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Student Retention in an Introductory STEM Course: A Mixed Methods Study of Student Motivation and Teaching Approaches

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STUDENT RETENTION IN AN INTRODUCTORY STEM COURSE: A MIXED METHODS STUDY OF STUDENT MOTIVATION AND TEACHING APPROACHES

By Lina Wang

This Dissertation is Submitted in Partial Fulfillment of the Requirements for the
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Abstract

Science, Technology, Engineering, and Mathematics (STEM) education is vital to all students. Student motivation, both intrinsic and extrinsic, have been found to be very influential in how successful a student is in a STEM classroom (Krapp, 2007; Lamb, Annetta, Meldrum, & Vallett, 2012; Schoon, Ross, & Martin, 2007; Skinner, Saxton, Currie, & Shuststerman, 2017). The current study examined what correlations, if any, we present between teaching approaches, intrinsic motivation, and extrinsic motivation of students in an undergraduate, non-major, introductory chemistry course at a mid-sized, four-year university in the Midwestern United States. In the focus groups, students were highly motivated by grades and program requirements. However, students who enjoyed guided learning had significant differences between intrinsic value, self-determination, and self-regulation. Though students found the course challenging and uninteresting, the external motivation of grades increased their intrinsic motivation, which is reported to be associated with high levels of effort and task performance (Froiland et al., 2012). This correlation seems to suggest guided learning can have an impact on student motivation in an introductory STEM course.

CHAPTER I

Introduction

Background of the Problem

Science, Technology, Engineering, and Mathematics (STEM) education have been at the forefront of government education reform in elementary and secondary schools. However, STEM education reform in higher education has rarely been addressed as government reform (National Research Council, 2012). STEM education became a topic of national concern after the publication of *Rising Above the Gathering Storm* by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies (2007). In this report, the authors called for an emphasis on developing K-12 STEM education programs to help increase student interest in pursuing STEM-related careers. The authors stated that the United States of America was not achieving at the same rate of students in other countries when it came to STEM education. They predicted a lack of educational reform emphasizing K-12 STEM education would develop poorly prepared working STEM professionals in the industrial sector.

Brown, et al. (2011) examined how the decrease in undergraduates pursuing STEM fields has caused a decline in STEM professionals, thus leading to more unfilled jobs. The authors believed STEM education is not well understood, has no clear vision, and is lacking in school systems (Brown et al., 2011). Over the past few years, there has been an increase in trying different teaching approaches to STEM introductory courses in undergraduate education (Armbruster, et al., 2009; Chrispeels et al., 2014; Elliot et al., 2016; Zeichner, 2010). However, there is still a lack of understanding of how to better motivate students to continue pursuing STEM degrees.

STEM education in and of itself is vital to all students regardless of whether students pursue a STEM degree or not. As stated by National Research Council (2012), "Students who do not pursue these careers need to understand science and engineering to serve in their roles as citizens, consumers, and leaders of business and government who need to make wise science-informed decisions in their personal and professional lives" (p. 8). At the forefront of this dilemma is discipline-based education research (DBER). DBER determines how different teaching methods for each STEM-discipline can be improved to foster learning and teaching.

Teaching Method

Within STEM education, the most common form of teaching is the lecture method for teaching course content. This method transfers information from the professor to the student (Sullivan & McIntosh, 1996). Lecture methods have long been the standard for STEM courses (Andrews & Lemons, 2015; Gibbons, Villafañe, Stains, Murphy, & Raker, 2018). Most university STEM faculty still utilize lecture models as the primary mode of education, despite overwhelming studies that show a more student-centered learning environment increases student learning (Stains et al., 2018). A study by Gibbons et al. (2018) designed to examine teacher thinking and self-efficacy measures based on enacted instructional practices found a connection between beliefs and instructional practices. This suggests that despite the prominent call for active learning environment reform in STEM classes (Andrews & Lemons, 2015; Armbruster et al., 2009; Elliot et al., 2016), perhaps teachers need to explore a belief change before they can accept educational reform (Gibbons et al., 2018).

A study by Elliot et al. (2016) incorporated an active learning component to the lecture in a large-enrollment introductory biology course at Iowa State University by implementing a faculty learning community. The faculty learning community allowed instructors to develop new pedagogies, adapt active-learning strategies, discuss challenges and progress, provide critiques for classroom interventions, and share materials. The authors found a correlation between the percentage of classroom time spent in active-learning modes and student learning gains, and a weak positive correlation with student attitudes toward learning biology. Another active learning study by Armbruster et al. (2009) integrated student-centered ideas as well. They found incorporating active and problem-based learning into every lecture, reordering course content, and creating a more student-centered learning environment significantly improved student engagement, student satisfaction, and academic performance. Chrispeels et al. (2014) encouraged undergraduates in a non-major biology course to participate in a service-learning program where they led middle school and high school students, through a case study on plant genetics. The undergraduates who taught high school students scored higher on questions specific to the high school curriculum compared to those who taught middle school students. However, overall, both groups of undergraduate students showed they had a better understanding of topics related to the curriculum they had taught.

Student motivation

Apart from focusing on creating student-centered or active learning environments, student motivation is a key measure of STEM success (Krapp, 2007; Lamb et al., 2012; Schoon, Ross, & Martin, 2007; Skinner et al., 2017). Student motivation can come from students' level of engagement in class, type of information presentation, their own identity as a scientist, relationships with peers and family, or type of classroom environment (Lamb et al., 2012; Skinner et al., 2017). These factors suggest that motivation and interpersonal relations are a necessary part, along with cognitive and pedagogical teachings, to consider when creating STEM-focused classes (Skinner et al., 2017).

These intrinsic (self-interest, discipline) and extrinsic (e.g., family, community) factors have shown correlations with student attitudes and achievement toward science (Krapp, 2007; Schoon et al., 2007). A study by Lamb et al. (2012) determined the Science Interest Survey (SIS), a survey targeting middle and high school students to identify their current and future interest in STEM, that asked questions related to peer influence, student attitudes, and situational interests, was accurate at assessing science interest levels in students. Another study evaluated how an emphasis on socioscientific issues could positively influence student attitudes, by using a revised Scientific Attitude Inventory and Changes in Attitude about the Relevance of Science Survey over four semesters of an introductory geology course (Pelch & McConnell, 2017). Another study by Connell, Donovan, and Chambers (2016) assessed how increasing active-learning pedagogies, consistent formative assessment, and cooperative learning groups improved undergraduate perceptions of biology and learning biology in a summer Biology 101 course.

Problem Statement

Modern teaching approaches have shown to be useful in developing positive student perceptions of STEM courses. Studies have demonstrated how specific teaching approaches can increase student learning and attitudes. However, there is still a lack of research determining how intrinsic and extrinsic factors, coupled with teaching approaches, influence each other to better understand the role each plays in shaping student's motivation to succeed in STEM courses. Studies have not shown whether teaching instruction or student motivation plays a more significant part in a student's interest in STEM fields or whether they act in tandem.

Purpose Statement

Although instruction in the classroom has been studied thoroughly, the association of intrinsic (self-motivation) and extrinsic (parent, friend influence) motivation to teaching approaches in STEM classes have been less researched. Thus, this research aims to determine the correlation, if any, between different teaching approaches (i.e., lab versus lecture) and undergraduate student motivation (self-interest, instructor inspiration, and personal influences) in an undergraduate, non-major, introductory chemistry course at a mid-sized, four-year university in the Midwestern United States.

Research Questions

- How do teaching approaches affect undergraduate student motivation?
- How do intrinsic factors affect undergraduate student motivation?
- How do extrinsic factors affect undergraduate student motivation?

- How do teaching approaches, intrinsic factors, and extrinsic factors contribute to undergraduate student motivation in STEM science classes?

Significance of Research

This research aims to shed light on the underlying factors contributing to undergraduate student success and interest in introductory STEM classes. Professors who teach an introductory STEM class will benefit from the findings, as they will be able to see what motivates students to perform in STEM classes. If the results show something a professor can change in their teaching approach, it will help in the retention of students in STEM classes. Having successful undergraduates in STEM courses will allow students to develop critical thinking skills, become more aware of their environment, and potentially increase STEM interest and understanding.

Delimitation

This study was limited to undergraduate students in an undergraduate, non-major, introductory chemistry course at a mid-sized, four-year university in the Midwestern United States.

Definition of Key Terms

Active learning

Classes where students actively engage in working on a question or problem designed to facilitate conceptual understanding and apply it to their own lives.

Directed Note-Taking

A split-page structure where the teacher guides students to take notes with main ideas on the left and supporting material on the right.

Extrinsic Motivation

Behavior that comes from an individual when carrying out an activity to attain a separable outcome.

Intrinsic Motivation

Behavior that comes from within an individual, out of will and interest in the activity at hand.

Laboratory Class

Classes that utilize active learning in the laboratory as a method of information transfer from the professor to the student.

Lecture Class

Classes that focus on using lectures as the method of information transfer from the professor to the student.

POGIL

Process Oriented Guided Inquiry Learning facilitates student learning by utilizing student-centered, group-learning strategies, and research-based philosophies.

STEM Education

Education in the subjects of science, technology, engineering, and mathematics, including computer science.

STEM Courses

Full semester classes in science, technology, engineering, and mathematics that have a lecture and, or laboratory part.

CHAPTER II

Literature Review

Introduction

The report, *Rising Above the Gathering Storm*, by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies (2007), called for an emphasis on developing K-12 STEM education programs to help increase student interest in STEM-related careers, as the U.S. was and still may be failing to achieve high rates of student retention in STEM courses compared to other countries. The U.S. awarded 10% of the global 7.5 million degrees in science and engineering fields conferred between 2000-2014 (National Science Board, 2018). China and India led the number of degrees conferred, comprising 22% and 25%, respectively. Whereas the European Union was only slightly ahead of the U.S. at 12% of degrees conferred (National Science Board, 2018). The following chapter presents an analysis of literature concerning how two different teaching approaches (lecture and active learning) influence intrinsic and extrinsic student motivation in undergraduate, introductory STEM classes. This chapter examines research that has been done on different teaching approaches, intrinsic factors, and extrinsic factors, separately, as there has been a lack of studies that show how all three are related to each other.

STEM Education

Science, Technology, Education, and Mathematics Education, or STEM Education, is the “education in the subjects of science, technology, engineering, and mathematics, including computer science” (STEM Education Act of 2015). STEM is an acronym initially used by the National Science Foundation to promote Education-related programs (Mohr-Schoreder, Cavalcanti, & Blyman, 2015). Tsupros, Kohler, and Hallinen (2009), as cited in Mohr-Schoreder et al. (2015), defines STEM education even further,

> STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy. (p. 10)

The STEM field began to gain national attention in the 1950s with the launch of the Russian satellite, *Sputnik* (Mohr-Schoreder et al., 2015). The launch of *Sputnik* spurred the United States to form the National Aeronautics and Space Administration. This beginning of STEM innovation led to a rise in federal policies surrounding STEM education. President George W. Bush passed the *American Competitiveness Initiative* (2006) aimed to improve the training of mathematics and science teachers and providing grant money to schools. During President Obama's tenure as president, two initiatives, *Educate to Innovate* (The White House, Office of the Press Secretary, 2009) and *Change the Equation* (The White House, Office of the Press Secretary, 2010) were created to foster business community involvement in STEM education, increase diversity in STEM fields, improve STEM teacher quality, and increase federal investment in STEM (Mohr-Schoreder et al., 2015).

