ABSTRACT

PIGFORD, KIMBERLY M. Motivation Mediated Student Performance in Undergraduate Biology Active Learning Environments (Under the direction of Miriam Ferzli and Margaret Blanchard).

A mounting body of evidence has shown that student-centered instructional practices are more effective than traditional teacher-centered methodologies in Undergraduate STEM courses. Several studies have shown the effectiveness of student-centered pedagogies through increases in student performance, retention, and higher achievement by underrepresented groups. While all these studies demonstrate the exceptional benefits to students by implementing student-centered learning, very few offer any explanations as to why it is so effective. One area of the literature that could shed light on this is research on student motivation and how it impacts student performance. While a few of the aforementioned studies have examined student affective gains in addition to performance gains, there has been little work done to examine how student motivation for learning in a course compares between students taught in a student-centered manner and those taught in a traditional manner where lecture dominates. The purpose of this dissertation is to explore those difference between the two instructional modalities through the lens of self-determination theory to shed light on student motivation and performance increases in student-centered learning environments.

This dissertation is a collection of three manuscripts. The first manuscript uses a mixed-methods explanatory case study to examine students’ intrinsic motivation in three introductory biology classrooms each using differing amounts of student-centered teaching. The second manuscript quantitatively examines levels of instructor support in those same three classrooms and the impact of instructor support on student performance, motivation, and behaviors. The third manuscript is a comparative mixed-methods case study that examines student performance
and motivation in two separate student-centered classrooms: one taught in a traditional large lecture auditorium setting and one taught in a specialized learning space using the SCALE-UP model (Student-Centered Active Learning Environments with Upside-down Pedagogies).

The results of these studies indicate that student intrinsic motivation is positively correlated with the amount of active learning in the classroom. It suggests that this increase is due to the nature of student-centered learning which allows the student to take ownership of their learning and interact in a meaningful manner with course content. The role of the instructor is one of supporter and facilitator. The instructor’s main job is to support the student in their autonomous learning. Instructor support in the student-centered classroom was shown to positively predict student performance, motivation, and positive behaviors. Furthermore, student-centered learning seems to work regardless of the environment in which it is implemented. There were few differences in performance and motivation between the student-centered classroom in the traditional lecture hall and in SCALE-UP. However, the unique design of specialized environments like SCALE-UP do enable higher degrees of collaborative and social learning which may enhance students’ participation scores and their sense of relatedness or belonging to a learning community.

Overall, this dissertation suggests that student performance is higher in student-centered learning environments due to increases in students’ autonomous motivations to learn. During student-centered learning, students are given the chance to make meaningful choices in their own learning, engage with the material under the guidance of an instructor who can provide meaningful feedback, and interact with both their peers and instructors forming a sense of belonging to a learning community. The very nature of student-centered learning environments
nurtures the development of autonomous motivation in students leading to increases in student performance and overall wellbeing.
Motivation Mediated Student Performance in Undergraduate Biology Active Learning Environments

by
Kimberly M. Pigford

A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Science Education

Raleigh, North Carolina
2018

APPROVED BY:

Miriam Ferzli
Committee Co-Chair

Margaret Blanchard
Committee Co-Chair

Kristin Busch

LaTricia Townsend

Betty Black
BIOGRAPHY

My initial goal as a child was to become a veterinarian and to that end I chose to go to North Carolina State University with the eventual goal of being accepted into the vet school. Early on in my undergraduate education I decided that this career path was not for me and began to look at other options. I was particularly drawn to research and participated in a REU (Research Experience for Undergraduates) program in Puerto Rico during my 3rd year researching the habitat preferences of a small fish native to the rainforest streams on the island. I greatly enjoyed the experience and was convinced that scientific research was the career path for me. I graduated with a B.S. in Zoology the next year with the full intention of applying to a program to pursue a Ph.D. in Zoology.

I took a year off after graduating with the intention of doing some work in the biotech industry prior to going back to school. Unable to find a position due to the poor job market I began private tutoring. While I had done some work with teaching during my undergraduate career, I did not put much focus on it. Tutoring was where I found, completely by accident, that I had a love for education and helping students. I tutored both children and adults in topics ranging from mathematics and physics to biology and chemistry. I particularly enjoyed working with older children and adults in the sciences. I revised my career goals with the idea that I would enjoy working with the public in a non-traditional educational setting such as a museum or zoo. I applied for and was accepted into the M.Ed. program for science education at North Carolina State University with this goal in mind.

I admit I was a little overwhelmed with the program to begin with. Most of my peers were already teaching in the public-school system and were continuing their education to further their own teaching careers. However, I persevered and was successful as a non-traditional
member of the program in all my courses. The pivotal moment in the program that drove me to where I am now occurred in my second semester. I was taking a course on educational theory and I became fascinated with the research on learning theory, particularly what motivates students to learn in the classroom setting. I wrote a final paper for the course on student motivation that was well received by the professor. He made the comment that he sincerely hoped I was considering a career in educational research as he thought I would be well suited to it.

Once again, I began questioning my goals for my eventual career. I had come full circle back to my original love for research, albeit a vastly different subject than organismal biology. During the last year of the M.Ed. program, in addition to teaching a section of the introductory biology laboratory, I began collaborating with faculty in the biology department examining student learning and motivation in introductory biology classrooms. I developed a special interest in the benefits of classrooms utilizing active learning particularly NCSU’s SCALE-UP (Student-Centered Active Learning Environments with Upside-down Pedagogies) program. I changed my career goals again and began considering Ph.D. programs for science education with the goal of teaching biology at the college level while conducting discipline-based education research within the department. While some consider it unorthodox to stay at a single university for one’s entire higher education career, I chose to remain at NCSU for my Ph.D. so that I could continue my work with the biology SCALE-UP program that I had started during my M.Ed.

I have continued both my teaching and my work on student motivation and learning in biology courses utilizing active learning. I am excited to share my findings and contribute to the growing knowledge base for improving the undergraduate learning experience for biology students. I have found a career path that combines my love of teaching with my love of research.
The road to get to where I am now has had some unexpected curves and bumps along the way. It has given me a unique perspective on the undergraduate experience and the tumultuous time that it is for many students. As an incoming freshman, I thought I had everything planned out and knew exactly what I was doing. I strongly relate to the students who get to college and find out that life is not that simple. I can share my story with them and hope they find some comfort in it. It is okay to change your mind and explore other options. That is what the higher educational experience should be all about and I look forward to guiding students on that journey.
ACKNOWLEDGMENTS

I never truly understood the saying “it takes a village to raise a child” until I decided to embark on the journey of writing a dissertation. It would take me more pages than I can count to truly thank all the people who have helped me down this long road. So many people have come together to help make this dissertation a reality, from my advisers and committee members who have provided constant support and guidance all the way to friends and acquaintance who were willing to listen to me complain about my woes or brag about my accomplishments, depending on the day.

First, and foremost, I want to thank Dr. Miriam Ferzli who has supported and guided me through the past six years. You have not only been one of the best advisers and mentors I could have ever asked for but have also become one of my closest and dearest friends. Your influence and guidance have led me to become a better individual, both professionally and personally, than I could have ever imagined. I truly could not have done this without you and am so proud to be one of your students.

I was fortunate enough to have not one, but two main advisers during this journey and so I would also like to thank Dr. Meg Blanchard whose door was always open. You were never more than a hallway, phone call, or email away and I truly appreciate all your support, valuable feedback, and help through this process.

To my other committee members, Dr. Busch, Dr. Townsend, and Dr. Black, thank you so much for all you have done for me throughout this process. I truly value all the support and guidance you have provided to me throughout the planning and writing process.

I would also like to thank all my peers in both the Biology Department and Science Education Department here at North Carolina State University. I was fortunate to belong to not
one, but two, excellent communities of likeminded peers whose support and comradery were so crucial to my success.

To my partner, Brett West, thank you so much for supporting me through this entire journey and patiently listening to me rage in frustration or excitedly go on about my work, even when you did not have a clue what I was talking about.

To my mother, father, step-father, sister, grandparents, and other family, thank you for always believing in me and telling me I can do anything I set out to do. To my friends, Sarah Elliot, Jackie Stott, Aimee Fraulo, and so many more thank you for dragging me away from my work when I needed a break and then pushing me back to it when I lagged. To Sylvia Collins, thank you for always being supportive of me, providing me with guidance, and for taking care of my admittedly spirited horse these past few months while I was busy working. It will be nice to come back to a well-exercised dressage horse instead of a wild steed!

Last, but not least, thank you to all the faculty and students in the Biology Department at North Carolina State University without whom my work would have been impossible. Special thanks go out to all the faculty teaching the introductory biology classes and their students who were willing to accommodate me in their classrooms and answer my seemingly endless surveys. I cannot thank you enough for all your help and support.

To everyone else who I was unable to mention, thank you again from the bottom of my heart for all the support, guidance, and kindness that has been shown to me during this memorable journey.
# TABLE OF CONTENTS

LIST OF TABLES .......................................................................................................................... x
LIST OF FIGURES ......................................................................................................................... xi

## Chapter 1: Introduction and Literature Review ........................................................................ 1

Student Achievement in Undergraduate Stem ............................................................................. 1
Review of the Literature .................................................................................................................. 3
Defining Student-Centered Learning .............................................................................................. 4
  Intellectually Active ..................................................................................................................... 6
  Socially Active ........................................................................................................................... 7
  Physically Active ......................................................................................................................... 7
Student-Centered Learning Reforms with Specialized Classrooms ............................................. 8
Active Learning and Student Performance ................................................................................... 9
  Future Research on Active Learning ........................................................................................ 10
Motivation in Active Learning Environments ................................................................................ 10
  Social Cognitive Theory ........................................................................................................... 11
  Self-Efficacy ............................................................................................................................. 12
  Expectancy Value Theory ......................................................................................................... 13
  Goal Orientation Theory ........................................................................................................... 15
Self-Determination Theory ........................................................................................................ 19
  Autonomy ................................................................................................................................. 21
  Competence ............................................................................................................................... 22
  Relatedness ............................................................................................................................... 23
Overview of the Dissertation ....................................................................................................... 24
  Purpose of the Project ............................................................................................................... 24
  Overarching Research Approach .............................................................................................. 25
  Research Questions .................................................................................................................. 25
  Overview of Chapters ............................................................................................................... 26
Theoretical Framework ................................................................................................................. 28
References ..................................................................................................................................... 32

## Chapter 2: Investigating Students’ Intrinsic Motivation ............................................................ 40

Introduction .................................................................................................................................... 40
  Theoretical Framework ............................................................................................................. 40
  Research Focus and Research Questions ................................................................................. 45
Methods ......................................................................................................................................... 46
  Data Collection and Analysis .................................................................................................... 47
    Survey Instrument .................................................................................................................... 49
    Statistical Analysis .................................................................................................................. 50
    Focus Group Analysis ............................................................................................................ 51
Results ........................................................................................................................................ 52
  COPUS Analysis ...................................................................................................................... 52
  Intrinsic Motivation Inventory Analysis .................................................................................... 54
  Focus Group Analysis ............................................................................................................... 56
    Autonomy Need Satisfaction ................................................................................................. 57
    Competency Need Satisfaction ............................................................................................. 58
Chapter 3: Exploring Instructor Autonomy Support ........................................... 73
  Introduction ........................................................................................................ 73
  Self-Determination Theory .............................................................................. 75
  Purpose ............................................................................................................. 77
  Methods ........................................................................................................... 78
  Section Descriptions ...................................................................................... 79
  Data Collection and Analysis ........................................................................ 79
  Instructor Autonomy Support ......................................................................... 80
  Relationship Between IAS and Student Outcomes ....................................... 81
    Student Behavioral Outcomes .................................................................... 81
    Performance ............................................................................................... 83
    Ability .......................................................................................................... 84
  Results .............................................................................................................. 84
  Discussion ....................................................................................................... 88
  References ....................................................................................................... 93

Chapter 4: Investigating the Motivations and Active Learning: A Comparison .... 97
  Introduction ...................................................................................................... 97
  Theoretical Frameworks .................................................................................. 100
    Self-Determination Theory ..................................................................... 100
    Active Learning Framework .................................................................. 101
  Methods .......................................................................................................... 102
    Participants and Context ......................................................................... 102
    Data Collection and Analyses ................................................................ 103
      Classroom Observations ...................................................................... 103
      Open Response Items .......................................................................... 104
    Student Performance and Motivation .................................................... 105
  Results ............................................................................................................. 107
    Active Learning Measures ...................................................................... 107
    Student Perceptions of Course Components ......................................... 110
      Intellectually Active Course Components ...................................... 110
      Physically Active Course Components ........................................... 112
      Socially Active Course Components .................................................. 115
    Passive and Not Specified Course Components .................................... 117
    Student Performance and Motivation ..................................................... 119
  Discussion ........................................................................................................ 119
  Implications .................................................................................................... 122
  References ....................................................................................................... 125
Chapter 5: Discussion .................................................................................................................. 129
  Overview of Dissertation Goals ................................................................................................. 129
  Findings ...................................................................................................................................... 131
  Conclusions ............................................................................................................................... 133
  Limitations ............................................................................................................................... 135
  Future Directions ..................................................................................................................... 136
  References ............................................................................................................................... 137

Appendices ................................................................................................................................... 139
  Appendix A: Intrinsic Motivation Inventory .............................................................................. 140
  Appendix B: Focus Group Protocol ........................................................................................... 141
  Appendix C: Focus Group Consent Form .................................................................................... 143
  Appendix D: Learning Climate Questionnaire ........................................................................... 146
  Appendix E: Intrinsic Motivation Inventory (Chapter 3) .......................................................... 147
  Appendix F: Open-Ended Survey Questions ............................................................................. 149
  Appendix G: Intrinsic Motivation Inventory (Chapter 4) .......................................................... 150
LIST OF TABLES

Table 2.1 Descriptive Statistics for IMI sub-scales. ................................................................. 55
Table 2.2 One-way ANOVA results for IMI Sub-scales ............................................................ 56
Table 2.3 Post-hoc analysis for significant IMI Sub-scales measures using Tukey HSD test ... 56
Table 2.4 Themes and Subthemes of focus group participants’ motivation for learning biology. ................................................................................................................................. 57
Table 3.1 Descriptive Statistics, one-way ANOVA, and post-hoc (Tukey HSD) analysis results for perceived instructor autonomy support in three different sections of an introductory biology course ................................................................................................. 85
Table 3.2 Correlations Among Study Variables (n=482) .......................................................... 87
Table 3.3 Multiple Regression Testing the Effects of Instructor Autonomy Support on Student Motivation Variables and Performance, Controlling for HS GPA and SAT scores (n=395) ................................................................................................................................. 88
Table 4.1 Intellectually Active Codes with example quotations and frequencies for both Modified and SCALE-UP Sections .................................................................................................. 112
Table 4.2 Physically Active Codes with example quotations and frequencies for both Modified and SCALE-UP sections ....................................................................................................... 115
Table 4.3 Socially Active Codes with example quotations and frequencies for both Modified and SCALE-UP Sections ............................................................................................................. 116
Table 4.4 Passive and Not Specified codes including quotations and frequencies for both the modified and SCALE-UP section .......................................................................................... 118
Table 4.5 Descriptive Statistics and T-test Results for Student Performance and Motivation ................................................................................................................................. 119
LIST OF FIGURES

Figure 1.1 Dale’s (1969) Cone of Learning................................................................. 5
Figure 1.2 Active Learning Environment Framework based on Edwards (2015).............. 6
Figure 1.3 Failure Rates in Undergraduate STEM Courses (Freeman et al., 2014).......... 10
Figure 1.4 Bandura’s Social Cognitive Theory (1978).................................................. 12
Figure 1.5 Expectancy-value Theory Model. ................................................................. 14
Figure 1.6 Goal Orientation Framework (Dweck, 1986, pg. 1041).................................. 16
Figure 1.7 2X2 Goal Orientation Framework (Elliot & McGregor, 2001, pg. 502).......... 18
Figure 1.8 Motivation Continuum adapted from Ryan & Deci (2008).............................. 21
Figure 1.9 Model of Self-Determination Theory............................................................. 24
Figure 2.1 Self-determination Theory Model derived from Deci & Ryan (1985). This model illustrates the connection between basic psychological need satisfaction, increased motivation, and increased development in individuals................................. 43
Figure 2.2 Observed instructor behaviors during 150 minutes of classroom observation using the COPUS protocol................................................................. 53
Figure 2.3 Observed student behaviors during 150 minutes of classroom observation using the COPUS protocol................................................................. 54
Figure 4.1 Observed main instructor behaviors during 150 minutes of classroom observations using the COPUS protocol...................................................... 108
Figure 4.2 Observed student behaviors during 150 minutes of classroom observation using the COPUS protocol...................................................... 109
Chapter 1 Introduction and Literature Review

Student Achievement in Undergraduate STEM Courses

Student performance and retention in undergraduate science classrooms have been an issue for some time now and much research has gone into attempts to increase student scores (Micari & Pazos, 2014; Saravanan, Kingston, & Gin, 2014). The Higher Education Research Institute (2010) reports that even though the number of incoming college students interested in STEM (Science, Technology, Engineering, & Mathematics) degrees is steadily rising, the number of these same students who manage to graduate with a STEM bachelor’s degree within five years is dropping. The trend is more prominent in underrepresented groups within the STEM field; although they are just as likely to enroll in a STEM based program (Anderson & Kim, 2006), they are more likely to switch to a non-science major or not finish the degree (Georges, 1999; Tsui, 2007).

While suggested reasoning for poor performance and retention in undergraduate STEM programs is multifaceted, several studies have illustrated that poor pedagogical practices have a large impact on student persistence in STEM programs (Fairweather, 2008; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012; Seymour & Hewitt, 1997; Tsui, 2007). Traditional teaching practices in undergraduate STEM courses are characterized by large lecture formats, large class sizes, and primarily instructor-centered modes of instruction (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, et al., 2014; Fairweather, 2008; Gasiewski et al., 2012; Wilke, 2003). Traditional pedagogies in STEM courses, especially in introductory courses where the modality is more common, often result in a lack of student engagement with course material (Gasiewski et al., 2012). Students find their courses to lack relevance and value to their lives, often cite that the material is too difficult, and feel that there is too much rote memorization (Felder, 1993;
Seymour, 1995; Seymour & Hewitt, 1997). Additionally, non-majors often cite that science courses are not only too difficult, but also boring, suffer from a lack of motivation to learn science, and possess poor attitudes regarding science courses (Wilke, 2003).

Considering this research, it is no surprise that major reforms have been pushed for at the college level, mostly in the form of improving instructor pedagogical knowledge and encouraging more student-centered teaching practices (Docktor & Mestre, 2011; Fairweather, 2008; Freeman et al., 2014; Wieman, 2007). Student-centered learning is a constructivist based approach to the classroom setting in which the student becomes an active participant in their own learning (Freeman et al., 2014). A quantitative meta-analysis conducted by Freeman et al. (2014) found strong evidence that student performance in undergraduate STEM courses was positively affected by the inclusion of student centered methodologies in the classroom. Gasiewski et al. (2012) reported that students in more active, collaborative learning environments reported higher levels of engagement and satisfaction with their introductory STEM courses, as compared to students in courses that were predominately lecture based. Other studies have corroborated these findings in the general literature on college teaching and learning (reviewed by Pascarella & Terenzini, 2005).

However, despite these findings and current support for student-centered learning by organizations such as the National Research Council (NRC, 2003, 2012) and the American Association for the Advancement of Science (AAAS, 2011), the lecture format continues to be the predominant format for college science teaching (Fairweather, 2008). College instructors cite various reasons for their reluctance to utilize student-centered teaching strategies including time commitments involved and the perceptions that the research process is more valued than the teaching process at their institution (Fairweather, 2008; Massy, Wilger, & Colbeck 1994). Other
underlying reasons for the reluctance of college science instructors to utilize student centered teaching strategies include lack of pedagogical knowledge and funding (Fairweather, 2008).

Most research on STEM education assumes that empirical evidence to support teaching reforms is necessary for adoption; meaning that institutions are reluctant to spend resources on adopting new teaching practices unless research clearly illustrates and explains the effectiveness of implementing those practices. There is a plethora of current research illustrating the effectiveness of student-centered learning practices (see Fairweather, 2008 & Freeman et al., 2014), however, related research explaining why those practices are so effective is lacking. There is currently a need for research that goes beyond simply establishing larger performance gains in these learning environments and instead seeks to further refine knowledge on why student-centered learning environments are more effective than traditional formats (Fairweather, 2008; Freeman et al., 2014).

One genre of well-established research that could be used to begin filling in this gap is research on motivation particularly student motivation in classroom settings. Research on student motivation and its effects on performance could shed light on higher performance trends in classrooms utilizing student-centered strategies. To date, very little research has been done on how student motivation affects performance in undergraduate student-centered learning environments and there is currently a call for exploratory studies examining this area of research (Pillai et al., 2011).

**Review of the Literature**

This review of the literature includes:

A. A thorough exploration of student-centered learning
B. A thorough exploration of SCALE-UP (Student-Centered Active Learning Environments with Upside-down Pedagogies) a model for student-centered learning involving redesign of the physical classroom space

C. An overview of studies on student performance in student-centered learning environments.

D. An overview of student motivation in student-centered learning environments.

E. An analysis of self-determination theory as it is utilized in STEM higher education.

This review provides guidance in attempting to answer the research question, as well as provides insights into the environmental factors at play in a student-centered learning environment that may positively impact student motivation and consequently performance.

**Defining Student-Centered Learning.**

Defining active learning can prove to be quite the challenge due to the numerous student-centered pedagogies that are capable of fitting the definition. Furthering the problem, academic researchers each tend to adapt a slightly different definition for active learning depending on their goals and thus attempt to define their own meanings in each work. Broadly speaking, Freeman et al. (2014) classified any type of learning environment that involved the student actively participating in the lesson for any amount of time as being an active learning environment. Petress (2008) preferred defining active learning by saying what it is not. Active learning is the opposite of passive learning. In passive learning, students are dependent fully upon the instructor during the learning process and merely act as vessels that receive knowledge, a sort of *tabula rasa*. In this way, active learning as a pedagogical theory clearly has roots in the theoretical framework of constructivism. Constructivism, based on the work of Swiss developmental psychologist Jean Piaget, posits that human beings construct knowledge based on
interactions between their prior experience and the learning environment (###). Following a constructivist viewpoint, Dale (1969) summarized the active learning philosophy graphically (see figure 1) using his ‘cone of learning’ model. The model illustrates the degree to which an individual can remember information when presented in a certain way. It suggests that information presented in an active manner, a manner in which the person actively engages and participates in learning, is more easily remembered than information delivered in a passive manner. Teaching methods should vary as appropriate to the topic, but the bulk of learning should be situated more towards the bottom of the pyramid, than the top.

**Figure 1.1** Dale’s (1969) Cone of Learning.

Going further, Edwards (2015) developed a theoretical framework (see figure 2) to describe active learning that breaks the construct down into three separate components: social, intellectual, and physical. Each component comprises a different element of the active learning environment. The most successful active learning environment should include all three aspects of the model.
Figure 1.2 Active Learning Environment Framework based on Edwards (2015).

*Intellectually Active.*

Students in the classroom should be intellectually engaged with their course material, rather than passively accepting knowledge from an instructor (Edwards, 2015). Examples of intellectually active learning strategies include problem/project based learning, inquiry based learning, concept maps, etc. Inquiry based learning involves students actively exploring course material either on their own or in groups. Students in mathematics courses who utilized inquiry based learning performed the same as or better than students in a traditional setting and reported higher levels of interest in the course material (Kogan & Laursen, 2014). Online webquests have been demonstrated to improve exam performance in an introductory biology course, as well as result in higher levels of student reported intrinsic motivation for learning course material (Ferzli, Pigford, & Black, 2015). Project and problem based learning involve learning that takes place within an authentic context or setting. Students explore real-life problems and situations based on course material (Stefanou, Stolk, Prince, Chen, & Lord, 2013). Project/problem based learning result in higher levels of self-regulated behaviors, lower levels of extrinsic motivation, and increased perceptions of autonomy (Lord, Prince, Stefanou, Stolk, & Chen, 2012; Stefanou
et al., 2013). Higher levels of self-regulation and feeling of autonomy then result in deeper learning (Blumenfield, Kempler, & Kracikj, 2006).

