Abstract

Using student motivation to design groups in a non-majors biology course for team-based collaborative learning: Impacts on knowledge, views, attitudes, and perceptions

By

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The importance of student motivation and its connection to other learning variables (*i.e.,* attitudes, knowledge, persistence, attendance) is well established. Collaborative work at the undergraduate level has been recognized as a valuable tool in large courses. However, motivation and collaborative group work have rarely been combined. This project utilized student motivation to learn biology to place non-major biology undergraduates in collaborative learning groups at East Carolina University, a mid-sized southeastern American university, to determine the effects of this construct on student learning. A pre-test measuring motivation to learn biology, attitudes toward biology, perceptions of biology and biologists, views of science, and content knowledge was administered. A similar post-test followed as part of the final exam. Two sections of the same introductory biology course (n = 312) were used and students were divided into homogeneous and heterogeneous groups (based on their motivation score). The heterogeneous groups (n = 32) consisted of a mixture of different motivation levels, while the homogeneous groups (n = 32) were organized into teams with similar motivation scores using tiers of high-, middle-, and low-level participants. Data analysis determined mixed perceptions of biology and biologists. These include the perceptions biology was less intriguing, less relevant, less practical, less ethical, and less understandable. Biologists were perceived as being neat and slightly intelligent, but not very altruistic, humane, ethical, logical, honest, or moral. Content knowledge scores more than doubled from pre- to post-test. Half of the items measuring views of science were not statistically significantly different from pre- to post-test. Many of the factors for attitudes toward biology became more agreeable from pre- to post-test. Correlations between motivation scores, participation levels, attendance rates, and final course grades were examined at both the individual and group level. Motivation had low correlations with the other variables. Changes in group membership (*i.e.,* attrition) were evaluated at the group level and showed the highest rates with the heterogeneous groups and the lowest with the homogeneous middle groups. Group gender ratios were examined, but showed no correlation with final course grade. Linear regression was utilized to identify any variables that might be useful in predicting the final course grade of each student. Only participation, attendance, and final exam grade were predictive, but as they were components of the final course grade, they were not useful for the model. Differences between the groups were also examined to determine if the group type was predictive of final course grade, but no significant difference was found. Results of the study are discussed in the context of the literature on student motivation to learn science. Implications of the study are discussed through the lens of the Millennial generation's perspectives on teaching and learning. Millennials often consider an education to be a commodity and may expect results with less effort. Millennials may be expressing a pseudo-intrinsic motivation in order to impress peers and instructors, while they may actually be more extrinsically motivated to succeed.

USING STUDENT MOTIVATION TO DESIGN GROUPS IN A NON-MAJORS BIOLOGY COURSE FOR TEAM-BASED COLLABORATIVE LEARNING: IMPACTS ON KNOWLEDGE, VIEWS, ATTITUDES, AND PERCEPTIONS

A Thesis

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In Partial Fulfillment of the Requirements for the Degree

Masters of Science

by

Kristi L. Walters

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DEDICATION

As with any huge endeavor, there are a number of people that helped me along the way. I am grateful to all of the ladies who provided care for my children while I worked. I would be lost without: Lindsey Barber, Lauren Campbell, Tabitha Nogueira, Madison Brame, Anna Tart, Sarah Tart, Merritt Blanton, Jillian Osborne, Amanda Powell, and June Walters. It was reassuring to know my children were receiving love and attention from such wonderful women.

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INTRODUCTION

Purpose of the study: To understand how to effectively construct teams of undergraduate students in the life sciences to maximize learning outcomes and encourage an appreciation of biology through achievement of affective and perceptual learning outcomes.

Objectives

Research questions:

1. Does the construction of collaborative groups based on motivation predict non-major biology students' learning success in a biology course?
2. What group structure (homogeneous or heterogeneous) is associated with the highest learning success and team participation?
3. How do student demographics impact group structure and learning success?
4. How do classroom characteristics impact learning success?
5. How does collaborative group work impact students' attitudes toward biology, perspectives of biology and biologists, and views of science?
6. How does collaborative group work impact students' attendance, team attrition, and gender ratios?

Anticipated results:

1. I expect the most highly motivated students (regardless of group) will be more successful in the course than their less motivated peers.

2. I expect the homogeneous high teams will have the highest average final course grades and the homogeneous low students will have the lowest final course grades. I expect the heterogeneous teams will have the highest team collaboration scores. I anticipate the homogeneous high and low groups will have difficulties working together and will have lower team collaboration scores. I assume the homogeneous middle groups will work well together.

3. I expect students who have had a previous science course will perform better than their cohorts. I do not expect other demographic features to have an impact on final course grades.

4. I expect the morning session of the course will perform better than the afternoon section.

5. I expect the participants' attitudes toward biology, perspectives of biology and biologists, and views of science will become more agreeable after working in collaborative groups for the semester.

6. I expect that homogeneous high groups will have the highest attendance grades, while the homogeneous low have the lowest attendance rates. Team attrition and gender ratios will likely not be significantly different between the groups.

Contextual Evidence

Undergraduate student persistence in STEM fields

Many students enter the biology program at East Carolina University with aspirations of going to medical school or pursuing a research career in the life sciences.

Anecdotally, one such student with whom the author is acquainted decided the biology program was "too hard" and she was going to switch majors to a non-science field. She is not a lazy student who could not keep up with the large workload or understand the concepts (she performed well in her high school Advanced Placement Biology course and on the accompanying exam); instead she became discouraged with the structure of her large lecture courses and the traditional teaching methods (*e.g.,* lecture-only format, reduced instructor interaction compared to high school, and minimal formative assessment feedback) associated with them. The transition from high school to college can be difficult for many students. The level of motivation to learn that is possessed by a student can greatly impact their success in their studies. In other words, motivation can impact a student's persistence in their program (Tuan, Chin, and Shieh, 2005).

Personality factors may influence motivation (Clark and Schroth, 2010). Students respond to the pressures of academic life in different ways. Having a higher level of motivation can facilitate the transition, as motivated students possess a clear perspective of their goals and why they are in school (Partin, Haney, Worch, Underwood, Nurnberger-Haag, Scheuermann, and Midden, 2011). This enables learning to occur. Tinto (1993) reminds us that in formal school contexts "Learning leads to persistence, its absence is a root of leaving" (p. 215). If this young woman did not feel she was learning anything in her classes, this likely impacted her motivation to continue learning, which in turn likely contributed to her decision to exit the program.

Sadly, this is not an unusual scenario, with 40-60% of undergraduate science students leaving the field (Creech and Sweeder, 2012; Seymour and Hewitt, 1997). Students who had higher grade point averages in high school may be better at studying and ‘playing the game of formal schooling’. Such students may also be more motivated to get better grades and take their academic career more seriously; however, none of this means they will remain in a Science, Technology, Engineering, and Math (STEM) program (Jin, Imbrie, Lin, and Chen, 2011). Seymour and Hewitt (1997) describe poor teaching, confusing material, decreased confidence in their ability to do science, competition with peers, and an unpleasant environment as factors influencing students, especially women and underrepresented minorities, to leave STEM programs. French, Immekus, and Oakes (2005) also noted poor teaching, loss of interest in science, and curriculum overload as factors contributing to the attrition of STEM students.

Persistence of women and underrepresented minorities

The attrition rates of underrepresented minorities can be about twice those of other undergraduate students in STEM fields (Dennis, Phinney, and Chuateco, 2005; Seymour and Hewitt, 1997). Summers and Hrabowski (2006) along with Dennis et al. (2005) discuss factors that contribute to the loss of underrepresented minorities. These include: academic and cultural isolation, the impact of low expectations on the student’s motivation and performance, unsupportive peers, and perceived as well as actual discrimination. Deficient academic preparation in high school, financial concerns relating to funding their education (due to high correlations with minority socio-economic status), and family responsibilities are the top challenges facing underrepresented minorities. About a third of underrepresented minority students switched from STEM because they felt it had been the wrong choice for them personally (Seymour and Hewitt, 1997). This is often the result of active recruiting to the field (when the student did not possess an interest) or because of familial pressure to be in a STEM career, which then fades as students become more entrenched in their STEM majors during their undergraduate careers.

Other challenges faced by underrepresented minority students include: different patterns of socialization and ethnic cultural values (*i.e.,* understanding which normalized behaviors are acceptable or unacceptable in STEM fields), cultural variations in educational socialization (*e.g.,* students are more accustomed to individual attention), ethnic isolation and perceptions of racism, pressure to be a role model, and lack of support from within their program (Dennis et al., 2005; Seymour and Hewitt, 1997). Many Asian American students easily form peer study groups that are supportive when a student is successful, however, that support can waiver when the student faces difficulties. The opposite is true for African American students. Peer groups are very supportive when a student faces a challenge, but these same peer groups may withdraw support when the student is successful (Seymour and Hewitt, 1997).

Linley and George-Jackson (2013) propose that a significant hurdle to women in STEM is the “maleness” of the experience. Students are expected to independently persevere through the challenges of a STEM program without assistance from faculty. It is considered a rite of passage that male students may be more comfortable experiencing than their female counterparts. This can be a challenge for some women who expect and need to feel supported by mentors. Without this support, young women can begin to lose confidence in their ability to succeed and take the lack of support personally. It erodes their motivation to remain in STEM and eventually contributes to their decision to leave. Programs have been established at many universities that address these issues and are intended to aid this transition (Szelényi, Dedson, and Inkelas, 2013). Even with support programs, it is clear that persistence of all undergraduate students within STEM fields is a real issue facing the nation. One of the most significant influences on student persistence is traditional teaching methods.

Women prefer cooperative learning styles (beginning in childhood) and men tend to lean towards more competitive strategies (Seymour and Hewitt, 1997). Although it should be noted that 25.8% of the men in the Seymour and Hewitt (1997) study switched from SME (note: in 1997 the term STEM had not yet been coined and the group of related fields was referred to as Science, Math, and Engineering) to another field because of the competitive nature of the programs. A disproportionately large number of women leave STEM fields because they feel less confident, experience lower self-esteem, and a reduction of career ambitions during their first two years of undergraduate study. Perhaps part of the solution to retaining these equally competent and prepared young women is to utilize more group work during the early years of their college education. The inclusion of group work would be an alternative to offering special programs and scholarships directed toward women, as these offerings can have negative consequences (*e.g.,* bitterness from male peers, reduced self-confidence of female beneficiaries) for the women they are attempting to help. Also, some women avoid such programs because they do not want to receive special assistance based purely upon their gender (Seymour and Hewitt, 1997). Seymour and Hewitt (1997) also observed that 24.7% of men and 9.7% of women that switched from STEM programs did so because they never found a peer study group and 15.7% of those men and 7.5% of those women attributed the lack of peer help as a factor in their leaving the program.