Federal STEM education efforts have cost \$2.8-3.4 billion between 2010-2016, with 34% of that going toward programs aimed to sponsor higher education STEM degrees. (Granovskiy, 2018). The National Science Foundation’s Improving

Undergraduate STEM Education program gives financial support to projects that focus on developing curricular materials, instruction materials, new assessment tools for measuring student learning and improve the diversity of students and instructors in STEM education (Granovskiy, 2018).

In agreement with the increased federal push for STEM education, there seems to be an uptick in overall graduate student enrollments and degree attainment for traditionally underrepresented groups (Granovskiy, 2018). However, concerns remain regarding achievement gaps, STEM teacher quality, international STEM assessment rankings of United States students, foreign student enrollments and better educational attainments of other countries, and the lack of STEM professionals to meet STEM labor demands (Granovskiy, 2018). The gender gap and minority gap can be used to classify the achievement gap in regards to STEM education. Studies have shown, there are fewer women obtaining STEM degrees (Bergeron & Gordon, 2017; Wang & Degol, 2017). Likewise, underrepresented minority groups, such as Latinx, Black, and American Indians/Alaskan Natives, are still lagging behind Caucasian and Asian students when it comes to retention in STEM degrees (Haak, HilleRisLambers, Pitre, Freeman, 2011; Jordt et al., 2017; Olszewski-Kubilius, Steenbergen-Hu, Thomson, & Rosen, 2017). When students are a part of the achievement gap, lower retention rates often follow. This achievement gap ultimately leads to lower diversity within the STEM field and workforce (Jordt et al., 2017).

Over the years, there has been a steady stream of students graduating with STEM degrees. Students with higher levels of academic achievement and higher positive affects (high experience of positive emotions) were more likely to persist in STEM programs

(Simon, Aulls, Dedic, Hubbard, & Hall, 2015). However, there is a lack of diversity of Hispanic, Black, and women representation. Hispanics were awarded 12.1% of STEM bachelor’s degrees in 2014 (an increase from 2004), while Blacks were below 9% (consistent with 2004 data). Women earned only 21% of bachelor’s degrees in engineering and computer science (Gravoskiy, 2018; Strayhorn, 2010). There have been efforts to increase underrepresented groups in STEM fields through the American Innovation and Competitiveness Act (January 2017). This Act allows the National Science Foundation to award grants aimed to increase underrepresented populations participation in STEM fields, encourage the creation of grants for STEM apprenticeship opportunities and computer science education, expand undergraduate research opportunities, and recognize outstanding mentors in STEM fields. INSPIRE Women Act (February 2017) was created to encourage women and girls to study STEM fields, with an emphasis in aerospace is another example of federal efforts to increase underrepresented populations in STEM fields (Granovkiy, 2018).

Concerns and Challenges in STEM Education

Underrepresented ethnic populations (i.e., Blacks, Latinos, American Indians/Alaskan Natives) had a lower percentage rate (24%) of completing STEM degrees in six years of initial enrollment compared to White students (40%; Strayhorn, 2010). According to the Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development (2000), about half of undergraduates who intended to major in STEM change fields within their first two years of study. A mixed-methods study by Ortiz and Sriraman (2015) examined what factors were thought to impact student decisions to persist in STEM fields at Texas State University, a

Hispanic Serving Institution. In 2012, 6.7% of Hispanics and 0% of Blacks graduated with a STEM degree in 4 years compared to 19.8% of White students. Overall, 1% of total STEM degrees awarded in 2012 at Texas State University were American Indian/Alaskan Native, 2% were Asian/Pacific Islander, 3% were Black, 23% were Hispanic, and 67% were White (Ortiz & Sriraman, 2015). Six percent of the STEM workforce in the United States is comprised of underrepresented populations. In comparison, only 4.6 percent hold advanced degrees despite efforts to increase student retention rates of underrepresented populations and a 40% growth in STEM employment (Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development, 2000).

Reform in STEM education was brought to the attention of many policymakers and University administrators (Granovskiy, 2018; STEM Education Act of 2015). Some scholars believe it should begin with teaching approaches (Andrews & Lemons, 2015; Armbruster et al., 2009; Elliot et al., 2016), others believe it is based heavily on student self-efficacy (Sawtelle, Brewe, & Kramer, 2012; Simon, Aulls, Dedic, Hubbard, & Hall, 2015), while yet others believe having relatable mentors are most beneficial (Capri et al., 2013).

Teaching Approaches

Lecture

The word “lecture” was created in the 14th century derived from the Latin word *lectus*, meaning “I read, I recite” (Executive Office of the President, President’s Council of Advisors on Science and Technology, 2012; Merriam-Webster Online, n.d.). Today, most introductory STEM courses, whether online or in the classroom, are taught through various forms of lectures (Executive Office of the President, President’s Council of Advisors on Science and Technology, 2012). The various lecture formats include active-learning, student-centered, and traditional (Elliot et al., 2016; Sullivan & McIntosh, 1996). Despite the different forms, the basis of lecturing involves transferring information from the instructor to the student (Sullivan & McIntosh, 1996). Lectures often promote memorization over conceptual understanding and are efficient in presenting a large amount of content to a large audience (Booth, 2001; Bransford, Brown, & Cocking, 2000; Gasiewski, Eagan, Garcia, Hurtado, & Chang, 2012). Since the 1990s, there have been concerns about the effectiveness of lecturing and its correlation with student success in the classroom (Connell, Donovan, & Chambers, 2016; Elliot et al., 2016; Gasiewski et al., 2012; Sullivan & McIntosh, 1996). Concerns ranged from improper training of lecturers (Arredondo, Busch, Douglass, & Petrelli, 1994) to a lack of student involvement (McIntosh, 1996). The National Research Council (2003) argued transformations needed to occur in traditional lecture-based courses to student-centered learning classrooms. To address these concerns, over the past few decades, researchers have begun to examine how increasing active-student learning in a lecture-based classroom affects student success. However, instructional barriers such as the efficiency of implementing active-learning in large lectures and differences in classroom teaching approaches make it difficult for instructors to fully implement active learning in the classroom (Connell et al., 2016). To adequately understand these transformations, active learning must be first defined.

Active Learning

Active learning is when students actively engage in working on a question or problem designed to facilitate conceptual understanding and apply it to their own lives; sometimes while the instructor pauses lecturing (Andrews & Lemons, 2015; Gasiewski et al., 2012). However, it is essential to note that active learning sometimes does not involve any lecturing at all. There are many types of active learning, including case studies, clicker use (small handheld devices used to collect student responses in class for interactive questions), collaborative learning (i.e., peer-led team learning, inquiry labs), cooperative learning (i.e., problem-based learning), and service-learning (Andrews & Lemons, 2015; Chrispeels et al., 2014; Gasiewski et al., 2012; Smith et al., 2005). Active learning has improved retention of information and critical thinking skills in all students, leading to a decrease in the achievement gap between ethnic groups and different genders (Executive Office of the President, President's Council of Advisors on Science and Technology, 2012).

Elliot et al. (2016) compared classes with increased active-learning strategies, such as using clickers and group problem solving, in an undergraduate introductory biology class at Iowa State University. The authors assessed student learning and attitudes at the beginning and end of a 15-week semester. Results showed students in the class with the highest amount of student-centered learning activities had a higher score change on content assessments utilizing clickers than other reform. The authors concluded that instructors of the classes reported active learning was better for student learning compared to traditional lecture formats (Elliot et al., 2016).

At the University of Virginia, a course of 180 students was reformatted to include small-group activities, increase student understanding of the connectedness of student knowledge and course content, and related course concepts to other majors/disciplines (Swap & Walter, 2015). They found students seemed to enjoy the course more compared to previous years, with some students stating, “the instructor thoroughly engaged the entire class and know(s) how to intrigue [their] audience and made [us] want to come to lecture every day!" (p. 13). A meta-analysis of 225 studies comparing scores or failure rates of student performance in undergraduate STEM courses using a lecture or active learning found lecture courses attributed to 55% failure rates (Freeman et al., 2014). The authors also found active learning was most beneficial in small classes and when introducing concept learning across all STEM disciplines (Freeman et al., 2014).

An introductory undergraduate biology class (Biology 101), which had one of the highest failure rates at Western Washington University, was reformatted to increase active-learning via permanent working groups with assigned seating, activity-based classes, online pre-lectures, and formative assessment (Connell et al., 2016). Over four years, the authors collected data on student attitudes towards science, student attitudes towards learning science, and student achievement using surveys and formal assessments in class. Students who were in the reformatted Biology 101 class had a mean exam score 8.4% higher than students in a slightly reformed Biology 101 class, as well as a higher mean post-assessment score. However, the authors recognized there might be a limitation to the number of active-learning strategies an instructor can feasibly incorporate in a large introductory class (Connell et al., 2016).

Although active-learning correlates with higher student achievement, not all students welcome active-learning with open arms (Brigati, 2018). Lake (2001) found students in a physiology course with active learning reported feeling as though they learned less and had a less effective instructor, despite having better course grades compared to traditional lecture sections. A mixed-method study using a self-developed survey, one-on-one interviews, and four-person focus group discussions found undergraduate STEM students held mixed views on whether active learning helped them succeed in the classroom (Welsh, 2012). Students who did not care for active learning thought it was a waste of time and money. The students believed clicker learning was useless as many students just copied another's response instead of trying to figure it out themselves or were used solely for recording attendance. Additionally, some students perceived class group discussions as a waste of time as not everyone in the large science class was productive. Despite this negative feedback, students also provided ways they thought active learning would be useful. These included how the techniques were used, well-integrated, challenging questions in the lecture, good structure/instruction with group discussions, and knowing the students' preference (Welsh, 2012).

Researchers at Ball State University implemented a student-led lecture, where students had 40 minutes to review and discuss with their peers the specific learning object, followed by 10 minutes of clicker questions (Bernot & Metzler, 2014). The researchers found no difference in overall course grade between the student-led lecture and instructor-led lecture. However, students did not like the student-led class. Students commented that the instructor did not teach, going to class was pointless, students did not prefer the style of teaching or lack of teaching, and they did not pay money to educate themselves (Bernot & Metzler, 2014).

POGIL

Process Oriented Guided Inquiry Learning (POGIL) facilitates student learning by utilizing student-centered, group-learning strategies, and research-based philosophies (Moog & Spencer, 2008; POGIL Project Team, 2019). POGIL, developed in the mid-1990s, consists of three key elements: 1. Students work in small, self-managed teams on guided inquiry material, 2. Development of process skills, and 3. POGIL is student-centered (Brown, 2010; Moog & Spencer, 2008; POGIL, 2019). POGIL aims to allow students to develop content mastery by learning information processing, communication skills (Moog & Spencer, 2008). The National Science Foundation funded the POGIL project to allow for further development and publication of POGIL approaches in various disciplines (POGIL, 2019). King College in Tennessee implemented POGIL activities into an Anatomy and Physiology course over four consecutive semesters during 2008 and 2009 (Brown, 2010). Each activity allowed student groups to work through critical-thinking questions. Brown (2010) found an increase in As (80% of grades) and a decrease in D/F grades (0%) by the end of the four semesters. In the final semester, none of the students failed the final exam with a mean increase of score from 68.08 in spring 2008 to 88.33 by fall 2009. The author concluded that although student perceptions of the course did not change significantly, those in the POGIL class achieved better grades and emphasized the importance of group work (Brown, 2010). Vishnumolaka, Southam, Treagust, Mocerino, and Quershi (2017), found student attitudes, self-efficacy, and experiences were higher after POGIL activities in an undergraduate chemistry course.