**Socially Active.**

Social constructivism posits that human development is firmly situated within the social environment resulting in knowledge being constructed through interactions with others (Vygotsky, 1978). Aspects of student-centered active learning placed within the socially active framework are grounded within this tenant (Stump, Hilpert, Husman, Chung, & Kim, 2011). There are a multitude of instructional strategies that fall within the socially active category, but most can be defined as being collaborative in nature. Collaborative learning is a technique that relies on students in the classroom actively working together, exchanging ideas, and sharing responsibility for learning. This form of learning improves student’s critical thinking skills, increased retention of material, and results in higher levels of academic achievement (Gokhale, 1995; Harris, Bransford, & Borphy, 2002). By helping one another with the course material, students are able to clarify their own knowledge of the content. Their attempts to explain and elaborate on the material with others leads to a more sophisticated understanding of the material (Armstrong, Chang, & Brickman, 2007). Collaborative learning has been demonstrated to promote greater achievement on a wide variety of skills and tasks, including acquisition, retention, and accuracy of knowledge (Johnson, Johnson, & Smith, 1998; Springer, Stanne, & Donovan, 1999).

**Physically Active.**

Students in the classroom should not only be physically and intellectually active, but also should be physically active as they engage in course materials (Edwards, 2015). Examples of physically active learning techniques include experiential learning, manipulatives, models, and
other hands-on projects. Experiential learning is prevalent in undergraduate STEM education through laboratory work, project-based course work, and other outside sources of learning such as internships (Singer, Hilton, & Schweingruber, 2005). An analysis of interviews with 62 graduating STEM seniors demonstrated that experiences like experiential learning and participation in other authentic learning situations was critical to learning and development (Thiry, Laursen, & Hunter, 2011). Other areas of physically active learning involve working hands-on with models, manipulatives, or other artifacts related to course material. Exploratory activities involving physical objects have been shown to increase student’s involvement and promote retention of course material (Johnson, Johnson, & Smith, 1991).

**Student-Centered Learning Reforms with Specialized Classrooms.**

While many reforms and studies on active learning focus on implementing reform in already existing classroom spaces, some reforms call for a redesign of the entire learning experience from the classroom up. One example of this is SCALE-UP (Student Centered, Active Learning Environments with Upside-down Pedagogies). The SCALE-UP program was designed to address limitations of implementing active learning in traditional large auditorium tiered seating while still accommodating large enrollment classes (Beichner & Jeffrey, 2003; Beichner, 2008; Foote, Neumeyer, Henderson, Dancy, & Beichner, 2014). The SCALE-UP format radically changes the traditional view of the classroom. Students are placed facing each other at round tables seating 9 students each with no clear front of the room delineated. White boards and other instructional technologies are made available for the students use to facilitate collaboration and sharing of student work. The instructor is aided by 3-4 undergraduate teaching assistants (UTAs) who are assigned to 2-3 tables of students whom they interact with all semester. In order to accommodate the time spent doing active learning activities, the class structure is flipped.
SCALE-UP students spend out-of-class time exploring background content and use in-class time for extending learning through collaborative problem-, model-, and case-based learning. The format has proven a successful example of a student-centered learning environment for various subjects, including biology, across the country (Beichner, 2008; Benson, Orr, Biggers, & Moss, 2010; Brooks, 2011; Cotner, Loper, Walker, & Brooks, 2013; Dori & Belcher, 2005; Foote et al., 2014; Olver-Hoyo & Allen, 2005).

**Active Learning and Student Performance.**

Despite recent evidence for the support of student-centered, active learning in the college classroom, traditional teacher-centered, lecture still dominates as the preferred teaching method. Active learning has been consistently shown to increase student retention and performance in undergraduate STEM courses. A recent meta-analysis by Freeman et al. (2014) examined two hundred and twenty-five studies in the published and unpublished literature that reported either student performance or failure rates for undergraduate STEM classrooms utilizing some form of active learning. The types and intensities of active learning utilized in each study varied. They found significant differences for student performance and failure rates (see Figure 3) in active learning classrooms. Figure 3A shows the number of studies that reported either an increase or decrease in failure rates, while figure 1B illustrates the shift in percentage of students who fail a lecture course versus an active learning course. Student performance in the active learning classroom was increased by just under half of a standard deviation (mean difference of .47) compared to student performance in traditional classroom settings. Likewise, the study found that students in traditional classrooms were one and a half times more likely to fail the course than students in courses utilizing active learning. Other studies examining the effectiveness of
active learning in undergraduate STEM courses have found similar results (Ruiz-Primo, Briggs, Iverson, Talbot, & Sheaprd, 2011; Springer et al., 1999).

Figure 1.3 Failure Rates in Undergraduate STEM Courses (Freeman et al., 2014).

**Future Research on Active Learning.**

A detailed examination of why student-centered learning environments is so successful would prove useful for institutions wishing to implement the learning model in lieu of traditional lecture.

**Motivation in Active Learning Environments.**

The study of motivation examines the reasons behind why an individual may make a certain choice (Braver et al., 2014). A large review of the literature conducted by Braver et al. (2014) reported that the study of motivation originally stemmed from behavioral studies. Skinner (year) was one of the most famous behaviorists who contributed to early motivation research, using his extensive work with animals in a laboratory setting. The explanation then was that external forces drive motivational responses, such as food deprivation in laboratory studies. Later, researchers began to look at more internal forces that drive motivation and a large number of theories within several disciplines emerged (Schunk, Pintrich, & Meece, 2008). These psychological theories on student motivation span several decades of research and provide support for the central role of motivation in student performance (Linnenbrink & Pintrich, 2002;
Schunk et al., 2008). Within student-centered undergraduate STEM courses, motivation and performance has primarily been examined using self-efficacy theory, expectancy-value theory, and achievement goal theory (Schunk et al., 2008). These theories build on the concept that students are active “meaning makers” of their experiences within the classroom (Freeman, Alston, & Winborne, 2008). The theories build from social cognitive theory which suggests that students actively build perceptions based on learning experiences that influence their effort and persistence in the academic setting (see Schunk et al., 2008).

**Social Cognitive Theory.**

Social cognitive theory has its roots in the work of Holt and Brown in their 1931 book, *Animal Drive and the Learning Process. An Essay Toward Radical Empiricism*, which suggested the idea of learning as being a social and interactive process. Miller and Dollard (1941) revised Holt’s social learning theory arguing that four factors (drives, cues, responses, and rewards) contributed to learning. They posited that if an individual were driven to learn a behavior they would do so via observation. Learning is then positively reinforced when an individual is rewarded for correctly imitating the observed behavior. Social learning theory was expanded once again by Bandura and his colleagues during a series of studies conducted in 1961 and 1963 known as the Bobo doll experiment (Bandura, 1977). The study explored the display of aggressive behaviors by children specifically high lighting the importance of observational modeling in the acquisition of novel behaviors. Based on this work Bandura published his second book in 1986 in which he renamed social learning theory to social cognitive theory (figure 4) and posited that human behavior arises from an interaction between personal, behavioral, and environmental influences (Bandura, 1978).
Personal influences refer to whether an individual possesses high or low self-efficacy for performing the behavior, or in other words whether a person believes they can perform the observed behavior. Behavioral influences deal with the feedback given after an individual performs the behavior. Lastly environmental influences refer to external factors that impact an individual’s ability to successfully complete a behavior (Bandura, 1978). Put in the perspective of the classroom, if a student believes they can learn the course material, are placed in an environment conducive to learning, and are provided with positive feedback when they experience success then higher learning gains will occur.

**Self-Efficacy.**

Self-efficacy is based on an individual’s belief in their ability to succeed at a task (Bandura, 1977). An individual’s sense of self-efficacy plays a major role in how they approach goals and challenges. Self-efficacy has been extensively studied in the academic setting in regards to self-regulation, motivation, and student achievement (reviewed by Pajares, 1996).
Self-efficacy has been linked with college major and career choices. For instance, mathematics self-efficacy was found to be predictive of mathematics interest and choices in math related courses in undergraduate students. Higher levels of self-efficacy for a topic tend to result in higher levels of motivation, confidence, and performance across academic settings (Pajares, 1996).

Within research on student-centered learning environments most studies have explored how the environment impacts student’s levels of self-efficacy for course material as compared to students in traditional learning environments. Wilke (2003) utilized a quasi-experimental, Solomon four group design to demonstrate that active learning in a physiology class resulted in higher reported levels of student’s self-efficacy for learning physiology. Attitude surveys reported that students in the active learning sections enjoyed the class, thought they learned more material than they would have in a traditional setting, and stated that they would take an active learning course again if given the chance. Students in the lecture section reported that they also would have preferred being in the active learning section. Engineering students who reported using collaborative learning strategies were associated with increased self-efficacy for learning course material and course grade (Stump, Hilpert, Husman, Chung, & Kim, 2011).

*Expectancy-Value Theory.*

Expectancy-value theory (Wigfield & Eccles, 1992, 2002) is a motivational theory that focuses on an individual’s expectancies, their beliefs about successfully completing a task; and values, beliefs regarding why a task is important enough to engage in (figure 5). The two components are considered to be separate constructs, but are often related in a positive manner. Higher levels of expectancy beliefs lead to an increase in perceived value of a task (Linnenbrink
and increases in perceived value often lead to increases in positive expectancies (Hulleman, Godes, Hendricks, & Harackiewicz, 2010).

Value related beliefs can be further broken down into four main categories: utility, attainment, cost, and intrinsic value (DeBacker & Nelson, 1999; Eccles et al., 1993). Utility value refers to the perceived usefulness of completing a task, while attainment value deals with the importance of completing a task for personal self-development and identity. Cost is the measure of how worthwhile a task is based on the time and effort needed to complete the task. Lastly, intrinsic value refers to how much enjoyment is obtained from completing the task. These task values have been positively linked with engagement and achievement in both younger children (Wang & Eccles, 2013; Wigfield, 1994), as well as college level students (Bong, 2001; Marchand & Gutierrez, 2016). Of the four value constructs, it is suggested that utility value is the most sensitive to instructional format (Hulleman et al., 2010).
Relatively few studies have examined the impact of student-centered learning on student motivation using the expectancy-value model specifically. Most have largely looked at the pedagogies impact on increasing the various task value constructs. For instance, utilizing a problem-based learning approach that introduced students to information in a meaningful way (i.e. utility and attainment value) positively impacted student’s expectancy beliefs (Wijnia, Loyens, & Derous, 2011).

**Goal Orientation Theory.**

Carol Dweck’s achievement goal theory states that motivation is dependent upon what type of goal an individual seeks to obtain (Ames, 1992; Dweck, 1986). In earlier models (see figure 6) of the theory achievement fell into two main categories, performance (maladaptive) goals or learning (adaptive) goals (Grant & Dweck, 2003). Individuals with performance goals are generally focused on the end result for whatever activity they are engaged in. For these individuals, the focus is usually on earning a good grade in a class and receiving positive judgement for their performance (Ames, 1992); where as individuals with learning goals tend to focus more on developing new skills, gaining understanding, and learning new material. Students focused on learning goals are mastery-oriented and tend to be life-long learners and view failures as a learning opportunity to be valued (Bandura & Dweck, 1985; Elliott & Dweck, 1988). These students view intelligence as a malleable entity capable of changing over time. They view failure or challenge as a cue to increase their effort or consider a different approach at the task (Ames, 1984; Leggett, 1986; & Nicholls, 1976). In contrast, students focused on performance goals view intelligence as a fixed, innate trait, and as such seek positive judgements on their learning ability (Bandura & Dweck, 1985; Elliott & Dweck, 1985). For these students, effort can be a double-edged sword and many are careful to only attempt tasks that they believe they can succeed at,
choosing to avoid tasks they perceive to be too hard and the resultant negative judgement that may result from their failure (Covington & Omelich, 1979; Elliott & Dweck, 1985; Frankl & Synder, 1978).

<table>
<thead>
<tr>
<th>Achievement Goals and Achievement Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Theory of intelligence</strong></td>
</tr>
<tr>
<td>Entity theory (Intelligence is fixed)</td>
</tr>
<tr>
<td>Incremental theory (Intelligence is malleable)</td>
</tr>
<tr>
<td><strong>Goal orientation</strong></td>
</tr>
<tr>
<td>Performance goal (Goal is to gain positive judgments/avoid negative judgments of competence)</td>
</tr>
<tr>
<td>Learning goal (Goal is to increase competence)</td>
</tr>
<tr>
<td><strong>Behavior pattern</strong></td>
</tr>
<tr>
<td>If high → Mastery-oriented</td>
</tr>
<tr>
<td>but</td>
</tr>
<tr>
<td>If low → Helpless</td>
</tr>
<tr>
<td>Avoid challenge</td>
</tr>
<tr>
<td>Low persistence</td>
</tr>
<tr>
<td>If high → Mastery-oriented or</td>
</tr>
<tr>
<td>Seek challenge (that fosters learning)</td>
</tr>
<tr>
<td>low</td>
</tr>
<tr>
<td>High persistence</td>
</tr>
</tbody>
</table>

**Figure 1.6** Goal Orientation Framework (Dweck, 1986, pg. 1041).

Critics of achievement goal theory argued that this dichotomous framework was too simple (see Grant & Dweck, 2003). They noted that many successful students within the school environment are performance goal oriented. In a review of the literature Grant & Dweck (2003) provide several examples of studies that support this view especially in high achieving female students. This prompted a new development within the framework to a model that separated performance goals into performance approach and performance avoidance goals (Elliot & Church, 1997; Elliot & Harackiewicz, 1996; Grant & Dweck, 2003). Grant & Dweck (2003) identify several primary reasons for why a student may be oriented towards a performance goal mind-set. Some students use their successes as a means of validating the self, while others take on a more competitive mindset based upon others or themselves. For students who value competition or simply want to do well, there is little evidence to suggest that maintaining a performance goal mindset harms their performance, although they may not be as focused on actual learning as their mastery minded peers (Dweck & Leggett, 1988; Grant & Dweck, 2003). Thus, these students are classified as performance approach students. Conversely, students who
place emphasis on their successes as a measure of their self-worth, are performance avoidant if they perceive the task to be too difficult for success and thus tend to suffer from lower motivation and success in school (Dweck & Laggett, 1998; Grant & Dweck, 2003).

The triarchic model of achievement goals was taken one step further by Elliot & McGregor (2001) who argued that mastery approach students should also be placed into two categories, mastery approach and mastery avoidant, like the breakdown for performance goal mindsets. Mastery oriented students had traditionally been viewed as enjoying challenging problems and learning new skills (Ames, 1992; Dweck, 1986; Dweck & Laggett, 1988). Elliot & McGregor (2001) posited that not all mastery approach students took this view. Some students attempted to master material to avoid appearing incompetent. They place strong emphasis on avoiding misunderstandings. The student’s focus on avoiding failure prompted Elliot & McGregor to propose the new mastery avoidant category into the model (see figure 6).

Perceived competence forms the basis on which a student’s orientation goal is formed (Elliot & McGregor, 2001). The type of competence and, therefore, achievement goals, can be distinguished using two dimensions: how it is defined and how it is valenced (see figure 7). Competence can be defined in one of three ways, absolute (mastery of the task), intrapersonal (improved performance on the task), or normative (performance compared to others). Young children rely solely on absolute competence when evaluating their current or potential successes; however, by age 7 all individuals can assess their successes using any of the three definitions of competence (Butler, 1998; Ruble & Frey, 1991). Absolute and intrapersonal competence are generally placed together in the 2 X 2 achievement goal model as both deal with learning or mastering new information (Elliot & McGregor, 2001). The distinction between absolute/intrapersonal and normative competence is present beginning with the classical model.
of achievement goals through the dichotomy of judging one’s performance relative to others or the requirements of the task (McClelland, Atkinson, Clark, & Lowell, 1953; Murray, 1938).

Competence can be valenced in either a positive (seeking success) or negative possibility (avoiding failure). A person processes most stimuli in terms of valence first and foremost, generally without awareness (Bargh, 1997; Zajonc, 1998), which immediately evokes either an approach or avoidance response (Cacioppo, Priester, & Berntson, 1993) forming a central aspect of early achievement motivation theory (Atkinson, 1957; Murray, 1938). Consequently, the 2 X 2 achievement goal framework is based on the dichotomous definition and valence of perceived competence (Elliot & McGregor, 2001). Utilizing CFA analysis, Elliot & McGregor (2001) found support for the 2 X 2 framework in three separate studies examining goal orientation in undergraduate introductory psychology students.

![Image: 2X2 Goal Orientation Framework](Elliot & McGregor, 2001, pg. 502)

**Figure 1.7 2X2 Goal Orientation Framework** (Elliot & McGregor, 2001, pg. 502).

A review of the literature revealed no substantial work regarding the impact of student-centered learning on achievement goals. This may not be so surprising since most of the work such as the studies referenced earlier concern themselves more with the impact of goal orientation on performance and motivations and less on how various instructional techniques impact goal orientations themselves. Within the active learning literature a few studies have
explored the mediating effects of goal orientation on performance and motivation. For instance, learners in a blended learning classroom that reported higher learning goal orientations (mastery approach) also reported higher motivation to learn resulting in higher satisfaction, metacognition, and grades (Klein, Raymond, & Wang, 2006).

**Self-determination Theory.**

Self-determination theory posits that individuals are inherently drawn to grow, master challenges, and integrate new experiences as they continually develop and refine their own sense of self (Deci & Ryan, 1985a; Ryan & Deci, 2000). However, personal growth does not occur in a vacuum, since social environments play a key role in either supporting or thwarting an individual’s growth. Environments that support a person’s psychological need for autonomy, relatedness, and competence provide the ideal setting for encouraging social and cognitive development (Deci and Ryan, 2000; Deci & Ryan, 2008). In an education setting, when these three needs are supported in the classroom, students are more likely to internalize their motivations leading to autonomous, self-regulated learning. Students who are autonomously motivated and self-regulated are more driven and interested in learning than their more extrinsically motivated counterparts. Deci & Ryan (2000) define relatedness as the longing to feel connection with others and be included in a social group. Autonomy is the level of control that one perceives to have over one’s behavior and successes. Competence is the level of ability or success that an individual believes he possesses when attempting a task.

Autonomy, relatedness, and competence play significant roles in fostering the development of intrinsic motivation in individuals (Deci & Ryan, 1985a; Sheldon & Niemiec, 2006). SDT places motivation on a continuum containing three broad categories: ammotivation, extrinsic motivation, and intrinsic motivation. Ammotivation is at the far left of the spectrum and
individuals experiencing possess very low levels of autonomy, competence, and relatedness for the specific situation in question (Deci & Ryan, 2000; Ryan & Deci, 1985a). Individuals driven by extrinsically motivated factors fall somewhere in the middle of the continuum with moderate amounts of autonomy, relatedness, and competence (Deci & Ryan, 2000). Individuals driven by purely intrinsic motivation are placed at the right side of the continuum. They possess the highest amounts of autonomy, competence, and relatedness. This is the rarest of the three situations; intrinsically motivated individual’s will experience the highest success and are said to be completely self-determined in their behaviors and actions (Braver et al, 2014; Deci & Ryan, 2000).

Intrinsic motivation is the most ideal form of motivation and leads to the highest levels of success (Braver et al, 2014). However, critics argue that it is simply not possible for every individual to possess high levels of intrinsic motivation leading to success at every task they attempt to undertake. Deci & Ryan (2000) report on research that answered this criticism by proposing a continuum of varying degrees of extrinsic motivation lying between ammotivation and intrinsic motivation as a model to explain varying motivators on their effects on a person’s self-determined behavior or lack there-of. Four types of extrinsic motivation exist on this continuum. External regulation is placed the closest to ammotivation. People driven by external motivation are simply performing some task in exchange for a reward. People who are experiencing introjection perform a task because of feelings of self-worth, guilt, or shame placed upon them by others (i.e. a student choosing to study to avoid a parent’s disapproval). Introjection occurs when an individual begins to accept or recognize the external value of performing a task and chooses to engage in the task independently i.e. a student studies because they are aware they must perform well to pass a class. Finally, integration is the closest
externally regulated form of motivation to intrinsic motivation, often referred to as self-determined extrinsic motivation. Integration involves taking the recognized value of an activity and fully integrating it into one’s self-identity. Continuing with the example above, the student chooses to study because they recognize the inherent value of performing well in the class to increase their own development in some area of their life. Ryan & Connell (1989) found significant evidence for support of this motivation continuum (see figure 8) in terms of type of motivation for elementary children when engaging in classroom activities such as homework and answering teacher questions.

![Motivation Continuum](image)

**Figure 1.8** Motivation Continuum adapted from Ryan & Deci (2008).

*Autonomy.*

External rewards have been shown to lower intrinsic motivation levels in several different settings, including the academic (Deci, Koestner, & Ryan, 1999; Tang & Hall, 1995; Weiner, 1992). In a meta-analysis of the research, Deci et al. (1999) found significant evidence to suggest that providing extrinsic rewards, such as monetary prizes or other tangible items, for good performance reduced student’s intrinsic desire to complete a task. This was illustrated in several age groups ranging from elementary aged students to college level students. When an extrinsic reward is provided for doing an otherwise intrinsically enjoyable activity, people feel that their behavior is being controlled by the external reward. There is a shift in the locus of control for the
behavior and an internally regulated behavior becomes a purely externally regulated behavior (Deci & Ryan, 2000).

It is not only external rewards that lower an individual’s sense of autonomy, and thus intrinsic motivation to perform a task. Threats, surveillance, evaluation, and deadlines have all also led to a decrease in intrinsic motivation (Amabile, DeJong, & Lepper, 1976; Deci & Cascio, 1972; Harackiewicz, Manderlink, & Sansone, 1984; Lepper & Greene, 1975). These motivational factors shift the locus of control from the internal to the external creating a sense of lack of control within the individual and subsequent loss of interest in performing the task (Deci & Ryan, 2000).

In contrast, research has shown that providing choices and acknowledging individual’s feelings enhanced performance and confidence at tasks, presumably by maintaining an internal locus of control for the task (Deci & Ryan, 2000). An internal locus of control helps to satisfy an individual’s need for autonomy resulting in higher intrinsic motivation and better performance at a task (Deci & Ryan, 2000).

**Competence.**

Early work quickly showed that positive feedback on a performed task enhances intrinsic motivation for the task (Boggiano & Ruble, 1979; Deci 1971) while negative feedback tended to decrease intrinsic motivation (Deci & Cascio, 1972). These results are linked to the need for competence, suggesting that positive feedback provides feeling of satisfaction for correctly doing a task thus encouraging the development of intrinsic motivation for that task (Deci & Ryan, 2000). This connection is only apparent when an individual feels responsible for the correct performance of the task and the positive feedback does not have over shadow the person’s sense of autonomy (Fisher, 1978; Ryan, 1982). Thus, working together if the needs for both autonomy
and competence are met in regard to an activity, an individual will possess a higher level of intrinsic motivation for completing the activity (Deci & Ryan, 2000).

**Relatedness.**

Competence and autonomy have primarily been found as the most influential factors on developing intrinsic motivation (Deci & Ryan, 2000). However, some research does support the role of relatedness on intrinsic motivation. In one experiment, children displayed lower intrinsic motivation when an adult facilitator ignored the child’s attempts to socially engage (Anderson et al., 1976). In other studies, teachers who were warm and caring appeared to be a factor towards the development of intrinsic motivation in students (Ryan & Grolnick, 1986; Ryan, Stiller, & Lynch, 1994). Not all tasks appear to require a strong relatedness support, however a sense of societal security does appear to increase the tendency for the development of intrinsic motivation and innate growth (Deci & Ryan, 2000).

