/27	3.56(.892)	4.22(.934)		
11. The teacher will be more helpful in a SCALE-UP class style than in a traditional lecture class style.	Lecture	104/42	3.43(.963)	3.24(1.055)	0.011*	.000*
	Scale-Up	27/27	3.96(.898)	4.48(.753)		
12. I will be more aware of what is expected of me in a SCALE-UP class style than in a traditional lecture class.	Lecture	104/42	3.12(.874)	3.17(1.010)	0.006*	.000*
	Scale-Up	27/27	3.67(1.074)	4.48(.753)		
13. I will retain more knowledge from this course in a SCALE-UP class style than in a traditional lecture class.	Lecture	104/42	3.43(.911)	3.5(1.042)	0.254	0.003*
	Scale-Up	27/27	3.67(1.074)	4.26(.903)		
14. I like biological science.	Lecture	104/42	3.45(1.114)	3.45(1.234)	0.066	0.732
	Scale-Up	27/27	3.85(.949)	3.56(1.188)		
15. I plan to pursue a career in biological science.	Lecture	104/42	2.94(1.291)	2.62(1.188)	0.472	0.335
	Scale-Up	27/27	3.15(1.433)	2.93(1.412)		
16. Doing activities in class helps me understand the material better.	Lecture	104/42	4.08(.784)	4.1(.790)	0.277	0.098
	Scale-Up	27/27	3.89(.847)	4.41(.694)		

Notes. Results of the Likert portion of the student opinion survey comparing between pre survey opinion between the two environments and post survey opinions

* are marked on statistically significant values $p<.05$

Table 4

Likert Questions	Survey Time	n of students Scale-Up/Lecture	Mean Scale-Up(Std. Dev.)	Mean Lecture(Std. Dev.)	t test p-value Scale-Up	t test p-value Lecture
8. I will like a SCALE-UP class style better than a traditional lecture class style.	Pre-Survey	17/28	3.71(1.047)	3.29(.976)	0.086	1
	Post-Survey		4.29(.849)	3.29(1.213)		
9. I will learn more with a SCALE-UP class style than in a traditional lecture class style.	Pre-Survey	17/28	3.59(.870)	3.5(.882)	.029*	0.394
	Post-Survey		4.24(.903)	3.32(1.124)		
10. I will be more interested in the content of this course in a SCALE-UP class style than in a traditional lecture.	Pre-Survey	17/28	3.71(.686)	3.32(1.020)	.011*	0.787
	Post-Survey		4.35(.606)	3.25(1.143)		
11. The teacher will be more helpful in a SCALE-UP class style than in a traditional lecture class style.	Pre-Survey	17/28	4.18(.809)	3.46(1.036)	.027*	0.456
	Post-Survey		4.65(.606)	3.29(1.182)		
12. I will be more aware of what is expected of me in a SCALE-UP class style than in a traditional lecture class.	Pre-Survey	17/28	3.76(.903)	3.00(981)	.013*	0.476
	Post-Survey		4.47(.800)	3.18(1.124)		
13. I will retain more knowledge from this course in a SCALE-UP class style than in a traditional lecture class.	Pre-Survey	17/28	3.82(.809)	3.36(.989)	.017*	0.565
	Post-Survey		4.47(.717)	3.5(1.171)		
14. I like biological science.	Pre-Survey	17/28	3.76(.1.033)	3.46(1.105)	0.668	0.083
	Post-Survey		3.71(.1.105)	3.79(1.166)		
15. I plan to pursue a career in biological science.	Pre-Survey	17/28	2.94(1.391)	3.21(1.343)	0.361	0.039
	Post-Survey		3.18(1.334)	2.86(1.325)		
16. Doing activities in class helps me understand the material better.	Pre-Survey	17/28	3.88(.781)	4.21(.833)	0.138	0.447
	Post-Survey		4.24(.752)	4.32(.612)		

Notes. Survey results of Likert portion comparing pre and post survey results in the same environment
* are marked on statistically significant values $p<.05$

Table 5

Scale-UP						Lecture Hall					
Pre			Post			Pre			Post		
Most excited	biology understanding and interest	7	Most liked	teacher	4	Most excited	teacher	11	Most liked	class in general	2
	Scale-up	14		Scale-up	19		Biology	50		teacher	22
	finish	3		test reviews	1		Finished	15		EC and clickers	9
Least Excited	tests	14	Least Liked	nothing	14		Not lecture	4		nothing	2
	Scale-Up fears	5		group work	2					online PP and lecture	5
	Biology/school hatred	2		lack of lecture	1	Least Excited	lecture	8	Least liked	nothing	5
				tests	7		class in general	41		hard/fast	3
Comment s	Excitement/fear of scale-up and		Comments	like scale up	3		Biology	16		negative lecture/size	12
				teacher	3		Chemistry	5		assignments/clickers	3
				increase lecture time	1		Scale-up	2		exams	5
			Teacher v. Environment	teacher	6					amount/content of material	11
				both	12	Comments	lecture good		Comments	like teacher	6
				environment	4		lecture bad			dislike lecture	2
							teacher good			hard/fast	3
										increase test reviews	1
									Teacher Vs.	Teacher	20
										Both	3
										environment good	2
										environment bad	11

Note. Open ended portion of survey results for the SCALE-UP and lecture teaching methods