The authors utilized a convergent, parallel mixed methods approach, where qualitative data was used for triangulation purposes. Students took the Attitudes toward the Study of Chemistry Inventory and the Chemistry Attitudes and Experiences Questionnaire. Qualitative data was collected in the form of semi-structured interviews after the surveys were taken. Students were found to have better intellectual accessibility, emotional satisfaction, self-efficacy, and attitudes toward the study of chemistry.

Despite the concern over traditional lectures, lectures are still one of the most common forms of teaching (Gasiewski et al., 2012). Active learning mixed in with traditional lectures has shown to improve student retention, student attitudes, and student achievement (Connell et al., 2016; Gasiewski et al., 2012; Swap & Walter, 2015). Likewise, POGIL activities have been found to increase student learning in chemistry courses and other science courses (Brown, 2010; Moog & Spencer, 2008; Vishnumolaka et al., 2017). However, teaching approaches are not the only factor in increasing student retention and success in STEM courses. Student motivation, both intrinsic and extrinsic factors, are vital components to student success in STEM courses.

Directed Note-Taking

Directed note-taking is split-page method for note-taking. Students write down main ideas on the left side of a page while writing supporting evidence or material on the right (Spires & Stone, 1989). Directed note-taking also utilizes a self-questioning strategy to monitor levels of involvement before, during, and after notetaking. Lastly, the direct, explicit teaching of the notetaking process was based on Pearson’s model for teaching reading comprehension (Spires & Stone, 1989).

Before the directed note-taking process, students are encouraged to ask themselves some planning questions (i.e., what is the purpose for listening to this lecture?, Do I feel motivated to pay attention?) (Spires & Stone, 1989). Once the teacher begins lecturing, students should ask themselves monitoring questions (i.e., Am I concentrating well? What should I do when comprehension fails?). Lastly, once notes are completed, students should evaluate their learning and understanding (i.e., Did I achieve my purpose? Did I process the lecture at a satisfactory level?). This method begins with the teacher guiding students through the three different steps listed above. As time goes on, the teacher can start to release more and more responsibility to the students, so that students can complete the task by themselves (Spires & Stone, 1989).

Student Motivation

Motivation comes in different levels and types (Ryan & Deci, 2000). A motivated person is someone who is "energized or activated toward an end" (p. 54), while an unmotivated person is one who feels no inspiration to act. The Self Determination Theory (SDT) distinguished different types of motivation based on reasons that gave rise to specific actions (Ryan & Deci, 2000). SDT related human motivation and personality to frame differences in cognitive and social development and individual differences. The theory focused on how social and cultural factors could help or hinder a person's sense of free will and initiative, well-being, or the quality of their performance. SDT also stated all people seek the need to develop competence, the need for creating connections with others, and the need for autonomy (Froiland, 2012). When students feel autonomous by achieving the three items, they are more likely to adopt intrinsic goals leading to greater intrinsic motivation (Froiland, 2012; Simon et al., 2015).

Intrinsic

Intrinsic motivation is behavior motivated by the inherent benefits done for the satisfaction of oneself (Froiland, 2012; Ryan & Deci, 2000). Intrinsically motivated individuals act for the fun or challenge rather than external pressures or rewards (Ryan & Deci, 2000). Under the SDT, the Cognitive Evaluation Theory (CET) specified that feelings of competence through rewards, communications, and feedback could enhance intrinsic motivation when accompanied by a sense of autonomy as it satisfies a basic psychological need for proficiency in human nature. CET is especially important in classrooms. Students with high intrinsic motivation pursue subjects of interest inside and outside of school because it provides enjoyment and purposeful learning (Froiland, 2012). Intrinsic motivation has been associated with high effort, high task performance, and a preference for the challenge (Froiland, 2012; Patall et al., 2008). Teachers that support students to be independent learners showed greater intrinsic motivation, curiosity, desire for challenge, and productivity of students (Froiland, 2012; Ryan & Deci, 2000).

Along the lines of SDT, student self-efficacy is a belief in one’s ability to perform a specific task derived from personal mastery experiences, vicarious learning experiences, social persuasion, and physiological state (Bandura, 1977). Mastery experiences are the primary basis of one’s self-efficacy beliefs. Mastery experience is any experience that successfully completes a task, resulting in one’s confidence to complete a similar task. Vicarious learning experiences occur when one observes another individual perform a similar task regardless of if the other person was successful or failed. Social persuasion experiences include verbal suggestions from others about one's abilities. This experience can lead to a negative or positive impact depending on the verbal suggestions.

Lastly, the physiological state can hinder or facilitate one's confidence in performing a task. Examples of physiological states include stress, anxiety, depression, or sadness (Bandura, 1977).

Sawtelle, Brewe, and Kramer (2012) surveyed students in an introductory physics with Calculus I class to determine sources of self-efficacy at a school with a primarily Hispanic student population. The authors found a higher self-efficacy correlated with higher success in the classroom. The authors also found that men in the course tended to utilize mastery experiences to determine self-efficacy while women focused more on vicarious learning experiences. Sawtelle et al. (2012) suggested self-efficacy could be used to understand student retention in the classroom, as it was a good predictor of success. Along the lines of differences between men and women, Van Soom and Donche (2014) examined the correlation between academic self-concept (one’s perceived ability in an academic context) and autonomous motivation (when one engages in a behavior because it is seen to be consistent with one’s intrinsic goals and values). They found women had high autonomous motivation and low self-concept, while male students tended to have low autonomous motivation and high self-concept (Van Soom & Donche, 2014). On the other hand, students with lower autonomous motivation are reported to have higher levels of frustration and dissatisfaction with course content (Dyrberg & Holmegaard, 2018).

Continuing motivation, where an individual will return to a task area on their own, is an example of intrinsic motivation (Fortus & Vedder-Weiss, 2014). The authors found students tend to lose continuing motivation as they get older, especially in female students. However, in an Israeli democratic school (a school co-managed by students, parents, and school staff, that do not necessarily follow national curricula), continuing motivation did not change as students moved from 5th to 8th grade (Fortus & Vedder-Weiss, 2014).

Intrinsic motivation can also vary, depending on a student's perception of their ability. Cotner, Thompson, and Wright (2017) assessed differences and similarities between biology majors and non-STEM majors at the University of Minnesota. The survey covered student science identity, confidence, and perceptions of science, scientists, and scientific processes. Non-STEM majors averaged lower in science confidence, identified as an artistic person instead of science person, viewed science as a static area, and had a more diverse population. However, despite these differences from Biology majors, non-STEM major students still identified science as being useful and necessary to learn and use in everyday life (Cotner et al., 2017).

Extrinsic

Extrinsic motivation, as described by Ryan and Deci (2000), is carrying out an activity to attain a separable outcome. Organismic Integration Theory (OIT) deduces four main types of regulatory styles of extrinsic motivation. External regulation is the least autonomous form of extrinsic motivation. Behaviors performed to satisfy an external demand or to obtain a reward defines external regulation. A slightly more controlling internal regulation where a person carries out an act to enhance or maintain one's self-esteem and feeling of worth is introjection. Third, identification is a self-determined type of extrinsic motivation. Under identification, one determines personal importance to a specific behavior/task. Lastly, integration occurs autonomously when "identified regulations have been fully assimilated to the self" (Ryan & Deci, 2000, p. 62). Deci and

Ryan (1985), proposed using extrinsic motivation by prompting integrated self-regulation to increase student success. For example, tokens, exchangeable for goods, are given for desired learning behaviors in a token reinforcement program, encouraging students to develop excellent learning skills in exchange for a reward.

In STEM education, extrinsic motivation can cause students to “complete tasks with resentment, resistance, and disinterest or with an attitude of willingness that reflects an inner acceptance of the value or utility of a task” (Ryan & Deci, 2000, p. 54-67). Lin, McKeachie, and Kim (2003) sampled 73, 73, 432, and 72 students, over four years, across nine different undergraduate courses on intrinsic and extrinsic motivation using the Intrinsic Goal Orientation and Extrinsic Goal Orientation scale of the Motivated Strategies for Learning Questionnaire. The authors found students with average extrinsic motivation levels and high intrinsic motivation had higher grades than students with low/high extrinsic motivation. Likewise, they determined intrinsic motivation often worked adversely with extrinsic motivation. This finding led the authors to propose moderate levels of extrinsic motivation were the optimal level for student success in the classroom (Lin et al., 2003).

Learning environment was also examined as an extrinsic factor to student success. The Biology Motivation Questionnaire II of 300 students in a large-enrollment Biology I course compared Face-to-face vs. virtual laboratories (Reece & Butler, 2017). Overall, researchers found a decline in student motivation over the semester in both courses, but no difference in knowledge, performance, or motivation to learn between the two different laboratories (Reece & Butler, 2017). One hundred thirty-six college students were surveyed on their perception of extrinsic rewards given by parents and teachers for academic performance in elementary to high school (Davis et al., 2006). Male students who received greater external rewards from both parents and teachers showed higher extrinsic and intrinsic motivation. Female students who received greater external rewards as children, exhibited lower levels of extrinsic motivation. Seventy-seven percent of students said rewards were effective academic motivators. However, at the college level, students who reported rewards were effective were less extrinsically motivated than those who thought rewards were bad (Davis et al., 2006).

Extrinsic motivation is complex in itself, affected by the type of extrinsic motivation, student levels, learning environments, and gender. Deci and Ryan (1985) advocated for the use of extrinsic motivation to help bolster a student's natural intrinsic motivation for learning and success. In line with this, a meta-analysis of 154 peer-reviewed articles, conference papers, dissertations, and unpublished research found that intrinsic motivation correlated more for quality, while extrinsic motivation increased the quantity of student performance (Cerasoli & Nicklin, 2014). The two types of motivation were found to have complex interactions, suggesting that a balanced approach would be best for student success in all classrooms (Cerasoli & Nicklin, 2014).

Need for More Research

Student motivation, along with teaching approaches in the classroom, play a large roll in student success as presented above. In STEM education, finding a balance between extrinsic motivation via teaching approaches and intrinsic motivation in the classroom is crucial to student retention rates (Cerasoli & Nicklin, 2014; Lin et al., 2003). The review of the literature included a discussion on the importance of STEM education and retention to fulfill industrial needs, as well as to better society (Granovskiy, 2018).

Additionally, teaching approaches, intrinsic, and extrinsic student motivation all play a role in student success in STEM courses.

Much of the literature calls for additional research. For example, Xu (2018) called for a more in-depth investigation into the relationship variations between students' academic/social experiences and student retention rates at different class levels.