Proponents of SDT (see figure 9) argue that learning environments that encourage the development of student autonomy, relatedness, and competence increase a student’s inclination to develop intrinsic motivation in regards to the course subject (Deci & Ryan, 2000; Vallerand et al., 2008). Students with high levels of intrinsic motivation are categorized as self-regulated learners, possess increased levels of metacognitive awareness, and often outperform peers who are more extrinsically motivated to perform in a course (Baker, 2003; Burton, Lydon, D’Alessandro, & Koestner, 2006; Deci & Ryan, 2000; Guay, 2010; Taylor, Jungert, Mageau, Schattke, Dedic, Rosenfield, & Koestner, 2014).
Overview of Dissertation

Purpose of Project.

The purpose of this study is to explore the impacts of student-centered learning on student motivation and learning through the lens of self-determination theory in an effort to understand the role of student motivation on learning biology. The project stems from a growing interest in *why* student-centered learning environments are so effective in terms of student motivation for learning, performance, and other affective outcomes. The goal of the project is to dichotomize the inner workings of the student-centered learning environment through the lens of self-determination theory in an attempt to explain what makes these learning environments so effective for students. It is hoped that aspects of the findings can then be used to further inform practice and implementation of student-centered learning environments at the undergraduate STEM level.
**Overarching Research Approach.**

This work combines three stand-alone papers that each portray a growing understanding of the impacts of student-centered learning environments on student performance and motivation. The first paper is a mixed-methods explanatory case study examining students’ intrinsic motivation and basic psychological needs satisfaction across three different learning environments using differing amounts of active learning. The second paper is a quantitative analysis of instructor support in the three different learning environments using differing amounts of active learning and how that support impacts student performance, motivation, and other affective variables. The third paper is a comparative mixed-methods case study that examines differences between two different student-centered learning environments and the impact on student performance and motivation. The following sections of this chapter present the overarching research questions for this dissertation, further detail on the three manuscripts included herein, and the theoretical framework through which the findings of the three studies was examined.

**Research Questions.**

The overarching research questions to be explored in this dissertation are:

1. In what ways do student-centered learning environments impact students’ motivation and performance?
2. What differences are there in terms of student performance and motivation between student-centered classrooms conducted in traditional auditorium settings and classes conducted in specialized learning environments like SCALE-UP?
Overview of Chapters.

Chapter 2 (which addressed research question 1) is an explanatory mixed-methods case study that explores the links between students’ basic psychological needs, intrinsic motivation, and their participation in biology courses with varying degrees of active learning. Students completed Likert-style surveys that measure intrinsic motivation for learning biology. This was paired with focus group data that targeted which aspects of active learning were most conducive for promoting student intrinsic motivation and how those aspects aligned with SDT’s three basic psychological needs. Results showed that intrinsic motivation is positively correlated with the degree of active learning used in the classroom. The active learning components identified in the focus groups all related in some way to one of the three basic psychological needs, with the need for relatedness being the most prominent indicating that students most appreciated the social and collaborative aspects of student-centered learning environments. The study provides an explanation for why active learning is effective.

Chapter 3 is a quantitative study that utilized measures of students’ perceived instructor autonomy support and motivation combined with student performance data to examine the effects of student-centered learning on perceived instructor autonomy support and the impacts that autonomy support has on students’ intrinsic motivation, performance, and other affective variables. The work is a continuation of chapter 2 and further addresses research question 1. The study illustrated that instructor autonomy support is higher in student-centered learning environments as compared to classrooms taught in a more traditional manner. Furthermore, instructor autonomy support was shown to be positively predictive of students’ intrinsic motivation, performance, and other affective outcomes such as competence, effort, and value. The study further suggests that student-centered learning environments due to their very design
nurture students’ development of volitional motivation towards learning by providing students with the opportunity to engage in course content meaningfully while being fully supported by instructors whose main role is that of a guide or facilitator of learning.

Chapter 4 is a comparative case study that addresses research question 2 by comparing a student-centered learning environment taught in a traditional auditorium setting (modified lecture) to a student-centered learning environment taught in a specialized physical classroom (SCALE-UP). Classroom observations compared with open-ended student survey responses, and student motivation and performance data were combined to examine differences between the two classrooms. The study suggests that largely there were no differences in the amount of active learning occurring in each of the two class types. However, due to the nature of SCALE-UP collaborative learning and other social interactions were much more prominent than in the modified lecture which was restricted in effectively implementing more socially based forms of active learning. Based on student responses, SCALE-UP students appeared to acknowledge and appreciate the use of collaborative learning and greater access to interactions between their peers and instructors citing these aspects of the classroom as being the most useful to their learning. Due to this difference SCALE-UP students had higher participation scores and higher levels of perceived relatedness or feelings of belonging to a learning community. There were no other differences in terms of performance and student motivation between the two class types. The results suggest that active learning can be effective in any environment provided it is properly implemented, but that specialized classroom environments like SCALE-UP can provide students with additional benefits due to the ease in which collaborative and more social forms of learning can be implemented. The conclusion (Chapter 5) will revisit the original overarching research
questions and use the combined knowledge from the three papers to address them including practical implications and identifying areas for future research.

**Theoretical Framework.**

Examining student performance and motivation through the theoretical perspective of self-determination theory (SDT) could explain increased student performance in student-centered learning environments. SDT is an organismic-dialectic theory that posits that individuals are naturally driven to explore and grow as individuals when placed in a nurturing environment that provides for three basic psychological needs: competence, autonomy, and relatedness (Deci & Ryan, 2000). In an education setting, when these three needs are supported in the classroom students are more likely to internalize their motivations leading to autonomous, self-regulated learning (Deci & Ryan, 1985a). Students who are autonomously motivated and self-regulated are more driven and interested in learning than their more extrinsically motivated counterparts (Deci & Ryan, 2000).

Formally Self-Determination Theory (SDT) is a meta-theory that is comprised of six mini-theories, each of which address a certain aspect of motivation and personality functionality based on the principle that individuals are driven to grow and explore and are supported or thwarted by their environments. The six theories that comprise SDT include: Cognitive Evaluation Theory (CET), Organismic Integration Theory (OIT), Causality Orientations Theory (COT), Basic Psychological Needs Theory (BPNT), Goal Contents Theory (GCT), and Relationships Motivation Theory (RMT) (Ryan & Deci, 2000).

Cognitive Evaluation Theory is primarily concerned with intrinsic motivation, internally driven motivation to perform a task solely for the sake of the task (Deci & Ryan, 2000). CET focuses on the roles competence and autonomy play in supporting the development of intrinsic
motivation. The theory explores the effects of social contexts, such as rewards, as well as ego-involvement, and interpersonal controls on competence and autonomy and the resulting intrinsic motivation for a task (Ryan & Deci, 2000).

Not all motivation that impacts individual performance is purely intrinsic in nature (Deci & Ryan, 2000). Organismic Integration Theory addresses the roles that various types of extrinsic motivation play on an individuals’ behaviors. Specifically, it addresses the various forms of extrinsic motivation, how each form develops, and the impact it has on the individual (Ryan & Deci, 2000). Extrinsic motivation exists on a continuum of internalization. Extrinsic motivations that are more internalized are closer to intrinsic motivation on the continuum result in more autonomous, self-regulated behaviors (Ryan & Connell, 1989).

The type of motivation an individual possesses for any task can be impacted by both their own teleological views and the environment they are in (Deci & Ryan, 2000). Causality Orientations Theory deals with an individual’s view on the cause for changes in their environment and the resultant ways in which they regulate their behavior (Ryan & Deci, 2000). COT identifies three main types of causality orientations: autonomous, controlled, and impersonal/amotivated. Persons who possess an autonomy orientation view themselves in control of their own actions and tend to be motivated by more intrinsic reasons (Deci & Ryan, 2000). The controlled orientation stems from an individual who views actions as being externally controlled and are more focused on extrinsic motivating factors, such as rewards or punishments (Deci & Ryan, 2000). The impersonal/amotivated is the least adaptive of the orientations. The individuals perceive their actions as being controlled by luck or fate and therefore have no interest in regulating their own behaviors (Ryan & Deci, 2000).
Environmental factors can also play a role on an individuals’ motivations and well-being. Basic Psychological Needs Theory specifically addresses three psychological needs (competence, autonomy, and relatedness) and the manner in which the environment either supports or thwarts the meeting of those three needs in individuals (Deci & Ryan, 1985a). Environments that support the three needs result in an inclination for the development of intrinsic motivation and self-regulated behavior, whereas environments that thwart need satisfaction negatively impact an individual’s well-being and result in less internalized motivations (Deci & Ryan, 2008).

Goal Contents Theory addresses the differences between intrinsic and extrinsic goals and their impact on need satisfaction and motivation (Deci & Ryan, 2000). Extrinsic goals, such as rewards, appearance, or outside approval, contradict intrinsic goals and are associated with lesser well-being and lower intrinsic motivation (Deci & Ryan, 2000). In contrast, intrinsic goals, such as personal growth and accomplishment, are linked with higher levels of intrinsic motivation and wellness (Braver, Krug, Chiew, Kool, Westbrook, Clement, et al., 2014, Deci & Ryan, 2000).

The final mini-theory, Relationships Motivation Theory, focuses specifically on the need for relatedness, the forming of close relationships or a sense of belonging to a group. RMT posits that the need for interpersonal interactions is not only beneficial to an individual’s well-being and motivation but may be essential for most people (Deci & Ryan, 2000). High-quality relationships are not only linked with the need for relatedness but have also been shown to satisfy the need for autonomy and competence, though to a lesser degree.

All six of the mini-theories overlap and interact with one another. Environmental factors, an individuals’ goals, and teleological beliefs all interact and contribute to the degree of satisfaction for the three psychological needs of competence, relatedness, and autonomy. The
satisfaction of these three needs then has a direct impact on the internalization of motivations and resultant behaviors. For an in-depth overview and description of the theories see Ryan & Deci (2000), as well as Deci & Ryan (1985, 2000).

Self-determination theory is well suited for this dissertation's goal of examining motivation in student-centered learning environments due to SDT’s emphasis on the environment’s impacts on an individual’s developing motivation. This dissertation draws primarily from CET and BPNS. Classroom environments that support students in their needs for competency, autonomy, and relatedness encourage the development of autonomously motivated students interested in learning material of their own volition. Students who are autonomously driven to learn and participate in class should experience higher levels of overall performance and wellbeing.
References


Chapter 2 Investigating Students’ Intrinsic Motivation for Learning Biology Across Three Different Undergraduate Course Formats

Introduction

Providing an enriched undergraduate classroom environment through the use of active learning allows students to take ownership of their own education and has been found to result in higher student performance, increased levels of engagement, and satisfaction when compared to traditional classrooms (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, et al., 2014; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012). Findings from many studies delineate the value of active learning for enhancing overall performance gains, yet there remains a need to further refine knowledge on why active learning environments are effective for learning (Fairweather, 2008; Freeman et al., 2014). For example, what specific characteristics of the undergraduate active learning environment are integral to student academic successes? An examination of an active learning environment’s impact on student motivations for learning may contribute to addressing part of this question. Consequently, the aim of this research is to examine student intrinsic motivation in three sections of the same introductory biology course taught using differing levels of active learning.

Theoretical Framework.

Motivation drives everything from persistence to performance and plays a direct role in students’ perceptions of themselves as learners (Freeman, Alston, & Winborne, 2008, p 228). Studies on motivation in undergraduate courses have found a large body of evidence to support the link between higher motivation and performance (Hulleman, Godes, Hendricks, & Harackiwiecz, 2010; Klein, Raymond, & Wang, 2006; Linnenbrink & Pintrich, 2002; Schunk, Pntrich, & Meece, 2008; Wilke, 2003). There are several theoretical frameworks that have been
used to examine student motivation in undergraduate STEM courses, chief among them are self-efficacy theory, expectancy value theory, and achievement goal theory (reviewed by Schunk et al., 2008). These theories are all drawn from social cognitive theory (Bandura, 1977), which suggests that individuals actively build perceptions based on learning experiences that then influence effort and performance in the academic setting (Schunk et al., 2008). Each of these theoretical frameworks tend to focus on specific aspects of human motivation as it relates to learning and student experiences. For instance, Hulleman et al. (2010) utilized expectancy value theory to focus on student expectancies and values within a course and the impact these had on performance. One theoretical framework that has not received much attention within undergraduate STEM research is self-determination theory (SDT). SDT is a theory of motivation that specifically concerns itself with the internal development of the individual and how environmental factors thwart or support that development (Deci & Ryan, 2000). This emphasis on the role that the environment plays in motivational development makes it well suited for examining student motivation within active learning environments, and as such, SDT was chosen as the most appropriate framework on which to base this study. There are two main tenets underlying SDT: first, individuals are inherently driven to engage with their environments; and second, individuals possess a natural tendency to integrate and internalize information from the outside world into their own sense of self and psyche (Deci & Ryan, 2012). The external social context plays a direct role on an individual’s behaviors in that it has a direct effect on how they see themselves and their relationship to their environment.

In SDT, motivation is broadly defined as either autonomous or controlled (Deci & Ryan, 1985). Autonomous (self-generated) forms of motivation are generally presumed to be of greater importance to the development of a person’s sense of self and self-regulation of their behaviors
The highest quality type of autonomous motivation is naturally derived from within. Individuals who possess intrinsically driven motivation typically experience the highest success in their endeavors and are considered to be completely self-determined in their behaviors (Braver, Krug, Chiew, Kool, Westbrook, & Clement et al., 2014; Deci & Ryan, 2012). An individual who is intrinsically motivated engages in an activity because of inherent enjoyment, thus increasing the likelihood that they will continue to engage in the activity (Deci & Ryan, 2012). Within an education setting, students who possess high levels of intrinsic motivation are typically self-regulated learners who possess higher metacognitive awareness and performance gains than their peers (Baker, 2003; Burton, Lydon, D’Alessandro, & Koestner, 2006; Deci & Ryan, 2000; Guay, 2010; Taylor, Jungert, Mageau, Schatke, Dedic, Rosenfield, & Koestner, 2014). A recent study at the undergraduate level found that students characterized as high achievers reported higher levels of intrinsic motivation than students characterized as low achievers (Malik & Parveen, 2015). Previous studies have found similar results with levels of intrinsic motivation generally being linked to high performance and well-being in students across all levels of education (Boiché, Sarrazin, Grouzet, & Pelletier, 2008; Leveque, Zuehlke, Stanek, & Ryan, 2004; Ryan, Connell, & Plant, 1990; Wang, 2008).

Intrinsic motivation can either be fostered or thwarted by the external environment (Deci & Ryan, 2008). Individuals experience a natural tendency to integrate external influences and experiences into their own internal motivational landscape, a process known as internalization (Deci & Ryan, 2012). According to SDT, environmental impacts on a person’s intrinsic motivation are mediated by supporting or thwarting three basic psychological needs (competence, autonomy, and relatedness) which are required for positive psychological growth and overall well-being (Deci & Ryan, 2000; Deci & Ryan, 2008) (see figure 1). Social
environments that support individuals’ need for autonomy, competence, and relatedness are most successful at fostering intrinsic motivation (Deci & Ryan, 2008). Autonomy refers to the level of control that an individual perceives to possess over his or her behaviors and successes, while competency is the level of ability that an individual believes they possess for correctly completing a task (Deci & Ryan, 2000). Relatedness is defined as the longing to feel connection with others and be included in a social group (Deci & Ryan, 2000). Active learning classrooms provide for an enriching social learning environment that should support these three needs by providing students with the strategies and guidance to develop autonomy and competence. This learning mode should encourage students to actively engage with course material and take ownership of their own learning, while at the same time providing a strong support network that fosters the students’ sense of relatedness, or belonging, to a close-knit learning community.

**Figure 2.1** Self-determination Theory Model derived from Deci & Ryan (1985). This model illustrates the connection between basic psychological need satisfaction, increased motivation, and increased development in individuals.
Providing choices and acknowledging students’ feelings enhances performance and interest in a task, presumably by maintaining an internal locus of control leading to increases in intrinsic motivation and performance (Deci & Ryan, 2000). In contrast, studies have illustrated that extrinsic rewards, threats, surveillance, evaluations, and deadlines lead to a decrease in intrinsic motivation; because they shift the locus of control from the internal to the external, resulting in decreased autonomy (Amabile, DeJong, & Lepper, 1976; Deci & Cascio, 1972; Harackiewicz, Manderlink, & Sansone, 1984; Lepper & Greene, 1975). Some of the initial studies on intrinsic motivation established that real time, positive feedback on a performed task enhances intrinsic motivation for the task (Boggiano & Ruble, 1979; Deci, 1971); whereas negative feedback has been shown to decrease intrinsic motivation for tasks (Deci & Cascio, 1972). Positive feedback satisfies individuals’ need for competency by providing satisfactory feedback for correctly completing a task (Deci & Ryan, 2000). The link between competency and increases in intrinsic motivation is heavily mediated by the need for autonomy (Deci & Ryan, 2012; Fisher, 1978; Ryan, 1982). An individual must feel responsible for correctly performing a task; otherwise, positive feedback merely results in furthering an external locus of control and decreasing felt competence and autonomy.

Autonomy and competence are considered to be the most influential factors on developing intrinsic motivation (Deci & Ryan, 2000). However, relatedness has been shown to be a factor in several different educational settings. Early experiments showed that children displayed decreased intrinsic motivation for a task when an adult facilitator ignored the child’s attempts to socially engage (Anderson, Manoogian, & Reznick, 1976). Others suggested that students with teachers who are warm and caring possess higher levels of intrinsic motivation than students with less relatable instructors (Ryan & Grolnick, 1986; Ryan, Stiller, & Lynch,
1994). To a certain degree, a student’s sense of relatedness is directly tied to their relationships with instructors and peers.

**Research Focus and Research Questions.**

The first part of this study aims to explore levels of intrinsic motivation as measured by students’ interest/enjoyment, perceived competence, and perceived choice in three different introductory biology course formats: 1) a traditional teacher-centered lecture course, 2) a modified lecture course that is more student-centered than traditional lecture, and utilizes several active learning pedagogies, and 3) SCALE-UP (Student-Centered Active Learning Environments with Upside-down Pedagogies), a classroom environment specifically designed to be student-centered that relies primarily on active learning pedagogies. The second part of the study further investigates students’ basic psychological needs satisfaction and how it relates to their intrinsic motivation in active learning settings by analyzing student responses in the learning environment with the highest level of active learning, the SCALE-UP section.

The study addresses the following research questions:

1. How do the perceived levels of interest/enjoyment, perceived competence, and perceived choice differ between introductory biology students in learning environments with differing levels of active learning?

2. Do students’ perceptions of factors affecting their performance and intrinsic motivation in an introductory biology SCALE-UP section conform to SDTs three basic psychological needs?

It was hypothesized that students in classroom environments utilizing the highest amount of active learning would report the highest levels of intrinsic motivation via higher levels of interest/enjoyment, perceived competence, and perceived choice, as compared to students in
learning environments with moderate to no active learning. In addition, factors identified by SCALE-UP students as having a positive effect on their performance and intrinsic motivation were anticipated to align with one of the three basic psychological needs ascribed by SDT.

**Methods**

To address the research questions, this study utilized a quasi-experimental, explanatory mixed-methods design (Creswell, 2012) for examining students’ intrinsic motivation in three sections of a biology course at a large southeastern university each with three different teaching methods: traditional, modified, and SCALE-UP. To measure intrinsic motivation, quantitative measures were obtained for students’ interest/enjoyment, perceived competence, and perceived choice in each of the three course formats. This was combined with classroom observations to connect levels of active learning in each of the three course formats with students’ intrinsic motivation. Following this analysis, two focus groups were conducted with the SCALE-UP format, the format with the highest levels of active learning, to explore student perceptions of factors affecting their motivation and performance in the class. The purpose of the focus group was to explore how well student responses aligned with the three needs for autonomy, competence, and relatedness.

The introductory biology course being examined was comprised of lecture and a required laboratory component. The course was the first part of a two-part introductory biology sequence and covered topics in ecology, evolution, and biodiversity. The students enrolled in the course were primarily freshman students majoring in the life sciences. The current study examined only the lecture component of the course and students were not asked to report about their perceptions regarding the laboratory component. Data was collected from three concurrent sections of the
course each using a different instructional method: traditional lecture (245 student seats),
modified lecture (245 student seats), and SCALE-UP (96 student seats).

The traditional lecture was taught in a large auditorium lecture hall by an experienced
faculty member who often received very positive reviews on student evaluations and has
received the highest recognition for achievement in teaching. The modified lecture was
conducted in the same auditorium style classroom as the traditional lecture, however, it was
taught by an experienced faculty member well-versed in active learning pedagogies. The course
included several active learning components utilized throughout the semester that were modified
to work well within the auditorium style setting. The SCALE-UP section was taught by the same
instructor who taught the modified section; however, it occurred in a room designed specifically
as an active learning environment, in which students work collaboratively at round tables to
complete in-class tasks while an instructor circulates to assist students with their learning.
SCALE-UP students spend their out-of-class time exploring basic background material and focus
on extending knowledge through collaborative, problem-, model-, and case-based learning
during in-class time. This format changes the traditional view of the classroom by placing
students at round tables facing one another with no clear or delineated “front of the room.”
Instructors move around the class assisting students and spend little to no time lecturing. The
format has proven a successful example of an active learning environment for a variety of
subjects, including biology, across the country (Beichner, 2008; Foote, Neumeyer, Henderson,
Dancy, & Beichner, 2014).

Data Collection and Analysis.

To establish the amount of active learning occurring in each of the three sections the
Classroom Observation Protocol for Undergraduate STEM (COPUS) (Smith, Jones, Gilbert, &
Wieman, 2013) was utilized to observe each class for a total of one week (150-minute student contact time). The traditional lecture section met three times a week for 50 minutes, while the modified lecture and SCALE-UP sections each met two times a week for 75 minutes. Each section was observed during the same academic week and was covering the same material. Two individuals observed the courses to ensure reliability. The inter-rater reliability score for the two observers was calculated using Cohen’s kappa (κ). COPUS is a structured classroom observation protocol that utilizes a series of codes to characterize student and instructor behavior in 2-minute intervals for the duration of the class. There is a total of 25 codes in two separate categories, one for what the students are doing, and one for what the instructor is doing. Since its development, COPUS has been used successfully in several studies to assess and characterize undergraduate STEM courses. For instance, Connell, Donovan, & Chambers (2016) used the instrument to characterize the use of student-centered pedagogies in two biology classrooms in their study examining the impact of increased student-centered pedagogies on student learning and attitudes about biology.

To measure students’ intrinsic motivation and perceptions regarding their learning, student responses were collected through a validated survey tool and focus groups in compliance with Internal Review Board guidelines. Measures were obtained utilizing a quasi-experimental comparison design. Students self-selected which course section they enrolled in prior to the start of the semester; however, they were blind with regard to the teaching format of each section (traditional, modified, or SCALE-UP). A total of N=482 students (n=183 for traditional, n=207 for modified, and n=92 for SCALE-UP) from the three different sections volunteered to complete the Intrinsic Motivation Inventory (IMI) using an online survey tool during the last week of the course, prior to the final exam. There were no significant differences between those
students who chose to volunteer and those who did not. To encourage responses that were forthright, students were assured that their responses would remain anonymous, would not be accessed by the investigator until after the end of the course, and that course instructors would not have access to students’ responses. Sample sizes were not equal in each section due to differences in class size between the auditorium sections (240 seats) and the SCALE-UP section (96 seats), as well as the voluntary nature of the survey. Although convenience sampling does not ensure the sample is representative of the target population, it was deemed to be the most effective method of data collection for this population of students (Creswell, 2002).

Survey Instrument.