Table 6. Observation Results

	Time Observed	SCALE-UP	Lecture
Lecture length		Avg. 32.5 mins; in class activity rest of class	75 mins w/ clicker questions
Attendance		Avg. 91.5%	Avg. 60%
Students on Task	20 min	87.50%	76%
	60 min	Activity=85%	48.75%
What are students doing?	15 min	Approx. all note taking or Active Listening	Avg. 26% on phones rest note taking or Active Listening
	40 min	Occasional phone or off task conversation but 80% still on activity or talking about related topics	Avg. 35% on phones rest note taking or staring blankly
Students talking on topic to each other	15 min	N/A listening to teacher	
	40 min	In groups about 5/8 people talking about assignment	
Teacher checks in w/ students		At least twice, more including Undergrad Assistant	

Note. Observations Results; taken 4 times in each environment then averaged

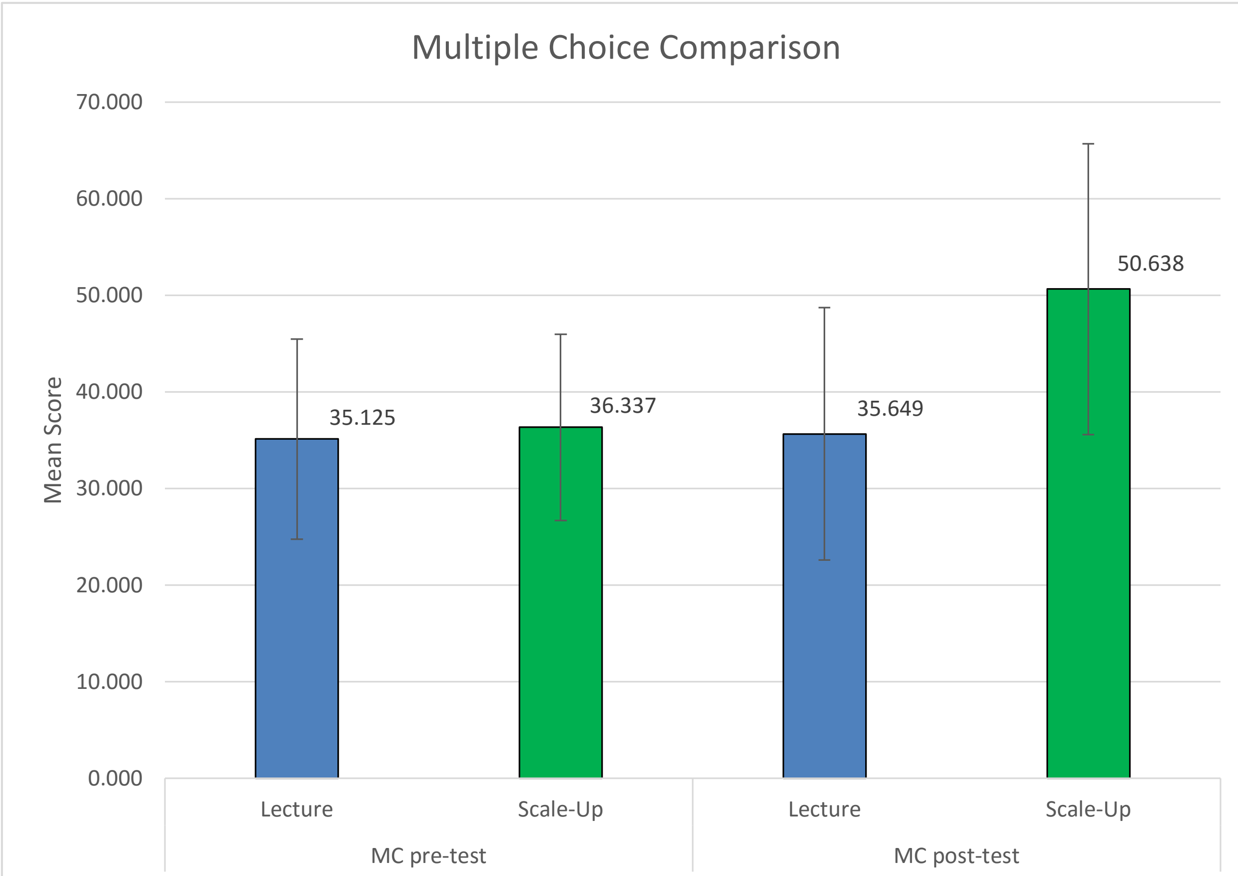

Figure 1. Comparison of mean scores of multiple-choice (MC) questions of pre and post-test for SCALE-UP and traditional lecture methods. Error bars indicate one standard deviation.