Skinner et al. (2017) recommended future research should link features of teaching an institution has control over to the outcomes of deep learning and persistence in STEM majors. Additionally, Skinner et al. (2017) suggested student motivation and extrinsic motivation factors may be helpful to consider for student success in STEM courses. Andrews and Lemons (2015) called for studies to investigate similarities and differences in the adoption of new teaching approaches in different STEM disciplines. Likewise, Gibbons et al. (2017) supported reviewing various course levels, STEM majors versus non-STEM majors, and course contexts with instructional styles. What is missing from these studies is an understanding of how teaching approaches, intrinsic motivation, and extrinsic student motivation contribute to student success in introductory STEM courses.

This study will contribute new lines of knowledge and inquiry to STEM education literature by researching undergraduate experiences and success in introductory STEM courses. Past research has considered factors that may affect student retention and success in STEM courses. However, no studies have provided enough insight into the relationship between teaching approaches, intrinsic motivation, and extrinsic motivation toward student success. This study is designed to address the concern of student retention rates in STEM courses at the undergraduate level.

CHAPTER III

Methodology

The purpose of this study was to examine correlations between intrinsic student motivation, extrinsic student motivation, and teaching approaches. A convergent parallel mixed-methods study was used (See Table 1). This type of design collects qualitative and quantitative data in parallel, analyzes them separately, and merges the data to create a comprehensive set of findings. In this study, student motivation (intrinsic and extrinsic) tested the theory that positive student perceptions of different teaching approaches could positively influence student motivation in an introductory STEM course. The qualitative data were collected in focus groups that explore student perception of student success in the course based on teaching approaches. The reason for collecting both quantitative and qualitative data was to determine whether there was a correlation between student motivation and teaching approaches in the classroom. The two forms of data brought more significant insight into the problem than would be obtained by either type of data separately.

Table 1

The Different Steps to the Convergent Parallel Mixed-Methods Study Design.

Step		Analysis Procedure
Step 1	-	Quantitative Data Collection
	-	Qualitative Data Collection
Step 2	-	Quantitative Data Analysis
	-	Qualitative Data Analysis
Step 3	-	Identify similarities and differences between 2 sets of results.

Step 4	-	Interpret and summarize separate results.
Step 5	-	Explain divergences or discuss correlations to produce an understanding.

Subjects

Students in an undergraduate, non-major, introductory chemistry course (CHEM 100) at a mid-sized, four-year university in the Midwestern United States were invited to complete an in-class survey and focus group interview (see Appendix A and B). In the Spring of 2020, there were 94 students enrolled in the class. Of those 94 students, 83 students consented to share their answers for the quantitative survey while 67 students consented to share their answers for the focus groups. The first quantitative survey had 81 responses. Of those 81 responses, 45 students were elementary education majors, eight Communication Science and Disorders majors, and four were undecided majors. Seventy students were female, while 11 were male. When asked about ethnicity, seventy-one students were white, four black, two Latinx, three other/mixed, and one did not respond.

Chemistry 100

CHEM 100, titled Chemistry in Society, is a four-credit non-science major course that investigates the world of chemistry, the nature of matter, and our interactions with chemicals daily (Minnesota State University Mankato, 2017). The course takes place over 16 weeks and has both laboratory and lecture components. Most students enrolled in the course are elementary education majors, who are taking it to fulfill a course requirement for their undergraduate major. Spring 2020 had four different sections, with up to 24 students in each section. The lecture time had four laboratory sections, for a total of 96 possible students. At the beginning of the Spring 2020 semester, CHEM 100 was designed to have POGIL, traditional lecture, and directed note-taking teaching approaches. Students worked in groups, pairs, and individually during lecture and lab. The instructor instilled Process Oriented Guided Inquiry Learning (POGIL) practices within the lecture activities. Materials for the first two exams (generally Chapters one through four) relied on POGIL activities. Exam 3 (Chapter five through seven) materials focused more on the traditional lecture, while Exam 4 material (Chapters nine and ten) utilized directed note-taking (see Table 2).

However, the onset of the COVID-19 pandemic resulted in the transition of the course to a total online delivery method for the final five weeks of the semester. Therefore, the following adjustments were made to the course, instead of the lecture method and directed notes for the second half of the Chemistry 100 class, students were given learning goals, worksheets, and lecture videos to watch with recommended homework problems (see Table 2). Instead of Exams 3b and 4, the instructor implemented four quizzes, and divided the final exam into three parts (corresponding to exams 1, 2, and 3a). Laboratory activities were changed from in-person to alternative laboratory assignments.

Table 2

Teaching Approaches Based on Each Exam in CHEM 100 for the Semester.

Exam	Teaching Approach	Teaching Approach: COVID-19 changes
1	POGIL Practices	POGIL Practices
2	POGIL Practices	POGIL Practices
3	Traditional Lecture	Traditional Lecture (exam 3a only)

		Online videos (quizzes instead of exam)
4	Directed Note Model	Online videos (quizzes instead of exam)

Data Collection Procedures

Quantitative Data

A survey adapted using components from the Science Motivation Questionnaire II (SMQ II) (Glynn et al., 2011) and Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich & DeGroot, 1990) was used (See Appendix A). Five student demographics were surveyed, including major, sex, ethnicity, age range, and parental level of education.

Shawn M. Glynn, Emeritus from the University of Georgia, developed the SMQ II to assesses college and high school student motivation to learn in science courses (Glynn, n.d.). Glynn's instrument has been used in multiple studies in the research of gender and motivation to learn science, combines intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation in one survey (Zeyer, 2018). Additionally, it is also validated for biology, physics, and chemistry courses, and for science majors and non-science majors (Glynn et al., 2011). For chemistry courses, "chemistry" substitutes for the word "science" (Glynn, n.d.). As long as the copyright, "Science Motivation Questionnaire II © 2011 Shawn M. Glynn," is included, Glynn provides written approval for the use of the SMQ II survey on his website.

McKeachie, Pintrich, Lin, and Smith (1986) designed the MSLQ to assess college students' motivational orientations and the use of different learning strategies. Two sections make up the MSLQ, section one focuses on motivation (31 Likert items assessing goals and value beliefs), and section 2 focuses on learning strategies (31 items assessing cognitive strategies and 19 items related to students' managing resources for a college course) (Pintrich & DeGroot, 1990). According to the MSLQ manual (Pintrich, Smith, Garcia, & McKeachie, 1991), the instrument takes about 20-30 minutes to administer in class. 15 different scales make up the MSLQ, which can be used together or singly to fit the needs of the instructor. While being created, the questionnaire had undergone reliability and validity testing for five years (Pintrich et al., 1991). Permission to use the MSLQ is given on the University of Michigan website for valid research purposes if the instrument is cited appropriately (University of Michigan School of Education, n.d.).

To analyze how practical students perceived effective teaching approaches, a Likert scale survey containing questions (i.e., POGIL, level of student understanding) about the course was in the quantitative survey. The paper survey was distributed during the second week of classes (pre). A Qualtrics survey was distributed during the 16th week of scheduled classes (post). This 25-30 minute paper survey included the entirety of the SMQ II that entailed 42 questions related to intrinsic and extrinsic motivation subscales from the MSLQ, six teach approach perception questions, and five demographic questions.

Qualitative Data

A one-hour facilitated, focus group was conducted around midterms to collect information on which teaching approach students perceived as most beneficial in student engagement and increasing their learning. Additionally, questions about the students' extrinsic motivation and intrinsic motivation were added in the focus groups to allow for comparison between qualitative and quantitative data collected (see Appendix B). The researcher’s goal was to fully understand how helpful different teaching approaches throughout the semester were by collecting and analyzing the descriptions students provide in the guided focus group with open-ended questions.

Groups of 12 students were created based on consent and normal lab time (morning and afternoon sections), creating eight different focus groups. Five of those groups consisted of only students who consented. The other three had a mix of students who did consent and did not consent. Six different facilitators (facilitators A-F) comprised of teaching assistants and trained researchers, guided students through a series of questions focused on various teaching approaches and their motivation (Appendix B). Facilitator A conducted one of four morning lab groups in Room 1. Facilitator B conducted one of the afternoon lab groups in Room 1. Facilitator C conducted a morning and an afternoon lab group in Room 2, Facilitator D conducted one of the morning lab groups in Room 3, Facilitator E conducted one of the afternoon lab groups in Room 3, and Facilitator F conducted a morning and an afternoon lab group in Room 4 (Table 3).

Table 3

Focus Group Facilitators by Room Number, Number of Students, Group of Students, and If the Focus Group was Transcribed. .

Facilitator (type)	Room	Group (Only Consented or Mix)	Transcribed?
A (Teaching Assistant)	1	Only Consented	Yes
B (Teaching Assistant)	1	Mix	No
C (Trained Researcher)	2	Only Consented	Yes
D (Trained Researcher)	2	Only Consented	Yes
E (Trained Researcher)	3	Only Consented	Yes
F (Trained Researcher)	4	Mix	No

Following Creswell and Poth (2018), interviews were recorded, utilized an interview guide, were conducted in a distraction-free place, and consent obtained as approved by the institutional review board for the five focus groups of consented students were sent to Rev.com for transcription to be utilized as the qualitative data for this dissertation. Accuracy of returned transcripts from Rev.com (generally within three days of submission) were rechecked by comparing them to the original audio file.

Data Analysis

Quantitative Data

Since the survey items used have undergone analysis for reliability from various publications (i.e., Pintrich and DeGroot, 1990), there is a minimal need in this study to re-determine reliability. Likert scale items were categorized by their subscales for intrinsic, extrinsic, or teaching instruction themes. Intrinsic data were sub-coded as self-efficacy, intrinsic value, intrinsic motivation, and self-determination. Extrinsic data were sub-coded as cognitive strategy use, self-regulations, grade motivation, and career motivation. Teaching approaches were sub-coded as teacher approach/explanation, group work, guided learning, and active learning.

Student responses were decoded once survey responses were collected to keep the students anonymous to the. Once categorized, each theme score was averaged for standardization. For all statistical analyses, an alpha of 0.05 was used. Normality was checked for motivation subthemes with a normal quantile plot and Shapiro-Wilks analysis. Outliers were determined by residual normality plots for each subtheme. Those that did not pass the Shapiro-Wilks test (small p-value) were analyzed with a Kruskal-Wallis test. Those that did pass normality were analyzed with an ANOVA. Post-hoc tests (Tukey’s HSD and Steel-Dwass method) were conducted to determine any significance between the teaching approach response. In all analyses, the teaching approach subthemes were ordinal (independent variable), while the different motivation subthemes were nominal (dependent variable). JMP Pro14 (Student edition) was used to analyze quantitative data. The use of JMP Pro14 was due to the familiarity of the program to the researcher. JMP Pro14 allows for ANOVAs, MANOVAs, regressions, etc. to be conducted.

The hypotheses to be tested are:

- H0: Neither teaching approaches nor intrinsic and extrinsic factors will affect student motivation in STEM courses.
- H1: Teaching approach, specifically, active learning (i.e., laboratory activities), will increase intrinsic student motivation in STEM courses.
- H2: Intrinsic factors, such as self-belief and interest in STEM, will positively affect student motivation in STEM courses regardless of the teaching approach.
- H3: Extrinsic factors, such as good grades and to fulfilling goal areas, will negatively affect student motivation in STEM courses regardless of the teaching approach.

Qualitative Data

Qualitative data from the focus group were open coded to reflect single ideas. These open codes were then be combined to create axial codes. Following Creswell and Poth (2018), once axial codes were created, identity codes were contrived to determine major themes. Once the data was coded and analyzed, major themes were compared to qualitative data for extrinsic and intrinsic student motivation to determine any overlap or correlations between the datasets.