The IMI (See Appendix A) is a multidimensional instrument designed to assess individual personal experiences during a task (McAuley, Duncan, & Tammen, 1989), and has been used successfully in a wide variety of research fields including education (see Monterio, Mata, & Peixto, 2015). For the purposes of this study, the introductory biology course was considered “the task.” The IMI scale is comprised of six individually validated subscales that assess participants’ interest/enjoyment, perceived competence, effort, value/usefulness, pressure/tension, and perceived choice. The subscales were designed to be implemented individually or in any combination without negatively impacting validity. Each subscale is composed of a series of both positive and negative seven-point Likert-style items with one being not true at all, four being somewhat true, and seven being very true. The items were modified slightly to refer to the introductory biology course. This study utilized three of the subscales: interest/enjoyment subscale, perceived competence, and perceived choice. The interest/enjoyment subscale is composed of 7 items and was utilized as a direct measurement for intrinsic motivation (Montero, Mata, & Peixto, 2015). Examples items include “I enjoyed taking
this course very much” and “This course did not hold my attention at all” (reverse coded). Both
the perceived competence scale and the perceived choice scale are considered to be positive
predictors of intrinsic motivation (Monterio, Mata, & Peixto, 2015) and are can be used as direct
measures of two of the basic psychological needs: competence and autonomy. At the time of the
this study a tested and reliable subscale for relatedness was not included in the IMI. Given this,
plus research suggesting that competence and autonomy are both considered the two most
important of the three needs (Deci & Ryan, 2000) a measure for relatedness was not included in
this study. The perceived competence scale is composed of six items. Example items include “I
think I was pretty good at taking this course” and “this was a course I couldn’t do very well in”
(reverse coded). The perceived choice scale is composed of seven items. Example items include
“I felt like it was my own choice to complete this course” and “I took this course because I had
to” (reverse coded).

**Statistical Analysis.**

Cronbach’s alpha was calculated for all three scales to ensure the validity for the
population being studied. One-way ANOVAs were utilized to determine whether there were
significant differences in students’ responses on the scale, based on the course types. Levene’s
tests were conducted for equality of variances to account for the non-parametric state of the data
(Field, 2013). Post-hoc testing was used to deconstruct differences between the three course
formats. Effect sizes for mean differences were calculated using Cohen’s \(d\) (Cohen, 1988). A
Cohen’s \(d\) value of greater than 0.2 represents a small effect size, greater than 0.5 to represents a
medium effect size, and greater than 0.8 to represent a large effect size.
Focus Group Analysis.

After analysis of the IMI, the SCALE-UP section was selected for further exploring the link between intrinsic motivation and basic psychological needs satisfaction in an active learning environment. Due to the difficulty in recruiting and finding a mutually acceptable time to schedule the focus group session, two semi-structured focus group sessions lasting approximately twenty minutes each were conducted. Volunteers from all students in the SCALE-UP section were recruited via email towards the end of the semester. Seven first year students (representing 7% of the whole class) who majored in life sciences or planned to declare the major responded, chose to take part in the study, and self-identified their gender, race/ethnicity, and major. Five attended the first session (2 male; 3 female) and two attended the second (2 female, 1 URM). The demographics of the volunteers (71% female, 29% male, 86% Caucasian, 14% URMs, 100% freshman class standing) broadly mirrored the demographics of the SCALE-UP section (67% female, 33% male, 73% Caucasian, 27% URMs, 92% freshman, and 8% other class standing).

Prior to the start of both focus group sessions, students were given copies of the focus group protocols (See Appendix B) and a consent form (See Appendix C). The talking points in the sessions focused on the participants’ intrinsic motivations (if any) for learning introductory biology and the role of the active learning format on their intrinsic motivation and learning. After the session, transcripts for each focus group were transcribed verbatim. Data was coded and analyzed using methods similar to Moran, Russinova, Yim, & Sprague (2013). An inductive process of multiple rounds of open coding was used to identify emergent codes, followed by a second deductive process which utilized a self-determination perspective to arrange emergent codes according to the three psychological needs for autonomy, competency, and relatedness.
(three themes). For example, the student statement “I’m actually able to connect with other students” was coded as a ‘peer interaction’ and placed under the ‘relatedness’ theme. Two coders examined the transcripts independently and achieved an inter-rater reliability score of 87.8%, scores higher than 70% are considered to be an acceptable measure of reliability. All codes were organized and compiled into a code book for data analysis.

To ensure trustworthiness of the study, peer checking was utilized for the focus group protocol. In addition, during the focus groups, the interviewer (first author) utilized active listening techniques to ensure understanding of student comments and responses. It should be noted that the investigator for this study was a graduate teaching assistant in SCALE-UP when the study was completed. This provided a unique advantage as an observer in the study, but also presented the possibility for data collection bias as focus group participants may have been hesitant to share negative views of SCALE-UP with their teaching assistant. Every precaution was taken to mitigate these biases during the focus groups. Students were assured that their responses would remain anonymous and have no effect on their grade. They were also assured that as an assistant instructor, the investigator would have no input on final grades and that nothing revealed in the study would be available to the main instructor of the course until after final grades were submitted.

**Results**

**COPUS Analysis.**

Analysis of the classroom observations revealed stark contrasts between the three sections for both instructor and student behavior (see figures 2 and 3). Cohen’s kappa (κ) showed high agreement between the two classroom observers, κ=.833, p<.0005. The traditional lecture was largely dominated by lecturing by the instructor and passive listening by the students. Some
didactic questioning was minimally interspersed throughout the class time. It should be noted that the instructor did ask students if they had any questions regularly during the lecture period. The students never responded. Question and answer periods noted on the graph specifically refer to the instructor posing a question regarding the material to the students and then selecting a student to answer the question.

In stark contrast, most of the time observed in the SCALE-UP classroom was dedicated to collaborative group work with the instructor circulating the room and spending one-on-one time with different groups of students. Minimal lecturing and clicker questions make up the bulk of the rest of the time. The modified lecture resembles a mixture of the two modalities with a smaller amount of student group activity work with consequent instructor behavior than SCALE-UP and a smaller amount of instructor lecturing and consequent student behavior than the traditional lecture.

**Figure 2.2** Observed instructor behaviors during 150 minutes of classroom observation using the COPUS protocol.
Figure 2.3 Observed student behaviors during 150 minutes of classroom observation using the COPUS protocol.

**Intrinsic Motivation Inventory Analysis.**

Analyses of the three motivational scales suggest that students in course formats utilizing active learning techniques possess higher levels of interest/enjoyment and perceived choice for learning biology at the end of the semester than their counterparts in the traditional lecture format. The Chronbach’s alpha values for the three scales (α=.95, α=.93, and α=.85 respectively) were well within an acceptable range for the scale when calculated using the entire sample (N=485) indicating the scales are reliable and an adequate measurement of the motivational factors being measured. Significant differences were found between all three course types for the interest/enjoyment scale and perceived choice, but not perceived competence (See table 1 for descriptive statistics and table 2 for ANOVA results).

Levene’s test was non-significant for both the interest/enjoyment and perceived choice scale making Tukey’s test appropriate for post-hoc analysis. Post-hoc analysis for the
interest/enjoyment scale (see table 3) showed a significant difference between traditional lecture and both active learning course types, as well as a significant difference between the modified lecture and SCALE-UP. Compared to the traditional lecture, levels of interest/enjoyment in the modified lecture were about one quarter standard deviation higher ($d=.25$) representing a small effect size, while levels in SCALE-UP were slightly less than two-thirds a standard deviation higher ($d=.61$) representing a medium effect size. Post-hoc analysis for the perceived choice scale (see table 3) showed a significant difference between SCALE-UP and the other two modalities, but no differences were found between the traditional lecture and the modified lecture. Compared to the traditional format, perceived choice values were about two-thirds standard deviation higher ($d=.63$) in SCALE-UP and compared to the modified format perceived choice values were about two-fifths higher ($d=.43$) both representing a medium and a small effect size respectively.

Table 2.1 Descriptive Statistics for IMI sub-scales.

<table>
<thead>
<tr>
<th>Course Type</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interest/Enjoyment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>92</td>
<td>5.009</td>
<td>1.340</td>
<td>.1397</td>
</tr>
<tr>
<td>Modified</td>
<td>207</td>
<td>4.536</td>
<td>1.456</td>
<td>.1012</td>
</tr>
<tr>
<td>Traditional</td>
<td>183</td>
<td>4.163</td>
<td>1.430</td>
<td>.1057</td>
</tr>
<tr>
<td>Total</td>
<td>482</td>
<td>4.484</td>
<td>1.454</td>
<td>.0662</td>
</tr>
<tr>
<td><strong>Perceived Choice</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>92</td>
<td>4.801</td>
<td>1.381</td>
<td>.1439</td>
</tr>
<tr>
<td>Modified</td>
<td>207</td>
<td>4.572</td>
<td>1.414</td>
<td>.0983</td>
</tr>
<tr>
<td>Traditional</td>
<td>183</td>
<td>4.460</td>
<td>1.393</td>
<td>.1030</td>
</tr>
<tr>
<td>Total</td>
<td>482</td>
<td>4.573</td>
<td>1.402</td>
<td>.0639</td>
</tr>
<tr>
<td><strong>Competence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>92</td>
<td>4.058</td>
<td>1.402</td>
<td>.1462</td>
</tr>
<tr>
<td>Modified</td>
<td>207</td>
<td>3.440</td>
<td>1.441</td>
<td>.1002</td>
</tr>
<tr>
<td>Traditional</td>
<td>183</td>
<td>3.210</td>
<td>1.301</td>
<td>.0962</td>
</tr>
<tr>
<td>Total</td>
<td>482</td>
<td>3.470</td>
<td>1.412</td>
<td>.0643</td>
</tr>
</tbody>
</table>
Table 2.2 One-way ANOVA results for IMI Sub-scales.

<table>
<thead>
<tr>
<th>Interest/Enjoyment</th>
<th>df</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>2</td>
<td>11.08</td>
<td>.001*</td>
</tr>
<tr>
<td>Within Groups</td>
<td>479</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>481</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Competence</td>
<td>2</td>
<td>1.82</td>
<td>.164</td>
</tr>
<tr>
<td>Between Groups</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>479</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>481</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived Choice</td>
<td>2</td>
<td>11.60</td>
<td>.001*</td>
</tr>
<tr>
<td>Between Groups</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>479</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>481</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2.3 Post-hoc analysis for significant IMI Sub-scale measures using Tukey HSD test.

<table>
<thead>
<tr>
<th>Interest</th>
<th>SCALE-UP</th>
<th></th>
<th>Std. Error</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>SCALE-UP</td>
<td>Modified</td>
<td>.179</td>
<td>.023*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traditional</td>
<td>.182</td>
<td>.000*</td>
</tr>
<tr>
<td>Modified</td>
<td>SCALE-UP</td>
<td>.179</td>
<td>.023*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traditional</td>
<td>.145</td>
<td>.027*</td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>SCALE-UP</td>
<td>.182</td>
<td>.000*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modified</td>
<td>.145</td>
<td>.027*</td>
<td></td>
</tr>
<tr>
<td>Perceived</td>
<td>SCALE-UP</td>
<td>Modified</td>
<td>.173</td>
<td>.001*</td>
</tr>
<tr>
<td>Choice</td>
<td></td>
<td>Traditional</td>
<td>.177</td>
<td>.001*</td>
</tr>
<tr>
<td>Modified</td>
<td>SCALE-UP</td>
<td>.173</td>
<td>.001*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Traditional</td>
<td>.140</td>
<td>.231</td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>SCALE-UP</td>
<td>.177</td>
<td>.001*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modified</td>
<td>.140</td>
<td>.231</td>
<td></td>
</tr>
</tbody>
</table>

Focus Group Analysis.

Analyses yielded three main themes that conformed to the three basic psychological needs of SDT, under which nine emergent subthemes were identified (Table 2). Participant comments in line with the need for relatedness were the most prominent, while comments in line with the need for autonomy were least prominent. Most participant comments regarding factors affecting learning performance and intrinsic motivations for biology were primarily related to
peer-peer and student-instructor interactions, closely followed by specific active learning strategies utilized within the SCALE-UP classroom.

Table 2.4 Themes and Subthemes of focus group participants’ motivation for learning biology.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Subthemes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomy</td>
<td>Active learning</td>
</tr>
<tr>
<td>Competence</td>
<td>Lack of confidence when alone</td>
</tr>
<tr>
<td></td>
<td>Learning confidence in SU</td>
</tr>
<tr>
<td></td>
<td>Learning strategies</td>
</tr>
<tr>
<td></td>
<td>Physical environment</td>
</tr>
<tr>
<td>Relatedness</td>
<td>Connection with instructor</td>
</tr>
<tr>
<td></td>
<td>Gaining different perspectives</td>
</tr>
<tr>
<td></td>
<td>Help from peers</td>
</tr>
<tr>
<td></td>
<td>Peer interaction</td>
</tr>
</tbody>
</table>

**Autonomy Need Satisfaction.**

The only subtheme identified with the need for autonomy was active learning practices that placed emphasis on students being active meaning makers in their own learning. Students attributed their performance to student-centered teaching practices such as problem-solving, case studies, and modeling activities, for example, that provided them with a sense of ownership or autonomy over their own learning.

“I think [the instructor] tells us about it [course material], and then we work directly with it. You don’t sit there and get talked at.”
Other instances of the active learning code involved students taking initiative within their own studying. One student mentioned actively using study guides and other course materials to improve upon their own learning: “I take those and study what I missed and that usually helps out.”

**Competency Need Satisfaction.**

Several themes emerged that fit within the category of competency. Students felt they were better able to learn material due to the social aspects of active learning and did not feel confident in their abilities to learn as much on their own. They also attributed their learning confidence to active learning pedagogies and available classroom amenities within SCALE-UP.

“I just feel like since we are so interactive, and [the instructor] gives us these guided notes, it just makes it so much easier to come to class and learn it, because it is there and it’s making it easier for you to learn it.”

“I go to take the practice test and I realize I understood a lot more than I thought I did, which is different for me.”

Several students attributed some of their learning successes to the use of classroom amenities such as whiteboards and computers when completing assignments. Students also commented on their lack of learning confidence when alone and cited the example of a lecture setting: “if it is individual then you’re just like…I think I get a little stressed out whenever it’s just me by myself…because I think this way, but everyone else might think the exact opposite way and they are correct and I’m wrong.” All of the participants felt that they would have been less successful at introductory biology in a traditional lecture style course.
**Relatedness Need Satisfaction.**

Most of the emergent subthemes matched to the psychological need for relatedness. The subthemes fell into two broad categories, those that fit with student-instructor interactions, and those that fit with student-student interactions. Students felt they gained instructional value from the relationships they were able to develop both with their instructor and their peers. They found their peers useful when they felt they needed help with course material and thought that it was good to have access to multiple perspectives during class time. Students found the most value in being placed within groups and having the group structure to rely on throughout the semester.

“…you might not always see what someone else is seeing in the problem and you learn how to see it in a different way.”

“…you actually get more connection with them [group members] and you actually are able to benefit off of their thoughts.”

Participants found that they could gain different perspectives by interacting with group members, achieve external validation of their own thoughts and ideas, and form a learning community that they then utilized throughout the semester. When asked if they thought this sense of community would be the same in a lecture setting, they all answered in the negative, citing examples of cramped seating, a decreased chance to meet people, and a lack of group activities.

**Discussion**

This study was novel in several key ways. It investigated intrinsic motivation of students in three different introductory, college level biology course types each utilizing varying amount of active learning.
**Active Learning and Intrinsic Motivation Across Three Course Formats.**

There were distinctly different levels of active learning occurring in the three different course formats and these levels correlated positively with students’ interest/enjoyment which in this study was used as a direct measure of students’ intrinsic motivation. Intrinsic motivation for learning biology was higher for students in learning environments with moderate to high levels of active learning as compared to those with little-to-no active learning. This finding indicates that the degree of active learning mattered for students’ intrinsic motivation. In the modified lecture, students expressed significantly higher levels than did students in the traditional lecture format. Furthermore, students in the SCALE-UP section reported significantly higher intrinsic motivation than did those students in the modified lecture class. These results give a more nuanced understanding of the effects of the degree of active learning rather than simply a comparison between traditional and modified lecture, or SCALE-UP as compared to traditional instruction. In addition, unlike studies that have documented that students in active learning environments are more engaged and satisfied with their introductory STEM courses (e.g. Gasiewski et al., 2012; Pascarella & Terenzini, 2005), or that students in traditional lectures were bored and unengaged (Wilke, 2003), this study used a comparison of all three formats. Intrinsic motivation values varied directly based on the amount of active learning occurring in the classroom with SCALE-UP being highest and traditional lecture being lowest. This provides strong evidence that the amount of active learning utilized in a classroom impacts student intrinsic motivation and potentially performance.

Quantitative findings also indicate that the amount of active learning positively correlates with perceived choice, a direct measure of autonomy, and a positive predictor of intrinsic motivation (Deci & Ryan, 2000). However, this effect was only seen in the SCALE-UP format.
and not in the modified lecture perhaps suggesting that perceived choice only differs in learning environments with much higher levels of active learning than would be expected in a traditional format or perhaps the effects on perceived choice can be attributed to the specialized physical environment of the SCALE-UP classroom and the high degree of collaborative and student-centered work that environment facilitates as seen in the COPUS results. This taken in conjunction with the lack of differences found in the perceived competence values suggests that differences in interest/enjoyment and by proxy intrinsic motivation between the three course formats may not entirely be attributed to the needs for competence and autonomy and may instead rely on differences in perceived relatedness which was not measured in this study or some other factor that the self-determination theory does not account for. The qualitative findings of this study were used to continue exploring this idea.

**Student Perceptions of Active Learning in SCALE-UP.**

Participants felt that active learning practices had a positive impact on their performance and intrinsic motivation in regard to introductory biology in SCALE-UP. All participants unanimously agreed that they enjoyed the SCALE-UP format preferring it to other lecture based courses, corroborating the results of the interest/enjoyment subscale of the IMI. None thought they would enjoy learning the material more if they had been placed in a lecture section of introductory biology. One participant stated, “there have been classes that I have taken in the past in lecture halls, and even though I enjoyed the material…it was tough for me to sit through class and really pay attention because it was a lecture hall.” Participants also attributed the amount of material learned in the class to the format and felt that their learning would be diminished if they had been placed in a lecture section. One student commented, “in a lecture hall, I think you are so focused on getting the notes down that you don’t have time to learn.”
Student comments on the impact of active learning on their intrinsic motivation and performance in introductory biology aligned with the three basic psychological needs of SDT. Students felt that active learning techniques, such as case studies and modeling, allowed them the chance to actively participate in their own learning. Active learning involves the student becoming an active participant in the learning process (Freeman et al., 2014). They are not passively sitting and listening to a lecture, but rather actively engaging in the course material. In this way it is understandable that they begin to develop a sense of autonomy and ownership regarding their work in class.

Active engagement with the course material also provided students with an increased sense of confidence in their learning abilities. Many claimed that their performance in the course would not have been as high if they had been placed in a lecture section. Active learning is situated within a constructivist theoretical viewpoint (Freeman et al, 2014). By having students actively work with the course material they are building meaning for themselves, rather than simply memorizing facts. This allows for a better understanding of course material and consequently higher levels of confidence in their learning abilities, supporting the students’ need for competence and further enhancing intrinsic motivation for learning biology (Deci & Ryan, 2000).

Most of the participant comments in the focus groups aligned with the need for relatedness with their peers and instructors. Similar to Ryan et al. (1994), participants reported an appreciation for connection with their instructors in the course and cited this relationship as one of the reasons for their successes and enjoyment. Participants noted the lack of this relationship with other instructors in lecture based courses. Often, active learning practices are collaborative in nature, stemming from a social constructivist (Vygotsky, 1978) viewpoint. Students in the
classroom actively work together and share responsibility for learning. Unlike traditional passive formats, active learning allows for more one-on-one time for students with their instructors and peers providing for the development of a much richer relationship than would be possible in a traditional lecture setting. The apparent importance of the relatedness need is in contrast to previous research that places more emphasis on the needs for competence and autonomy (Deci & Ryan, 2000). However, similar results in an education study examining motivational support of online mentors suggests that relatedness support may be playing a much larger role in an educational setting than previously thought (Freeman, Anderman, & Jensen, 2007; Scogin & Stuessy, 2013), especially in educational settings like active learning environments where there is large emphasis on social interaction.

Conclusions

This study supports the assertion that students’ intrinsic motivation levels are highest in undergraduate biology classroom environments that utilize active learning techniques. In fact, it provides evidence that the degree of active learning is important for developing students’ perceptions of interest/enjoyment for learning biology. In combination with previous studies that link intrinsic motivation levels and student performance (Malik & Parveen, 2015), these findings provide a plausible explanation for larger learning gains found in active learning environments. Furthermore, findings from the SCALE-UP focus groups support the self-determination model of motivation as a valid framework (Deci & Ryan, 2000) to explain performance and intrinsic motivation increases observed in active learning environments (Freeman et al., 2014). Learning environments must provide students with the opportunities to be autonomous in their learning, develop a sense of competency for course material, and provide for the creation of social relationships in order to support students in becoming proficient, self-regulated learners.
Students’ responses suggest that they place the most emphasis on aspects of the active learning environment that most align with the needs for relatedness and competence. That is not to say that the need for autonomy is not being met in the active learning classroom. Environments that support the need for autonomy of learners can increase need satisfaction for relatedness and competence (Deci & Ryan, 2012). An instructor that supports student autonomy is perceived as being more open to student opinion, and therefore, more relatable. An environment that encourages student autonomy can lead to increased self-confidence with respect to learning abilities. It follows that factors in an active learning environment that support autonomy mediates factors related to competence and relatedness, as students’ comments seem to indicate.

Future research should focus on broadening these findings by conducting further focus groups with more diverse learners from different course structures beyond the SCALE-UP model, and incorporating other measures of motivation and performance to further explore the link between basic psychological needs satisfaction, intrinsic motivation, and student performance within undergraduate STEM active learning environments. Discovering further support for the use of a self-determination framework to model active learning environments could prove beneficial in aiding efforts for promoting active learning practices in undergraduate STEM programs.

There were several limitations in the design of this study, such as the use of self-reported data. Self-report values can be subject to bias; however, several actions were taken to limit bias in student responses. High Cronbach’s alpha values ensured internal consistency for all three scales (Gay, Mills, & Airasian, 2006). In addition, the use of an odd point scale gives students the option to select a neutral response removing the pressure of choosing one side or the other if the student is unsure. The method has been shown to limit response bias in past research.
(Femandez & Randall, 1991). Finally, both positively and negatively worded items were used in all three scales to limit response bias (Nunnally, 1978; Spector, 1992). Negatively worded items act to capture students’ attention when completing the survey limiting the chance that the student will skim and automatically select responses as they progress through the survey (Chen, Dedrick, & Rendina, 2007).

In addition, there is valid concern that the perceived choice scale may have been worded poorly given that all items in the scale refer to a choice in taking the ‘course’ which is a required component of the curriculum for all life sciences majors. In this sense, the students did not in fact have a choice in taking the course. However, the SCALE-UP students did report significantly higher values for the perceived choice scale than the other two formats. This suggests that even though the course was a required component, the students still perceived that they had some choice in taking the course and that perception of their own choice was higher than the other two formats. The survey was given at the end of the course so perhaps SCALE-UP students were not thinking of the fact that they were required to take the course when completing the survey or perhaps some component of the SCALE-UP course did influence their perception of their own choice in taking the course. Regardless, future studies utilizing the perceived choice scale should consider rewording the scale to refer to ‘the work’ in the course instead of the ‘course’ itself.

There is also a possible bias due to the fact that one instructor taught both active learning formats, while another taught the traditional lecture format suggesting that differences in data could be attributed to the instructor rather than course format. These three sections were taught by highly successful and awarded faculty members, and the students in each of the sections participated at a high rate. Thus, the findings point to the course format rather than instructor effects. Furthermore, differences in results for intrinsic motivation between the two active
learning formats (taught by the same instructor) do lend credence to the data. While it is almost certain that instructor attitudes play a role in the development of intrinsic motivation and basic psychological need satisfaction (Deci & Ryan, 2012), our results indicate that pedagogical methods are also a large factor. The modified lecture and SCALE-UP section were taught by the same instructor, yet SCALE-UP students reported higher levels of intrinsic motivation than those enrolled in the modified section.