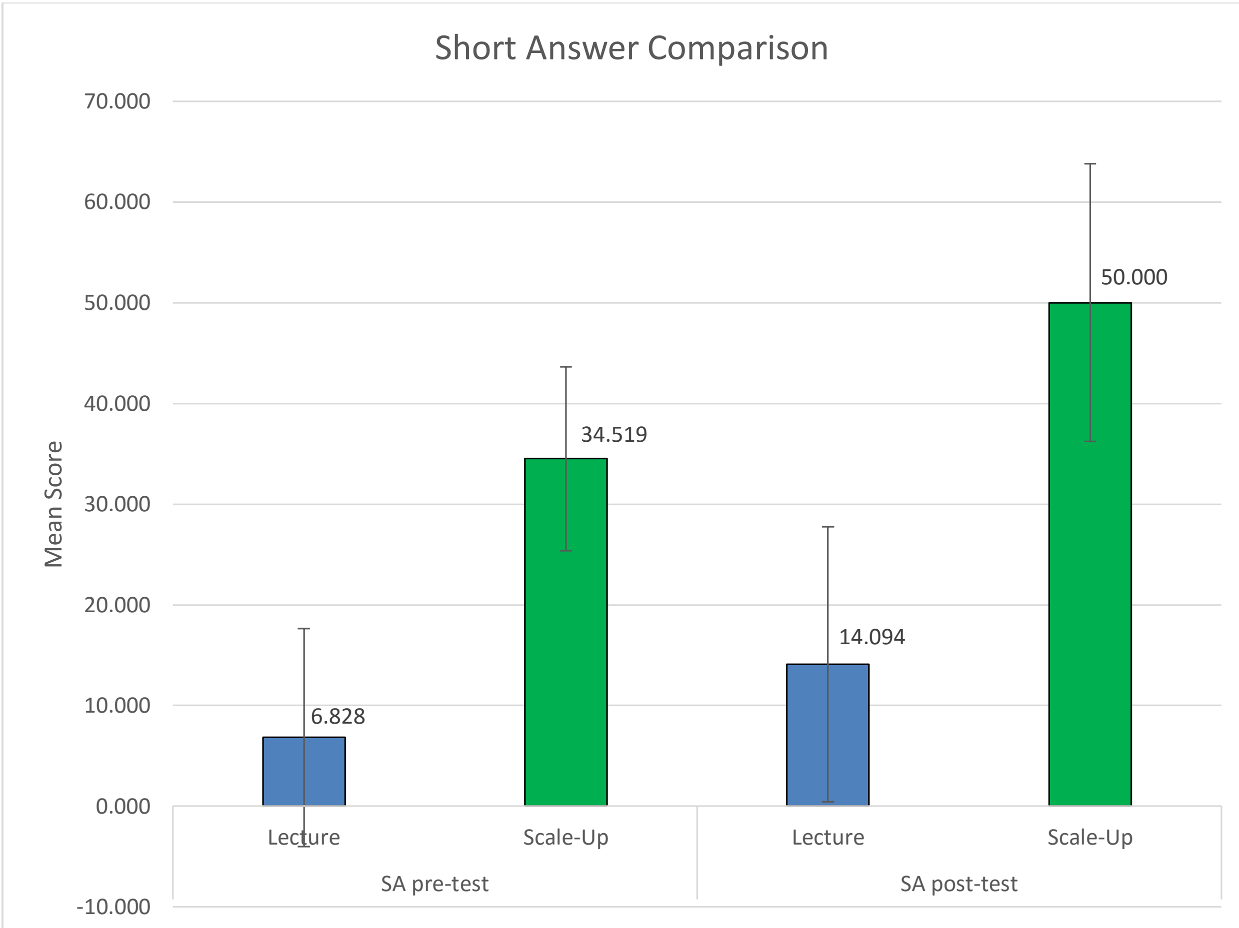

Figure 2. Short answer (SA) mean scores for SCALE-UP and traditional lecture methods for the pre and post-tests on content knowledge. Error bars indicate one standard deviation.

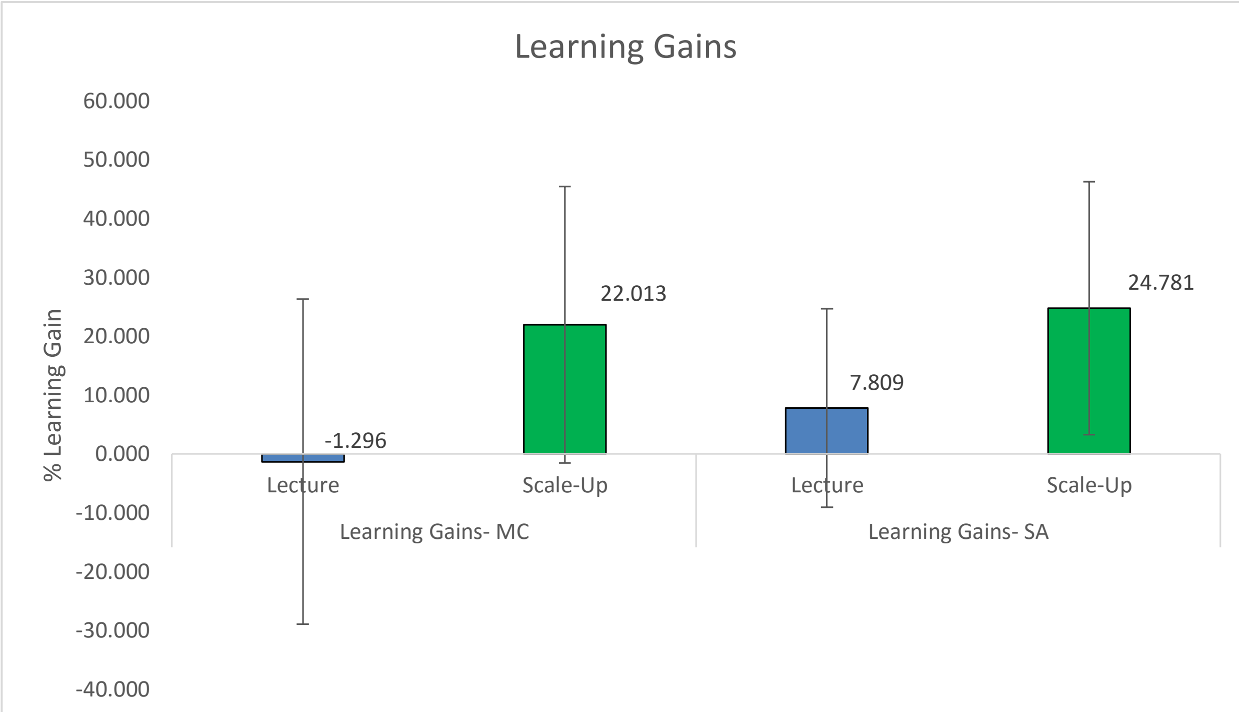

Figure 3: Learning gain percentages from pre-test to post-test In the SCALE-UP and traditional lecture method. Error bars indicate one standard deviation.