Merging of the Data

A table compared content areas represented in both the quantitative and qualitative datasets (Creswell & Clark, 2018). Additionally, quantitative results were compared and contrasted to the qualitative results as a type of constant comparison data. Per Creswell and Clark (2018), a comparison discussion was created for the mixed methods report. Quantitative and qualitative results were summarized individually before comparisons between the two datasets were reported. The questions to be answered by merging the data are as follows:

- How do teaching approaches affect undergraduate student motivation?
- How do intrinsic factors affect undergraduate student motivation?
- How do extrinsic factors affect undergraduate student motivation?
- How do teaching approaches, intrinsic factors, and extrinsic factors contribute to undergraduate student motivation in STEM science classes?

Potential Bias

The researcher has a background in biology and chemistry, attends Minnesota State University, Mankato, and has worked with the instructor of the chemistry course. The researcher recognized that her own experiences might have influenced her analysis of student motivation and how students view teaching approaches in STEM courses.

CHAPTER IV

Results and Findings

Quantitative Data

Normality

When tested for normality with an alpha of 0.05, only the subthemes, Career Motivation (Extrinsic Motivation, SMQII) and Intrinsic Value (MSLQ, Intrinsic Motivation) did not differ significantly from a normal distribution with p-values of 0.1304 and 0.6510 respectively (Table 4). The following subthemes did differ significantly from a normal distribution: Intrinsic Motivation (SMQII, p-value= 0.0203), Self-efficacy (SMQII, p-value= 0.0255), Self-determination (SMQII, p-value 0.0448), Grade motivation (SMQII, p-value<0.001), Self-efficacy (MSLQ, p-value=0.0050), Intrinsic value (MSLQ, p-value=0.6510), Cognitive strategy use (MSLQ, p-value=0.0146), and Self-regulation (MSLQ, p-value= 0.0021; see Table 4).

Table 4

Summary of Shapiro-Wilks Analysis of Subtheme and Teaching Approach/Explanation

Subtheme (Survey)	Shapiro-Wilks p-value
Intrinsic Motivation (SMQII)	0.6510
Self-Determination (SMQII)	0.0255
Grade Motivation (SMQII)	0.0010
Career Motivation (SMQII)	0.1304
Self-Efficacy (MSLQ)	0.0050
Intrinsic Value (MSLQ)	0.6510
Cognitive Strategy Use (MSLQ)	0.0146

Self-Regulations (MSLQ)	0.0021

Kruskal-Wallis Results

Significance was found for intrinsic motivation (p-value= 0.0075; Table 4), self-efficacy (SMQII and MSLQ p-value=0.0002 & <0.0001; Table 4), self-determination (p-value= 0.0117; Table 4), and grade motivation (p-value= 0.0246; Table 4) when analyzed against teacher presentation and explanation.

Students who agreed the teacher presentation and explanation were concise and clear reported higher intrinsic motivation than those that were neutral (p-value= 0.0331; Figure 1). Students who were neutral on whether the teacher presentation and explanation were concise and clear had significant lower self-efficacy than students who slightly agreed (SMQII: p-value= 0.0294, Figure 2a; MSLQ p-value= 0.0047; Figure 2b), and students who agreed (SMQII: p-value= 0.0005; MSLQ p-value= <0.0001). Self-determination and grade motivation did not show any significant pairwise comparisons.

Figure 1

Box and Whisker Plots of Intrinsic Motivation Subtheme from the SMQII Showing Mean, Range, and 95% Confidence Intervals by Teaching Presentation and Explanation responses.

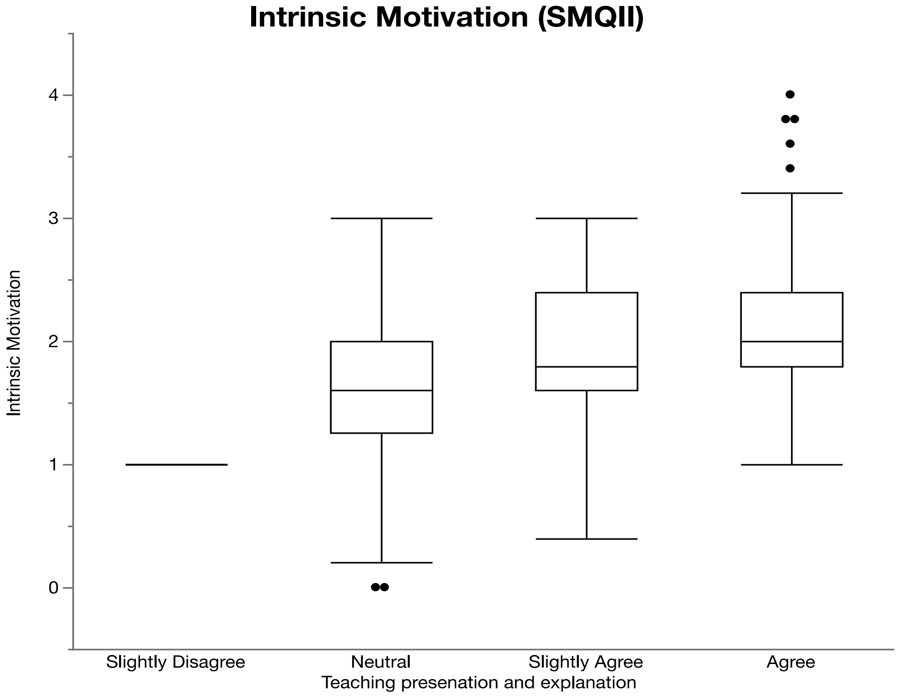


Figure 2a

Box and Whisker Plots of Self-Efficacy Subtheme from the SMQII and MSLQ (b) Showing Mean, Range, and 95% Confidence Intervals by Teaching Presentation and Explanation Responses.

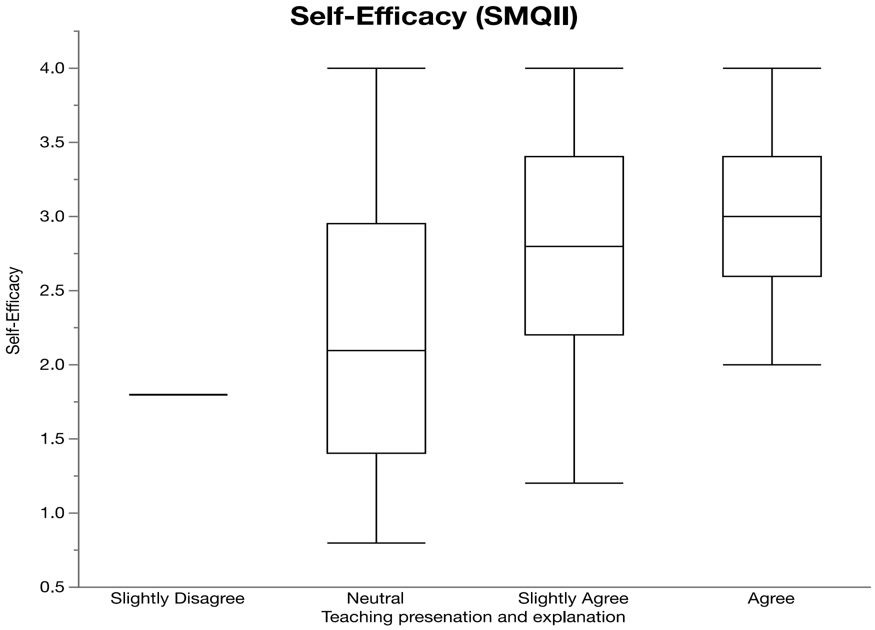


Figure 2b

Box and Whisker Plots of Self-Efficacy Subtheme from the MSLQ Showing Mean, Range, and 95% Confidence Intervals by Teaching Presentation and Explanation Responses.

When looking at guided learning, significant correlations were found for self-determination (p-value= 0.0209), self-efficacy (p-value= 0.0409), Cognitive strategy use (p-value= 0.0003), and self-regulation (p-value= 0.0195).

Students who enjoyed guided learning reported higher self-determination than students who were neutral about guided learning (p-value= 0.0289; Figure 3). Students neutral about enjoying guided learning reported lower cognitive strategy use than students who slightly agreed (p=0.0216; Figure 4), and students who agreed (p-value= 0.0004). Likewise, students who enjoyed guided learning had higher self-regulation scores than those that were neutral (p-value= 0.0283; Figure 5).

Figure 3

Box and Whisker Plot of Self-Determination Subtheme from the SMQII Showing Mean, Range, and 95% Confidence Intervals by Guided Learning Responses.

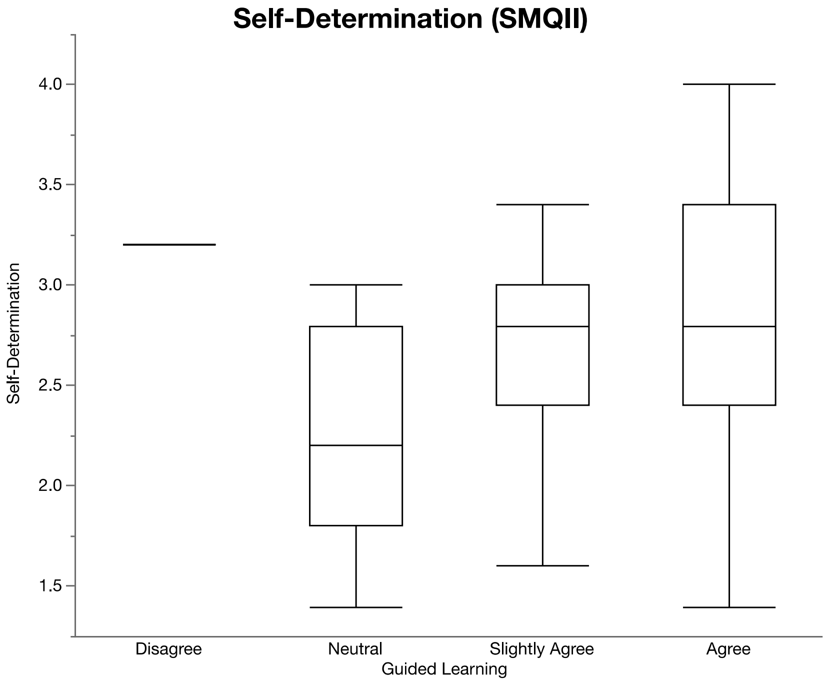


Figure 4

Box and Whisker plots of Self-Regulation Subtheme from the MSLQ Showing Mean, Range, and 95% Confidence Intervals by Guided Learning Responses.