Focus group data was limited only to the SCALE-UP section due to resource constraints and finding a mutual time for meeting, resulting in a low number of volunteers. However, the demographics of the students that volunteered did roughly match the demographics of the entire section suggesting they were an accurate representation. Furthermore, due to scheduling issues two focus group sessions were held and there were no major differences found between the two. It would be beneficial to obtain more student opinions and have more time to adequately discuss student viewpoints. Lastly, SCALE-UP as a learning model relies on a highly specialized physical classroom environment and is only one example of an active learning space. Results from the focus groups are not to be generalizable to other active learning models, but rather provides an interesting perspective for the findings of this study. Further studies will be needed to corroborate findings that make connections between intrinsic motivation and student successes in varying types of active learning environments.

Aside from these limitations, the present study provides exciting new insights into the positive impact of active learning environments on student intrinsic motivation in undergraduate STEM classrooms. Previous studies have found strong links between motivation and performance (Hulleman et al., 2010; Klein et al., 2006; Schunk et al., 2008) as well as higher performance and active learning environments (Freeman et al, 2014). Our research begins to
bridge the gap between these findings and suggests that higher performance in active learning environments can be attributed at least in part to higher levels of intrinsic motivation.
References


Chapter 3 Exploring Instructor Autonomy in Three Introductory Biology Classes Utilizing Differing Amounts of Student-Centered Learning

Introduction

Active learning instructional practices are becoming more commonplace in undergraduate STEM courses thanks to a growing body of research illustrating the positive benefits to students (see Freeman et al., 2014) and several national calls for reform that emphasize the development and use of active learning practices (National Research Council, 2003, 2012; American Association for the Advancement of Science, 2011). Active learning pedagogies fall under the umbrella of student-centered, meaning that the focus of teaching is placed on the student rather than on the teacher, giving students a more active voice in the learning process (Freeman et al., 2014). The instructor becomes a guide whose main job is to facilitate learning utilizing student-centered instructional practices that result in higher student performance and learning outcomes as demonstrated by Freeman et al. (2014) meta-analysis. Other works continue to report successes in improving student performance through student-centered learning practices (e.g. Cleveland, Olimpo, & DeChenne-Peters, 2017, Eichler & Peeples, 2016, Rodriguez, 2016, Ryan & Reid, 2015), yet there are few studies that have examined the impact of student-centered teaching practices on affective variables. One example would be Jeno et al.’s. study (2017), which found that the utilization of team-based learning resulted in significant increases in students’ intrinsic motivation and competence. There are other studies that report similar findings regarding student motivation in courses that implement student-centered pedagogies (Cleveland, Olimpo, & DeChenne-Peters, 2017; Jeno, Grytnes, & Vandvik, 2017; Olimpo, Fisher, & DeChenne-Peters, 2016).
Student-centered instructional practices derive from constructivist theory which argues that students construct their own understanding of the world based on interactions between their prior experience and the learning experience (Piaget, 1973; Vygotsky, 1978). Students may enter the classroom with misconceptions based on prior knowledge. It then becomes the instructor’s job to scaffold the students’ learning experiences so that they can recognize these misconceptions and replace them with newly constructed understandings. Instructors must be able to properly support the students throughout this learning process by helping them reconstruct their knowledge without undermining the constructed understanding of the world around them. Student-centered learning places the student in a more autonomous position in which the student mediates the learning process by determining and accomplishing their own learning goals. It then becomes the instructor’s role to support that process rather than dictate or micromanage student learning (Dochy, Segers, Van den Bossche, & Gijbels, 2003).

Often students placed in student-centered environments may be unprepared for their new role as autonomous meaning-makers, having been accustomed to playing a more passive role in traditional teacher-centered classrooms (Kember, 2001; Reeves, 2006). To address this issue, constructivist learning approaches, such as student-centered learning environments, must be extensively scaffolded as a means to support the student through the learning process (Schmidt, Loyens, Van Gog, & Paas, 2007). One study examined student-centered learning across several different institutions and included instructors who ranged in their knowledge to successfully implement student-centered learning (Andrews, Leonard, Colgrove, and Kalinowski, 2011). Their overall findings suggested that there were no overall student learning gains when instructors, who despite claiming to use student-centered learning in their classrooms, lacked the pedagogical knowledge to implement the pedagogy successfully. The study does not provide
evidence that student-centered instructional practices are not successful, which has been clearly demonstrated by Freeman et al. (2014), but instead highlights the importance of the role the instructor plays in successfully implementing the student-centered environment.

In order for students to be successful in any learning environment the instructor must support and nurture the students’ sense of autonomy and volition regarding their own learning (Jang, Reeve, & Deci, 2010; Reeve, 2006). Instructors who correctly utilize student-centered learning with proper scaffolding provide the appropriate supportive environment for students to succeed (Reeve, Jang, Carrell, Jeon, & Barch, 2004; Sierens, Vansteenkiste, Goossens, Soenens, & Dochy, 2009). In contrast, students in traditional large lecture classrooms may not have as many opportunities for autonomy over their learning due to the teacher-centered nature of instruction in these settings. This present study utilizes the theoretical framework of self-determination theory to evaluate the impact of instructor support on student motivation, performance, and behavioral outcomes in a traditional lecture course and two different course formats that successfully implement student-centered teaching practices.

**Self-Determination Theory.**

Self-determination theory (SDT) posits that motivation can broadly be broken down into two categories: controlled and autonomous. Behaviors that are autonomous are driven from an internal perceived locus of causality (deCharms, 1968), are perceived as completely voluntary, and are supportive of personal growth, performance, and overall wellbeing (Deci & Ryan, 2000). By comparison, controlled forms of motivation are perceived as being generated from an external force such as coercion from figures of authority or feelings of guilt or self-worth associated with completing a task (Ryan, 1982).
Intrinsically motivated behaviors are fully derived from within and are the prototype for autonomous behaviors (Deci & Ryan, 2000). Individuals who are intrinsically motivated to complete a task do so because the task is enjoyable in and of itself. However, not all tasks are inherently enjoyable to complete, thus, extrinsically motivated behaviors exist that are driven by forces outside of the task itself such as the promise of a reward or the threat of a punishment (Deci & Ryan, 2000; Deci & Ryan, 1985a). Extrinsic motivation is comprised of several forms of motivation that range from being fully externally controlled to fully internally regulated depending on how internalized the behavior has become (Deci & Ryan, 1991; Deci, Eghrari, Patrick, & Leone, 1994). Individuals who perform tasks solely for a reward or to avoid punishment are considered to be externally regulated in terms of their motivation (e.g. “If I don’t study, my teacher will be upset with me”). The reasoning for the behavior is fully derived from an external place and thus fully controlled. Individuals who experience introjected regulation chose to perform a task because of feelings related to self-worth, guilt, or shame placed upon them by others (e.g. “If I don’t study, I’ll feel bad about myself”). Introjection represents a partial internalization in that the behavior arises from an internal thought process but is not part of the person’s sense of self (Deci & Ryan, 1991). On the opposite end of externally controlled extrinsic motivation, internal regulation can be divided into identified and integrated. Identified regulation occurs when an individual performs a task because they recognize some external value to completing the task (e.g. “I need to do well in this course because I want to receive a good grade”) and represents further internalization than introjected behaviors. Integrated regulation represents full internalization and occurs when an individual recognizes the inherent value of the task even though they may not necessarily enjoy the task itself (e.g. “I need to do well in this course because I want to go to medical school”) (Deci & Ryan, 2000). To
summarize, autonomous behaviors are either intrinsically motivated or fully internalized expressions of extrinsic motivations. On the other hand, controlled behaviors are driven by fully external controls that are of less internalized forms of extrinsic motivation.

SDT proposes that the external social environment and resulting interpersonal context can influence the degree to which individuals are largely autonomous or controlled in their motivations and behaviors. Environments that support an individual by allowing for the expression of autonomous behaviors can foster personal growth and wellbeing, while environments that seek to constrain and control can have the opposite effect (Deci and Ryan, 2000; Deci & Ryan, 2008). Deci & Ryan (1985b) proposed the concept of autonomy support as a means of examining the support towards the development of autonomous behavior facilitated by a person in a position of authority (e.g. an instructor) to others (e.g. students). For example, an autonomy-supportive instructor might provide students with the means and knowledge to complete an assignment, while encouraging them to develop their own methods in problem solving. Appropriately structured student-centered learning is at its root an autonomy-supportive mode of instruction. Students are encouraged to take control of their own learning, are given meaningful choices in their learning, and are largely supported by their instructors.

Purpose.

The purpose of this study is two-fold: 1) to examine perceived levels of teacher autonomy support in three sections of an introductory biology class that are each taught using differing amounts of active learning and 2) to determine what effect perceived teacher autonomy support has on student performance, motivation, and other behavioral outcomes. It is hypothesized that sections of the course utilizing higher amounts of active learning will have higher perceived
teacher autonomy support and that support will have positive, meaningful impacts on student performance and behavioral outcomes.

Previous studies utilizing SDT have supported the connection between teacher autonomy support and student performance and behavioral outcomes. Williams & Deci (1996) illustrated that teacher autonomy support in a medical interviewing course had a positive significant effect on medical students’ autonomous motivation, perceived competence, and valuing of course topics. Black and Deci (2000) also found that teacher autonomy support had a positive impact on students’ autonomous motivation, interest in learning, perceived competence, lowered anxiety, and course performance. This study is novel in that it explores differences in instructor autonomy support between a traditional teacher-centered large lecture introductory biology course and the same course taught in student-centered way.

Methods

The biology course being examined is composed of a lecture and laboratory section. It is the first in a two-semester introductory course, and focuses on the topics of ecology, evolution, and biodiversity. Students enrolled in the course were primarily freshman majoring in the life sciences for whom it is a required course. The current study examined the lecture component of the course and students were not asked about the laboratory component. Three sections of the course were examined, each which utilized active learning pedagogies to varying degrees: (1) traditional lecture using little to no student-centered learning practices in a large auditorium classroom, (2) modified lecture, which is a traditional lecture modified by using student-centered learning practices in a large auditorium classroom, and (3) SCALE-UP (Student Active Learning Environments with Upside-down Pedagogies) model, with fully integrated active learning in a collaborative learning space.
**Section Descriptions.**

The traditional lecture section was taught in a large auditorium lecture hall by an experienced faculty member who has received the highest recognition for achievement in teaching and received very positive reviews on student evaluations. A separate instructor, well-versed in student-centered pedagogies and the *SCALE-UP* model, taught both the *modified lecture* and *SCALE-UP* formats. The *modified* section was taught in the same auditorium classroom as the traditional lecture. Unlike the traditional lecture, the *modified* section included active learning components utilized throughout the semester that were *modified* to work well in a large auditorium setting. *SCALE-UP* is a specialized learning environment designed for collaborative learning techniques. It occurs in a classroom that allows students to sit at round tables and work in groups of three to complete in-class tasks while an instructor and several teaching assistants circulate to assist students with their learning. *SCALE-UP* uses aspects of “flipped classroom” teaching in which students spend outside class time learning the basics of course topics so that in-class time can be devoted to expanding student knowledge though collaborative, problem-, model-, and case-based learning. Research has shown that students enrolled in the *SCALE-UP* section exhibit increased learning gains and other positive behavioral outcomes as compared to students in more traditional learning settings (Beichner, 2008; Foote, Neumeyer, Henderson, Dancy, & Beichner, 2014).

**Data Collection and Analysis.**

This study utilized a quasi-experimental quantitative design to achieve two aims: (1) examine the differences of perceived autonomy support between the three different introductory biology classrooms being studied and (2) examine the predictive relationship between instructor autonomy support and student performance and affective outcomes. A survey was administered
to collect data on intrinsic motivation and instructor autonomy support. All survey data was collected using an online survey tool (Qualtrics) in accordance with Institutional Review Board for the Protection of Human Subjects in Research. Student composite SAT scores and High School GPAs was collected from the university’s office of institutional research and planning. Performance data consisting of the final course grade was collected at the end of the semester from both instructors teaching the course. Students self-selected which course they enrolled in prior to the start of the semester based on their schedule and timing of the section, but they were blind with regard to the teaching format of each section (traditional, modified, or SCALE-UP). One survey was administered containing both the Intrinsic Motivation Inventory (IMI) (See Appendix D) and the Learning Climate Questionnaire (LCQ) (See Appendix E). It contained all measures for the study and was sent out the last week of classes before finals. There were a total of 548 students enrolled in the three sections with 96 students enrolled in SCALE-UP, 239 enrolled in the modified section, and 213 enrolled in the traditional section. Of that total, 482 students (n=92 SCALE-UP, n=207 modified, and n=183 traditional) volunteered to complete the survey. Statistical analysis revealed no major differences in performance between those students who chose to participate and those who chose to not to participate.

**Instructor Autonomy Support.**

Perceived levels of instructor autonomy support (IAS) were obtained using the Learning Climate Questionnaire (LCQ; Williams, Wiener, Markakis, Reeve, & Deci, 1994). The LCQ is a 15 item Likert-type survey on a seven-point scale designed to assess the autonomy support of the instructor in the classroom. Students are asked to agree or disagree with each item with 1 being “strongly disagree” and 7 “being strongly agree.” A main point of SDT asserts that the quality of the social context influences both motivation and performance (Deci & Ryan, 2000).
Environments can either be autonomy supportive (which encourage self-determined motivation and behavior) or controlling (which decreases self-determined motivation and behavior). The LCQ directly measures the degree to which students perceive their instructors (person in a position of authority) to be either autonomy supportive or controlling. Example items include, “I feel that my instructor provides me choices and options,” “My instructor conveyed confidence in my ability to do well in the course,” and “I don’t feel very good about the way my instructor talks to me” (reverse coded). Each item on the scale was reworded to refer to the instructor of the introductory biology course that the student is enrolled in.

To compare differences in levels of perceived IAS between the three classrooms, a one-way ANOVA analysis was conducted. To account for differences in sample size between the course sections, Levene’s statistic was calculated as a test of homogeneity of variances (Field, 2013). In order to deconstruct the ANOVA findings a post-hoc analysis was conducted using the Tukey HSD test. According to the central limit theorem, the large sample sizes in this study (> 30 - 40), there is an assumption of normality regardless of the shape of the data (Ghasemi & Zahediasl, 2012).

**Relationship Between Instructor Autonomy Support and Student Outcomes.**

**Student Behavioral Outcomes.**

Student intrinsic motivation was measured using the Intrinsic Motivation Inventory (IMI; McAuley, Duncan, & Tammen, 1989), which is a family of seven individually validated Likert-type, seven-point scales, designed to assess personal experiences during a task (See appendix B). The scales include, 1- interest/enjoyment, 2- perceived competence, 3- perceived choice, 4- tension, 5- effort, 6- value, and 7- relatedness. The original IMI contained four of the seven scales: interest/enjoyment, perceived competence, effort, and tension (McAuley, Duncan, and
Tammen, 1989). Subsequent studies added the perceived choice (Ryan, Koestner, & Deci, 1991), value (Deci, Eghrari, Patrick, & Leone, 1994) and relatedness scale (Richer & Vallerand, 1998). Each scale consists of a set of statements placed on a scale of 1 to 7. Students are asked to rank how true each statement is for them with 1 ‘being not true at all’ and 7 being ‘very true.’ The scales are designed to be implemented individually or in any combination without negatively impacting validity. The scales have been used successfully in a wide variety of fields including education (Monterio, Mata, & Peixto, 2015). All but the perceived relatedness scale were used in this study: interest/enjoyment, effort, value, perceived competence, perceived choice, and tension (See appendix B for scales). All scales were slightly modified to refer specifically to the introductory biology course that the student was enrolled in. The interest/enjoyment scale, comprised of seven items, is considered to be a direct measure of intrinsic motivation, the prototype of autonomous motivation. Examples include, “I enjoyed taking this course very much” and “I thought this course was boring” (reverse coded). The effort scale, comprised of five items, measures the amount of effort individuals put into a task. The amount of effort put into a task should directly correlate with how motivated an individual is to successfully complete a task. For this study, effort should positively relate to intrinsic motivation. Examples from the effort scale include, “I put a lot of effort into this course” and “I didn’t try very hard to do well in this course” (reverse coded). The value scale is composed of seven items assessing how important students felt the course was to them. Example items include, “I believe taking this course was beneficial to me” and “I think taking this course could help me to graduate with a life sciences degree.” The perceived competence scale is composed of six items and is a measure of how well the student thought they did in the course. Example items include “I think I did well in this course” and “I couldn’t do well in this course” (reverse coded). The perceived choice scale is
composed of seven items and is a measure of the degree to which students perceived it was their choice to complete the course. Example items include, “I felt like it was not my own choice to take this course” (reverse coded) and “I took this course because I wanted to.” The tension scale, comprised of five items, is a measure of how tense or nervous an individual is while completing a task. It is considered to be a negative predictor for intrinsic motivation. Example items include “I did not feel nervous at all in this course” (reverse coded) and “I felt very tense during this course.” Perceived instructor autonomy support should have a positive impact on all measures except for tension which should illustrate a negative relationship with teacher autonomy support.

Performance.

Performance was measured by students’ final course grade which was out of 600 total points for all three sections of the course. A laboratory component of the grade worth an additional 300 points was not included in the analysis. Course grades were obtained from the instructors of the sections after the course had ended. Both instructors followed the same syllabus and the same point allocations for calculating final grade with 300 points deriving from exams, 150 points deriving from the final exam, and 150 points deriving from participation consisting of student quizzes, activities, and homework assignments for a total of 600 points.

To examine the effect of teacher autonomy support on student behaviors and performance, hierarchical linear multiple regression modeling was used similar to the methods of Black & Deci (2000) that examined the impact of instructor autonomy support in an organic chemistry course. Hierarchical linear regression modeling is used when an investigator wishes to control for certain variables in the model (Field, 2013). To test the hypothesis that perceived instructor autonomy support would predict higher student subjective experiences as reflected in higher values on the IMI, measures for interest/enjoyment, effort, value, perceived competence,
perceived choice, and perceived tension were individually regressed hierarchically onto perceived teacher autonomy support after first removing variance attributable to student ability (measured by HS GPA and SAT scores). In addition to examine effects on student performance, measures for final course grade were also regressed hierarchically in a similar manner.

*Ability.*

Two measures of ability were used as control variables in the hierarchical regression modeling. The first was students’ high school cumulative GPA and the second was the combined score for students’ Math and Verbal SATs. Both measures were obtained from the university’s office of institutional research and planning. Of the 482 students who responded to the survey with both the LCQ and the IMI, 86 students SCALE-UP were missing data for both high school GPA and composite SAT scores (n=8; SCALE-UP, n=44 lecture; and n=34, traditional lecture). As such, data from these students were excluded from the hierarchical regression analysis that examined the effects of instructor autonomy support on student performance and outcomes. The resulting sample size is still sufficiently large, and an examination of the demographic data revealed no major differences between those students whose data was reported and those students whose data was not reported suggesting no negative impacts on the hierarchical analysis.

*Results*

Findings of this study demonstrate that instructors who use student-centered instructional practices are perceived by students as being more autonomy-supportive than those who teach in a more traditional manner. The perceived levels of instructor autonomy support positively predict student levels of intrinsic motivation, behavioral outcomes, and course performance. There were significant differences in instructor autonomy support between the three sections of the
introductory biology course. To deconstruct these differences, post-hoc analyses revealed that perceived teacher autonomy support was higher for both the modified lecture section and SCALE-UP, than for the traditional lecture section. Values for the SCALE-UP section were slightly higher than the modified lecture section but not to a significant degree. Table 1 shows descriptive statistics, one-way ANOVA results, and post-hoc analyses. The Chronbach’s alpha value (α=.95) was well within an acceptable range for the scale when calculated using the entire sample (n=482) suggesting good internal validity. Levene’s test for homogeneity of variance was non-significant indicating differences in sample size between the three sections did not invalidate the ANOVA findings.

**Table 3.1** Descriptive Statistics, one-way ANOVA, and post-hoc (Tukey HSD) analysis results for perceived instructor autonomy support in three different sections of an introductory biology course.

<table>
<thead>
<tr>
<th>Course Type</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Descriptive Statistics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>92</td>
<td>5.685</td>
<td>1.065</td>
<td>.1111</td>
</tr>
<tr>
<td>Modified</td>
<td>207</td>
<td>5.578</td>
<td>1.080</td>
<td>.0751</td>
</tr>
<tr>
<td>Traditional</td>
<td>183</td>
<td>5.225</td>
<td>1.121</td>
<td>.0829</td>
</tr>
<tr>
<td>Total</td>
<td>482</td>
<td>5.465</td>
<td>1.108</td>
<td>.0505</td>
</tr>
<tr>
<td><strong>One-way ANOVA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>2</td>
<td>7.371</td>
<td>.001*</td>
<td></td>
</tr>
<tr>
<td>Within Groups</td>
<td>479</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>481</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Post-hoc Tukey</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>.1370</td>
<td>.003*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified</td>
<td>.1397</td>
<td>.716</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified</td>
<td>SCALE-UP</td>
<td>.1370</td>
<td>.716</td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>.1109</td>
<td>.004*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traditional</td>
<td>SCALE-UP</td>
<td>.1397</td>
<td>.003*</td>
<td></td>
</tr>
<tr>
<td>Modified</td>
<td>.1109</td>
<td>.004*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results indicate that perceived instructor autonomy support does have a positive significant impact on student motivation and behavioral outcomes, as well as, student performance. Instructor autonomy support positively predicted levels of students’ interest/enjoyment, perceived competence, perceived choice, effort, value, course performance, and negatively predicted student tension. For all IMI subscales, the Chronbach’s alpha values ($\alpha > .85$) were well within an acceptable range for the scales when calculated using the entire sample ($n=482$) suggesting good internal validity.

Table 2 presents Pearson’s correlations among the study variables that allows for the inspection of the hypothesized relationships between perceived instructor autonomy support, motivation variables, and student performance. All of the expected relationships were positively highly significant with p-values less than .001, and all went in a positive direction except for the relationship with tension which was negative. Of note were the relationships between all of the following: instructor autonomy support and interest/enjoyment, perceived tension, perceived competence, and value. Cohen (1992) suggests that r values greater than .1 represent a small effect size, values greater than .3 suggest a medium effect size, and values greater than .5 suggest a large effect size. Using Cohen’s criteria for effect size, the results indicate a large effect size for the relationship between instructor autonomy support and interest/enjoyment; medium effect sizes for the relationships with perceived tension and competence; and small effect sizes for the relationships with the remaining study variables: perceived choice, effort, and final course grade.
Table 3.2 Correlations Among Study Variables (n=482).

<table>
<thead>
<tr>
<th></th>
<th>IAS</th>
<th>I/E</th>
<th>Comp</th>
<th>Tension</th>
<th>Choice</th>
<th>Value</th>
<th>Effort</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I/E</td>
<td>.604**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comp</td>
<td>.472**</td>
<td>.561**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tension</td>
<td>-.406**</td>
<td>-.343**</td>
<td>-.511**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Choice</td>
<td>.196**</td>
<td>.400**</td>
<td>.174**</td>
<td>-.084</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value</td>
<td>.490**</td>
<td>.677**</td>
<td>.519**</td>
<td>-.332**</td>
<td>.202**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effort</td>
<td>.252**</td>
<td>.310**</td>
<td>.189**</td>
<td>.050</td>
<td>.091*</td>
<td>.308**</td>
<td></td>
</tr>
<tr>
<td>FG</td>
<td>.223**</td>
<td>.314**</td>
<td>.611**</td>
<td>-.249**</td>
<td>.172**</td>
<td>.332**</td>
<td>.265**</td>
</tr>
</tbody>
</table>

Notes: IAS= Instructor Autonomy Support; I/E= Interest/Enjoyment; Comp= Perceived Competence; FG= Final Course Grade; *p<.05; **p<.01.