CHAPTER 5: DISCUSSION

The results of this study support the overall hypothesis that students prefer and perform better in a SCALE-UP style classroom. The pre/post-test results support the hypothesis that SCALE-UP classes improve overall learning when compared to traditional lecture. The student and teacher opinions support SCALE-UP and both groups prefer it to traditional lecture. Observations of the classrooms show the instructor is using it correctly and that students are less engaged in traditional lecture. These results support general conclusions in the science education literature regarding the importance of student-centered learning for the future higher education.

Pre/Post-Test

With the multiple choice pre-test, as expected, the two classes showed no significant difference in scores, suggesting they were fairly equal in knowledge coming into the course. It was unexpected and interesting that there was a significant difference in the two pre-tests for the short answer section. The mean for the lecture class for the SA was 6.828 and the SCALE-UP was 34.519, a significant difference at a p-value of less than 0.001. This shows that students in the SCALE-UP class already have some advantage over the lecture students in open-ended responses. This advantage does not appear to reflect different previous content knowledge given the absence of a difference between the two classes in the MC section (p=0.470). The students were told that the pre-test did not count for a grade, so is it possible that the small size class and grouped learning environment in the SCALE-UP classroom had already created an atmosphere wherein students take classwork more seriously. One reason might be because they cannot fade into the crowd easily, with fewer students than in a lecture hall. Another thing that might be happening is student self-selection. Students with more motivation could be choosing the smaller more active learning method from the beginning, casing more motivation to already be present. However this could go the other way as well; Students who are already making great grades in a lecture hall may choose to stay with that method because they know it works. Whatever the reason, most SCALE-UP attempted the short answer questions on the pre-test, whereas most of the lecture hall students did not even make a guess. The potential for such a strong initial effect on student motivation is an interesting outcome of this study, which was unexpected and not accounted for in the research design. It certainly warrants further investigation.

I hypothesized that there would be a difference between the pre- and post-test scores within each of the two classes, as well as a greater overall improvement from pre to post-test in the SCALE-UP classroom compared to the lecture class. The data gathered do indicate that the SCALE-UP class learned more core biological content than the lecture class based on the analyses of learning gains. Not only was there a significant difference in learning gains between the two classes, but in several instances students in the lecture room did worse on the post-test than the pre-test. This was true even after scores of zero on the MC post-test were removed to correct for some students not finishing on time. The difference in learning gains, MC means and SA means, was still significant with or without these zeroes (both at $p < 0.001$). This was true for the short answer questions as well, scores were removed from the data set if there was nothing written in the response space. Null exams were removed because some students in the lecture section ran out of time, so we made the conservative assumption the exams without any writing were from individuals who did not finish. With or without these zeroes the p-value for a significant difference between classes was still less than 0.001 for both the MC and SA sections of the test. Because there was an adjustment for zeroes in the lecture class but not in the SCALE-UP class, it is possible that a higher learning gain was estimated for the lecture class than occurred. Potentially, students in the lecture class scored zeroes because they did not bother to or had no confidence in answering the questions. In contrast, students in the SCALE-UP class had a much higher response rate and most with some success. This may indicate that students were more highly engaged, but also had a much greater inclination to make an effort to respond. This is consistent with prior observations that show when students are given more control of their own learning; they try harder and do better on exams (Kolber, 2015).

Short answer results are often used to test critical thinking or deeper understanding of the content (Anderson et al., 2005; Hoellwarthet al., 2005; Omelicheva and Avdeyeva, 2008). These research data suggest that the SCALE-UP classroom students are more confident and have enhanced critical-thinking on short answer questions. The SCALE-UP students showed that they could defend their answer by expounding on the question in a coherent paragraph. This showed that the student knew what they were talking about and could bring to bear information not given in the question, as well as connect information from other parts of the course. In contrast, some of the lecture students did not even attempt to answer the SA questions and just wrote 'I don't know.' The types of activities in a SCALE-UP class are intended to target such higher-level of thinking (Smith et al, 2005) and that appears to have occurred in this instance. Overall, student success on content and critical thinking questions was significantly greater in the SCALE-UP classroom than the lecture hall.

Student Opinion Survey

The survey yielded some surprising and not so surprising results. Since the pre-opinion survey was completed during the third week of class, students already had some idea about what the SCALE-UP classroom would be like; however, the lecture students were left to guess about what this new classrooms was like. In contrast, the SCALE-UP students most likely had had experience in a lecture hall setting. This could explain some skewed data. For example, the pre-survey/pre-survey differences could be explained by the fact the SCALE-UP students already had a feel for the SCALE-UP environment, whereas the lecture students did not and, therefore, were mostly neutral (Score 3) making the lecture classroom somewhat of a control group when compared to the SCALE-UP group. The SCALE UP students already averaged agree (Score 4) for questions #11 (teacher will be more helpful) and #12 (I will be aware of what is expected of me). In the post-test, these opinions grew stronger and more favorable towards SCALE-UP with the averages increasing from the pre-survey, in some cases, by a whole point. This is generally true in the comparison from pre-survey to post-survey with significant differences in the SCALE-UP targeted questions. Surprisingly, there was not a significant difference or increase in liking activities to help students learn better (Question #16), but that could be because the pre-survey average was already at 4 (Agree) in the pre-survey; it did increase in the post-survey but not enough to be significant.