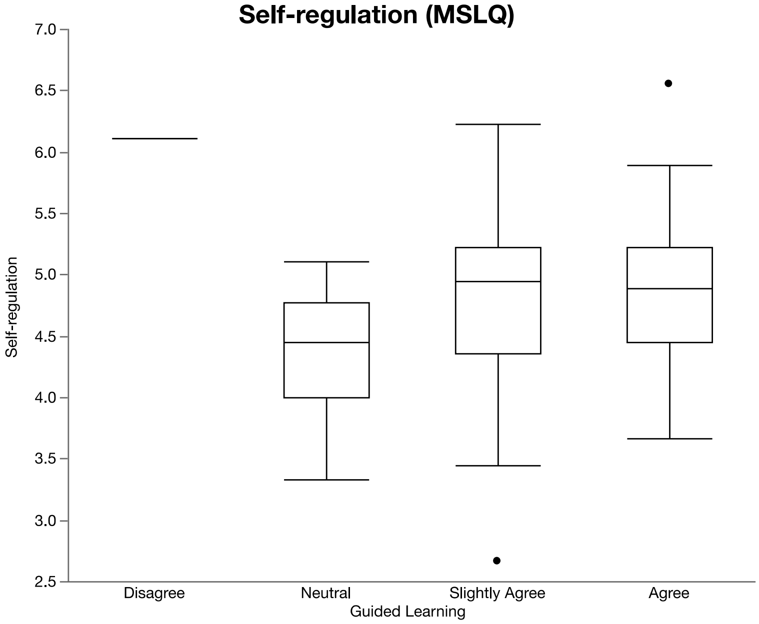
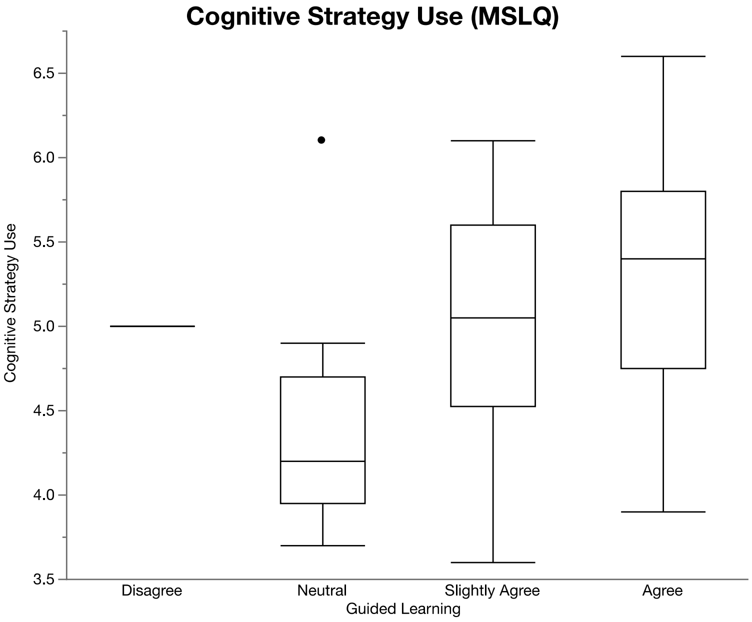


Figure 5

Box and Whisker plots of Cognitive Strategy Use Subtheme from the MSLQ Showing Mean, Range, and 95% Confidence Intervals by Guided Learning Responses.



Cognitive strategy use was significant (p-value= 0.0238) when compared to active learning enjoyment. However, pairwise comparisons did not show differences. When looking at active learning enjoyment, significance was found for self-determination (p-value= 0.0119) and intrinsic value (p-value= 0.0010) (Figure 6). Students who agreed they enjoyed active learning reported higher intrinsic values than those that slightly disagreed (p-value =0.0023) and slightly agreed (p-value =0.0250) (Figure 6b). Those that slightly disagreed that they enjoyed active learning also reported lower intrinsic values than those that were neutral (p-value =0.0173) and slightly agreed (p-value =0.0426) (Figure 6b).

Figure 6a

Box and Whisker plots of Self-Determination Subtheme from the SMQII Showing Mean, Range, and 95% Confidence Intervals by Active Learning Responses.

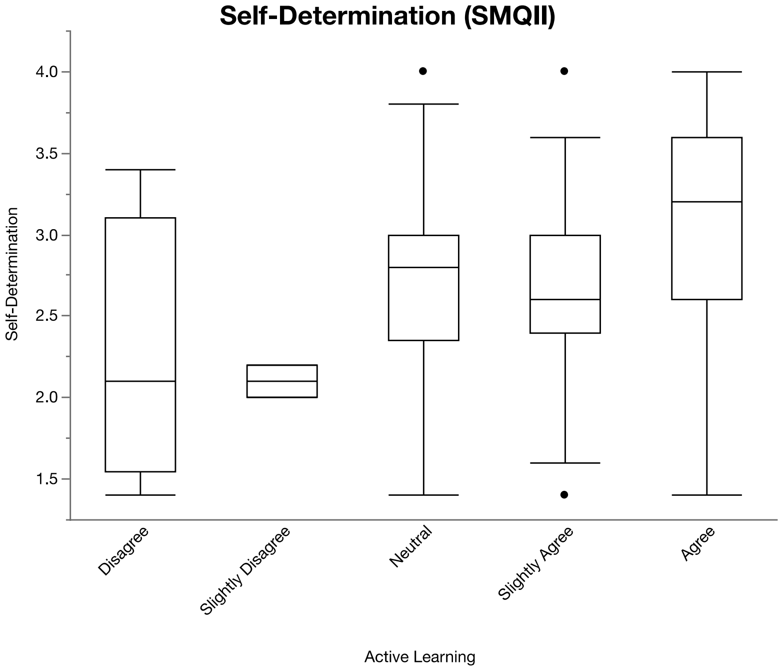
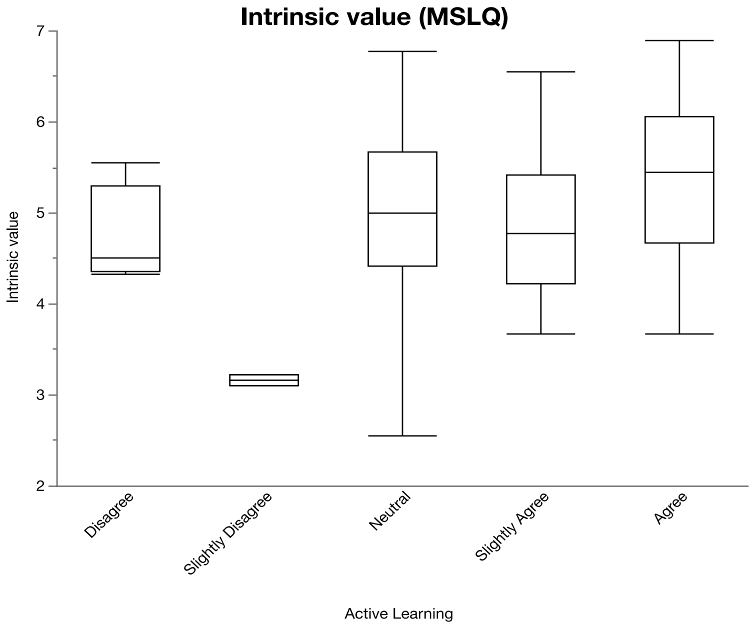


Figure 6b

Box and Whisker plots of Self-Determination Subtheme from the MSLQ Showing Mean, Range, and 95% Confidence Intervals by Active Learning Responses.



ANOVA results

Students who agreed the teacher presentation and explanation were concise and clear had higher intrinsic value ratings than all other responses (p-value= 0.0278, 0.0024, and 0.0063) (Figure 7a). Students who agreed they enjoyed guided learning reported slightly higher intrinsic value than students who were neutral (p-value= 0.0017; Figure 7b).

Figure 7a

Box and Whisker plots of Intrinsic Value Subtheme from the MSLQ Showing Mean, Range, and 95% Confidence Intervals by Teaching Presentation and Explanation Responses.

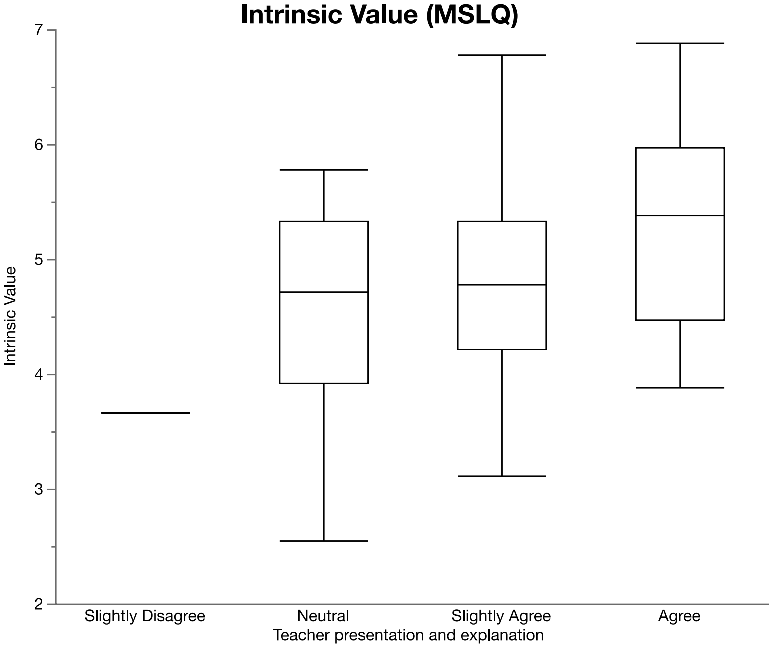
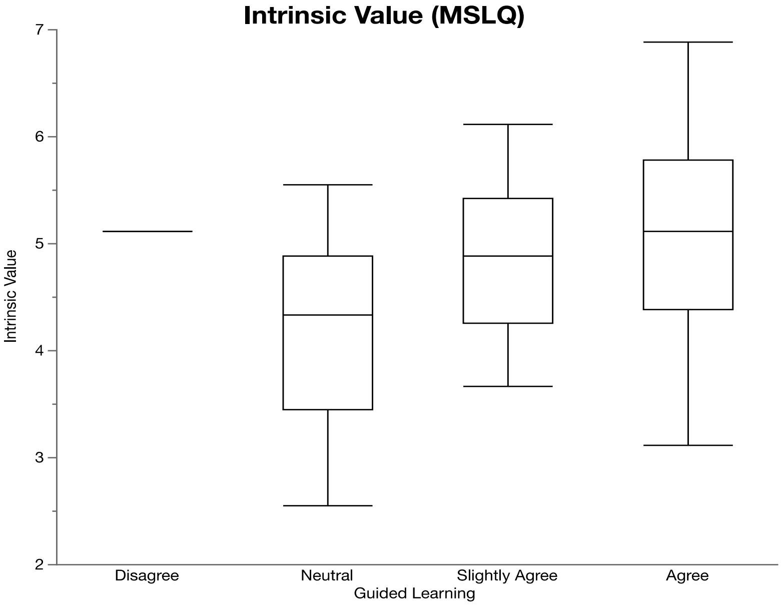


Figure 7b

Box and Whisker plots of Intrinsic Value Subtheme from the MSLQ Showing Mean, Range, and 95% Confidence Intervals by Guided Learning Responses.



When looking at guided learning, there was a significant correlation with intrinsic value (p-value= 0.0100). However, pairwise comparisons did not show any significance.

Table 5

F-statistic or Chi-Square Probability for Each Teaching Approach and Subtheme Comparison with Significant Results for Each Statistical Test.