Connecting traditional teaching methods to student persistence

Traditional teaching methods are defined here as those utilizing a lecture-only format where the students are implicitly encouraged to memorize material (Chen and Wang, 2013). Students in traditional learning environments are not active learners, and are expected to sit quietly, and accept knowledge while the instructor transmits that knowledge as the lone classroom authority. The instructor may not expect rote learning, as opposed to comprehension of the material or transfer, but it is often explicitly and implicitly reinforced by the structure of the learning environment as well as the assessment methods (Momsen, Long, Wyse, and Ebert-May, 2010). This is not to say that lecture in and of itself is inherently bad for student learning; it just encourages acquisition of lower order learning objectives, which are often in conflict with the instructor's spoken objectives as well as student interest and motivation.

The technology used in STEM classrooms has moved into the 21st century and many college lecture halls have state of the art technology with the ability to use multimedia to enhance the learning process. However, in the presence of these technological advances, many instructors still resort to utilizing 20th century teaching methods (Lord, 2013). These older teaching methods unfortunately can result in greater apathy and indifference for the learning process in STEM students. In a decade where the number of students graduating with STEM degrees is decreasing dramatically, many talented students are lost from the "pipeline" in STEM majors because they have a difficult time adjusting to the classroom structure and traditional teaching methods especially common in introductory undergraduate courses (Minchella, Yazvac, Fodrea, and Ball, 2002; Seymour and Hewitt, 1997). Recent work in science education strongly encourages the termination of traditional teaching practices in favor of inquiry-based methods (McNeill, Pimentel, and Strauss, 2013).

Student affective responses to traditional instruction

Not surprisingly, students frequently feel lost due to the lack of personal attention and connection in the lecture-only format that typically occurs in association with large class sizes (Sweet and Pelton-Sweet, 2008). Students also report a lack of inspiration in their introductory courses while underrepresented minorities feel unwelcomed by many STEM faculty in these more passive learning environments (President's Council of Advisors on Science and Technology, 2012). A feeling of being unwelcomed is highly problematic, as students may possess the skills and knowledge to be successful in STEM fields, but leave the field when they do not feel they belong or cannot envision themselves as successful scientists and engineers (Estrada, Woodcock, Hernandez, and Schultz, 2011). A sense of belonging is more than just feeling part of a group. It involves the understanding by the individual that they are an effective and valuable part of the learning team regardless of their ability or success (Ames, 1992). This concept is important to note, as some faculty perceive the purpose of introductory science courses is to "weed out" weak or unintelligent students. Instead programs are losing many high-achieving and potentially successful students (Summers and Hrabowski, 2006). It is not due to these students being unable to succeed in STEM fields, but rather because they are unwilling to remain in a field where they feel little connection.

According to the report from the President's Council of Advisors on Science and Technology (2012), the United States needs one million more STEM professionals in the next decade in order to be socially and economically competitive. The report states that for this goal to be reached, there is a need to increase STEM retention to at least 50 percent. The council recommends research-based pedagogies such as active learning, discovery-based research courses and labs, improved math education, and partnerships between industry and education (President's Council of Advisors on Science and Technology, 2012). The connection is clear: the STEM pipeline is 'leaking' and implementation of research-based instructional strategies into introductory STEM classrooms could help retain more highly-qualified and more diverse individuals in the field.

Traditional instruction, learning environments, and student perceptions

Seymour and Hewitt (1997) discuss how students (especially female students) have negative experiences in freshman STEM courses. The students reported:

> Poor teaching or organization of material; hard or confusing material, combined with loss of confidence in their ability to do science; cut-throat competition in assessment systems geared more to weeding out than to encouraging interested students; dull subject matter; and grading systems that did not reflect what students felt they had accomplished. (p.11)

For students already feeling overwhelmed by the college experience, challenging courses combined with poor teaching can be especially demotivating.

Returning to the initial anecdote that opened this thesis, we revisit the question: What, if anything, could have been done differently to keep this young woman (and others like her) in the STEM pipeline? The current challenge is that educators must find a way to address the perceived lack of connection (and diminished motivation of students) in large classes and pragmatically implement these strategies. The educational experiences of recent high school graduates are often quite different from the college experience (Calaguas, 2011). At many colleges and universities, classes contain hundreds of students sequestered in a lecture hall for a few hours each week. For an incoming freshman that might be accustomed to a class of 30 students in high school, this represents a huge adjustment to their learning environment.

The structural design of the classroom may also be a shift for freshmen. The large lecture halls utilized for most introductory STEM courses are static, unlike the flexible seating options (*i.e.,* chairs and desks that can be moved around the room for collaborative work) the students utilized in high school. This unfortunate reality has existed for several decades (Strang, 1946). Empirical work has linked classroom environments with student achievement and attitudes (Pickett and Fraser, 2012). The significance of the overall learning environment is discussed in Church, Elliot, and Gable (2001). They note the importance of the student perceiving that the lecture is interesting on their ability to feel engaged with the learning process. Furthermore, the student's sense of connection to the classroom environment can affect their personal learning goals which in turn mediate motivation to learn.

The assessment method utilized in many courses may be another aspect of the learning environment that is problematic for student learning and motivation. Frequently, only a few summative exams (*i.e.,* evaluations of learning) are used to objectively measure student learning and fail to include subjective evaluations or formative (*i.e.,* evaluations for learning) assessments (Weaver and Qi, 2005). Students rarely have the same opportunities they previously had in high school to demonstrate their understanding of the material to the instructor multiple times. Students also miss opportunities with summative and formative assessment formats that have been shown to be critical for student learning (Taras, 2008). Some of these assessment limitations are imposed by the large-enrollment in many introductory courses and the perceived workload of the instructor, which are all fair concerns in these learning environments. However, both objective and subjective evaluations are critical in assessing a student's understanding of the material and promoting student learning. Lack of faculty preparation in educational assessment methods may be largely to blame for this oversight (Gardner and Jones, 2011), but the pragmatics of large-enrollment classes and time demands on faculty are also critical considerations (Michaelsen, 2002b). Large-enrollment classes do not only impact affective aspects of student adjustment to college culture, but may also greatly impact the valid and reliable measurement of student learning in these contexts.

Faculty roles and challenges in defining effective learning environments

Faculty perform a critical role in defining STEM learning environments and these learning environments are frequently in direct conflict to effective student learning. STEM students (Science and Math students specifically) are less willing than other majors to tolerate "weeding out" practices (real or perceived), since these students feel they have less to gain on their career paths (Seymour and Hewitt, 1997). Seymour and Hewitt (1997) report that the frustrations of students include being in learning environments with STEM faculty who dislike teaching (and are vocal about their disdain for the practice), faculty who place low value on teaching, faculty who openly prioritize research, and faculty who lack incentive to improve their teaching skills.

Students themselves have a critical role and responsibility in defining the learning environment, but this role is moderated in traditional learning environments. Students themselves often downplay their own responsibilities in the learning process; this detachment then places more responsibility and critique on faculty in many studies. The competing time and resource demands on faculty does not absolve them from creating effective learning environments, but provides justification for why traditional learning environments are so prevalent in introductory courses.

The students surveyed by Seymour and Hewitt (1997) wanted instructors who challenged them and used teaching methods and assessments that demonstrated what the students had learned. Participants in that study also appreciated creative thinking, current topics, and energetic discussions. The students wished to be able to apply what they knew and yearned for more demonstrations. Finally, they wanted a professor who was organized, enthusiastic, willing to listen to their questions, and interested in using collaborative learning techniques.

From a pragmatic point of view, especially in these days of budget cuts, reducing class sizes is unlikely to occur at many colleges and universities, as the constraints of time and money are prohibitive (Crowe, Dirks, and Wenderoth, 2008; Haak, HilleRisLambers, Pitre, and Freeman, 2011). Other solutions need to be discussed so students are not lost in the science pipeline and that those who remain are acquiring the knowledge, skills, and habits of mind required to become effective biologists.

Theoretical considerations behind creating effective learning environments

Challenges faced by faculty when establishing learning environments include; the structure of the classrooms themselves and outdated theoretical assumptions of student learning and cognition. The utilization of large-enrollment sections of courses to teach introductory material is based on the archaic philosophical assumption that the most important role of the instructor within the classroom is the effective and efficient delivery of content to students who are largely “empty vessels” waiting to be filled with knowledge (Kazempour, Amirshokoohi and Harwood, 2012). These teacher-centered methods do not take into consideration the volumes of science education research that instead recommend inquiry-based, student-focused instruction based in constructivist philosophies as the most effective means of assisting students in achieving critical learning objectives in STEM fields (Kazempour et al., 2012). It should also be noted, that *knowledge* is being defined in this study with an adaptation by the author of Straus, Tetroe, and Graham (2009). Knowledge is the acquisition and processing of information through sharing, translating and incorporating experiences.

One solution is grounded within a *social constructivist* philosophy of teaching and learning (Vygotsky and Cole, 1978). Social constructivist pedagogical philosophies promote interactive exercises to foster collaboration between the students and encourage them to participate in constructing their own learning within a social setting. *Collaborative learning* is defined by Springer, Stanne, and Donovan (1999) as “relatively unstructured processes through which participants negotiate goals, define problems, develop procedures, and produce socially constructed knowledge in small groups” (p. 24). Collaborative group work as an active learning technique has been shown to increase academic achievement, promote positive attitudes about science, increase students' reasoning ability, and encourage student retention in the STEM fields (Armstrong, Chang, and Brickman, 2007; Bowen, 2000; Haak et al., 2011; Jenson and Lawson, 2011; Johnson, Johnson, and Smith, 1998; McKinney and Graham-Buxton, 1993).

This is in contrast to *cooperative learning*, where the small groups are more structured, as they work toward common goals. In cooperative learning, social skills and communication are vital for the students and they often have assigned roles within the team (Springer, Stanne, and Donovan, 1999). Participants are responsible for their own learning. The team members may be separated by distance and therefore depend upon technology to maintain contact. According to Johnson and Johnson (2009), cooperative groups are long-lasting teams whose primary goals are to offer "support, encouragement, and assistance to make academic progress and develop cognitively and socially in healthy ways as well as holding each other accountable for striving to learn" (p. 374). Group work along with the sense of being a part of the team is also crucial to self-confidence and required for effective learning (Chesser-Smyth and Long, 2013). Cooperative learning has been shown to improve student achievement (Baer, 2003) and it can create a supportive learning environment where students' affective needs are addressed while effectively "shrinking" the classroom for students. One final component of cooperative learning should be noted; it is frequently associated with heterogeneous groups (often based on demographics or academic performance). Many definitions often include the word *heterogeneous* when referring to cooperative learning (Baer, 2003). Following this brief introduction to the theory behind designing effective learning environments, we now look at the theoretical underpinning of these ideas in more detail.