An interesting note to point out is the change from pre to post- survey in the lecture room, where there was a significant decrease in thoughts of pursuing a career in science after this class. It is as if there was curiosity for biology coming in, but after the class these students were less inclined to pursue science. This could be because the traditional lecture environment does not offer learning in-line with how scientists actually work and address problems, so that students have misconceptions about what pursuing a career in science would be like. In contrast, this type of thinking occurs in the SCALE-UP classroom (Kober, 2015). Once a student has taken a SCALE-UP class they report that the environment helps them more with learning, class expectations, and teacher helpfulness. This is important for enabling students to keep an interest in biology, especially for intended biology majors. Seymour (2002) performed a four-year study to investigate the main reasons students switch majors. She found one of the biggest reasons for changing programs was that the learning environment and instructors were not helpful. This is an area that SCALE-UP could help substantially; the learning environment is reported to be more helpful with respect to both learning and understanding expectations. The instructor is also more available for student interaction and considered to be more helpful. Furthermore, direct experience in doing science does not occur in lecture, meaning that if students are not taking a lab, they will not be doing hands on science. Handelsman et al. (2004) laid out the reasoning behind why this is true and discussed how to correct this in research on scientific teaching. The most important thing for a scientific mind is active-learning and hands-on involvement with the information. This concept, although not new, was Beichner's (1999) motivation in combining lecture and lab into the SCALE-UP project (Schwab, 1958). This approach helps to teach students to think like a scientist, not just memorize facts.

The lecture students had a more neutral opinion and, in the comment section, complained mostly about the large classroom and the inability to learn in that environment. Most of the students reported that, if they liked the class at all, it was because of the teacher. Most complaints sounded like this one: "The environment definitely affected my experience most in this course. Students around me were very distracting and it was also difficult to feel like I was engaged in a class of that size." In contrast, the SCALE-UP students reported in their own words that they enjoyed the atmosphere, as it helped them pay attention and become more actively involved in their schoolwork. For example, one student said this about the classroom: "The close knit style of the classroom helped me feed off of others' ideas to better my own understanding of the course content. The in class assignments helped me learn the material better and also allowed me to practice putting my knowledge to work when completing the assignments." This shows that students can adjust to a new learning environment and are happy about it once the class is over. When Beichner et al. (2006) implemented the SCALE-UP, program student opinions were mixed until later in the semester. Most of these students had taken physics before in a traditional lecture class, but preferred the SCALE-UP method because they felt their learning was "at a deeper conceptual level." This also supports the idea that students learn more deeply if they are responsible for their own learning and are not depending on the instructor to spoon-feed them the information. The cooperative environment keeps students engaged and constantly reevaluating the material to address whatever problem they have been given (Kober, 2015). Hopefully, putting the responsibility on the students makes them want to learn instead of simply trying for a good grade. This attitude can be seen somewhat in the student opinion survey. In the pre-survey, more of the students worried about the new environment that might cause them to receive a lower grade; in the post- survey responses, however, students celebrated their learning and no one mentioned grades.

Teacher Opinion Survey

Only two instructors were teaching this class during the semester that was analyzed, and their opinions are not statistically different; however, they do address some of the misconceptions teachers have about changing to this type of classroom. In these teachers' opinions, students are more successful in a SCALE-UP class than a traditional lecture class. After Beichner (2006) implemented SCALE-UP, the main teacher concern was time they would have to devote to this new method. Instructors in this case indicated that there is more time needed to prepare for class, but this extra time decreases in subsequent classes and leaves the instructor with about the same amount of time preparing, as would be the case with a standard lecture course. This tells us that the teachers can also adapt to this new learning environment and that it is worth it for the students if they do. It should be pointed out, however, that the instructors in this study already have taken the time to adopt the SCALE-UP idea, and have trained and prepared appropriately. This indicates that more of the administration and more faculty need to become involved in active-learning. The results of this and other studies indicate a need to create more of these SCALE-UP environments, so they continue to benefit students (Kober, 2015).

Observations

The observations in this study show trends that have been talked about most commonly in the literature (Hoellwarth et al., 2005). Students lose interest in lecture almost exponentially as class time goes on, and become distracted with phones or stare blankly. This was seen in the lecture hall, as well as somewhat in the SCALE-UP classroom if the lecture went longer than 20 minutes. Simply having a smaller sized class also plays a role as individuals are less anonymous and the teacher more easily notices if students are paying attention. The smaller sized class also allows the teacher to personally check in on individual learning progress. The lecture classroom does not allow for that; the teacher leaves it up to the students to reach out if they do not understand something. In the SCALE-UP classroom the teacher can check in and help guide students through the topic, which was seen during the observations in this study. Interestingly, the size of the classroom may not matter if there are sufficient teachers or teaching aids to provide the opportunity for students to have the kind of student-teacher interaction seen in the SCALE-UP classroom. Beichner (2006) has done a class of 100 students in the SCALE-UP style, but he had four teaching assistants to balance out the larger student to teacher ratio. The observations also showed that the SCALE-UP instructor in this study was utilizing the class as it was intended. Total lecture times lasted, on average, less than half as long in the SCALE-UP

(32.5 min.) environment as the lecture hall class (75 min.). About half of the class time was reserved for in class activities done with a group. Students were talking to each other in their groups and were visibly more engaged in the material rather than sitting and passively listening to a lecture. On average, 85% of the SCALE-UP class were still paying attention 60 minutes into the class, where only an average of 48.75% of the students were paying attention in the lecture class. The delay in the third observation for the lecture class should not affect the overall results as it was only a week apart and they were still going over similar material as the SCALE-UP class. However, the last day of observations for the SCALE-UP class (a review session that did not include an exercise) likely had impacts of increasing the average lecture time and scaling down student attention/participation. Even with some discrepancies in when the classes were observed there are clear patterns that support improved student engagement and attendance in the SCALE-UP environment compared to the traditional lecture environment.