Subtheme	Statistical Test	Teaching Approach	F statistic/ Chi-Square Probability
Intrinsic Motivation	Kruskal-Wallis	Teacher presentation and explanation	0.0075
Self-efficacy	Kruskal-Wallis	Teacher presentation and explanation	0.0002 (SMQII) & <0.0001 (MSLQ)
Self-determination	Kruskal-Wallis	Teacher presentation and explanation	0.0117
Grade motivation	Kruskal-Wallis	Teacher presentation and explanation	0.0246
Self-determination	Kruskal-Wallis	Guided Learning	0.0209
Self-efficacy	Kruskal-Wallis	Guided Learning	0.0409
Intrinsic Value	ANOVA	Guided Learning	0.0289
Cognitive Strategy Use	Kruskal-Wallis	Guided Learning	0.0003
Self-regulation	Kruskal-Wallis	Guided Learning	0.0195

Cognitive Strategy Use	Kruskal-Wallis	Group Work	0.0238
Self-determination	Kruskal-Wallis	Active Learning	0.0119
Intrinsic value	ANOVA	Active Learning	0.0010

Qualitative Data

Learning Better

When asked, “Do you learn better in class or labs and why?” most students (15 responses) responded with class, because of example, focus/clarity, structure, and teaching style. One student stated, “I think during lecture, personally, because during lab, I feel like a lost duck...when I get to lecture, I know exactly what I’m doing..” The five students that responded they learned better in lab cited the hands-on nature, worksheets, length, and struggle in lecture as reasons. Specifically, one student claimed, “I’m more of a hands-on person when I’m learning.” At least six students responded or agreed that they struggled with connecting the lecture and lab learning material.

Working in Groups or Individually

The second question, “Do you enjoy working in groups or on your own and why?” was almost unanimously groups. One student reported both groups and individual work was enjoyable since they learned better with multiple review chances and wanted to test themselves after studying. Another student said that it depended on the group. Reflecting on why, most participants brought up collaboration, discussion, conversation, motivation, and ease as reasons why they enjoyed group work more. One of the negative things about group work some participants stated was that the grades were the same for all group members, “I definitely like working in groups more, because I feel like it’s just a couple more people you can bounce ideas off of, but I don't necessarily like that my grade reflects on working within a group or how my peers are doing."

Similarities and Differences in Learning

"How would you describe similarities and differences of your learning in exam one and exam two material?" was the third question in the focus group. The majority of students reported exam two felt rushed, was more of a struggle, less clear, and harder than exam one. A few students thought exam one was harder since they did not know what to expect. One participant expressed, "I felt like he was very clear about what was going to be on the test, so we knew exactly what to study for, unlike this exam two." On the other hand, one student thought exam two was easier because they "knew what the exam formats were."

Most Beneficial to Learning

Question four, "What did you find most beneficial to your learning in class and why?" found that students enjoyed the resources and handouts in class, but wanted more overview before exams and more guidance on worksheets. Students reported, "I like the handouts that he gives us to follow along while he's teaching, it helps me stay focused." Though students did like the worksheet exercise, students wished the instructor "would go through a few problems first and then go through it on our own, but I like them (worksheets) because then I can do it on my own and understand what I'm actually doing."

Grade Motivation

When asked, "How much does needing to get a C or better motivate you to study in Chemistry 100?" an overwhelmingly majority answered "A lot." Students cited major requirements and high GPA as primary reasons. A few students also mentioned they are generally A/B students, so they try very hard to achieve a C or better.

Most influential Factor to Motivation

Question six asked participants, “What do you think is the most influential factor to your motivation to study in Chemistry 100?” Cost, grades, requirements, and goals were the main themes. More specifically, students did not “want to waste my money or the money that I get help from scholarships.” They also cited “getting into programs and getting closer to your goal, then graduation and that kind of stuff” were the most significant factors for motivation. A few students wanted an increase in visual presentation, such as more examples or the use of PowerPoint.

Implementation of Teaching Approaches in the Future

Participants then answered the question, “What teaching approaches do you hope your future university professor would implement?” Resources, communication, and class structure were the main themes reported. Participants wanted more clarity and communication about their assignments and expectations. “It’s being able to communicate more with your students and the students communicating with you. I think it is heavily important to everyone’s success,” is what one student shared. Others stated the worksheets, study guides, and homework helps them, so they would want them implemented in the future with the addition of PowerPoint presentations. Under the theme of class structure, participants enjoyed how structured the class was, including going over examples.

What Approaches Would You Implement

The eighth question, “If you become a teacher or trainer, or mentor in the future, what approaches would you implement?” found classroom structure, classroom activity, class environment, and connectivity as main themes. Under classroom structure, students reported wanting more hands-on activities, a flipped classroom, more checking of understanding, and pairing students up based on their level of understanding. When talking about the class environment, students reported, “I really want to carry on that enthusiasm he has,” and “he does keep me interested because truthfully, chemistry is so boring to me. I could care less about it. He keeps me interested in lecture because he is so energetic and he relates it to things.”

Additional Comments

The last question in the focus group asked if participants had anything else they wanted to add that was not covered. Participants reported a change in classroom location, and the need for review were things they wish were changed for future classes. When asked to elaborate on the classroom location, responses included, “a different classroom would be nice since we do a lot of group work” and “smaller class sizes.” On the other hand, many participants reported they enjoyed the class structure and the instructor’s enthusiasm toward the subject. One student said they liked being able to keep past exams to use as study guides in conjunction with worksheets. Other students reiterated how they enjoyed the instructor cares about the students and wants them to do well. Two others referred to resurrection points, where students can gain points back on the final to show their mastery of the content.

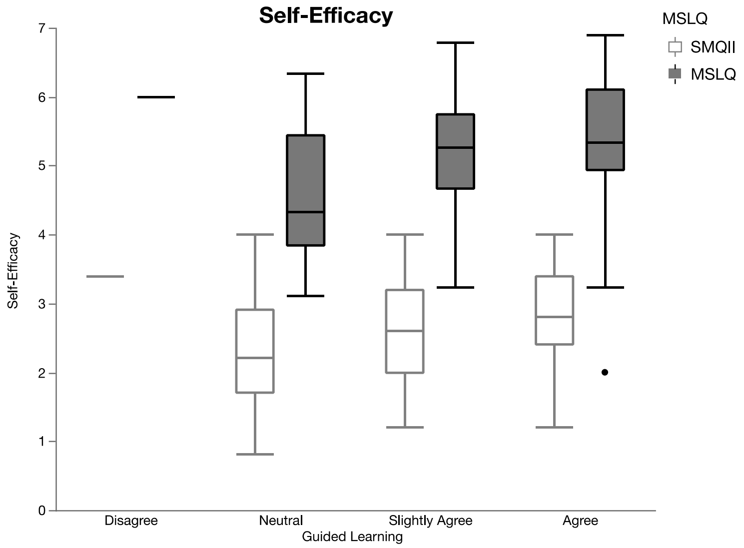
Merged Data

When looking at the responses from the focus group, it is easy to see how much grades and program requirements motivate students to do well in Chemistry 100. However, the questionnaire results did not show any correlation between grade motivation and teaching approaches.

Students who enjoyed guided learning had higher self-regulation scores, which corroborates with students reporting they used the worksheets and exams as study guides. Likewise, those in focus groups stated they enjoyed it because they were able to plan and problem solve with others before going home to study by themselves (Figure 8).

Figure 8

Box and Whisker Plots of Self-efficacy Subtheme from the SMQII and MSLQ (shaded) Showing Mean, Range, and 95% Confidence Intervals by Guided Learning Accompanied by Supporting Focus Group Responses.



"Chemistry is hard."

"I'm more of an examples, what test questions will look like type of person."

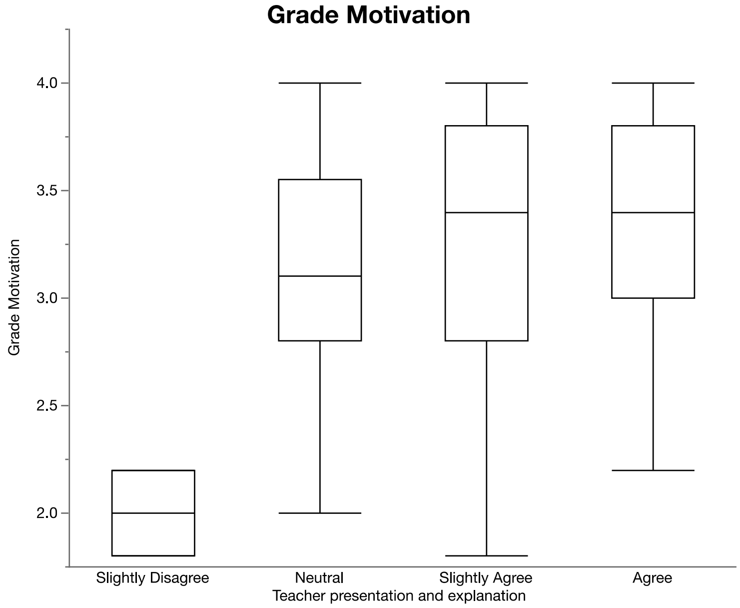
"I'm more of an independent worker."

"I felt like exam 2 was more difficult. I don't know how to memorize things well."

When looking at students who thought the instructor's presentation and explanation were concise and clear, students were highly motivated to do well for their program requirement despite their dislike of chemistry. As one student stated, “GPA and getting more than a C is really important because it sets you apart.” Another student said, “if you don’t do well, it can wreck your chances of getting into the program” (Figure 9). Likewise, those that enjoyed guided learning reported higher intrinsic value than those who were neutral. When looking at focus group responses, students who liked the worksheets found it beneficial to their understanding of the material.

Figure 9

Box and Whisker Plots of Grade Motivation subtheme from the SMQII Showing Mean, Range, and 95% Confidence Intervals by Teaching Presentation and Explanation Accompanied by Supporting Focus Group Responses.



“GPA and getting more than a C is really important because it sets you apart.”

“If you don’t do well, it can wreck your chances of getting into the program.”

“I didn’t know we had to get a C or better, so kind of sad now.”

“I need it for gen a, but it’s not part of my major, so it wasn’t something I’m like super excited to be taking.”

High self-determination and enjoyment of guided learning were seen when students presented the idea of the use of PowerPoints during lecture. Students reported they enjoyed using PowerPoints to follow along in classes while taking notes and to use as a review to help them focus. Students who enjoyed active learning also reported lower intrinsic motivation, which is similar to students who said they liked labs, but only because it was shorter and “they wanted to get it over with.”

CHAPTER V

Discussion

The present study sought to determine the correlation, if any, between different teaching approaches (i.e., lab versus lecture) and undergraduate student motivation (self-interest, instructor inspiration, and personal influences) in an undergraduate, non-major, introductory chemistry course at a mid-sized, four-year university in the Midwestern United States.

Students overwhelming agreed that group work and guided learning was enjoyable, along with high self-regulation scores, showing that students recognized them as methods they knew would help them be successful. In a study conducted by Wang (2018), initiative learning, empowerment of group dynamics, creating effective learning environment, and barriers influencing students’ learning were found to be the most prevalent themes for small group work. Students likewise reported, “group learning is more effective, and I can learn a lot.” The author concluded small group work, similar to the POGIL instruction for Chemistry 100, had multiple advantages to the individual and group learning (Wang, 2018).