Social constructivism

Lev Vygotsky, the father of social constructivist thought, was a Russian psychologist who was described as a “neobehaviorist of cognitive development” (Vygotsky and Cole, 1978). Vygotsky’s research focused on the use of student language and tools during the social interactions of the learning process. Social constructivism is now being used in a variety of applications and learning environments.

The idea is an extension of constructivist theories that envisions student learning not as the “filling of an empty vessel”, but as the process of building upon the student’s previous knowledge and experiences using inquiry and more tangible encounters to construct their knowledge (Gordan, 2008; Squires and Schnackenberg, 2013). At its core, constructivism recognizes that students come to the classroom with numerous personal and education experiences, misconceptions, and perceptions; and their instructors must recognize this for teaching to be effective.

Social constructivist theory expands this idea to explain how the efforts of a group aid in the construction of knowledge and understanding in the individual to co-construct knowledge in social learning environments. Vygotsky hypothesized that higher mental processes (*e.g.,* logical memory, selective attention, decision making, and language comprehension) were established by social interactions and were impacted by the cultural environment of the learner (Vygotsky and Cole, 1978). This is the origin of the “social” component of social constructivism. In other words, learning does not take place in isolation, but is heavily influenced by the learning environment and the society of the student. Vygotsky extended constructivist thought by emphasizing the importance of the learning environment and how it is vital to the learning process.

Additionally, Vygotsky viewed language development as an important mediator of the social interactions within learning environments, and defined it as both a personal and social process (Bächtold, 2013; Gordan, 2008). Communication between individuals facilitates the acquisition of understanding during a discussion of the material. He stressed the importance of communication with other students for the cognitive growth of the individual (Bächtold, 2013).

While much of Vygotsky's empirical work focused on young children, his observations of the learning process have been shown to be applicable to learners of all ages. One of his most important discoveries is that the higher order cognitive skills of a younger child could be improved by working with an adult or more-capable peer (*i.e.*, someone with more highly developed memory skills). The *zone of proximal development* (ZPD) is the term Vygotsky created to refer to an individual student's ability to learn while interacting with peers. The circle on the left (Figure 1) represents the knowledge or skills that a student is capable of acquiring independently. The circle on the right signifies the skills the student is not currently capable of accomplishing (even with assistance), and the middle area denotes what a student can learn with assistance from a more experienced peer. This contribution is a key component of group learning and demonstrates why it is applicable and useful in the classroom (Vygotsky and Cole, 1978).

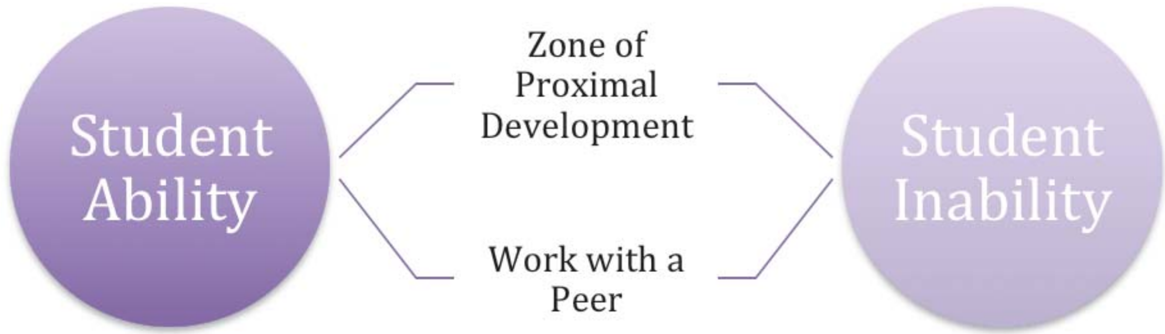

Figure 1.1. The Zone of Proximal Development. It bridges the gap between a student's abilities and their inabilities with the aid of a peer.

From a practical point-of-view a constructivist lesson will usually include four components: 1) learners constructing their own meaning, 2) new learning building on prior knowledge, 3) learning enhanced by social interaction, and 4) meaningful learning developing through authentic tasks (Cooperstein and Kocevar-Weidinger, 2004). The first component addresses how students purposely process new information (based on their own internal ideas about the world around them) to create understanding and promote learning. The second examines how students build upon previous experiences in order to incorporate new concepts, in essence 'building' new learning onto an existing scaffold. The next component considers the importance of social interactions as part of the learning experience as described in Social Constructivism Theory. Discussions with fellow students facilitate learning through clarification, argumentation, and dialogue. The final piece looks at the significance of using real-world models to enhance leaning and make it applicable to the lives of the students (Cooperstein and Kocevar-Weidinger, 2004). In a constructivist classroom, the instructor facilitates student learning in a step-by-step process until the students becomes more independent and take over their learning (Cooperstein and Kocevar-Weidinger, 2004).

Learning in teams

Theoretically grounded in social constructivism, *team-based learning* is the ideal choice for the science classroom, as it helps encourage interactions between students, initiates development of problem solving skills, involves students in active learning, and improves the quality of the learning experience (Fink, 2002). In addition, team-based learning mirrors the process and nature of collaboration in the sciences (Watson and Marshall, 1995). Other studies have noted benefits to students within team-based learning environments such as: higher retention rates (especially among minority students in STEM courses), significantly improved grades, more interactions within the classroom and with the instructor (*e.g.,* asking questions, office visits), increased sense of responsibility for their own learning, better interpersonal skills, greater problem-solving skills, and an improved ability to explain the material (Squires and Schnackenberg, 2013).

As defined by Fink (2002), team learning is an instructional method that is intended to support the development of high-performance learning teams that work together during the completion of significant learning tasks. According to Pintrich (1994), “the evidence is overwhelmingly in favor of having students work together cooperatively to accomplish tasks because of increased self-efficacy and interest, lower anxiety, more cognitive engagement, and generally better performance” (p. 38). It brings groups of students together (often with different abilities, interests, and levels of motivation) and allows them to work together to discover a solution to an assigned problem. Team-based learning is different from other student-centered, active learning methods by its use of teams (usually 5-7 students) that work together for an extended time (both during class time and independently), often for an entire semester. The teams are evaluated on a regular basis and receive timely formative and summative feedback from the instructor. Students must be prepared prior to class and are accountable for individual and group work.

Benefits of team-based learning

The interaction between the students as they discuss assignments helps improve their memory, stimulates cognitive function, and builds social connections (Michaelsen, 2002a). Encouraging the development of higher-order cognitive skills (through lecture alone) may become more challenging as the class size swells. Additionally, improving student participation in the learning process can help develop independent critical thinking skills (Crowe et al., 2008). The social interactions of group work promote learning as explained by Social Constructivism Theory and more specifically, the ZPD. Team members benefit from the diverse experiences and knowledge of the group members, and aid each other during the learning process by increasing one another's ZPD.

Group work and more active learning can encourage students to use higher-order cognitive skills *(i.e.,* the application, analysis, synthesis, and evaluation levels of Bloom's Taxonomy) as well as improve the students' comprehension of the material by discussion with their classmates (Crowe et al., 2008; Haak et al., 2011). After experiencing active learning, students performed better on exams (even as the difficulty of the exams increased) and were able to apply the concepts they had learned to novel situations (Haak et al., 2011). Similar results were observed with McNeill et al. (2013); when more group work was incorporated into the classroom, the students performed better on assessments; however, when more lecture was added, student performance decreased.

Perhaps the greatest appeal of using team-based learning in the classroom is that the majority of class time is spent on active-learning exercises instead of lecture. Thereby shifting the focus and responsibility of learning from instructor to student (Michaelsen, 2002b). This helps keep the students engaged and increases the interactions between the students and the instructor (*i.e.,* since the instructor is no longer a lecturer, but is now a facilitator of the teams). This allows the students to take greater responsibility for their own learning. The benefits of a more intimate classroom (*i.e.,* lack of anonymity and decreased student passivity) can be achieved through team-based work. An additional benefit is that during class time, the instructor can focus on the more challenging concepts in the course, while students cover the basics outside of class and then work together to understand the material during class time. The increased accountability felt by the students also helps improve attendance and class preparedness (Michaelsen, 2002b). In other words, it allows the valuable (and brief) time spent in class each day to be of greater benefit to the students.

Participation with the other team members can provide academic and personal support for students especially women and underrepresented minorities. Michaelsen

(2002a) notes that group work can reduce racial, ethnic, and physical ability stereotypes, as well as improve the self-esteem of students. Simply put, being part of a team can provide emotional and social support, in addition to the development of vital interpersonal skills necessary for future careers (Johnson and Johnson, 2009; Sweet and Pelton-Sweet, 2008; Trackey, 2013). Also, Millennials are more accustomed to group work than previous generations, and tend to be more comfortable working with peers (Crone and Mackay, 2007; Millenbah, Wolter, and Taylor, 2011).

Several policy documents have been published recently that reinforce the importance of collaborative, team-based classrooms. The American Association for the Advancement of the Sciences' (2011) *Vision and Change in Undergraduate Biology Education* stresses the importance of communication and collaboration in students and recognizes the need to transform the learning process. They also recommend group work to encourage social interactions and promote learning. Volumes of discipline-based education research also support these types of classroom learning environments as promoting student learning and persistence (National Research Council, 2012).

Simply encouraging students to talk in the classroom can be essential to learning, as it helps them process new information (Tanner, 2009). As a means of formative assessment, the students and instructor can more easily identify areas of confusion and student misconception as they are verbally working through the concepts. Promoting student participation (through talking) in the classroom is a component of most teaching strategies and can be utilized by any instructor (Tanner, 2009). Talking is an essential part of the social constructivist philosophy of learning.

There are some practical challenges to implementing group work in the classroom. Some students may be uncomfortable working in teams, as they feel they know more than their peers and believe they are unlikely to benefit from a group experience (Crowe et al. 2008). This often pertains to high-achieving students, who tend to have negative attitudes toward group work (Baer, 2003). Certain students simply prefer individual learning instead of group work or lack the motivation and maturity to work effectively within a team (Squires and Schnackenberg, 2013). Others may be unwilling to discuss their thoughts in front of fellow students (or the instructor) for fear of being ridiculed. However, these are the students that often benefit the most from participating in the group, as it challenges them to form their own explanations and assists with the construction of new knowledge (Tanner, 2009). Practice presenting their ideas to the team can also help an anxious student feel more comfortable (Hancock, Stone, Brundage, and Zeigler, 2010). When a student can successfully explain a concept in their own words to a peer, it helps them to better understand the information and is less intimidating than presenting to the entire class. Seymour and Hewitt (1997) discuss the value of group work in supporting struggling students and the positive impact on the students' self-confidence.