Conclusion

This study shows that there is great potential for the ECU Biology Department to transition into more SCALE-UP type courses. The results agree with those in the literature and past studies, indicating that students do better in an active learning environment than in a traditional lecture environment. More importantly, grades and learning improve more in the SCALE-UP classroom. Student opinions indicate that they prefer the new methods to the old, as do the teachers. Observations of the two classrooms show that students attend class more regularly and appear more engaged in the SCALE-UP classroom. Furthermore, the worries that students would not participate in group work was seen not to be a problem in this study, and some students even reported on the survey that they enjoyed interacting and learning from their fellow students. All of the evidence found in this study show that a SCALE-UP classroom is not only a viable option to replace lecture classes, but that it is better for the students overall.

Future Studies

In the future, this study should be repeated using multiple classes, preferably with the same teachers in both settings, as many students indicated that they liked the lecture class simply because of the teacher. Although the SCALE-UP class also liked the instructor, they more often mentioned the class environment as the major contributing factor. The problem with different class sizes could be teased apart in future studies. Some way of comparing the influence of the class environment could be looked at, since the rooms are completely different. Also reported in the literature are interesting trends in minorities doing better in sciences, as well as more students not dropping the class, when taking a SCALE-UP type course. Studies show that the more students are engaged, the more likely they are to continue on in college (Rethwisch et al., 2013; Tinto, 1997). This type of engagement is suggested to increase minority interest and retention (Seymour, 2002). A lack of enough survey participants did not allow for a complete analysis of this trend in my data. Issues like not being able to get teacher help, fading into the background, and not caring about learning are major factors in losing interest and dropping out. These are clearly shown in my data to be better accommodated in the SCALE-UP classroom, suggesting that more research would likely support the trend showing greater retention of students, minorities in particular, because of the SCALE-UP environment. Is there evidence that taking a SCALE-UP class increases retention of biology majors until graduation, or result in non-biology majors changing to biology? Regarding the teacher opinions, there should be more detailed information on how much time it takes to prepare for class compared the lecture, and how much that time decreases after the course has been taught once or twice.

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APPENDIX A-IRB Approval

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office 252-744-2914 · Fax 252-744-2284 · www.ecu.edu/irb

Notification of Exempt Certification

From: Social/Behavioral IRB
To: Samantha Mears
CC:
Terry West
Date: 1/21/2015
Re: UMCIRB 14-001530
Comparison of a Traditional Teaching Model to the Scale-Up Teaching Model in Undergraduate Biology: A Mixed Methods Study

I am pleased to inform you that your research submission has been certified as exempt on 1/20/2015. This study is eligible for Exempt Certification under category #1&2 .

It is your responsibility to ensure that this research is conducted in the manner reported in your application and/or protocol, as well as being consistent with the ethical principles of the Belmont Report and your profession.

This research study does not require any additional interaction with the UMCIRB unless there are proposed changes to this study. Any change, prior to implementing that change, must be submitted to the UMCIRB for review and approval. The UMCIRB will determine if the change impacts the eligibility of the research for exempt status. If more substantive review is required, you will be notified within five business days.

The UMCIRB office will hold your exemption application for a period of five years from the date of this letter. If you wish to continue this protocol beyond this period, you will need to submit an Exemption Certification request at least 30 days before the end of the five year period.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418

APPENDIX B: Student Opinion Surveys

Pre-Student Opinion Survey

1. First name?
2. Last Name?
3. What is your age?
   - Under 18
   - 18-20
   - 21-23
   - 24 or older
4. What is your gender?
   - Male
   - Female
   - Prefer not to answer
5. What is your ethnicity? (choose all that apply)
   - American Indian or Alaskan Native
   - Asian or Pacific Islander
   - Black or African American
   - Hispanic or Latino
   - White/Caucasian
   - Other
6. What is your current class rank?
   - Freshman
   - Sophomore
   - Junior
   - Senior
   - Other
7. Are you intending to major in biology?
   - Yes
   - No

	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
8. I will like a SCALE-UP class style better than a traditional lecture class style.	○	○	○	○	○
9. I will learn more with a SCALE-UP class style than in a traditional lecture class style.	○	○	○	○	○

10. I will be more interested in the content of this course in a SCALE-UP class style than in a traditional lecture style.	◯	◯	◯	◯	◯
11. The teacher will be more helpful in a SCALE-UP class style than in a traditional lecture class style.	◯	◯	◯	◯	◯
12. I will be more aware of what Is expected of me in a SCALE-UP class style than in a traditional lecture class.	◯	◯	◯	◯	◯
13. I will retain more knowledge from this course in a SCALE-UP class style than in a traditional lecture class.	◯	◯	◯	◯	◯
14. I like Biological Science	◯	◯	◯	◯	◯
15. I plan to pursue a career in biological science	◯	◯	◯	◯	◯
16. Doing activities in class helps me understand the material better.	◯	◯	◯	◯	◯

17. What are you most excited for in this class?

18. What are you least excited for in this class?

19. Any additional comments or things you want to mention?

Post-Student Opinion Survey

1. First name?
2. Last Name?
3. What is your age?
    - Under 18
    - 18-20
    - 21-23
    - 24 or older
4. What is your gender?
    - Male
    - Female
    - Prefer not to answer
5. What is your ethnicity? (choose all that apply)
    - American Indian or Alaskan Native
    - Asian or Pacific Islander
    - Black or African American
    - Hispanic or Latino
    - White/Caucasian
    - Other
6. What is your current class rank?
    - Freshman
    - Sophomore
    - Junior
    - Senior
    - Other
7. Are you intending to major in biology?
    - Yes
    - No