Intrinsic factors, such as intrinsic value and self-determination, seemed to have a more significant influence on student’s preference for a specific teaching approach, specifically guided learning. However, students did not report that active learning increased intrinsic motivation, rejecting H1. On the other hand, extrinsic factors, such as self-regulation, cognitive strategy use, and grade motivation were the top themes in student motivation. It seems as though extrinsic factors were a more significant driving force in Chemistry 100. Students reported getting a C or higher was of great importance to them, especially for those who needed the class for their competitive program, supporting this thought, but, rejecting H3.

When reviewing teaching approaches, intrinsic factors, and extrinsic factors, the teaching approach that stands out the most is guided learning. Students who reported they enjoyed guided learning had significant differences between intrinsic value, self-determination, and self-regulation. This shows a small correlation between intrinsic motivation and guided learning, thus supporting H2. Students reported a need for PowerPoint usage to help them focus, while also praising the use of worksheets, again to help them focus. Though students found the course challenge and uninteresting, the external motivation of grades increased their intrinsic motivation, which is reported to be associated with high levels of effort and task performance (Froiland et al., 2012).

Limitations

Due to the COVID-19 pandemic, a second focus group at the end of the semester was not able to be conducted. Likewise, teaching methods were not able to follow the traditional POGIL, lecture method, and directed note-taking, as outlined in Chapter II of the dissertation. Instead of the lecture method and directed notes for the second half of the Chemistry 100 class, the class was restructured to be entirely online. Students were given learning goals, worksheets, and lecture videos to watch with recommended homework problems. Instead of Exams 3b and 4, the instructor implemented four quizzes, and divided the final exam into three parts (corresponding to exams 1, 2, and

3a). Laboratory activities were changed from in-person to alternative laboratory assignments.

Recommendations for Further Research

The researcher recommends changing the Likert scales to match for future research. Likewise, choosing just the MSLQ to measure self-efficacy may be preferable as it is more robust and is created for college students. It could also be beneficial to have a measurement such as final grades (point values) to compare students who achieved high versus low to compare questionnaire items too. This would allow for comparisons between high achieving students and low achieving students to see if there are any differences between motivation. Additionally, changing the teaching method questions to reflect different teaching approach activities better would be beneficial and give a better picture of which teaching approach students thought was more helpful. Adding a short survey after exams four and five may help determine if the teaching approach was indeed an influential factor in student motivation. The student focus groups could benefit from some rewording, as students sometimes went off topic when answering the question.

Reflecting on the nature of the questions, it may be best to create four separate studies to examine the effects of teaching approach, intrinsic student motivation, and extrinsic student motivation on student retention in an introductory STEM course. This would allow the researcher to dive deeply into the perceptions and effects each factor has on student success. The fourth study could be a meta-analysis of the findings of teaching approaches, intrinsic motivation, and extrinsic motivation throughout several semesters.

Student motivation, both intrinsic and extrinsic correlation with teaching approaches, is challenging to characterize, as it depends on the delivery method of the instructor and student willingness to learn. Simple analyses of student motivation, looking at intrinsic and extrinsic motivation within themselves, are widely studied. The results of this study shed light on the complexity of the potential influences teaching approaches have on student motivation in an introductory STEM course. It also provides data to help conduct further research on the correlation between teaching approaches and student motivation.

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Appendix A

Questionnaire

STEM Motivation and Teaching Approaches

Q1 What is your age range?

○ 18-20

○ 21-24

○ 24-30

○ 30+

Q2 Sex

○ Male

○ Female

○ Other ____

Q5 Ethnicity

○ White

○ American Indian/Alaska Native

○ Asian

○ Black

○ Native Hawaiian/Other Pacific Islander

○ Other/Mixed

Q6 Parental level of education (Father)

- ○ High School/GED
- ○ Bachelor's Degree (4-year college)
- ○ Master's Degree (M.S., M.A., MBA etc)
- ○ Doctorate/Terminal Degree (i.e. Ed.D., Ph.D., J.D.)
- ○ None of the above
- ○ Other ____

Q7 Mother's level of Education

- ○ High School/GED
- ○ Bachelor's Degree (4-year college)
- ○ Master's Degree (M.S., M.A., MBA etc)
- ○ Doctorate/Terminal Degree (i.e. Ed.D., Ph.D., J.D.)
- ○ None of the above
- ○ Other ____

Q8 What is your major?

____

Q9 What year are you in college?

- ○ Freshman (1)
- ○ Sophomore (2)
- ○ Junior (3)
- ○ Senior (4)
- ○ PSEO (7)
- ○ Other (8) ____

Q10 In order to better understand what you think and how you feel about your science courses, please respond to each of the following statements from the perspective of "When I am in a chemistry course....."

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
The chemistry I learn is relevant to my life. (1)	○	○	○	○	○
I like to do better than other students on chemistry tests. (2)	○	○	○	○	○
Learning chemistry is interesting. (3)	○	○	○	○	○
Getting a good chemistry grade is important to me. (4)	○	○	○	○	○
I put enough effort into learning chemistry. (5)	○	○	○	○	○
I use strategies to learn chemistry well. (6)	○	○	○	○	○
Learning chemistry will help me get a good job. (7)	○	○	○	○	○
It is important that I get an "A" in chemistry. (8)	○	○	○	○	○
I am confident I will do well on chemistry tests. (9)	○	○	○	○	○
Knowing chemistry will give me a career advantage. (10)	○	○	○	○	○
I spend a lot of time learning chemistry. (11)	○	○	○	○	○
Learning chemistry makes my life more meaningful. (12)	○	○	○	○	○
Understanding chemistry will benefit me in my career. (13)	○	○	○	○	○
I am confident I will do well on chemistry labs and projects. (14)	○	○	○	○	○

I believe I can master chemistry knowledge and skills. (15)	○	○	○	○	○
I prepare well for chemistry tests and labs. (16)	○	○	○	○	○
I am curious about discoveries in chemistry. (17)	○	○	○	○	○
I believe I can earn a grade of "A" in chemistry. (18)	○	○	○	○	○
I enjoy learning chemistry. (19)	○	○	○	○	○
I think about the grade I will get in Chemistry. (20)	○	○	○	○	○
I am sure I can understand chemistry. (21)	○	○	○	○	○
I study hard to learn chemistry. (22)	○	○	○	○	○
My career will involve chemistry. (23)	○	○	○	○	○
Scoring high on chemistry tests and labs matters to me. (24)	○	○	○	○	○
I will use chemistry problem-solving skills in my career. (25)	○	○	○	○	○

Q11 Please rate the following items based on the different teaching approaches utilized in class.

	Disagree (1)	Slightly Disagree (2)	Neutral (3)	Slightly Agree (4)	Agree (5)
The learning objectives in each chapter are defined clearly.	○	○	○	○	○
Question and Problems in lab are defined clearly.	○	○	○	○	○
Length and presentation of the topics helped me follow the content knowledge easily.	○	○	○	○	○
I feel like I learn best in lab.	○	○	○	○	○
I enjoy working in groups.	○	○	○	○	○
I enjoy guided learning.	○	○	○	○	○

Q12 Please rate the following items based on your behavior in this class.

	Not at all true of me (14)	Untrue of me (15)	Slightly untrue (16)	Neutral (17)	Slightly true of me (18)	True of me (19)	Very true of me (20)
I prefer class work that is challenging so I can learn new things.	○	○	○	○	○	○	○
Compared with other students in this class, I expect to do well.	○	○	○	○	○	○	○
I am so nervous during a test that I cannot remember facts that I have learned.	○	○	○	○	○	○	○

It is important for me to learn what is being taught in this class.	○	○	○	○	○	○	○
I like what I am learning in this class.	○	○	○	○	○	○	○
I'm certain I can understand the ideas taught in this course.	○	○	○	○	○	○	○
I think I will be able to use what I learn in this class in other classes.	○	○	○	○	○	○	○
I expect to do very well in this class.	○	○	○	○	○	○	○
Compared with others in this class, I think I'm a good student.	○	○	○	○	○	○	○
I often choose paper topics I will learn something from even if they require more work.	○	○	○	○	○	○	○
I am sure I can do an excellent job on the problems and tasks assigned for this class.	○	○	○	○	○	○	○
I have an uneasy, upset feeling when I take a test.	○	○	○	○	○	○	○
I think I will receive a good grade in this class.	○	○	○	○	○	○	○
Even when I do poorly on a test, I try to learn from my mistakes.	○	○	○	○	○	○	○
I think that what I am learning in this class is useful for me to know.	○	○	○	○	○	○	○
My study skills are excellent compared with others in this class.	○	○	○	○	○	○	○

I think that what we are learning in this class is interesting.	○	○	○	○	○	○	○
Compared with other students in this class I think I know a great deal about the subject.	○	○	○	○	○	○	○
I know that I will be able to learn the material for this class.	○	○	○	○	○	○	○
I worry a great deal about tests.	○	○	○	○	○	○	○
Understanding this subject is important to me.	○	○	○	○	○	○	○
When I take a test, I think about how poorly I am doing.	○	○	○	○	○	○	○
When I do homework, I try to remember	○	○	○	○	○	○	○
I ask myself questions to make sure I know the material I have been studying.	○	○	○	○	○	○	○
It is hard for me to decide what the main ideas are in what I read.	○	○	○	○	○	○	○
When work is hard I either give up or study only the easy parts.	○	○	○	○	○	○	○
When I study, I put important ideas into my own words.	○	○	○	○	○	○	○
I always try to understand what the teacher is saying even if it doesn't make sense.	○	○	○	○	○	○	○

When I study for a test, I try to remember as many facts as I can.	○	○	○	○	○	○	○
When studying, I copy my notes over to help me remember material.	○	○	○	○	○	○	○
I work on practice exercises and answer end of chapter questions even when I don't have to.	○	○	○	○	○	○	○
Even when study materials are dull and uninteresting, I keep working until I finish.	○	○	○	○	○	○	○
When I study for a test, I practice saying the important facts over and over to myself.	○	○	○	○	○	○	○
Before I begin studying, I think about the things I will need to do to learn.	○	○	○	○	○	○	○
I use what I have learned from old homework assignments and the textbook to do new assignments.	○	○	○	○	○	○	○
I often find that I have been reading for class, but don't know what it is about.	○	○	○	○	○	○	○
I find that when the teacher is talking, I think of other things and don't really listen to what is being said.	○	○	○	○	○	○	○
When I am studying a topic, I try to make everything fit together.	○	○	○	○	○	○	○

When I'm reading I stop once in a while and go over what I have read.	○	○	○	○	○	○	○
When I read materials for this class, I say the words over and over to myself to help me remember.	○	○	○	○	○	○	○
I outline the chapters in my book to help me study.	○	○	○	○	○	○	○
I work hard to get a good grade even when I don't like a class.	○	○	○	○	○	○	○

Q24 Is there anything else you would like to add about this class?

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Appendix B

Qualitative Questions

Focus Group Questions

1. Do you learn better in lecture or labs?
    a. Why?
2. How would you describe similarities and differences between your learning in chapter 1-3 and 4-5?
3. What did you find most beneficial to your learning in class?
    a. Why
4. How much does needing to get a "C" motivate you to study in Chemistry 100?
5. What do you think is the most influential factor to your motivation to study in Chemistry 100?
6. If you could change anything in the course, what would you change?
7. As future teachers, what sort of teaching approaches did you take away from this course to potentially implement in your own classrooms?
8. Do you enjoy working in groups or on your own?
    a. Why?
9. Is there anything we didn't cover today that you would like to add?