Considerations of the composition of teams

What might the teams look like in an average large-enrollment biology classroom? The size often recommended in the literature ranges from three to ten students (Hickman and Wocial, 2013; Konyu-Fogel, DuBois, and Wallingford, 2013; Metoyer, Miller, Mount, and Westmoreland, 2014). For example, Michaelsen (2002a) prefers groups with five to seven students. According to Gardner and Walters (in press), five students is an ideal number because it allows for some attrition during the semester while maintaining the cohesion of the group. Five members also ensures sufficient members that the group is productive while keeping the group small enough that everyone can contribute. Anything larger can create logistical challenges, such as: scheduling a time for everyone to meet outside of class, coordinating discussions in class, and finding seating for the group together during class time.

The teams should be (if possible) a mixture of different racial groups, abilities, and genders to ensure the group functions efficiently (Michaelsen, 2002a). However, it must be noted that greater diversity in the groups may lead to the formation of sub-groups that diminish the group's interaction (Lau and Murnighan, 1998). During class time, the team members should sit near each other in order to facilitate interactions.

Historically, with this method of instruction, the team members have been randomly assigned to their groups (Baer, 2003; Dolmans and Schmidt, 2006). However, it is important to consider that college students are admitted to a university based on their academic similarities (Baer, 2003). Students at the same school tend to have comparable SAT scores, achievements, academic abilities, and ages. Baer (2003) recommends homogeneous groups in order to capitalize on these similarities, although he does acknowledge that student populations are inherently diverse (*i.e.,* academics and demographics can be superficial measures of a student's nature).

In the 1970's Belbin (McHarg, Kay, and Coombes, 2012) noted group function could be improved by controlling the structure of how groups were put together. He also observed that heterogeneous teams composed of individuals with different characteristics were the best functioning because diverse people had different strengths and weaknesses (which is supported by Social Constructivist Theory). He developed a self-perception inventory that grouped participants into one of eight categories. These constructs were then used to compose teams of diverse learners. Research demonstrated that this helped reduce problems for teams with poor group interactions. However, McHarg et al. (2012) found no significant difference between the groups based on Belbin’s theory and the control groups during a study of first year business students. That said, the idea of purposely structuring groups still has merit, as the authors hypothesized that the structured and control groups were similar because as business students, the group members still had to work together in order to sell their products during the course.

Michaelsen (2002a) encourages heterogeneous teams based on the even distribution of student talents and liabilities within the groups. He recommends using work experience, access to technology, and demographic data to create the learning teams. Mello and Ruckes (2006) hypothesized (in their theoretical review) that heterogeneous teams were better at dealing with changes and challenging situations, but that the members’ different backgrounds and views could become a weakness since they made different choices when dealing with a conflict and this could lead to problems with the teams’ cohesiveness. In such a situation, homogeneous teams may have an advantage, because they have similar inclinations and tend to work better together. They theorized that a heterogeneous team is better informed than a homogeneous team because of their diverse characteristics; however, a heterogeneous team may still find it difficult to work together. Mello and Ruckes (2006) further note that a homogeneous team may have similar background knowledge and will therefore have less information available to make complex decisions surrounding learning.

Baer (2003) worked with 137 undergraduates over three semesters while they were enrolled in a psychology course at a liberal arts college. He found that average and high-achieving students tended to perform better in homogeneous groups and some low-achieving students did better in heterogeneous groups. Most students with average or lower abilities tend to have more varied experiences and group type may not be as significant. Baer (2003) therefore recommends homogeneous groups because they will benefit the average and high-achieving students without harming the low-achievers.

Lau and Murnighan (1998) noted that highly diverse teams were more creative and innovative than groups with similar demographic attributes. They also discussed how creativity could be impaired by conflict within the teams. This conflict was often the result of the formation of fault lines (*i.e.,* the formation of subgroups based on demographic similarities between team members) within the group. However, this work was purely hypothetical and consisted of eight groups of four "individuals". Division may also occur when the members of a group focus on their own interests instead of team cooperation (Chatman and Flynn, 2001).

According to Wright and Drewery (2006), who worked with 250 ethnically diverse students from a small, liberal arts university in Hawaii, and Lau and Murnighan (1998), team diversity based on race, ethnicity, gender, and other factors can initially lead to division in the team, but this is often corrected when students spend more time getting to know one another. Eventually, the differences perceived by the team members become insignificant and the group becomes a cohesive team. Wright and Drewery (2006) also noted that teams with members from different cultures might benefit by having diverse methods for dealing with conflicts within the team.

Seymour and Hewitt (1997) propose that study groups may be more effective when faculty organize the students and offer suggestions for working together. Female students prefer self-organized groups, while males do not seem to have a preference (Ro and Choi, 2011). However, it would be difficult to allow students to self-select their groups in a large lecture class, especially when it is composed of mostly underclassmen that may or may not know each other well.

Ro and Choi (2011) observed that groups were more successful when women outnumbered men and that male dominated group performance was worse than female dominated or mixed groups. Women also performed better in all female groups, while men performed better in mixed groups. Unfortunately, women tend to be more stressed when working in groups than their male counterparts.

In conclusion, the diversity of heterogeneous groups can be advantageous because of the wider spectrum of talents, abilities, and perspectives distributed among the members. Homogeneous teams benefit from their similarities and cohesiveness; and they tend to get along better in social contexts. The type of group selected can benefit different individuals based on their gender and achievement levels. What is clear from the literature is that the best means to structure collaborative groups remains largely unanswered by the research literature. The literature has explored using other personal variables to build groups, while this study examines the use of motivation. The following section seeks to define this construct.

Defining motivation

Pintrich (1994) states that the most important mechanisms of motivational theory are the three components of motivational behavior 1) choice, 2) level of involvement, and 3) persistence. In the context of classroom learning environments, motivational behavior implies that students must *choose* to study over other perhaps more desirable activities. They must dedicate themselves to the learning task and put in the necessary time to learn both in and out of the classroom. They must not be discouraged by difficult assignments and instead remain engaged until the learning objective is achieved. These necessary behaviors help to illustrate the definitions of motivation.

According to Tuan et al. (2005), motivation is a multi-faceted construct and can be conceptualized as six sub-constructs. These include:

- Self-efficacy: Relates to a person's confidence in their ability to successfully complete a learning task. It is a major component of sustained motivation and has been shown to affect the program of study a student selects, how much effort they will put into their studies, and if they will persevere when faced with challenges. Students with higher degrees of self-efficacy are better able to use analytical and metacognitive skills to benefit their learning experience. This results in a better understanding of the material and higher grades (Chemers, Litze, and Garcia, 2001).
- Active Learning Strategies: Focus on the behaviors students exhibit as they build up their knowledge foundation (Tuan et al., 2005). This is classic constructionist theory and includes the recovery of current knowledge and the elucidation of new

information that is eventually assimilated by the learner using metacognitive strategies for learning.

- Science Learning Value: Deals with the importance of learning to the student, in other words, the intrinsic value that it holds. Learning for the sake of knowledge.
- Performance Goals: Are extrinsically motivated and include the rewards the students hope to achieve when they complete a learning task. This is usually in the form of a good grade or impressing their instructor or peers.
- Achievement Goals: Are intrinsic in nature and deal with the desire to prove something to one's self and accomplish something that holds value to the individual. The goals are achieved because of the beliefs and attributions of the learner and through their approach and engagement in learning activities (Ames, 1992).
- Learning Environment Stimulation: Relates to the learning practices that occur in the classroom (Tuan et al., 2005). The style of teaching and the student's response to that particular format can have an impact on motivation levels, along with their interactions with classmates and the instructor.

Motivation is a frequent topic of concern in many classrooms by both faculty and students (Pintrich, 1994). However, according to Ames (1992)

> Motivation is too often equated with quantitative changes in behavior (e.g., higher achievement, more time on task) rather than qualitative changes in the ways students view learning themselves in relation to the task, engage in the process of learning, and then respond to the learning activities and situation. (p. 268)

This is an important point to remember. While an instructor can create extrinsic motivation within students through the use of rewards or the fear of failure, it is more challenging to foster intrinsic motivation in students. This is in no way meant to dissuade encouraging intrinsically motivated behaviors; however, the instructor must simply be more thoughtful about how they motivate their students (Cooperstein and Kocevar-Weidinger, 2004).

Self-Determination Theory

Motivation is the foundation of Self-Determination Theory as described by Ryan and Deci (2000). Essentially, Self-Determination Theory deals with the need for people to feel they have a choice in their decisions without the application of external pressures. People need to feel autonomous, competent, and have a sense of relatedness to their environment. According to Ryan and Deci (2000), people with internal motivation have more interest, excitement, confidence, enhanced performance, persistence, creativity, higher vitality, better self-esteem, and a general well-being when compared to people with external motivation. This applies even if they have the same perceived level of competence and self-efficacy.

The theory also examines the development of personality and the self-regulation of behavior (Deci and Ryan, 1985). Intrinsic and extrinsic sources of motivation are vital components of the theory. Intrinsic motivation is considered to be the natural state (as witnessed in young children) and if it is not supported, it diminishes. Positive feedback is vital to the learning process and students need to feel confident and autonomous to be intrinsically motivated. Rewards, threats, deadlines, imposed goals, and pressured evaluations inhibit intrinsic motivation (Ryan and Deci, 2000). A student possessing intrinsic motivation for an activity may lose interest when offered a reward and may then require a reward for future participation in an activity (Ryan, Deci, and Williams, 1996).

Self-regulation is viewed along a continuum with the highest levels expressed by someone wanting to perform an action because they are truly interested in completing it versus someone whom feels compelled to do something by outside pressures (Deci, Ryan, and Williams, 1996). The sense of autonomy and volition experienced by the intrinsically motivated, self-determined student provides pleasure and a feeling of accomplishment (Deci, Ryan, and Williams, 1996). An extrinsically motivated student does not necessarily experience this pleasure. They may instead be more concerned about avoiding punishment or receiving a reward. According to Deci, Ryan, and Williams (1996), the exception occurs when the extrinsically motivated student internalizes (*i.e.,* converts the external pressures to internal motivations) or integrates (*i.e.,* the student makes the extrinsic forces personal) these outside forces and their behavior becomes self-regulating and volitional.