Table 3 shows the results from the multiple regression testing including R-sq. values and individual standardized beta values for each predictor in each model. The individual models tested included the predictive relationship between instructor autonomy support and all student outcome measures: interest/enjoyment, perceived competence perceived tension, perceived choice, effort, value, and final course grade. All models tested showed that instructor autonomy support did significantly predict the dependent variables when controlling for student ability with respect to high school GPA and SAT scores. Cohen (1988) suggests that R-sq. values in linear regressions greater than .02 can be viewed as a small effect, values greater than .13 reflect a medium effect, and values greater than .26 reflect a large effect. Thus, when controlling for student ability, instructor autonomy support had large positive predictive effects on student interest/enjoyment, perceived competence, value, and final course grade. There was a medium
negative effect on student tension, and small positive effects on perceived choice and perceived effort.

Table 3.3 Multiple Regression Testing the Effects of Instructor Autonomy Support on Student Motivation Variables and Performance, Controlling for HS GPA and SAT scores (n=395).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HS GPA</td>
<td>0.055</td>
<td>0.112</td>
<td>-0.011</td>
<td>-0.009</td>
<td>0.068</td>
<td>0.164**</td>
<td>0.267***</td>
</tr>
<tr>
<td>SAT Score</td>
<td>0.052</td>
<td>0.191***</td>
<td>-0.139**</td>
<td>0.093</td>
<td>0.089</td>
<td>-0.093</td>
<td>0.293***</td>
</tr>
<tr>
<td>Step 2:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IAS</td>
<td>0.580***</td>
<td>0.466***</td>
<td>-0.408***</td>
<td>0.191***</td>
<td>0.495***</td>
<td>0.259***</td>
<td>0.214***</td>
</tr>
<tr>
<td>Model R-Sq.</td>
<td>.343***</td>
<td>.292***</td>
<td>.191***</td>
<td>.046***</td>
<td>.269***</td>
<td>.096***</td>
<td>.266***</td>
</tr>
</tbody>
</table>

Notes: IAS= Instructor Autonomy Support; I/E= Interest/Enjoyment; Comp= Perceived Competence; FG= Final Course Grade; *p<.05; **p<.01, ***p<.001.

Another way to interpret the data is to examine the individual standardized beta values for each predictor variable. Individual standardized beta values indicate the degree to which the predictor variable impacts the dependent variable. Instructor autonomy support was a highly significant individual predictor variable for all dependent variables tested with p-values less than .001. According to the models, if instructor autonomy support is increased by one standard deviation then interest/enjoyment would increase by .58 standard deviations, perceived competence would increase by .47 standard deviations, student tension would decrease by .41 standard deviations, perceived choice would increase by .19 standard deviations, value would increase by .50 standard deviations, effort by .26 standard deviations, and final course grade by .21 standard deviations.

Discussion

Based on the findings of this study, there are positive impacts of student-centered pedagogies on student motivation, performance, and other behavioral outcomes. The study demonstrated that instructor autonomy support positively predicts students’ interest/enjoyment,
competence, choice, effort, value, and course performance while negatively predicts student tension. Furthermore, instructor autonomy support was found to be higher in classrooms that utilize student-centered learning explaining the increases often seen in student motivation, performance, and other behavioral outcomes in the literature (e.g. Cleveland, Olimpo, & DeChenne-Peters, 2017, Eichler & Peeples, 2016, Rodriguez, 2016, Ryan & Reid, 2015). In general, the success of the student-centered learning environments in terms of student performance and motivation may be positively attributed to increased perceived instructor autonomy support, since student-centered learning environments are by design autonomy supportive environments.

Student-centered pedagogies take the emphasis off the instructor and places it instead on the student (Freeman et al. 2014). This drastically changes the role of the instructor from a giver of knowledge, to a guide who instead helps the student create their own knowledge. When done correctly, this switch in roles produces an instructor, who by the very nature of the instructional techniques they are using, must be more autonomy supportive in the classroom as indicated by the initial results in this study. As student-centered learning takes place, the student takes center stage with increased opportunities for exploration and engagement with concepts. Students are given the chance to make meaningful choices in the classroom, allowed to explore material in a way that makes sense to them, and provided with meaningful praise and feedback during the learning process. All of these traits characterize an autonomy supportive environment shaped by instructors utilizing student-centered learning. A 2006 experimental psychology study examined autonomy-supportive teaching behaviors, including the ones mentioned above that comprise student-centered learning environments, and similar to the findings of this study found correlated increases in students’ interest/enjoyment, engagement, and performance (Reeve & Jang, 2006).
Findings in this study also found positive predictive relationships between teacher autonomy support and students’ interest/enjoyment, perceived competence, effort, value, and decreased tension all of which have been associated with increases in student motivation, performance, and well-being (e.g. Black & Deci, 2000; Grolnick & Ryan, 1989; Jeno, Grytnes, & Vandvik, 2017; Olimpo, Fisher, & DeChenne-Peters, 2016; Partin et al., 2011, William & Deci, 1996). Of particular interest is the relationship between instructor autonomy support and decreased student tension in the classroom. England, Brigati, & Schussler (2017) found that student anxiety increased when active learning was implemented in the classroom. Students in the study found the idea of being responsible for their own learning daunting. The results of the current study suggest that if instructors utilizing student-centered pedagogies are cognizant of the effects of being autonomy supportive they may be able to alleviate student stress and anxiety during student-centered learning activities reported by the above study. This finding highlights the importance of the instructor in successfully implementing student-centered practices.

Teacher autonomy support positively predicted student motivation and behavioral outcomes in this study, both related to increased performance. In addition, instructor autonomy support directly predicted student performance. More importantly, instructor autonomy support was found to be higher in classrooms where instructors implement student-centered pedagogies. This finding is important in that it not only bolsters the findings of Black & Deci (2000), which was the first study to connect instructor autonomy support with student performance in a natural sciences course, but also indicates that the very nature of student-centered learning environments bolsters student perceived levels of instructor autonomy support which then lead to increases in student motivation, performance and other behavioral outcomes.
There were several limitations to this study. The study only utilized two instructors, one of which taught a traditional lecture and one of which taught the two sections utilizing active learning. As a result, the finding that student-centered practices result in instructors who are perceived as being more autonomy supportive should be taken as a preliminary finding only and warrants further study with instructors teaching the same course who also are using active learning to the same degree. At the time of the study, this was not available. Since student perception of their instructors can bias their attitudes and perceptions of the course, this can lead to differences between the three formats that are solely due to the instructors and not to the pedagogical approach. For instance, one study examining active learning in undergraduate STEM courses found no student learning gains associated with the instructional methods (Andrews, Leonard, Colgrove, and Kalinowski, 2011). The authors contend that overall college biology instructors lack the nuanced understanding of student-centered pedagogies required to successfully implement active learning. In other words, these instructors may still be exhibiting controlling behaviors instead of expressing the appropriate level of autonomy supportiveness necessary to successfully implement student-centered learning. As mentioned, future studies may address this issue by looking at various instructors and the behaviors used by them to develop an autonomy-supportive classroom environment. Any differences in student outcomes between the various classrooms that can be attributed to differing levels of instructor autonomy support would further bolster the claim that the successful implementation of student-centered learning is largely dependent on the instructor’s ability to teach in an autonomy supportive way. Although positive relationships between instructor autonomy support and student outcomes were observed in this study, there are may be other factors at play in determining student outcomes such as students’ self-efficacy, interest in pursuing STEM careers, and possible demographic factors that
can impact student performance and motivation. Other avenues of research may include measuring different student outcomes, such as self-efficacy, or examining differences in groups of students such as underrepresented minorities in the STEM field.

Overall, this study presents two major findings. First, instructor autonomy support is higher in courses utilizing active learning than in those that do not, possibly as a result of the student-centered nature of active learning environments. Second, instructor autonomy support positively predicts student motivation, performance, and other behavioral outcomes. The results provide further support for the use of student-centered instructional practices and incorporating active learning into undergraduate STEM courses. Further, it highlights the importance of the instructor and their role in creating a successful student-centered learning environment.
References

American Association for the Advancement of Science (2011). Vision and Change in Undergraduate Biology Education: A Call to Action, Washington, DC.


Olimpo, J.T., Fisher, G.R., & DeChenne-Peters, S.E. (2016). Development and validation of the Tigriopus course-based undergraduate research experience: Impacts on students' content knowledge, attitudes, and motivation in a majors introductory biology course


Chapter 4 Investigating the Motivations and Active Learning of Undergraduate Biology Students in SCALE-UP and modified lecture classrooms: A Comparison Study

Introduction

College courses that utilize student-centered, active learning pedagogies have been shown to be more effective in promoting student achievement than traditional instructor focused pedagogies (Freeman et al., 2014). Calls for reform in STEM undergraduate education have emphasized the development and use of student-centered practices to enable student success (American Association for the Advancement of Science, 2011; National Research Council, 2003, 2012). Numerous studies have demonstrated the success of instructor implemented active learning in large enrollment undergraduate STEM programs in terms of both student performance and motivation (e.g., Allen & Tanner, 2005, Eichler & Peeples, 2016; Rodriguez, 2016; Smith, Stewart, & Shields, 2005; Walker, Cotner, Baepler, & Decker, 2008). Examples of active learning that can be implemented in large enrollment classrooms include activities such as think/pair/share, diagramming, and the use of individual response systems (clickers). Think/pair/share involves students being prompted by the instructor to think on a particular question or concept before sharing their thoughts with a partner, and then with the entire class. Students are capable of diagramming out learning concepts at their own desk either independently, in pairs, or as they follow along with an instructor working at the front of the class. Finally, clickers can be used in a variety of situations as students answer questions so that instructors can get student feed or check for student understanding of a concept being covered in class that day. All of these are examples of how a traditional lecture section can be turned into a modified lecture section in which active learning strategies are utilized in an otherwise traditional auditorium classroom setting.
Despite this success in implementation, one significant challenge that many institutions face in implementing student-centered practices is the physical environment of the large lecture auditorium (Bligh, 2000). Physical spaces can influence both instructor practices and student experiences (Brooks, 2011). Recent research has shown that aligning the physical classroom space with student-centered pedagogies is important for achieving higher learning gains for students (Knaub et al., 2016). In spite of this, many undergraduate classrooms are still tiered, ‘fish bowl’ type lecture halls with minimal seating space for each student, rendering several forms of active learning incompatible with the classroom environment (Milne, 2006; Oblinger, 2006; Whiteside, Brooks, & Walker, 2010). Innovative reforms have involved not only a re-design of the pedagogical practices within the classroom, but of the physical classroom itself.

Student-centered Active Learning Environments with Upside-down Pedagogies (SCALE-UP) was designed to address the limitations imposed upon incorporating active learning in large lecture halls typical of most undergraduate programs while still maintaining a high student enrollment (Beichner & Jeffrey, 2003; Beichner, 2008; Foote, Neumeyer, Henderson, Dancy, & Beichner, 2014). SCALE-UP consists of a unique physical environment design based on existing pedagogical research to be a social and collaborative active learning space. Students are seated at round tables and placed into a group of three so that there are three groups of three at each table. Students spend the majority of the semester working within their group of three or collaborating with the other groups at the table. White boards are placed strategically around the room to allow for students to collaboratively work on assignments and students are given access to technology, as needed, such as lab top computers placed at each table. The design utilizes 3-4 graduate or undergraduate teaching assistants (UTAs) who are assigned to interact with 2-3 tables of students. These teaching assistants spend the semester working with their groups of students,
scaffolding their learning and providing support. SCALE-UP is meant to be an active learning environment with minimal in-class time devoted to lecture. To accomplish this, it utilizes aspects of a flipped classroom model in which students spend out-of-class time learning basic material so that in-class time can be devoted to extending knowledge through collaborative, problem-, model-, and case-based learning. The format has proven a successful example of a specialized active learning environment in STEM undergraduate programs in terms of both student performance and motivation (Beichner, 2008; Benson, Orr, Biggers, & Moss, 2010; Brooks, 2011; Cotner, Loper, Walker, & Brooks, 2013; Dori & Belcher, 2005; Foote et al., 2014; Olver-Hoyo & Allen, 2005).

This study seeks to examine learning spaces and their effects on student outcomes and affective variables. The rationale is that learning spaces that allow collaborative and active types of learning may positively impact student achievement and motivation. The two types of learning spaces addressed in this study are a modified lecture classroom, as described above and SCALE-UP, a specialized physical classroom environment for active learning. While research has shown success for the SCALE-UP classroom as well as for the use of active learning pedagogies in large lecture undergraduate courses; currently, scant research has compared these learning formats and how they influence student behaviors and overall learning. The purpose of this study is to compare student performance, motivation, and perception of course resources between two sections of an introductory biology course taught by the same instructor and using the same syllabus but conducted in two separate learning environments: the SCALE-UP environment and a student-centered large lecture environment hereafter referred to as a modified lecture environment.
This quasi-experimental mixed methods study, based in the classrooms of introductory biology students and taught by the same instructor, will compare a SCALE-UP classroom to that of a modified lecture course. The following research questions are addressed:

1. How does the nature of active learning instruction compare in a SCALE-UP and a modified lecture environment?

2. What aspects of the course do students find most useful to their learning in both the SCALE-UP and modified learning environments?

3. How does the achievement and motivation of students compare in a SCALE-UP and modified lecture course?”

Theoretical Frameworks.

Self-Determination Theory.

To assess differences in motivation the study will utilize the self-determination theory of motivation (SDT; Deci & Ryan, 1985). SDT posits that individuals are inherently driven to grow and develop their own sense of self and psyche, but this does not occur in a vacuum. The environment plays a direct role in either thwarting or supporting a person’s development (Deci & Ryan, 2012). SDT’s emphasis on the role of the environment in the development of a person’s motivation makes it a useful theory for examining the impact of a learning environment on student motivation. In SDT, motivations are broadly classified as either being autonomous (driven from within) or controlled (externally driven) (Deci & Ryan, 1985). Autonomous forms of motivation, the highest of which is intrinsic motivation, are generally considered to be of higher quality than controlled forms of motivation and of greater benefit to a person’s development (Deci & Ryan, 1985). The environment plays a role in the development of a person’s motivations, either autonomous or controlled, by either supporting or thwarting three
basic psychological needs: autonomy, competence, and relatedness (Deci & Ryan, 2000; 2008). Deci & Ryan (2000) define autonomy as the feeling of internal control that a person feels they have over their behaviors and successes, competence as the level of ability a person believes they have for completing a task, and relatedness as a feeling of connection and belongingness to a certain social group or setting. In the classroom setting, environments that meet these three needs foster the development of autonomous motivation, which then can lead to gains in performance and well-being for the student (Boggiano & Ruble, 1979; Deci, 1971; Deci & Ryan, 2000; Harackiewicz, Manderlink, & Sansone, 1984; Ryan & Grolnick, 1986; Ryan, Stiller, & Lynch, 1994).

**Active Learning Framework.**

Edwards’ (2015) active learning framework will be used to examine the course resources that students utilize and find most important to their learning. Edwards’ framework breaks active learning into three components: socially, physically, and intellectually active. Each component comprises different elements of the active learning environment, and Edwards suggests that for an active learning environment to be most successful it should be comprised of elements from all three categories. Learning activities that fall within the socially active category can be defined as being collaborative in nature. These types of activities rely on and encourage peer-peer and student-instructor interactions to be successful. Activities that fall within the physically active category include any activities that place emphasis on students moving around or manipulating physical objects such as modeling, diagramming, and project-based learning. Finally, intellectually active based activities are those that encourage students to be mentally engaged, rather than passive (i.e. listening to an instructor but otherwise not engaging with the course.
material) but are not explicitly social or physical in nature. Intellectually based activities encompass a variety of things including WebQuests and case studies.

**Methods**

This study utilizes a quasi-experimental, explanatory mixed-methods design (Creswell, 2002).

**Participants and Context.**

This study took place as a large research-intensive university in the southeastern US. Two classes of introductory biology students were a part of this study, both taught by the same instructor: a *SCALE-UP* class and a *modified lecture* class. The instructor is highly experienced in active learning pedagogy, including the *SCALE-UP* model.

The introductory biology course was comprised of a lecture and a lab component and was the second part of a two-part introductory biology sequence that covered the topics pertaining to molecular biology. The students enrolled in the course were primarily lower classmen majoring in the life sciences. The current study focused on the lecture portion of the course and students were not asked about their experiences in the lab component. Data was collected from two concurrent sections of the course: a *SCALE-UP* section with 92 students enrolled and the *modified lecture* section with 165 students enrolled. Both sections of the course followed the same schedule, took the same quizzes and exams, and covered the exact same material. The only difference between the two section formats was the learning environment (*SCALE-UP* vs traditional large lecture hall) and the types of active learning activities that each environment allowed for.
Data Collection and Analyses.

Classroom observations.

Classroom observations using the Classroom Observation Protocol for Undergraduates STEM (COPUS; Smith, Jones, Gilbert, & Wieman, 2013) were conducted by two of the researchers to characterize the amounts and type of active learning used in both the SCALE-UP and modified lecture sections. This study utilized two separate observers to ensure reliability. Cohen’s kappa (κ) was used to calculate an inter-rater reliability score for the two observers. Observations were conducted during a complete week of instruction (150 minutes total). Both the modified lecture section and the SCALE-UP section met twice a week for a total of 75 minutes. COPUS is a structured observation protocol that calls for the observer to categorize instructor and student behavior in 2-minute intervals for the duration of the class period. COPUS utilizes a total of twenty-five codes across two separate categories to assess student and instructor behaviors. Example codes for instructor behaviors include ‘lecturing’, ‘asking a question’, and ‘one-on-one time with student’. Example codes for student behaviors include ‘answering a question’, ‘asking a question’, ‘clicker question’, or ‘class activity’. Only the main instructor’s behaviors were used when coding based on the COPUS in the SCALE-UP section. Behaviors of the UTAs were noted in observer notes but were not part of the COPUS data analysis. COPUS has been used successfully in several different studies including a study that utilized the instrument to quantify the use of student-centered pedagogies in two separate undergraduate biology classrooms similar to the current study (see Connell, Donovan, & Chambers, 2016). Using the codes, instructor and student behaviors were categorized and quantified as a percentage of the total class time.
**Open response items.**

An open-ended survey question (What aspects of the course did you think were most useful to your learning?) was used to ascertain which types of active learning were perceived as most useful by the students enrolled in both sections. The question was part of a larger open-ended survey concerning student experiences and learning in their introductory biology course given to students during the last week of class (See appendix F for full survey). Student responses were collected through an online survey tool (Qualtrics) in compliance with the guidelines of the Institutional Review Board for the Protection of Human Subjects in Research. Out of the 92 students enrolled in SCALE-UP, 61 chose to answer the open-ended survey and out of the 165 students enrolled in the modified lecture section, 115 chose to answer the open-ended survey. There were no differences in performance between students who chose to participate in the open-ended survey and those who did not for both sections. All student responses to the open-ended question were first open coded to identify emergent themes and then using Edwards (2015) active learning environment framework, the coded strategies were placed into one of four code groups: passive, physically active, intellectually active, or socially active based learning. For the purposes of this study activities were placed in one of the categories based on which category was most suitable. For example, the quote “the unit quizzes helped me learn the best” was given the code ‘quizzes,’ and “I liked the group work that we did in class” was given the code ‘group activities.’ The code ‘quizzes’ was then placed under the ‘intellectually active’ code family since it refers to any activity that is primarily mentally stimulating, but not necessarily physically or socially engaging. The ‘group activities’ code was placed under the ‘socially active’ code family, since it specifically referred to an activity with a social component. There
were three codes that did not fall within any of the four family codes: ‘course content,’ ‘instructor,’ and ‘room design,’ which were addressed outside of the active learning framework.

To gauge differences in the responses for the two sections, the number of students who cited a particular course component was reported for each section as a percentage of the total students in the sample. Reporting the percentage of the total sample allows for comparisons to be made between the two groups considering the differences in sample size. Many students mentioned more than one course component or learning strategy that they found useful. In these cases, the student responses were assigned multiple codes and the rate of each code was calculated independently of other codes. Thus, the total percentage rates for each section reported in the results exceeds one-hundred percent.

**Student Performance and Motivation.**

The Intrinsic Motivation Inventory (IMI) (see Appendix G for scales) was used to obtain quantitative measures for students’ interest/enjoyment, autonomy, competence, and relatedness and combined with performance measures to ascertain any differences in terms of student outcomes between the SCALE-UP environment with its unique physical requirements and the large lecture environment with utilized student-centered learning practices. The IMI is a set of seven individually validated Likert-type scales that measure various components related to motivation: interest/enjoyment, perceived competence, perceived choice, perceived relatedness, effort, value, and tension. The original IMI only contained four of the seven scales: interest/enjoyment, perceived competence, effort, and tension (McAuley, Duncan, and Tammen, 1989). Subsequent studies added the perceived choice (Ryan, Koestner, & Deci, 1991), value (Deci, Eghrari, Patrick, & Leone, 1994) and relatedness scale (Richer & Vallerand, 1998). Each
scale consists of a set of statements placed on a scale of 1 to 7. Students are asked to rank how true each statement is for them with 1 ‘being not true at all’ and 7 being ‘very true.’

The scales for interest/enjoyment, perceived competence, perceived autonomy, and perceived relatedness were utilized in this study to assess student intrinsic motivation and basic needs satisfaction. The interest/enjoyment scale is considered to be a direct measurement of intrinsic motivation. It consists of seven statements that students are asked to rank on a scale of 1 to 7 with 1 being not true at all and 7 being very true. Examples statements include “I enjoyed taking this course very much” and “I thought this course was boring” (reverse coded). The perceived competence scale consists of five statements on the same 1-7 scale and is a measure of the student’s felt competence or how well they thought they did in the course. Example items include “I think I performed well in this course” and “This was a course that I could not perform well in” (reverse coded). The perceived autonomy scale consists of six statements on the same 1-7 scale and is a measure of the students’ felt autonomy or how much choice they felt they had within the course. Example items include “I believe I had some choice about doing the work in this course” and “I completed the work in this course because I had no choice” (reverse coded). The perceived relatedness scale consists of seven statements on the same 1-7 scale and is a measure of the students’ felt relatedness or sense of belonging within the class. Example items include “I felt like I could really trust my classmates” and “I really doubt the other people in this class and I would ever be friends” (reverse coded).

Students were asked to complete the four IMI scales the last week of class through an online survey tool (Qualtrics) in compliance with the guidelines of the Institutional Review Board for the Protection of Human Subjects in Research. Of the 92 students enrolled in the SCALE-UP section, 70 students volunteered to complete the survey and of the 165 students
enrolled in the *modified lecture* section, 126 students volunteered to complete the survey. There were no differences in student performance between those students who chose to participate and those who chose not to participate.

Student performance measures were collected from the instructor of the two courses at the end of the semester. The grade for the course is out of a total of nine hundred points. There is a laboratory component of the course that accounts for three hundred points which was not examined in this study. Analysis was performed on differences in course total out of the six hundred points allocated specifically to the portion of the course outside of the laboratory (unit exams total four hundred fifty points and participation activities total one hundred and fifty points). Subsequent analysis was performed on student participation activity grades to determine any differences based on this component alone.

Performance and motivation scores for the two course types were compared using an Independent Samples t-Test. The motivation data did not follow a normal distribution, however, according to the central limit theorem, the large sample sizes in this study (>30-40), there is an assumption of normality regardless of the shape of the data (Ghasemi & Zahediasl, 2012). Due to unequal sample sizes, equality of variances between both groups was tested using Levene’s Test, which was non-significant for all variables and subsequently all statistics reported assume equal variances between samples.

**Results**

**Active Learning Measures.**

Analysis of the classroom observations showed that both sections of the course included high amounts of active learning, though the types of active learning varied considerably between the two sections (see Figure 1 for a comparison of instructor behaviors and Figure 2 for a
comparison of student behaviors). In the *modified lecture* section, the instructor spent 27% of the instructional time lecturing, and most of the rest of the instructional time was spent engaging students in question and answer sessions and working with students one-on-one during a class activity. Clicker questions were utilized during the lecture to gauge student understanding, before moving on with the lesson. The student behaviors largely mirrored the instructor’s behaviors, with students spending 36% of the time listening to the instructor, and the rest of the time was split between working on a class activity worksheet in pairs and answering questions posed by the instructor during whole-class question and answer sessions. Due to the difficulty of reaching students in the middle of the lecture hall, the instructor called an end to the class activity while students were still working so they could go over the assignment together as an entire class before class ended. This was when the majority of the question and answer sessions occurred.