	Strongly Agree	**Agree**	**Neither Agree nor Disagree**	**Disagree**	**Strongly Disagree**
8. I will like a SCALE-UP class style better than a traditional lecture class style.	○	○	○	○	○
9. I will learn more with a SCALE-UP class style than in a traditional lecture class style.	○	○	○	○	○

10. I will be more interested in the content of this course in a SCALE-UP class style than in a traditional lecture style.	◯	◯	◯	◯	◯
11. The teacher will be more helpful in a SCALE-UP class style than in a traditional lecture class style.	◯	◯	◯	◯	◯
12. I will be more aware of what Is expected of me in a SCALE-UP class style than in a traditional lecture class.	◯	◯	◯	◯	◯
13. I will retain more knowledge from this course in a SCALE-UP class style than in a traditional lecture class.	◯	◯	◯	◯	◯
14. I like Biological Science	◯	◯	◯	◯	◯
15. I plan to pursue a career in biological science	◯	◯	◯	◯	◯
16. Doing activities in class helps me understand the material better.	◯	◯	◯	◯	◯

17. (only on post-test) In your opinion, what affected your experience more; the teacher, the environment, or both? Please explain.

18. What did you like the most in this class?

19. What did you like the least in this class?

20. Any additional comments or things you want to mention?

APPENDIX C-Teacher Opinion Survey

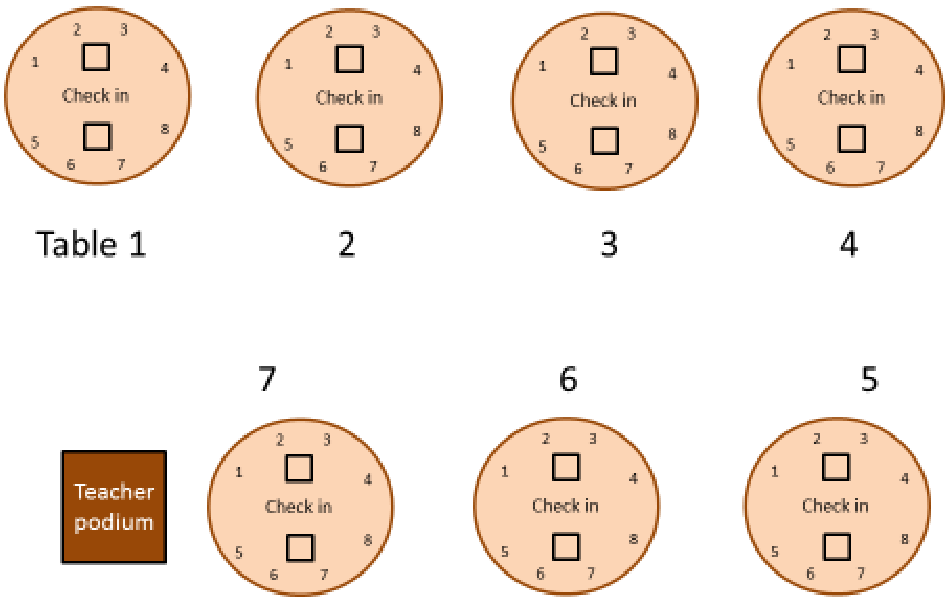
Teacher Opinion Survey

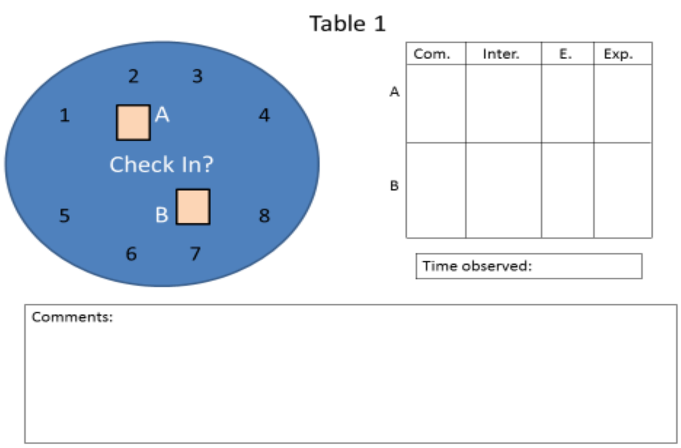
1. Name?
2. How many years have you been teaching?
3. How many times have you taught in the SCALE-UP classroom (not including this semester)?
4. In your Opinion answer the following questions.

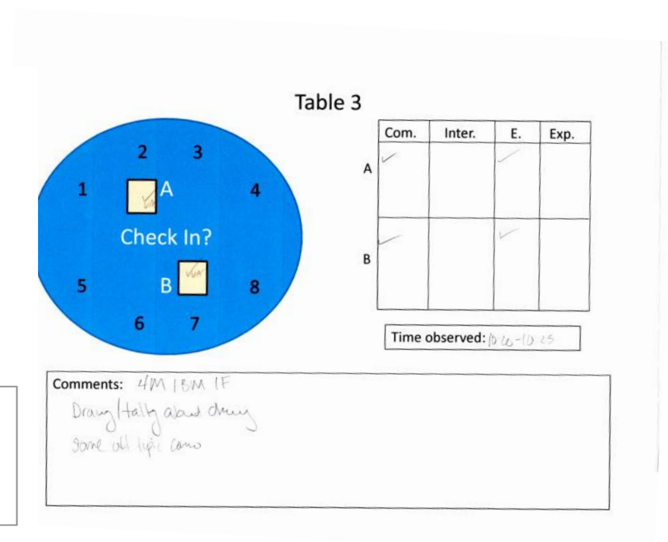
	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Students learn more with a SCALE-UP class style than in a traditional	○	○	○	○	○
Explanation/comments:					
I Like Teaching with a SCALE-UP style more than a traditional lecture	○	○	○	○	○
Explanation/comments:					
Students prefer a SCALE-UP class style over a traditional lecture style.	○	○	○	○	○
Explanation/comments:					
Students are more interested in the content of this course in a SCALE-UP class than a traditional lecture	○	○	○	○	○
Explanation/comments:					
Students have a better depth of understanding of the material in a SCALE-UP class than in a traditional lecture class.	○	○	○	○	○
Explanation/comments:					
All students contribute to group work.	○	○	○	○	○
Explanation/comments:					
It will take significantly more time to prep for this course in a SCALE-UP class than in a traditional lecture class.	○	○	○	○	○
Explanation/comments:					
Students particpate more in a SCALE-UP class than in a traditional lecture class.	○	○	○	○	○
Explanation/comments:					