Deci and Ryan (1985) discuss how instructional behaviors that encourage autonomy support an internal perceived locus of causality and provide a sense of competency for the student, thereby producing intrinsic motivation in the student, are the most effective. However, instructional activities that apply pressure to a learner tend to result in an external perceived locus of causality and interfere with creativity, restrict cognitive flexibility, and reduce intrinsic motivation. Instructional methods that imply the student cannot learn the material create a sense of incompetence and helplessness and ultimately destroy intrinsic motivation. This result is referred to as amotivation (Deci and

Ryan, 1985). It should be mentioned that an individual's personality determines how they respond to various instructional strategies. Some people will tend to be more intrinsically motivated, extrinsically motivated, or amotivated regardless of the teaching method (Deci and Ryan, 1985). Amotivation and the belief that external forces control your fate is the opposite of self-determination (Deci and Ryan, 1985).

Pintrich (1994) discussed the situation where students do not understand the connection between their behavior and eventual outcomes. These *learned helplessness* or *maladaptive motivational response patterns* results in apprehension, inaction, diminished effort, and the reduced likelihood of success (Ames, 1992). In contrast to students that express *mastery* or *adaptive motivational response patterns* (Ames, 1992). When students do understand that their efforts will result in a positive conclusion, they have higher expectations for themselves and tend to persist even when faced with challenges. A feeling of controlling his or her own destiny is essential for the student. Students with an *internal locus of control* (*i.e.,* students who perceived they were in control of their own environment and could influence it) were more successful academically and possessed higher self-esteem. Students with an *external locus of control* (*i.e.,* they believed that other powerful sources, such as teachers or parents, control the outcomes of their experiences) or students with unknown sources (*i.e.,* these students have no idea what determines their destinies) tend to perform at lower levels, have lower self-esteem, and think that everything is beyond their influence (Pintrich, 1994). Therefore, there is little motivation for these students to make changes in their study behaviors and attitudes. If they believe that studying will not make a difference in their grade, then they do not choose to study. Conversely, if a student thinks that studying will help improve their performance, they will still study, even if they do not possess a proclivity for the material.

Self-Determination Theory research is related to the definition of motivation by Tuan et al. (2005) through shared influences on motivation. Self-efficacy, Science Learning Value, and Achievement Goals are connected to positive Self-Regulation and intrinsic motivation, while Performance Goals relate to extrinsic motivation on the opposite side of the Self-Regulation spectrum. Active Learning Strategies and Learning Environment Stimulation are the methods for how learners (whether they are positively or negatively self-regulated) meet their learning goals.

Motivation as a means for structuring collaborative groups

In the past, teams have been organized by learning style, gender, ability level, member familiarity, ethnicity, personality type, and other factors (Arnulf, 2012; Kayes, Kayes and Kolb, 2005; Lei, Kuestermeyer, and Westmeyer, 2010). However, motivation has rarely been used to construct groups, even though educators view motivation as the driving force behind student engagement. Social and cognitive psychologists consider motivation to be a component of student persistence (Graham, Frederick, Byars-Winston, & Hunter, 2013). According to French, Immekus, and Oakes (2005), the properties of motivation consist of persistence, self-efficacy, goal setting, and resilience in attaining those goals. Simply stated, some researchers claim that motivation is perhaps the most significant psychological concept in education (Yoshida et al., 2008). According to Crone and Mackay (2007), what it really boils down to at the undergraduate level is, if students choose to make their educational experience a priority or not. Examining their initiative, efforts, persistence, and achievement of goals all takes place after they *choose* to make it a main concern. The self-regulation of a student's behavior is a personal choice and to use a colloquialism: *You can lead a horse to water, but you can't make it drink.*

There has been little research on the impact of group motivation in team settings. In a review by Dolmans and Schmidt (2006) focusing on tutorial groups, they reported the significance of the construct of motivation to team efficacy, and noted that student motivation impacted group efficiency and communication. They observed how students with lower levels of motivation interfered more with the group's learning process. This may be connected to the students' lack of interest in the subject material and the students demonstrated amotivation due to that lack of interest. Additionally, because the less motivated students lacked interest in the class, they were more disruptive and contributed less to the team.

The motivational levels of the group can also affect the cognitive function of the students (Dolmans and Schmidt, 2006). This is likely connected with the effects of socially constructed learning. Since the whole team is not working together, the dysfunction frustrates the other team members and impacts their ability to learn. Also, they are not receiving the benefits of team communication and the social interactions that properly functioning teams enjoy. De Grave, Dolmans, and Van Der Vleuten (2002) also directly observed the significance of motivation on group function, and noted its importance. The students in the tutorial groups they studied noted the lack of motivation in some of the group members and considered it the tutor's responsibility to re-engage those students. However, when another student had unequal participation, they tended to ignore them and did not expect the tutor to correct the situation.

Although motivation has been shown to be an important construct for group success, there is little concrete empirical evidence as to its importance in undergraduate achievement of critical learning outcomes when utilized to form structured learning teams. The above studies were small studies (De Grave et al., 2002; McHarg et al., 2012; Wright and Drewery (2006), involved medical school students (De Grave et al., 2002), examined dental students (McHarg et al., 2012), applied to the business world (Mello and Ruckes, 2006), used hospitality and tourism management students (Ro and Choi, 2011) or were reviews of other work (Dolmans and Schmidt, 2006).

Selecting team members based upon their individual motivation is a relatively new idea. Gardner and Walters (in press) first examined this method with undergraduate non-majors biology students. They used two treatment conditions. The first consisted of randomly assigned groups of students and the second featured heterogeneous groups based on motivation. The randomly assigned group was heterogeneous and statistically equivalent to the study group based on motivation levels and demographics. The study revealed that the participants had an increased interest in science by the end of the semester, along with improved performance on exams, but no significant difference in attitude or perceptions of biology and biologists. It was also observed (not surprisingly) that attendance correlated with grades. While it was determined that the students made progress during the semester, there was no evidence that it was due to their group organization or formation.

This study was designed to improve upon this past work by utilizing homogeneous groups in addition to heterogeneous groups, thereby allowing a comparison between the two types of groups. This project focused on undergraduates enrolled in a biology course for healthcare majors. Over 300 students participated in the study and they were organized into homogeneous and heterogeneous (essentially a control group) teams to discover if motivation is a useful construct to utilize for team construction and its impact (at the group and individual level) on student learning and affective outcomes in the course. The outcome variables measured during this project should indicate the successfulness of using motivation as the basis of team formation and include: Attitudes Toward Biology, Perceptions of Biology and Biologists, Views of Science, and Content Knowledge. The details and operational definitions of these measures are discussed in greater detail in the next chapter.

Relevance of research

This project will examine how best to structure groups of students for team-based collaborative learning by comparing the outcome variables of both heterogeneous and homogeneous teams grouped by motivation variables. The information on student attitudes, views of science, and perceptions of biology and biologists as critical learning outcomes should also be useful in designing learning interventions for STEM students. Data collected from this project could be beneficial in retaining promising students in STEM fields through deliberate group construction.

If we can better understand how students perceive biologists and biology and what drives these perceptions, then perhaps we can address the negative views and hopefully correct these perceptions while we encourage and promote the positive views. The ultimate goal is to create in students an interest and appreciation for biology. While not every student (obviously) will become a biologist, the poor perceptions of biologists and the less positive attitudes about biology by the general public may discourage potential STEM majors who have a difficult time visualizing themselves in the field.

It should be noted that inaccurate views of scientists appear to form during childhood (Finson, 2002) and may contribute to problems interacting with the community later in life. A lack of biological knowledge and a poor understanding of how science works (*i.e.,* Views of Biology) can also be problematic. Resulting in a population that has a difficult time interpreting and understanding new scientific discoveries and developments. Finally, if people believe the scientist stereotypes, they may be less willing to listen to and work with scientists. This could be especially problematic when dealing with the public regarding conservation issues.

METHODS

Data Collection

Experimental design

A quasi-experimental pre-post design was used. This format is common in educational settings where it would otherwise be impractical to divide a classroom into two completely separate groups. The lack of a true control group limits the ability of the researcher to draw definitive causative conclusions regarding the impact of the intervention, but it does allow for the evaluation of the effect of the intervention on the sample population (National Center for Technology Innovation, 2014).

The participants were selected from students enrolled in two sections of the same biology course. The experimental treatment was the composition of the small group learning teams with no true control group. Pre-tests were provided to all participants during the first week of the course as an online assessment through Qualtrics Survey Software (Qualtrics, Provo, UT) and a post-test was provided during the final exam (as part of the paper copy of the exam). All participants received the same educational intervention (*i.e.,* the class itself and the group work they completed during the semester).

The majority of the data collected for this project was self-reported by the participants. Due to the nature of this method of collection, there is a risk of bias from the participants. They may answer an item with what they believe is a more socially desirable selection in order to please or impress their instructor or because they believe that is how they should answer the item (Miller, 2012). For example, when asked *When learning new biology concepts, I attempt to understand them,* a participant may select *agree* because they think they should try to understand the concepts, but in reality, they would not make the attempt. This bias is not always observed with undergraduates, but it is a possibility that must be considered.

Survey fatigue can also be a concern. A number of campus groups use surveys to collect data (*e.g.,* libraries, students organizations, academic departments). Students may begin to feel burdened by the number of surveys they are asked to complete in a semester (Porter, Whitcomb, and Weitzer, 2004). This sense of overload can cause students to avoid or not complete a survey. The timing of the survey is also significant. This instrument was used at the beginning and again at the end of the semester. Unfortunately, this is a common time for other campus groups to also administer their surveys. Survey fatigue could impact the number of participants for this project.

The same instructor taught the two course sections twice a week on Tuesdays and Thursdays. The first section of the class occurred from 9:30 am to 10:45 am in a large lecture hall with stadium seating, while the second section was from 12:30 pm to 1:45 pm in a newer lecture hall with stadium seating. A typical class session was begun with a set of clicker questions to evaluate prior knowledge, a mini-lecture, a student-centered exercise completed by the small groups, and a final wrap-up activity that synthesized the classroom events of the day through either clicker questions or a whole-class discussion. Each class section was followed by a 50-minute discussion period used to clarify student questions posed at the end of the preceding class period. The potential differences (*i.e.,* Motivation, Pre-test Knowledge Score, Final Exam Grade, Final Course Grade, Participation Score, and Attendance) in the classroom experience between the two sections were examined using two independent sample t-tests and were found to be nearly identical (Table 3.14).