![Bar chart showing instructor behaviors during 150 minutes of classroom observation using the COPUS protocol.](image)

**Figure 4.1** Observed main instructor behaviors during 150 minutes of classroom observation using the COPUS protocol.
Figure 4.2 Observed student behaviors during 150 minutes of classroom observation using the COPUS protocol.

In contrast, in the SCALE-UP section, the instructor spent 18% of the instructional time lecturing, and the rest of the time was spent working with students one-on-one during a group activity and engaging students in question and answer sessions. Again, clicker questions were utilized during the lecturing to gauge student understanding before moving on. The student behaviors largely mirrored the instructor behaviors with students spending 18% of the instructional time listening to the instructor and the majority of the rest of the time working on a group activity. During this time, the instructor and the four undergraduate teaching assistants (UTAs) were circulating the room assisting students with the assignment as needed. In contrast to the modified lecture section, the SCALE-UP section students spent considerably more time working on the activity within their groups before the instructor utilized a question and answer session to go over the assignment as a whole class. The layout of the room made it possible to reach all students to check understanding and answer questions, so summarizing the activity as a class did not take as much time as it did in the modified lecture section.
Student Perceptions of Course Components.

Overall, course components that students felt were most useful to their own learning consisted of a variety of activities and resources that fell within one of the three active learning categories: mentally, physically, and socially. There were differences between the two sections in terms of which course components the students found to be the most helpful. The two most frequently cited course components by students in the modified lecture section fell within the mentally active and the physically active categories with students most frequently citing online learning resources and topic outlines provided by the instructor. The most frequently cited course components by students in the SCALE-UP section fell within the physically and socially active categories with students most frequently citing in-class activities without mention of group work, topic outlines provided by the instructor, and group activities. There was only code (lecturing) that fell within the ‘passive learning category,’ which was equally cited across the two sections. There were four codes for course components that did not fall within the active learning framework and were addressed separately: ‘course content’, ‘instructor’, ‘none’ and ‘room design.’

Intellectually Active Course Components.

The ‘Intellectually Active’ code family consisted of four course components: quizzes, homework assignments, online resources, and test-format (see Table 1). Codes that fell within this category were much more prominent in the modified lecture section than the SCALE-UP section. The most frequently cited course component for both sections was online class resources that consisted of animations, readings that furthered topics in class, and study guides. Nineteen students (17%) in the modified lecture section referenced the online course materials stating that it helped them study and prepare for exams or further learn the material after class. For example,
two of the *modified lecture* students wrote, “I thought the fact [the instructor] gave us study
guides that told us the most important topics to study for each unit were quite helpful and made
me feel extra prepared for all of the exams,” and “the study guides [the instructor] posted for the
tests were helpful…and provided a great way to synthesize and process the information.” In
comparison, only four *SCALE-UP* students (7%) reported the online course material as being
useful to their learning, although they also stated a similar reasoning for its usefulness. For
example, one student found “when the PowerPoints/practice exams were posted onto moodle” to
be most helpful, writing “it allowed the students, including myself, to go back and really read
and digest the information.”

Very few students cited the other three components (homework assignments, quizzes,
and test format) as being most useful to their learning, but those who did were mostly from the
*modified lecture* section. Seven students (6%) in the *modified* section found the assigned
homework to be useful, four (3%) thought the quizzes were most useful, and two (2%) found the
testing format to be most useful. Only one *SCALE-UP* student (1%) cited the quizzes as being
most useful to their learning and none cited homework assignments or test format. Students who
cited the quizzes found that they were useful in helping them or encouraging them to study for
the exams. For example, one *modified* section student wrote “I think the quizzes were more
useful to my learning because they made me review my notes more and practice studying for the
actual exam.” The one *SCALE-UP* student, who cited quizzes, explained similar reasoning
writing that “quizzes…[were] useful to (sic) getting my attention and jump starting my studying
for the exam.” The seven students in the *modified* section who found the homework assignments
most useful found that the assignments allowed them to practice and apply material. For
example, “I think that the homework assignments were useful, because they allowed us to put
what we learned in class and apply it.” The two students who thought the test-formats were most useful felt the open-ended nature of the exam allowed them to better understand and learn the material. For example, one student wrote “I thought the tests were a very useful test of the information. The part 2 section [short answer and essay questions] challenged full understanding compared to just memorization.”

**Table 4.1.** Intellectually Active Codes with example quotations and frequencies for both Modified and SCALE-UP Sections.

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>MODIFIED</th>
<th>SCALE-UP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Homework Assignments</strong></td>
<td>Assigned homework consisting of worksheets or practice problems that help students apply material learned in class</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“I think the home works that were assigned were very helpful”</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>N/A</td>
<td>0%</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Online Resources</strong></td>
<td>Any resources including animations, practice exams, and study guides found online</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“I also liked the practice quizzes and practice tests because it allowed me to have to recall what I learned.”</td>
<td>17%</td>
<td>N/A</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“…practice exams were posted onto moodle. It allowed the students, including myself, to go back and really read and digest the information.”</td>
<td>7%</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Quizzes</strong></td>
<td>Multiple choice in-class quizzes given throughout the semester</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“The unit quizzes helped me learn the best because they tested my knowledge before my test.”</td>
<td>3%</td>
<td>1%</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“I think the quizzes a week before the exam was useful to getting my attention and jump starting my studying for the exam.”</td>
<td>1%</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Test Format</strong></td>
<td>Exams which consisted of a multiple-choice section and an open-ended free response section</td>
<td>2%</td>
<td>N/A</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“I thought the tests were a very useful test of the information. The part 2 section challenged full understanding compared to just memorization.”</td>
<td>2%</td>
<td>N/A</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>N/A</td>
<td>0%</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Physically Active Course Components.**

There were four course components that fell within the ‘Physically Active’ code family: class activities, clicker questions, guided notes, and whiteboard activities (see table 2). Class activities consisted of a variety of in-class tasks that ranged from completing worksheets, writing out comparison/contrast diagrams, or other diagrams that modeled biological processes like cellular division, or concept mapping. A moderate number of students in both sections cited in-class activities as being most useful to their learning, though there were slightly more SCALE-
UP students (15% vs 10%). Many of the students in the modified section, who cited in-class activities as being useful, appreciated the time to practice and apply the material. For example, “at these times [during activities] I was able to test my knowledge and ask questions” and “the [class activities] were the most useful because they let me test how well I understood the material and gave me feedback on what I needed to study more.” Similarly, the SCALE-UP students also felt the activities gave them time to practice and apply the information (“they [the class activities] really forced me to synthesize and apply the information”); however, they were more apt to explicitly mention the more active components of the activities. For example, “there were many hands-on activities throughout the semester that helped make new material more familiar in a quicker way” and “I think the activities…were really helpful because it gave you more than just words to hold on to. I am a very visual and kinesthetic learner, so I need more than just talking to learn.” Fifteen students (13%) in the modified section found the use of clickers and clicker questions to be the most useful course component, while only two students (3%) in SCALE-UP found them to be useful. Clicker questions were utilized in both sections during lecture segments to check for understanding and as part of in-class review sessions for exams. The students in both sections who cited clicker questions as the most useful course component for their learning found them useful as a way of practicing the material and testing their knowledge.

The most frequently cited course component in the ‘physically active category’ for both sections (25% for Modified and 16% for SCALE-UP) were the topic guides that were available for students to download prior to coming to class. These notes consisted of bullet pointed topic outlines that provided students a framework for taking notes. The notes often also provided blank diagrams for students to follow along and label in class during lecture segments. The notes
provided students the option to be physically active (writing) during an otherwise passive activity (listening to lecture) without feeling the overwhelming need to frantically write down every word being said. For example, one student from the modified section wrote, “[the guided notes] were helpful because I was able to focus more on what was being said in class instead of trying to rush to write everything down.” Concept explanations and diagrams that were completed by the instructor during class were posted online for students to access after class, which students found useful during studying.

The last course component in the ‘physically active’ code family was specific only to SCALE-UP. Five students (8%) in SCALE-UP mentioned using the in-class whiteboards during class activities and stated that the whiteboards were useful to their learning. All the students found the whiteboards useful for applying and testing their own knowledge of a subject during class. For example, “I think that when we would have lecture and then try problems and skills on our own…on the white boards was useful because we would actually do an application of the skill we just learned about.”
Table 4.2 Physically Active Codes with example quotations and frequencies for both Modified and SCALE-UP Sections.

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>MODIFIED</th>
<th>SCALE-UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Activities</td>
<td>In-class activities that ranged from worksheets to diagramming (no mention of group work)</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“The scanned sheets that we did in class together were very helpful because it was more practice and went into more depth than just the PowerPoints”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“The in-class assignments. While a few were lengthy and somewhat tedious, they really forced me to synthesize and apply the information I had encountered in the lectures, something that I really appreciated.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clicker Questions</td>
<td>Multiple choice questions answered with a personal response device during class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“I thought that the clicker questions during class were very essential in learning the material taught”</td>
<td>13%</td>
<td>3%</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“I found that the clicker questions throughout the course helped me stay focused within the class.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topic Guides</td>
<td>Note and PowerPoint outlines that students were able to download prior to class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“I thought the in-class note scans were very important for my learning. I was able to listen in class rather than trying to just everything down…”</td>
<td>25%</td>
<td>16%</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“I found the lecture notes and the interactive guides really useful because it forced me to stay engaged.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whiteboard Activities</td>
<td>Use of the white boards available to students in SCALE-UP</td>
<td>N/A</td>
<td>8%</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“The whiteboard activities also got us up and moving, stimulating blood flow and getting our brains thinking in a way that sitting and listening just can’t do.”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Socially Active Course Components.

The final active learning code family, ‘Socially Active,’ was composed of three codes: group activities, instructor support, and undergraduate teaching assistant support (see table 3). Twenty-one percent (13 students) of SCALE-UP students listed group activities as a useful component of their learning. This code differs from the ‘class activity’ code discussed above in that the student explicitly mentions the work being group work or talks about interacting with other students during the activity. For example, “I liked the group work that we did in class…always helped me and made me understand it better talking to my classmates.” In contrast to the large number of SCALE-UP students who mentioned group activities as being important, only 2%, or two students, in the modified section mentioned it as being important.
The other two codes within the socially active component relate to one-on-one interactions with the instructor and UTAs, specifically the ability to ask questions or receive help on an activity. The code, ‘instructor support’ referred to any support given directly by the instructor to the student. For example, one SCALE-UP student wrote, “the communication between the professor…and us as students was helpful because they could explain everything a little more straight forward [sic] in detail.” Only four students (5%) mentioned one-on-one interactions with their instructor as being the most useful component of the course, three of whom belonged in the SCALE-UP section. This type of interaction is both scarce and brief for students in the modified lecture section and thus only one student (1%) from the modified section listed it as being most useful to their learning. The UTA code was pertinent only to the SCALE-UP section, since the modified lecture did not have these. Seven of the SCALE-UP student responses (10%) mentioned access to the UTAs as a useful component of the course. For example, “I enjoy having a TA in each area for answering questions and such,” and “having an assigned TA that was very hands on and available for help at any moment in the class was helpful.”

Table 4.3 Socially Active Codes with example quotations and frequencies for both Modified and SCALE-UP Sections.

<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>MODIFIED</th>
<th>SCALE-UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group Activities</td>
<td>In-class activities that ranged from worksheets to diagramming (specifically mentions group aspect)</td>
<td>2%</td>
<td>21%</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“I liked the group work that we did in class. That always helped me and made me understand it better talking to my classmates.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“I really enjoyed the small groups that we were able to have to collaborator on different topics and learn from each other.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructor Support</td>
<td>Any mention of help from or one-on-one time with the instructor</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>“The communication between the professor in helping us students was helpful because they could explain everything…”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“It [SCALE-UP] allowed me to have access to [instructor].”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UTA Support</td>
<td>Any mention of help from or one-on-one time with the UTA (specific to SCALE-UP)</td>
<td>N/A</td>
<td>10%</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>“I enjoy having a TA in each area for answering questions and such.”</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Passive and Not Specified Course Components.

Only one course component, lecture, fell within the ‘Passive Learning’ code family. An approximately equal percentage of students (seven (5%) from the modified section and three (7%) from the SCALE-UP section) (see table 4) felt that lectures were the most useful component of the course for their learning. Students in both sections felt that they gained the most from the instructor’s explanations of biological processes during the lecture. For example, one student from the modified section wrote “the way my instructor explained certain biological cycles was very useful to my learning. We would go through each process step by step and … [the instructor] would explain everything very clearly,” and one student from SCALE-UP wrote “…that’s (sic) [lecture] really helpful to me. I like the diagrams …used to explain topics.”

There were four codes that did not fall into any of the code families and were instead labeled ‘Not Specified’: ‘course content’, ‘instructor’, ‘none’, and ‘room design’. Several students (25% in modified and 20% in SU) misunderstood the prompt of the question (i.e., which course component was most useful to your learning) and instead provided the course topic they felt was most useful or important, for example, one student responded with “pedigrees were probably most useful for my learning.” The second code that did not fit within any of the categories was ‘instructor’. A few students, though more so in modified (8 students or 7%) than SCALE-UP (2 students or 3%) provided an answer that dealt with the personality or teaching ability of the instructor. For example, “my teacher was great at lecturing and explaining everything,” “[Instructor] had structured the course very well,” and “I liked that [instructor] was very good at explaining things slowly and took a lot of time to draw and write things out.” The third code that did not fit was ‘none’ and applied to one student (1%) in the modified section who wrote that there were no course components most useful to their learning. Finally, the fourth
code that did not fit within any of the categories was ‘room design’. This code is specific to SCALE-UP and refers to any generic mention of the SCALE-UP environment without specifying which aspects of the room they found most useful. For example, “I really liked…the overall set up of the SCALE-UP room. It’s beneficial to be in a lively, engaging atmosphere…” and “I think the structure and the SU format of the class definitely helped my learning in [course name].”

Three students (5%) felt that the room design was most helpful to their learning.

**Table 4.4** Passive and Not Specified codes including examples quotations and frequencies for both the modified and SCALE-UP section.

<table>
<thead>
<tr>
<th>Code Family</th>
<th>Code</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Component</td>
<td>Lecture</td>
<td>Lecture during which instructor was providing information directly to student</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>Lecture</td>
<td>“Lectures were by far and away the lynch pin of this course”</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>Lecture</td>
<td>“But I'm glad it wasn't all practice, and that [Instructor] still lectured a lot, because that's really helpful to me. I like the diagrams she used to explain topics.”</td>
</tr>
<tr>
<td>Not Specified</td>
<td>Course Content</td>
<td>Student misunderstood question and listed not valued course content</td>
</tr>
<tr>
<td>MODIFIED</td>
<td>Course Content</td>
<td>“I think the most important things to my learning were the reproduction parts because they can be applied the most to everyday knowledge and I actually feel like that info might help me in the future.”</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>Course Content</td>
<td>“Cellular respiration, genetics/DNA, and animal reproduction and development were the most useful because I will carry the knowledge with me as I move forward.”</td>
</tr>
<tr>
<td>Instructor</td>
<td>Student found aspects of instructor’s personality most useful</td>
<td></td>
</tr>
<tr>
<td>MODIFIED</td>
<td>Instructor</td>
<td>“The most useful tool to my learning in BIO 183 was my professor…is an amazing professor and really wants everyone to understand the material”</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>Instructor</td>
<td>“I really liked how engaging [the instructor] was”</td>
</tr>
<tr>
<td>None</td>
<td>Student found no aspects of the course useful</td>
<td></td>
</tr>
<tr>
<td>MODIFIED</td>
<td>None</td>
<td>“None”</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>None</td>
<td>N/A</td>
</tr>
<tr>
<td>Room Design</td>
<td>Any generic mention of the design and layout of the classroom (specific to SCALE-UP)</td>
<td></td>
</tr>
<tr>
<td>MODIFIED</td>
<td>Room Design</td>
<td>N/A</td>
</tr>
<tr>
<td>SCALE-UP</td>
<td>Room Design</td>
<td>“I really liked the overall set up of the SCALE-UP room. It was more beneficial to be in a lively, engaging atmosphere as opposed to a lecture hall”</td>
</tr>
</tbody>
</table>
Student Performance and Motivation.

The independent t-tests (see table 5) revealed that overall the two course structures were very similar in terms of performance and motivation measures. While course grade was higher in SCALE-UP than in the modified section, it was not significant. However, when examining the participation portion of the grade on its own, there was a significant difference between the two sections in favor of SCALE-UP.

For the IMI scales, the only significant findings were in differences between perceived relatedness. Students in the SCALE-UP section reported significantly higher values for perceived relatedness than those in the modified section. Student reported levels of interest/enjoyment and perceived choice were slightly higher in the modified section, though not to a significant degree. Levels of perceived competence were slightly higher in the SCALE-UP section, but not significantly.

Table 4.5 Descriptive Statistics and T-test Results for Student Performance and Motivation.

<table>
<thead>
<tr>
<th>Course Grade (600pts)</th>
<th>SCALE-UP</th>
<th>Modified Lecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>496.64</td>
<td>483.97</td>
</tr>
<tr>
<td>SD</td>
<td>63.46</td>
<td>85.85</td>
</tr>
<tr>
<td>t-value</td>
<td>1.239</td>
<td>3.927</td>
</tr>
<tr>
<td>df</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>Sig.</td>
<td>.217</td>
<td>.001*</td>
</tr>
<tr>
<td>Participation Grade (150pts)</td>
<td>136.71</td>
<td>128.22</td>
</tr>
<tr>
<td>Interest/Enjoyment</td>
<td>4.26</td>
<td>4.59</td>
</tr>
<tr>
<td>Perceived Choice</td>
<td>3.57</td>
<td>3.73</td>
</tr>
<tr>
<td>Perceived Competence</td>
<td>4.70</td>
<td>4.60</td>
</tr>
<tr>
<td>Perceived Relatedness</td>
<td>5.10</td>
<td>4.54</td>
</tr>
</tbody>
</table>

Discussion

This study set out to examine the differences between two sections of an introductory biology course taught by the same instructor in two different types of active learning
environments: a SCALE-UP and a modified Lecture section. While there was very little difference between the two sections in terms of amount of active learning occurring in the classroom, there was less lecturing in the SCALE-UP section than the modified section. Both sections spent considerable in-class time working on a class activity with the instructor moving around the classroom assisting students. In the modified section, students worked in pairs due to the constraints of the seating arrangement and the instructor could not reach students who were seated in the middle of the lecture hall. This was not the case in the SCALE-UP classroom where students were capable of working collaboratively in larger groups thanks to the open design of the classroom. In addition, the presence of the UTAs meant that students had the opportunity for more student-instructor interactions than is possible in the modified section.

Observations that higher levels of collaborative learning were more easily and successfully implemented in the SCALE-UP section was also illustrated in student responses for which course components they found most useful to their learning. Students in both sections reported on similar types of active learning within the intellectual, physical, and social active learning framework. However, there were differences in the types of activities students found most useful in each section. Students in the modified section listed activities in the intellectually and physically active category as most useful. They favored online course resources, interactive topic outlines, and clicker questions, which are all things that can be easily and successfully utilized in the large lecture environment. Students in the SCALE-UP section found activities within the physical and social category to be most useful, including interactive topic outlines, writing on the white boards placed throughout the classroom, and taking part in collaborative class activities.
Differences found between the two sections both in terms of observations and student perceptions are most likely due to the physical set-up of the two classrooms. The unique physical environment and the extra presence of the UTAs enables the successful utilization of collaborative learning which SCALE-UP students appear to appreciate. Students have more freedom to work together in larger groups and move around the classroom as needed. They can make use of physical classroom amenities like the white boards to collaboratively build models and practice course content. In addition, the UTAs provide guidance and support. These benefits are unique to the SCALE-UP classroom in that it is not as easy to conduct collaborative learning within the confines of the large auditorium setting. In contrast, the modified section relies less on collaborative learning, like working in pairs which can be difficult to accomplish in an auditorium setting, and more on didactic questioning by the instructor (with or without the use of a clicker) and filling out diagrams or topic outlines during class. These forms of active learning are more suited to the physical environments that modified lectures are conducted in.

In terms of student performance and motivation, SCALE-UP students had higher participation grades and higher perceived levels of relatedness or belonging to a learning community. Otherwise, performance and motivation levels were very similar between the two sections with no differences in final course grade, interest/enjoyment, perceived competence, and perceived autonomy. These findings indicate that the SCALE-UP environment aided students’ achievement when completing graded participation activities and increased their sense of belonging to a learning community. The modified section, due to its limited use of collaborative learning activities, is not as suitable for fostering a sense of community in students and thus, students may feel lower levels of relatedness and may not be as inclined to participate in class activities as do their SCALE-UP counterparts.
Implications.

The findings of this study provide support for incorporating active learning in the traditional lecture format and is in line with the literature that highlights the positive benefits of active learning on teaching and learning. This is particularly useful for large universities, at which instructors teach many of their science courses in auditorium style classrooms and do not have access to specialized learning environments like SCALE-UP. In terms of short-term student performance and motivation, students who were in the modified section did not appear to be at a disadvantage when compared to those enrolled in the SCALE-UP section. The findings bolster past studies demonstrating the success of implementing active learning in large enrollment undergraduate STEM courses (Allen & Tanner, 2005; Eichler & Peeples, 2016; Rodriguez, 2016; Smith, Stewart, & Shields, 2005; Walker, Cotner, Baepler, & Decker, 2008). However, unlike those studies which demonstrated higher learning gains in the students enrolled in the active learning sections compared to those enrolled in more traditionally taught sections, this novel study suggests that not only does the implementation of active learning in large lecture undergraduate STEM courses result in higher student performance and motivation as shown by previous studies, but it also can be just as effective as courses taught in specialized learning environments like SCALE-UP when the instructor is well versed in active learning pedagogy. A similar study recently examined differences in student performance and motivation between two sections of a course that were using different forms of active learning, though the learning environment did not differ in that study (Cleveland, Olimpo, & DeChenne-Peters, 2017). The study found no major differences in the two sections and like this study suggests that the benefits of active learning are present no matter what form it takes.
Despite the lack of major differences in student performance between the modified lecture and SCALE-UP, collaborative learning was more prevalent in the SCALE-UP section due to the easier mode of implementation, which may have resulted in the higher student participation scores and perceived relatedness. This may have long-term benefits for students in these environments, and points to the importance of classroom formats that facilitate collaborative learning. In fact, there are a multitude of studies illustrating the benefits of collaborative learning (Armstrong, Chang, & Brickman, 2007; Fakayode, Yakubu, Adeyeye, Pollard, & Mohammed, 2014; Gokhale, 1995; Harris, Bransford, & Borphy, 2002; Johnson, Johnson, & Smith, 1998; Springer, Stanne, & Donovan, 1999) and, the SCALE-UP environment was largely designed based on the positive findings of studies in collaborative and other social forms of learning (Beichner, 2008). A multi-institutional study conducted by Wilson et al. (2015) found that student belonging, particularly at the class level, was significantly important for behavioral and emotional engagement in STEM courses. Other studies found similar results suggesting that a student’s sense of relatedness and belonging to their learning community can have significant and broad impacts on many outcomes including performance, motivation, and retention (Bollen & Hoyle, 1990; Freeman, Anderman, & Jensen, 2007; Hausmann, Schofield, & Woods, 2007; Hurtado et al., 2007; Plett & Wilson, 2014).