5. Any further concerns or comments?

APPENDIX D: Observation sheets







General-ScaleUp

Lecture time:	
Students on task during lecture(approx %)?	
Multiple learning styles?	
Immediate feedback on lesson given?(y/n & type?)	
Teacher as a guide(y/n)?	
Attendance(approx. %)	

General-ScaleUp

4/1 @ 9:30 Thursday

Lecture time:	9:30 – 9:35, 9:48 – 10:10; 9:36 – 9:47
Students on task during lecture(approx %)?	taking notes, [illegible] 90%; [illegible] (1-3) [illegible] + yawns
Multiple learning styles?	lecture – Powerpoint; movie w/ lecture
Immediate feedback on lesson given?(y/n & type?)	Checked & [illegible] 1st part of activity
Teacher as a guide(y/n)?	yes
Attendance(approx. %)	80%

lecture [illegible] long only observed 1 once

General-Lecture

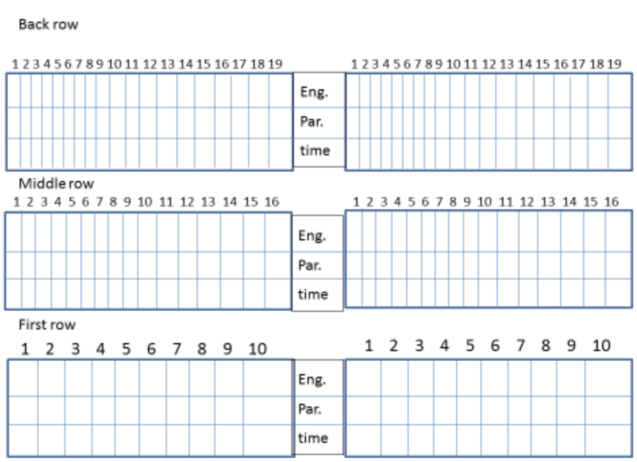
Lecture time:	
Students on task during lecture(approx %)?	
Multiple learning styles?	
Immediate feedback on lesson given?(y/n & type?)	
Teacher as a guide(y/n)?	
Attendance(approx. %)	

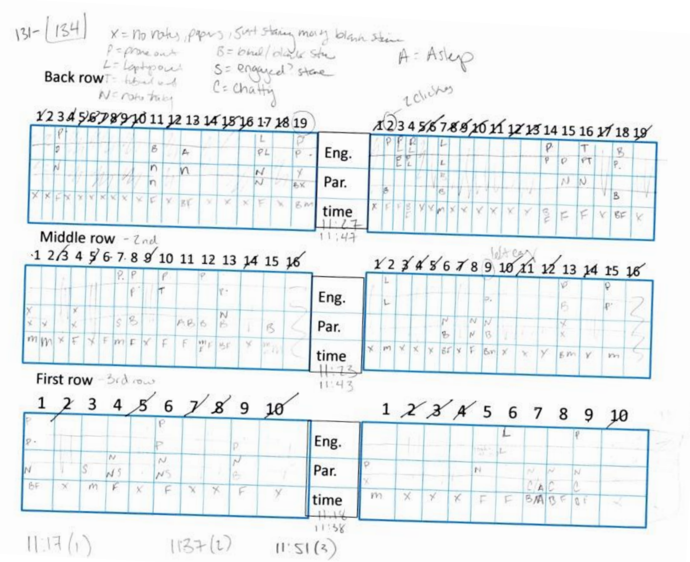
General-Lecture

4/1/2015 @ 11 thursday

Lecture time:	11am – 12:
Students on task during lecture(approx %)?	11:10 ~85%; 11:31 ~60-70%; 11:52 40-50%
Multiple learning styles?	lecture; Click quest
Immediate feedback on lesson given?(y/n & type?)	Click questions -> answers
Teacher as a guide(y/n)?	n sus lecture
Attendance(approx. %)	~60%

Progressing more phone use = extended phone use + Blank/Bored Stares





APPENDIX E: Terms

Active-learning - A lesson that engages the student actively. The student is not passively receiving information but is working with it in some way; for example, in-classroom activity, group work, presentations, etc.

"Experienced" teacher - This is a teacher who has taught in the SCALE-UP classroom previously. The teacher also implemented active learning and/or cooperative learning techniques while teaching in the classroom.

Independent sample t-test - Samples compared are independent of each other; comparing differences in mean scores.

Paired sample t-test - Samples are not independent of each other and are paired together, in this case by name; comparing the differences in mean score.

p-value - *p* values of 0.05 or lower are significant…in this case the differences were large enough to indicate some condition did affect the outcome.

SCALE-UP – Student-Centered Active Learning Environment for Undergraduate Programs

Traditional learning - The use of lecture in large enrollment courses. The teacher addresses the class, effectively delivering a PowerPoint talk on the subject matter.