The course covered a variety of biological topics (*e.g.,* natural selection, genetics, physiology). The subject of the *Nature of Science* was introduced the first week of class (prior to the close of the pre-test) and was particularly applicable to the participants' completion of the survey instrument. The instructor defined key terms (*e.g.,* theory, hypothesis) and differentiated them from common usage. The purpose, application, and limitations (*e.g.,* science cannot make moral, ethical, or value judgments, it cannot dictate how information will be used) of science were examined. The *Scientific Method* was introduced along with how it is actually used by researchers. Case studies were reviewed to help illustrate the concepts and examples of contradictory evidence were considered.

Participants

Participants were recruited from undergraduate students enrolled in two sections of BIOL1150 (*Principles of Biology: A Human Approach*) at East Carolina University, Greenville, NC, during the Fall 2012 semester. The first section of BIOL1150 had an enrollment capacity of 150 students and the second section had an enrollment capacity of 200 students (n = 350). The resulting number of participants was reduced to a final total of n = 312 because of attrition and unusable data. Institutional Review Board (IRB) approval was obtained as a result of an application (Appendix A) through East Carolina University's Medical Center Institutional Review Board (UMCIRB). All participants were required to indicate their willingness to participate in the study through a Letter of

Informed Consent (Appendix B) and were informed of their ability to withdraw from the study at any time.

The sample of participants was largely freshmen, composed primarily of Caucasian and African American students with a slight skew towards females (Table 2.1). This distribution is representative of the larger university undergraduate population that is 58.9% female and has a racial/ethnic distribution of 72% white, 15% black, 3% Hispanic, and 2% Asian (College Portrait of Undergraduate Education, 2014).

The majority of the participants were over the age of 18 and were able to provide consent to participate in this study through the informed consent letter. However, one student (0.3% of the course) reported being under the age of 17 and 33 students (10.6%) stated they were 17 years old at the start of the study. It should be noted that because these students were not technically able to provide consent, their information was not examined at the individual level. In addition, many of the participants who were 17 years old when they completed the pre-test in August 2012, were 18 years of age by the time they took the post-test in December 2012. Approximately 80 of the students had taken a previous science course, mostly consisting of chemistry and biology. (It was difficult to determine if a handful of the students had previous experience, because the codes they used were unrecognizable.) The majority of the majors were in healthcare or related fields (*e.g.,* Exercise Physiology, Physical Therapy, Public Health Studies, Athletic Training, Clinical Lab Science, Nursing, Recreational Therapy, and Health Fitness). There were also a few individuals with majors in Biology, Political Science, Business, Psychology, Education, Music, Criminal Justice, Hospitality Management, Graphic Design, and Communications. A large number of students were still undeclared, which is not unusual with freshmen. It should be noted that while the majority of the participants were not STEM students, they were enrolled in a STEM class. The data collected from this project will be useful for encouraging students from multiple backgrounds to enroll and persist in STEM courses.

Table 2.1

Participant Demographics

Attribute	Distribution
Gender	
Male	41.3%
Female	58.7%
Ethnicity	
Caucasian	76.2%
African American/Black	14.8%
Native American	0.6%
Hispanic/ Latino	2.3%
Asian	2.6%
Middle Eastern	0.3%
Pacific Islander	0.3%
Other or Mixed background	2.9%
Class ranking	
Freshman	85.9%
Sophomore	8.7%
Junior	4.5%
Senior	1.0%
Age	
Under 17	0.3%
17	10.6%
18	70.7%
19	8.0%
20	5.5%
21	2.6%
22	0.6%
23	1.0%
24	0.0%
Over 24	0.6%

Note. Gender, ethnicity, class ranking, and age information of student participants. n = 312

Description of measured variables

Approximately one week prior to the start of the course, enrolled students were contacted through the course Blackboard website email list, welcomed to the course and asked to complete an online survey (Appendix D) through Qualtrics Survey Software. The students were given approximately 10 days to complete the pre-test in order to accommodate schedule changes during the add-drop period. This pre-assessment asked demographic information and measured the following variables: a) general biology content knowledge, b) perceptions of biology and biologists, c) attitudes toward biology, d) views of science, and e) motivation to learn biology. As discussed above, the demographic information of interest was gender, race/ethnicity, class ranking, age, previous science courses taken, and current declared major (Tables 2.2 and 2.3).

A principle component factor analysis was completed for the motivation and attitude pre-test data. This method is largely exploratory and is utilized to find relationships within the data. It identifies items that cluster together based on the similarities of the responses of the participants. Factor analysis facilitates the examination of data from a broader view and allows the identification of themes (*i.e.,* the factors) from within the responses that might otherwise be unobserved. However, an exploratory factor analysis is limited by not incorporating inferential statistics and this method cannot test a hypothesis. It is therefore more likely to provide errors even when used with large or ideal sets of data (Costello and Osborne, 2005).

Table 2.2

Predictor (Independent) Variables

Variables	Data Type	Instrument
Level 1: Individuals		
Gender	Categorical/dichotomous	Demographic survey
Race/Ethnicity	Categorical/nominal	Demographic survey
Class standing	Categorical/nominal	Demographic survey
Previous science courses taken	Categorical/dichotomous	Demographic survey
Major	Categorical/nominal	Demographic survey
Age	Categorical/continuous	Demographic survey
Motivation	Ordinal	Students' Motivation Toward Science Learning
Attendance	Ratio data	% Classes attended, In-Class Exercises/Clickers
Participation	Ordinal & Qualitative	Peer Evaluations of Group Work
Level 2: Small Groups		
End of semester group size	Ratio data	
Group motivation composition	Categorical/nominal (hetero, homo high, homo mid, & homo low)	
Group gender ratio	Ratio data	
Level 3: Course Sections		
Time of day	Categorical/dichotomous	

Note. The three levels were originally utilized to facilitate using Hierarchical Linear Modeling for the analysis of the data. However, the final data was not compatible with this type of analysis and Linear Regression was used instead. The levels are still used here to organize the tiers of data (*e.g.,* individuals, groups, and sections) for the predictor variables.

Table 2.3

Outcome (Dependent) Variables

Variable	Instrument (# of Items)
Δ Content Knowledge	Content Assessment (26)
Δ Attitudes Toward Biology	Biology Attitude Scale (33)
Δ Perceptions of Biology	Science Perceptions Survey (20)
Δ Perceptions of Biologists	Science Perceptions Survey (21)
Δ Views of Science	Biology Attitudes, Skills, & Knowledge Survey (12)

Note. The outcome variables examined for the study. The number in parentheses in the second column indicates the number of survey questions for a particular variable.

General biology content knowledge

Content Knowledge was measured both pre- and post-intervention. The items covered concepts including the nature of science, some science terminology, the scientific process, genetics, cell biology, and ecology. Content assessment items were adapted by Gardner (2011) in part from Vance-Chalcraft (n.d.) and from the *Genetic Literacy Concept Inventory* (*GLCI*) developed by Bowling (2007). The post-test knowledge evaluation consisted of the final exam for the course written by the instructor and aligned with course content learning objectives.

The six items adapted from Vance-Chalcraft do not have reliability or validity data available, as they were intended for informal assessment within the department. However, the work of Bowling et al. (2008) has extensive reliability and validity data for the *GLCI*. Both content and discriminant validity were verified. For content validity, the questions were reviewed by genetics experts and found to useful in evaluating genetic knowledge (Bowling et al., 2008). The discriminant validity was confirmed by providing the survey to graduate and undergraduate students enrolled in introductory biology, genetics, and psychology classes. Not surprisingly, the graduate students (averaged 87%) performed better than the undergraduates (averaged <45%) and the variance was confirmed with a Games-Howell *post hoc* analysis. Reliability was assured with measures of stability and internal reliability. A test-retest was performed with psychology students who had less genetics knowledge and the Pearson correlation = 0.68. Internal reliability was calculated with Cronbach's α (a common measure of scale reliability, a score greater than 0.7 is usually acceptable) for the pre- and post-test scores from the main set of participants and was 0.995 (n = 395) for the pre-test and 0.997 (n = 330) for the post-test (Bowling et al., 2008).

Perceptions of biology and biologists

Perceptions of Biology and Biologists were measured pre- and post-intervention with an adaptation by Gardner (2011) of the Kitchen, Reeve, Bell, Sudweeks, and Bradshaw (2007) *Science Perceptions Survey* (*SPS*). This component of the instrument attempted to uncover students' affective reactions to biology and biologists. It focused on simple impressions and allowed the participants to select their level of agreement with a particular set of opposing dichotomous descriptive terms.

The *SPS* originally measured student perceptions of courses with analytical and information recall style teaching methods (Kitchen et al., 2011). The reliability coefficients for the first round of testing for the two scales were 0.93 for the analytical items and 0.88 for the recall series. A factor analysis found two factors for the analytical and five factors for the recall items. It was determined that the survey measured two types of perceptions: an idealistic perspective and a personal perspective of the participants. A second round of analysis after a revision of the survey found reliability coefficients of 0.92 for analytical and 0.87 for recall. Another factor analysis resulted in a reduction of factors for the recall items (from five to three) and the analytical factors remained constant. For the two analytical factors, 66.5% of the variance was explained and 66.7% was explained by the recall set (Kitchen et al., 2011). This demonstrated that the factor analysis was reliable in its ability to measure perceptions of biology and biologists.

Attitudes toward biology

Attitudes Toward Biology were measured both pre- and post-intervention and were adapted by Gardner (2014) from Osborne, Simon, and Collins (2003), Pell & Jarvis (2001), and Usak et al. (2009). The survey attempted to identify the affective responses of participants toward the study of biology. A principal component factor analysis was completed on the pre-test questions to verify the validity of the survey instrument. It uncovered seven factors (*e.g.,* Interest in Biology, Enjoyment of Biology, Appreciation of Biology, Application of Biology, Lab Experience, Challenge of Biology, and Opinions of Biology). These factors are operationally defined in the Results section. This is dissimilar from Gardner (2014), who found five factors while also working with non-major undergraduate biology students. Gardner's factors accounted for 59.37% of his variance and the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy = 0.893, Bartlett's Test of Sphericity – X^2 = 3235.34, p <0.0001. Therefore, Gardner's adaptation was a reliable measurement of Attitudes Toward Biology.

Views of science

Views of Science were measured both pre- and post-intervention with an instrument adapted from Lawson's (2012) online *Biology Attitudes, Skills, & Knowledge Surveys (BASKS)*. These items sought to identify participants' understanding of the nature of science. There were no sub-constructs and only twelve items. The items were previously validated with high school students by Adamson et al. (2003) and the Cronbach's α reliability coefficient was 0.77.