Future studies should seek to further explore differences between active learning formats, including assessing the specific benefits to specialized learning environments like SCALE-UP. These environments can be costly and difficult to create but may provide students with crucial benefits due to their ability to easily facilitate socially based learning opportunities that are otherwise not available to students restricted by the confining space of traditional lecture halls. While this study examined overall course performance and student participation, future studies
may consider other measures of student learning gains including pre-/post- measurements of conceptual understanding with validated concept inventories. With respect to motivation, this study examined intrinsic motivation which is one type of autonomous motivation and could be elaborated by exploring other measures of motivation such as identified motivations, the extrinsic form of autonomous motivation. In addition, examining task-value or student interest may prove enlightening. Lastly, although the data from the open-ended question in this study was illuminating regarding which course activities students found most useful in both sections, there were several limitations. The open-ended question asking students to identify course components most useful to their learning was misunderstood by a quarter of the students in both sections. Responses indicated that students thought they were being asked which topics covered in the course they found most useful instead of which course activities or components they found most useful. A different method of collecting the data such as in-person interviews or a list of given activities for students to choose from may allow for more accurate interpretation and probing for meaning.

To conclude, this study provides several important findings. It suggests that when properly implemented, active learning in a large lecture section does not put students at a disadvantage in terms of course performance and intrinsic motivation for learning when compared to a section of the same course taught in a specialized learning environment like SCALE-UP. However, findings do indicate that specialized learning environments may still present meaningful benefits to students beyond course performance as a result higher facilitation of socially based active learning. This study suggests that there is merit to continued research on specialized learning environments for undergraduate STEM courses, especially focusing on the long-term benefits of collaborative, active learning.
References


American Association for the Advancement of Science (2011). Vision and Change in Undergraduate Biology Education: A Call to Action, Washington, DC.


Beichner, R. J. and Jeffery, M. S., 2003. Introduction to the SCALE-UP (Student-Centered Activities for Large Enrollment Undergraduate Programs) Project. [Online] Available at: www.ncsu.edu/per/Articles/Varenna_SCALEUP_Paper.pdf [Accessed March 14, 2018]


Cotner S, Loper J, Walker JD, Brooks DC (2013). “It’s not you, it’s the room” (or, are the high-tech, active learning classrooms worth it?). *J Coll Sci Teach, 42*(6), 82–88.


Chapter 5 Discussion

Overview of Dissertation Goals

The goal of this dissertation was to explore the impact of student-centered learning on student motivation and performance through the theoretical lens of self-determination theory. Self-determination theory examines the role of the environment on the development of an individual’s motivations and resultant behaviors (Deci & Ryan, 2000). SDT broadly defines motivation as being either autonomous or controlled. Autonomous motivation is a self-driven motivation that derives from an inner locus of causality (deCharms 1968). Intrinsic motivation is the prototype of autonomous motivation (Deci & Ryan 2000). Individuals who are intrinsically motivated to complete a task do so because of the enjoyment derived from the task itself. Individuals who are primarily autonomously motivated to complete a behavior tend to experience a heightened sense of wellbeing (Deci & Ryan, 2000). Student performance has been positively linked with autonomous motivation in several studies (Hulleman, Godes, Hendricks, & Harackiwecz, 2010; Klein, Raymond, & Wang, 2006; Linnenbrink & Pintrich, 2002; Schunk, Pintrich, & Meece, 2008; Wilke, 2003). A recent study at the undergraduate level found intrinsic motivation was associated with higher performance during team-based learning exercises (Jeno et al., 2017). In contrast, controlled motivation is derived from an outside locus of causality (Deci & Ryan, 2000). Individuals experiencing controlled motivation perform behaviors not because they want to, but because of some sort of external pressure such as the threat of punishment or offer of a reward. Several earlier studies have demonstrated the negative effects of controlled motivation in terms of student performance and motivation (Amabile, DeJong, & Lepper, 1976; Deci & Cascio, 1972; Harackiewicz, Manderlink, & Sansone, 1984; Lepper & Greene, 1975).
Motivation does not develop in a vacuum, indeed the social environment plays a large role in the development of an individual’s motivations either autonomous or controlled. Environments that support three basic psychological needs of individuals (competence, autonomy, and relatedness) encourage the development of autonomous motivation, while environments that thwart those three needs tend to result in controlled forms of motivation (Deci & Ryan, 1985, 2000, 2008). To develop autonomous motivation for learning student’s must be in an environment that nurtures their sense of competence or ability to perform well in the class (Deci & Ryan, 1985, 2000, 2008). This is accomplished through careful scaffolding of class activities and meaningful feedback on activities (Deci & Ryan, 1985, 2000, 2008). Several studies have shown the positive correlation between increased levels of student competence with learning gains (Boggiano & Ruble, 1979; Deci, 1971). Students’ sense of autonomy must also be nurtured in the classroom environment. That is to say that students must feel like they are in control of their own learning, this is most easily accomplished by providing students meaningful choices regarding learning opportunities in the classroom (Deci & Ryan, 1985, 2000, 2012). Classroom environments that support student autonomy have also been shown to increase student performance and overall motivation for learning (Deci & Ryan, 2000). Finally, classroom environments must support students’ sense of relatedness or belonging to a learning community. Early work demonstrated the importance of the instructor in supporting students’ sense of relatedness by being open to their students and supportive of their feelings (Ryan & Grolnick, 1986; Ryan, Stiller, & Lynch, 1994). More recent studies at the undergraduate level have examined the effects of belonging to a learning community at either the classroom level or university level on student performance and retention (Bollen & Hoyle, 1990; Freeman, Anderman, & Jensen, 2007; Hausmann, Schofield, & Woods, 2007; Hurtado et al., 2007; Plett &
Wilson, 2014). Within the classroom setting, the instructor plays a crucial role in ensuring the classroom environment is supportive of the students’ three needs (Deci & Ryan, 2000). Instructors who are autonomy-supportive work to ensure that learning experiences within the classroom foster students’ needs for competence, autonomy, and relatedness. In contrast, controlling instructors who do not take the students’ needs into account run the risk of sabotaging their students’ volition and sense of self within the classroom resulting in decreased motivation and learning gains.

**Findings**

The first study used a quasi-experimental mixed methods design to examine students’ intrinsic motivation, competence, and autonomy between three sections of an introductory biology course utilizing differing amounts of active learning: a traditional lecture section with little to no active learning, a modified lecture section that utilized active learning instructional techniques suited to a large auditorium setting, and SCALE-UP, a specialized student-centered learning environment designed primarily for active learning. In addition, two focus groups with students from the SCALE-UP section, which utilized the highest amount of active learning, were conducted to examine which aspects of the course students felt was most beneficial to their motivation and learning. Active learning positively correlates with student intrinsic motivation and autonomy. Results from the focus groups with the SCALE-UP students suggests that classroom aspects that while the classroom aspects that students found most useful to their learning and motivation aligned with all three of basic psychological needs, aspects that align with relatedness were deemed to be most important to student.

The second study used a quasi-experimental design to examine the effects of instructor autonomy support on students’ intrinsic motivation, performance, and other behavioral outcomes
in the same three sections of introductory biology that the first study examined. The study presented two major findings. First, it was found that levels of instructor autonomy support were positively correlated with the amount of active learning utilized in the classroom. Second, levels of instructor autonomy support were found to be positively predictive of levels of students’ intrinsic motivation, performance, and other student behavioral outcomes. Students who perceived their instructor as being more autonomy supportive felt they had higher levels of competence, autonomy, put more effort in the course, placed more value in the course, and felt less tension/anxiety than did students who perceived their instructor as being less autonomy supportive. Given that levels of instructor autonomy support were perceived by students as being higher in the sections utilizing active learning, it can be inferred that students enrolled in student-centered learning environments experience increased benefits in terms of intrinsic motivation, performance, and behavioral outcomes.

The third study compared the learning spaces of two sections of the introductory biology course that employed active learning pedagogies. One section of the course was taught in a traditional lecture hall and the other was taught in a room specifically designed for collaborative, active learning. The study utilized a quasi-experimental mixed methods design that accomplished three things: an assessment of the amount and type of active learning occurring in both classrooms, an assessment of which course components students found most useful to their learning, and a comparison of student performance, intrinsic motivation, levels of perceived autonomy, competence, and relatedness. The instructor in both sections implemented similar amounts of active learning, but there were differences in the types of active learning activities. SCALE-UP is uniquely suited to collaborative learning and students were given more opportunities to engage in social learning activities than the modified lecture setting allowed for.
The layout of the SCALE-UP classroom ensured the main instructor had access to each student and could aid as needed. Furthermore, the presence of the undergraduate teaching assistants meant a lower student to instructor ratio and provided for more quality one-on-one time with either the main instructor or their UTAs. Students in the SCALE-UP section seemed to appreciate this difference citing physical and social learning components unique to the SCALE-UP environment as being most useful to their learning.

The two sections were very similar with respect to student performance and motivation. Students in the SCALE-UP section had higher rates of participation and higher perceived levels of relatedness or belongingness to the learning community than did students in the modified section. The results suggest that at the surface level there is little differences between the two formats and students in large lecture auditoriums that utilize student-centered learning are not at a disadvantage to those enrolled in specialized learning environments like SCALE-UP in terms of student performance and intrinsic motivation. However, students in specialized learning environments may be benefiting from the social nature of the classroom setting that is not possible in the large auditorium lecture setting.

**Conclusions**

Student motivation is positively impacted by the incorporation of student-centered pedagogies in the undergraduate STEM classroom. The first study clearly demonstrates that levels of intrinsic motivation, the prototype of autonomous motivation according to SDT, positively correlates with the amount of active learning occurring in the classroom. A recent study found similar increases of intrinsic motivation when they looked at team-based learning activities (Jeno et al., 2017). Student-centered learning environments support the development of students’ intrinsic motivation through environments that support the students’ ability to
meaningfully engage with course material in a volitional manner consistent with SDT’s model for the development of intrinsic motivation. Instructors support students’ development of autonomous motivation through student-centered learning pedagogies that place students center stage in the classroom allowing them to take ownership of their own learning. This support and development is not possible in more traditionally taught courses that are teacher-centered and provide students with little to no chance to interact with course material in a meaningful or volitional manner. Instructor autonomy support facilitated by student-centered learning leads to increases in student motivation, performance, and other positive behaviors. These positive benefits have been shown in the literature (e.g., Allen & Tanner, 2005, Eichler & Peeples, 2016; Rodriguez, 2016; Smith, Stewart, & Shields, 2005; Walker, Cotner, Baepler, & Decker, 2008) but this dissertation provides an explanation for the reasoning behind those benefits. Students perform better and experience greater affective outcomes in learning environments that acknowledge and nurture the students’ need to develop a volitional sense of self in the learning environment.

Students benefit from effective implementation of active learning pedagogies regardless of learning space it occurs in. This dissertation found no differences in terms of student performance and motivation between students being taught in a student-centered manner in a traditional large auditorium and those who had access to a specialized learning environment like SCALE-UP. This finding is encouraging for instructors who teach large classes in auditorium settings. It suggests that these students can benefit from the implementation of student-centered learning and not be at a disadvantage when compared to students with access to more innovative learning spaces. However, specialized classrooms for student-centered learning are usually designed with collaborative learning in mind. The collaborative and social nature of these
specialized learning environments may benefit students in terms of higher willingness to participate in class and increased feelings of belonging to a learning community. Several studies have illustrated the benefits of collaborative learning (Armstrong, Chang, & Brickman, 2007; Fakayode, Yakubu, Adeyeye, Pollard, & Mohammed, 2014; Gokhale, 1995; Harris, Bransford, & Borphy, 2002; Johnson, Johnson, & Smith, 1998; Springer, Stanne, & Donovan, 1999) and feelings of relatedness or belonging to a community of learners (Bollen & Hoyle, 1990; Freeman, Anderman, & Jensen, 2007; Hausmann, Schofield, & Woods, 2007; Hurtado et al., 2007; Plett & Wilson, 2014).

**Limitations.**

This dissertation faced several limitations and challenges. Firstly, this project only explored one example of SCALE-UP and one example of a modified lecture. To expand on the findings of this study future studies will need to examine several different varieties of student-centered learning environments both in the large auditorium setting and in cases where specialized classrooms have been built. Furthermore, the study only examined introductory biology students. There are many other subjects and classes in undergraduate STEM and findings in these settings may vary from the findings presented in this dissertation. Finally, there were several limitations in terms of what data was collected for this dissertation. Due to time and budget constraints the amount and type of qualitative data collected was less than ideal. It would have been beneficial to also collect qualitative data from the traditional lecture section studied including conducting further focus groups with a more diverse group of students, further classroom observations, and examination of classroom artifacts such assignments and projects. All of these would be hugely beneficial in further examining differences in terms of student participation, willingness to learn, and participate. Lastly, the only performance data examined in
this dissertation was course grade. Studies utilizing pre- and post-data would be more suited to controlling for students’ ability and for examining further differences in performance between the three class types.

**Future Directions.**

This dissertation clearly demonstrates the benefits of student-centered learning environments in terms of student performance and motivation. Student-centered learning environments place students’ as purposeful meaning makers in their own world. Instructors support the development of autonomously motivated learners who can then go out into the world and be productive members of society and the workforce. Classroom environments that can accommodate more collaborative and socially based active learning may be even further beneficial to students in terms of providing them with opportunities to interact more with their instructor and peers lending to a feeling of belonging to a learning community. Future work should continue to examine how student-centered learning impacts students’ motivations and their own sense of self as learners and scientists by expanding on the findings presented within this study. For example, it would be interesting to further examine the use of self-determination theory in examining student-centered learning environments including further in-depth analysis on how well instructor support predicts students’ psychological need satisfaction and how that in turn predicts motivation and performance. Results from that study would further bolster the applicability of self-determination theory to undergraduate education research studies interested in studying student motivation.
References


Appendices
Appendix A: Intrinsic Motivation Inventory

Please rank the following statements with how true they are for you on a scale of 1 to 7 with 1 being ‘not true at all’, 4 being ‘somewhat true’, and 7 being ‘very true’.

Interest/Enjoyment Scale
1. I enjoyed taking this course very much.
2. This course was fun to take.
3. I thought this course was boring.
4. This course did not hold my attention at all.
5. I would describe this course as very interesting.
6. I thought this course quite enjoyable.
7. While I was taking this course, I was thinking about how much I enjoyed it.

Perceived Competence Scale
1. I think I was pretty good at taking this course.
2. I think I did pretty well in this course compared to other students.
3. After taking this course for a while, I felt pretty competent.
4. I am satisfied with my performance in this course.
5. I was pretty skilled at taking this course.
6. This was a course that I couldn’t do well in.

Perceived Choice Scale
1. I believe I had some choice about taking this course.
2. I felt like it was not my own choice to complete this course.
3. I didn’t really have a choice about taking this course.
4. I felt like I had to take this course.
5. I took this course because I had no choice.
6. I took this course because I wanted to.
7. I took this course because I had to.
Appendix B: Focus Group Protocol

Introduction to Study

Thank you for coming today. My name is Kimberly Pigford and I am a third year PhD student. This focus group is part of my doctoral dissertation. I’ve brought us here together so that we can learn from each other about what is really going on in the BIO 181 SCALE-UP course at [Name of University where study took place]. This is a “no holds barred” discussion. I want to know what you’re seeing and experiencing, even if you think of it as negative. That is the only way I can help to improve your experience with the course. Of course, I would also really like to know about the good things as well, but just remember that there are no wrong responses here today. Our conversation should take no longer than an hour.

I am going to tape our conversation so that I can review it afterwards, but it goes no further than this group. Anything you say here will be held in strict confidence and will have no impact on your experience in the course. Since I am taping the conversation, try to speak up when talking and try to only talk one at a time. That being said, I do want this to be a group discussion so if you have something to add to the conversation please do not hesitate to jump in.

If you would, please also read and sign the consent form handed to you when you came in. Once we are ready to start, we will have some quick introductions and jump right into the discussion. Once again, thank you so much for agreeing to participate in this study.

Questions:

• Describe your experience with the SU format so far?

  What do you like/dislike about this learning format?

• What can you say about this format with respect to your learning of bio 181 concepts?

  Have you taken/are taking a course in a large lecture hall of 200+ students? If so, how do you think taking bio 181 in such a format would differ with respect to your learning as compared to SU?

• What sorts of activities do you feel were most helpful for your learning?

  If you could change anything about SCALE-UP, what would it be?

• Describe your level of excitement with respect to learning about biology when you first started the semester.

  How has that changed now that we are mid-way into the semester?

• Describe how being in SU has affected your appreciation for biology?

  How do you think your experience would differ had you taken the course in a large lecture format, auditorium style seating, 240 students?
- Of the activities that we have done over the semester, which types were you most excited about?

  Which made you interested in learning more about the topic?
Appendix C: Focus Group Consent Form

[University Name]
Department of Science Education

Research Study: Student Experiences in SCALE-UP

Researcher Name: Kimberly Pigford

FOCUS GROUP CONSENT FORM

What is the Research?

You have been asked to take part in a research study examining student perceptions of the SCALE-UP program. The purpose of this study is to explore student experiences in SCALE-UP in an attempt to understand why students perform better in this course format and to improve the SU experience for students overall.

Why have I been asked to take part?

You are a student currently enrolled in BIO 181 SCALE-UP section. You have been asked to take part in a group discussion looking at your experiences in SCALE-UP. I will be asking questions related to how you like SCALE-UP, how you feel your learning and motivation are impacted by the class format, and if there are any changes you would make to the program.

Voluntary Participation

This discussion is voluntary—you do not have to take part if you do not want to. If you do not take part, it will have no effect on anything that happens within your BIO 181 course.
If any questions make you feel uncomfortable, you do not have to answer them. You may leave the group at any time for any reason, no questions asked.

Risks

I do not think any risks are involved in taking part in this study.

Benefits
There are no direct benefits for taking part in this research. I hope to learn more about how students experience SCALE-UP and any way I can improve the experience. The discussion may
allow you to reflect on your own learning and performance within the class, which may have some indirect benefits for some people.

**Privacy**

Your privacy will be protected.
Your name will not be used in any report that is published.
The discussion will be kept *strictly confidential*.
The other students in the group will be asked to keep what we talk about private, but this cannot be assured.

Our conversation will be tape recorded, but only so I can remember what is said later on. All of the data will be kept secured and will be destroyed once the discussion has been studied. If you are not comfortable being recorded, you are not required to stay for the discussion and may leave at any time.

**Audiotape Permission**

I have been told that the discussion will be tape recorded. I understand that if I do not want to be tape recorded, I do not have to stay for the discussion and can leave at any time.

I agree to be audio taped ___Yes   ___No

**Payment**

There is no payment for taking part in this focus group. However, please enjoy the pizza and refreshments during our discussion as a token of my appreciation for your time and effort.

**Questions**

I have been given the opportunity to ask any questions I wish regarding this study. If I have any additional questions about the study, I may call Kim Pigford at 919-417-8818.

A copy of this consent form will be made available for me if I wish to have it.

*Please write your name below and check yes or no. If you want to take part Sign your name at the bottom.*

__________________________________________
NAME

_____ Yes, I would like to take part in the focus group.
No, I would not like to participate in the focus group.

SIGNATURE
DATE
Appendix D: Learning Climate Questionnaire

Please rank how strongly you agree with the following statements on a scale of 1 to 7 with 1 being ‘strongly disagree’, 4 being ‘neutral’, and 7 being ‘strongly agree.’

1. I feel that my instructor provides me choices and options.
2. I feel understood by my instructor.
3. I am able to be open with my instructor during class.
4. My instructor conveyed confidence in my ability to do well in this course.
5. I feel that my instructor accepts me.
6. My instructor made sure I really understood the goals of the course and what I need to do.
7. My instructor encouraged me to ask questions.
8. I feel a lot of trust in my instructor.
9. My instructor answers questions fully and carefully.
10. My instructor listens to how I would like to do things.
11. My instructor handles people’s emotions very well.
12. I feel that my instructor cares about me as a person.
13. I don’t feel very good about the way my instructor talks to me.
14. My instructor tries to understand how I see things before suggesting a new way to do things.
15. I feel able to share my feelings with my instructor.
Appendix E: Intrinsic Motivation Inventory (Chapter 3)

Please rank the following statements with how true they are for you on a scale of 1 to 7 with 1 being ‘not true at all’, 4 being ‘somewhat true’, and 7 being ‘very true’.

Interest/Enjoyment Scale
1. I enjoyed taking this course very much.
2. This course was fun to take.
3. I thought this course was boring.
4. This course did not hold my attention at all.
5. I would describe this course as very interesting.
6. I thought this course quite enjoyable.
7. While I was taking this course, I was thinking about how much I enjoyed it.

Perceived Competence Scale
1. I think I performed well in this course.
2. I think I performed well in this course compared to other students.
3. After being in this course for a while, I felt pretty competent.
4. I am satisfied with my performance in this course.
5. I was pretty skilled at completing the work in this course.
6. This was a course that I could not perform well in.

Effort Scale
1. I put a lot of effort into this course.
2. I didn’t try very hard to do well in this course.
3. I tried very hard in this course.
4. It was important to me to do well in this course.
5. I didn’t put much energy into completing the work in this course.

Tension Scale
1. I did not feel nervous at all in this course.
2. I felt very tense while doing work for this course.
3. I was very relaxed while doing work for this course.
4. I was anxious while doing work for this course.
5. I feel pressured in this course.

Perceived Choice Scale
1. I believe I had some choice about taking this course.
2. I felt like it was not my own choice to complete this course.
3. I didn’t really have a choice about taking this course.
4. I felt like I had to take this course.
5. I took this course because I had no choice.
6. I took this course because I wanted to.
7. I took this course because I had to.
Value Scale
1. I believe this course was of some value to me.
2. I think that taking this course was useful for my undergraduate career.
3. I think this course was important to take because it helped me learn biology.
4. I would be willing to take this course again because it had some value to me.
5. I think taking this course could help me during my undergraduate studies.
6. I believe this course was beneficial to me.
7. I think this is an important course to take.
Appendix F: Open-Ended Survey Questions

1. Prior to taking BIO 181 how interested were you in learning about the topics that were covered this semester?

2. During you BIO 181 course were there any activities that caught your attention and increased your interest in a topic you otherwise were not interested in? Please explain why this activity managed to catch your interest?

3. Are there any topics covered in BIO 181 that you are still interested in and want to learn more about? Why are you still interested in these topics?

4. Were there any topics covered in BIO 181 that you are interested in now that you were not at all interested in prior to taking BIO 181? Explain why.

5. What aspects of the course did you think were most useful to your learning? Why?

6. Describe a specific instance(s) in the course where you struggled with the material. What did you do to get through this difficult time?
Appendix G: Intrinsic Motivation Inventory (Chapter 4)

Please rank the following statements with how true they are for you on a scale of 1 to 7 with 1 being ‘not true at all’, 4 being ‘somewhat true’, and 7 being ‘very true’.

Interest/Enjoyment Scale
1. I enjoyed taking this course very much.
2. This course was fun to take.
3. I thought this course was boring.
4. This course did not hold my attention at all.
5. I would describe this course as very interesting.
6. I thought this course quite enjoyable.
7. While I was taking this course, I was thinking about how much I enjoyed it.

Perceived Competence Scale
1. I think I was pretty good at taking this course.
2. I think I did pretty well in this course compared to other students.
3. After taking this course for a while, I felt pretty competent.
4. I am satisfied with my performance in this course.
5. I was pretty skilled at taking this course.
6. This was a course that I couldn’t do well in.

Perceived Choice Scale
1. I believe I had some choice about taking this course.
2. I felt like it was not my own choice to complete this course.
3. I didn’t really have a choice about taking this course.
4. I felt like I had to take this course.
5. I took this course because I had no choice.
6. I took this course because I wanted to.
7. I took this course because I had to.

Perceived Relatedness Scale
1. I felt really distant to the other people in this class.
2. I really doubt the other people in this class and I would ever be friends.
3. I felt like I could really trust my classmates.
4. I would enjoy interacting with my classmates more in the future.
5. I don’t feel like I could really trust my classmates.
6. It is likely that my classmates and I could become friends if we interacted a lot.
7. I feel close to my classmates.