Motivation to learn biology

A Motivation Score was calculated using the *Students' Motivation Toward Science Learning* (*SMTSL*) survey (Tuan, Chin, and Shieh, 2005). The SMTSL survey consists of 35 items. Content, construct, and criterion-related validity was performed by Tuan et al. (2005) and Gardner (2011) found the survey to be valid and reliable at the undergraduate level. Gardner's factors accounted for 52.50% of the variance and the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy = 0.815, Bartlett's Test of Sphericity – $X^2 = 2474.24$, $df = 528$, $p < 0.0001$. A principle component factor analysis was again completed for this study to verify the validity of the survey and it uncovered nine components (*e.g.,* Science Learning Value*, Active Learning Strategies*, Self-confidence, Self-efficacy*, Achievement Goals*, Performance Goals*, Social Validation, Instructor Validation, and Connections to Learning) as opposed to the six found by Tuan et al. (2005) with Taiwanese junior high students. * Indicates factor titles derived from Tuan et al. (2005).

Factor analyses were utilized to look at the data in aggregate to validate the data for non-major biology students. The Perspectives of Biology and Biologists, Views of Science, and Knowledge items were not analyzed using factor analysis techniques, as they were not intended to provide an aggregate evaluation of the participants' opinion on a topic. Each item in these scales was analyzed individually.

Instrument completion and learning team construction

This instrument took approximately 20 minutes to complete during both pre- and post-administration. All participants were asked to use their Student Banner ID (student identification number) as a code number on the instruments in the study. Names were not used to ensure anonymity during the data collection and analysis phases.

The participants in each class section were randomly assigned to one of two treatments (*e.g*., heterogeneous or homogeneous) that determined how their small group would be structured by SMTSL score. It must be noted that 79 students did not use their student identification number when they completed the pre-test. Therefore, the author was unable to match their SMTSL score to an individual student. This necessitated placing all unknown students in heterogeneous groups.

Following random assignment of the study sample into heterogeneous and homogeneous categories, the individual students in the heterogeneous category were randomly assigned to small collaborative learning teams of five students each. As seen in the pilot study, randomly assigning students to heterogeneous small groups resulted in a good distribution of motivation levels within these groups, which was equivalent to the intentional construction of heterogeneous groups (Gardner, 2011).

The homogeneous category participants were placed in teams of five students each based upon their composite *SMTSL* motivation scores. The homogeneous students were grouped from high to low. The first five most motivated students (as indicated by high composite SMTSL scores) were placed in group 1, the next five in group 2, etc.

The Group-level Motivation Score (consisting of the average motivation score of all the individuals within a learning team had a range of 98 to 160 points and a possible maximum score of 175 points) was used to classify the homogeneous teams based on their motivation level into high (range of 135.1 to 160 points), middle (range of 125.1 to

135 points) and low (range of 98 to 125 points) levels of motivation. In course section A (coded as ‘A’ in the small groups below), seven homogeneous teams were classified as high motivation (Teams 1A, 2A, 3A, 4A, 10A, 11A and 12A), five homogeneous teams were classified as middle motivation (Teams 5A, 6A, 7A, 13A, and 14A), and three homogeneous teams were classified as low motivation (8A, 9A and 15A). In section B (coded as ‘B’ in the small groups below), seven homogeneous teams were classified as high motivation (Teams 1B, 2B, 3B, 4B, 11B, 12B, and 13B), eight homogeneous teams were classified as middle motivation (Teams 5B, 6B, 7B, 8B, 9B, 14B, 15B, and 16B), and two homogeneous teams were classified as low motivation (Teams 10B and 17B) (Table 2.4). Standard deviations of group motivation scores were calculated to ensure that the homogeneous teams had smaller standard deviations for their motivation scores, and that heterogeneous teams had broader standard deviations. A standard deviation of < 5 points was considered acceptable for homogeneous teams, while a score of > 5 points was suitable for a heterogeneous team. This allowed some flexibility in the formation of the teams, as not everyone in a homogeneous team could have a similar score. Most of the teams fell within the range. The exceptions were due to accidental switching of teams by participants at the beginning of the semester, heterogeneous team participants without motivation scores, and outlier Motivation Scores for homogeneous low teams.

Table 2.4

Team Motivation Scores by Section and Group Type

Section 1				
Homogeneous			Heterogeneous	
Team	Mean (SD)	Level	Team	Mean (SD)
1A	150.6 (9.40)[a]	High	16A	135.7 (8.96)
2A	143.4 (5.37)[a]	High	17A	138.0 (9.90)[c]
3A	137.5 (0.58)	High	18A	146.0 (15.56)[c]
4A	138.8 (7.95)[a]	High	19A	142.0 (11.58)
5A	133.8 (0.84)	Middle	20A	150.0 (0)[b]
6A	130.6 (1.52)	Middle	21A	134.0 (5.66)[c]
7A	127.2 (1.30)	Middle	22A	137.3 (8.14)
8A	123.6 (0.89)	Low	23A	146.0 (2.83)[c]
9A	117.0 (3.87)	Low	24A	138.0 (10.44)
10A	151.8 (3.49)	High	25A	146.0 (2.83)[c]
11A	143.0 (3.08)	High	26A	124.5 (6.36)[c]
12A	135.2 (3.03)	High	27A	144.0 (14.14)[c]
13A	131.0 (1.58)	Middle	28A	131.5 (8.85)
14A	127.0 (1.87)	Middle	29A	129.5 (2.12)[c]
15A	118.2 (6.72)	Low	30A	143.0 (19.80)[c]

Section 2				
Homogeneous			Heterogeneous	
Team	Mean (SD)	Level	Team	Mean (SD)
1B	155.4 (4.04)	High	18B	130.5 (22.96)
2B	148.8 (1.48)	High	19B	120.5 (15.93)
3B	139.8 (1.92)	High	20B	142.5 (18.70)
4B	137.0 (0.71)	High	21B	142.3 (15.37)
5B	134.6 (1.34)	Middle	22B	142.0 (0)[b]
6B	132.8 (1.30)	Middle	23B	135.0 (0)[b]
7B	131.4 (0.89)	Middle	24B	133.0 (26.87)[c]
8B	129.0 (1.22)	Middle	25B	116.0 (12.73)[c]
9B	126.3 (0.50)	Middle	26B	135.5 (9.85)
10B	121.8 (3.35)	Low	27B	145.5 (9.19)[c]
11B	155.2 (1.92)	High	28B	120.0 (0)[b]
12B	140.5 (10.33)[a]	High	29B	0.0 (0)[e]
13B	135.8 (5.34)[a]	High	30B	138.0 (2.00)
14B	135.0 (1.83)[a]	Middle	31B	137.0 (16.27)
15B	132.0 (1.00)	Middle	32B	132.5 (3.54)[c]
16B	128.6 (0.89)	Middle	33B	127.5 (6.36)[c]
17B	119.8 (7.50)[d]	Low	34B	141.5 (4.95)[c]

Note: Heterogeneous team motivation scores are incomplete means and do not reflect the scores of all team members, because some of the students placed on heterogeneous teams did not use their student identification number on the pre-test and could therefore not be individually identified. [a] One member of this team switched from a different team at the beginning of the semester and had a motivation score that was not compatible with the group type. [b] Only one member of this team completed the motivation survey, therefore a standard deviation could not be calculated. [c] Two or fewer members of this team completed the motivation survey, therefore the standard deviation is limited. [d] This homogeneous group included two of the lowest scoring participants on the motivation survey, and therefore has a larger standard deviation. [e] none of the students placed on this team used their student identification number on the pre-test.

Student attendance and participation

Other variables of interest that were measured during the course were student attendance rates and measures of student participation in their groups. Attendance was reported by percentage of classes attended by the student. Attendance was quantified by students' self-reports of attendance as a part of their group work and validated by student use of response devices ("clickers"). The data were collected by the instructor and used to determine part of the students' final grade in the course.

As endorsed by Trackey (2013), peer interaction was measured by a qualitative survey that students completed at the end of the semester for themselves and their group. The items measured student participation within the learning team (Appendix C). Composite scores from the survey were used to calculate each student's participation grade in the course. If a student failed to complete the team evaluation, they received a zero for their participation grade. The scores (based on a Likert scale) were averaged for all of the team members for each individual member that completed an evaluation.

Any changes in a group's size due to attrition were also noted at the end of the semester. Final course grades were collected to provide an overall view of the success of each student during the course and to offer a better understanding of the impact of the teams' interactions. These grades were converted from letter grades (A, B, C, D, and F) to a 4.0 scale to facilitate statistical comparisons.

Study intervention and procedure

Once assigned, the participants in the small groups were expected to remain in their groups through the duration of the semester. However, some student attrition was expected, along with changes in the composition of the groups due to personality conflicts. These changes were tracked and every effort was made to control for these situations. In instances of irreconcilable personality differences within groups, every effort was first made to have the students work out their issues within their group. If this could not be managed, effort was made to reassign a student to a similar type of experimental category group (heterogeneous or homogeneous). Within this study only one student moved groups over the course of the semester. If a student began to work with the incorrect group at the beginning of the semester, it was noted and they remained in that group (as it would have been problematic to move them unnecessarily). Results for any of these changes are noted in Chapter 3, but these are expected limitations to any social research study.

Data Analysis

Descriptive and inferential statistics

Descriptive and inferential statistics were calculated for most of the items in the instrument (Table 2.3). A mean, standard deviation, normalized gain scores, and a two-tailed t-test were calculated for the pre and post-test answers (with the exception of the motivation data (Table 2.2), which only had pre-test data) at both the individual and small group level. Normalized gain scores or $\bar{g}$-factors are useful when working with Likert scales, because this measurement more accurately depicts movement with Likert (ordinal) data from pre- to post-test (Colt, Davoudi, and Murgu, 2011). Most of the responses were examined collectively at the group and section level. Ratios were calculated for gender proportions and final team size in each of the groups. The gender ratios were examined to look for any correlation with Final Course Grades for the team and only utilized students that completed the course (*i.e.,* students who dropped the course, withdrew from school or had an unknown status were not included in the final calculations).

Hierarchical linear modeling

The original plan of this study was to collect quantitative data that would be examined using Hierarchical Linear Modeling (HLM), a form of regression analysis that allows the creation and analysis of predictive models with "nested" data that exist at various levels of hierarchical organization. HLM analysis is common in classroom studies where students are nested at hierarchical levels (*i.e.,* groups, classrooms, schools, districts, etc.) While at first glance, this data set *should* have been a perfect candidate for HLM, however, it turns out the groups and sections were too similar to each other for HLM to be useful. This was exposed when an Intraclass Correlation (ICC) was performed (the first step used in order to determine if the data was an appropriate fit for HLM), it revealed the ICC = 0.0072, while > 0.05 is necessary for HLM. Therefore more traditional linear regressions were selected to examine the data.

Linear regression

International Business Machine's (IBM) Service Product for Statistical Solution (SPSS) Version 21.0 was utilized to perform the linear regressions. Tests (*e.g.,* ANOVA and Tukey's Honest Significant Difference) were completed to examine correlations between variables (at the individual and group level) and to determine if group type impacted Pre-test Knowledge Scores, Final Exam Grade, Final Course Grade, Motivation Score, Participation, Attendance, and Previous Science Courses taken by the participants. Additionally, predictive models using group type (heterogeneous or homogeneous) were tested to determine if Previous Science Course experience could ascertain Final Course Grade.

RESULTS

Item Analysis

The analyses of the survey items, attendance data, participation data, final exams, and final course grades address the following research questions:

1. Does the construction of collaborative groups based on motivation predict non-major biology students' learning success in a biology course?
2. What group structure (homogeneous or heterogeneous) is associated with the highest learning success and team participation?
3. How do student demographics impact group structure and learning success?
4. How do classroom characteristics impact learning success?
5. How does collaborative group work impact students' attitudes toward biology, perspectives of biology and biologists, and views of science?
6. How does collaborative group work impact students' attendance, team attrition, and gender ratios?

Approximately 312 students completed the pre-test (a response rate of 95%) and 286 finished the post-test (a response rate of 91% after student attrition). As is typical of most survey research, some participants did not complete both the pre- and post-tests. In addition, some participants did not finish a survey or failed to answer select items during the survey. Most of the responses were examined in aggregate at the course section level and small group level. This allowed for a broader perspective of the data and removed any problems associated with analysis at the individual level (*i.e.,* underage participants, students without identification numbers, and students that missed items or did not complete either the pre- or post-test).

The majority of survey items used a Likert-type scale. The Motivation to Learn Biology items (Table 3.1) on the pre-test ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). The Attitudes Toward Biology items (Table 3.2) and the Views of Science items (Table 3.5) items featured a scale of 1 (*strongly disagree*) to 5 (*strongly agree*) for the pre- and post-test. The Perceptions of Biology (Table 3.3) and the Perceptions of Biologists (Table 3.4) pre-test items offered a sliding scale between two descriptive terms and the students moved the bar along the line (the pre-test was taken on-line using the Qualtrics survey website). For example, the first Perceptions of Biologists item asked “Biologists are?” and the students selected a point between 0 (*Sloppy*) and 5 (*Neat*). The pre-test scale ranged from 0 to 5 for all of these items. The post-test was a paper copy and lacked the sliding scale. It used a similar format and the participants selected a number from 1 to 5. It should be noted that the differences observed between having a scale of 0 to 5 on the pre-test and a scale of 1 to 5 on the post-test were minor. For example, on the first Perceptions of Biology item, the mean was 1.02 with a standard deviation of 1.22 and the p-value was < 0.0001. When the 0’s were adjusted to 1’s, the mean was 1.00 with a standard deviation of 0.90 and the p-value was 0.0003. The single Perspectives as Non-majors item (Table 3.5) ranged from 1 (*very good*) to 5 (*not good*) for the pre and post-test items.

Motivation to learn biology

The first section of the pre-survey measured the students’ motivation to learn biology. It addressed the first research question: Does the construction of collaborative groups based on motivation predict non-major biology students’ learning success in a biology course? The study instrument was adapted from the *Students' Motivation Toward Science Learning* (*SMTSL*) survey (Tuan, Chin, and Shieh, 2005). The SMTSL survey utilizes the word "science" in many of the items, which the author changed to "biology", in order to reflect the nature of the course in which the participants were registered. A principle component factor analysis was conducted to determine the content validity of the survey for undergraduates in a North American context, as Tuan et. al., (2005) had worked with junior high school students in Taiwan. The factor analysis revealed nine components (Table 3.1) instead of the six recognized by Tuan et. al., (2005). This is significantly different from Gardner (2014) who found three factors while working with undergraduates. Gardner's (2014) sample included an older group of participants (mean age of 20.5) and was skewed toward women (74.6% of the participants). Additionally, Gardner used a confirmatory factory analysis for his data, while this project used a principle component factor analysis. As mentioned in Chapter 2, a principle component factor analysis is exploratory, and is utilized when searching for relationships within the data. Alternatively, a confirmatory factory analysis is predictive and therefore more complicated, but is helpful when testing a hypothesis. These conditions may have contributed to the differences with the number of factors found in each study.

Table 3.1

Motivation to learn biology factor analysis

Item	Sci Learn Value	Active Learn Strat	Self-confid	Achie Goals	Perfor Goals	Self-effic	Social Value	Instru Value	Conn
Whether the biology content is difficult or easy, I am sure that I can understand it.						0.827			
I am not confident about understanding difficult biology concepts.						0.659			
I am sure that I can do well on biology tests.						0.684			
No matter how much effort I put in, I can't learn biology.			0.466			0.519			
When biology activities are too difficult, I give up or only do the easy parts.			0.801						
During biology activities, I prefer to ask other people for the answer rather than think for myself.			0.753						
When I find the biology content difficult, I don't try to learn it.			0.728						
When learning new biology concepts, I attempt to understand them.		0.474							
When learning new biology concepts, I connect them to my previous experiences.									0.697

Table 3.1 (Cont.)

Item	Sci Learn Value	Active Learn Strat	Self-confid	Achie Goals	Perfor Goals	Self-effic	Social Value	Instru Value	Conn
When I don't understand a biology concept, I find relevant resources that will help me.		0.428							
When I don't understand a biology concept, I'd discuss with the teacher or other students to clarify my understanding.		0.545							
During the learning process, I attempt to make connections between the concepts that I learn.		0.451							0.490
When I make a mistake, I try to find out why.		0.682							
When I meet biology concepts that I don't understand, I still try to learn them.		0.658							
When new biology concepts that I have learned conflict with my previous understanding, I try to understand why.		0.699							
I think that learning biology is important because I can use it in my daily life.	0.661								
I think that learning biology is important because it stimulates my thinking.	0.698								

Table 3.1 (Cont.)

Item	Sci Learn Value	Active Learn Strat	Self-confid	Achie Goals	Perfor Goals	Self-effic	Social Value	Instru Value	Conn
In biology, I think that it's important to learn to solve problems.	0.662								
In biology, I think it's important to participate in inquiry activities.	0.591								
It's important to have the opportunity to satisfy my own curiosity when learning biology.	0.436								
I participate in biology courses to get a good grade.					0.422			-0.400	
I participate in biology courses to preform better than other students.					0.689				
I participate in biology courses so that other students think I'm smart.					0.847				
I participate in biology courses so the teacher pays attention to me.					0.802				
During a biology course, I feel most fulfilled when I attain a good score on a test.				0.746					
I feel most fulfilled when I feel confident about the content in a biology course.				0.709					
During a biology course, I feel most fulfilled when I am able to solve a difficult problem.				0.667					

Table 3.1 (Cont.)

Item	Sci Learn Value	Active Learn Strat	Self-confid	Achie Goals	Perfor Goals	Self-effic	Social Value	Instru Value	Conn
During a biology course, I feel most fulfilled when a teacher accepts my ideas.							0.843		
During a biology course, I feel most fulfilled when other students accept my ideas.							0.836		
I am willing to participate in this biology course because the content is exciting and changeable.	0.583								
I am willing to participate in this biology course because the teacher uses a variety of teaching methods.	0.498							0.427	
I am willing to participate in this biology course because the teacher doesn't put a lot of pressure on me.								0.797	
I am willing to participate in this biology course because the teacher pays attention to me.								0.702	
I am willing to participate in this biology course because it's challenging.	0.643								

Table 3.1 (Cont.)

Item	Sci Learn Value	Active Learn Strat	Self-confid	Achie Goals	Perfor Goals	Self-effic	Social Value	Instru Value	Conn
I am willing to participate in this biology course because the students are involved in discussions.	0.555								

Note. Results of the Principal Component Analysis using a Varimax Rotation Method with Kaiser Normalization. The Rotation resulted in 11 iterations.

Five of the nine factors generated by the analysis (Table 3.2) were similar to Tuan et. al., (2005), and the author has recycled some of their factor titles. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy = 0.855 (it is an indicator of the amount of variance in the variables that could be produced by latent factors, anything greater than 0.6 is considered acceptable and this indicates the sample was sufficient), Bartlett's Test of Sphericity – X^2 = 3973.970 (which confirms the validity and suitability of the data), $p < 0.0001$ (at a 0.05 level of significance), and the Variance Explained = 62.697% of the model. In other words, the data was appropriate for a factor analysis. It should be noted that the values reported here are in aggregate for the class.

Student motivation has multiple components revealed by this and other factor analyses (Gardner, 2014; Tuan et al., 2005). *Science Learning Value* was agreeable overall with a mean of 3.92 and a standard deviation of 0.75. This factor included items such as: *"I think that learning biology is important because I use it in my daily life"* and *"I am willing to participate in this biology course because it is challenging"*. This factor deals with the importance of learning to the student, in other words, the intrinsic value that it holds for them.

Table 3.2

Motivation Factor Analysis Means, SD, and Range

Factors	Mean (SD)	Component Fit Range
Science Learning Value (9 items)	3.92 (0.75)	.436 - .698
Active Learning Strategies (5 items)	4.23 (0.59)	.474 - .699
Self-confidence (3 items)	1.89 (0.76)[a]	.728 - .801
Achievement Goals (3 items)	4.36 (0.68)	.667 - .746
Performance Goals (4 items)	2.75 (1.16)[a]	.422 - .847
Self-efficacy (4 items)	3.01 (1.19)[b]	.519 - .827
Social Validation (2 items)	3.68 (0.80)	.836 - .843
Instructor Validation (2 items)	3.45 (0.87)	.702 - .797
Connections to Learning (3 items)	3.90 (0.72)	.490 - .697

Note. n = 312 participants responded. [a] All of these items were negatively worded, but were not reverse coded for the factor analysis, therefore they are actually leaning toward the *agree* side of the scale. [b] Two of the four items were negatively worded, but were not reverse coded for the factor analysis.

The factor for *Active Learning Strategies* had a mean of 4.23 and a standard deviation of 0.59, and was on the *strongly agree* side of the scale. Examples of items include: *"When I make a mistake, I try to find out why."* and *"When new biology concepts that I have learned conflict with my previous understanding, I try to understand why."*. These items demonstrate interest in learning and include the efforts and behaviors students use to comprehend material.

The *Self-confidence* group of items had a mean of 1.89 and a standard deviation of 0.76. They fell near the *agree* part of the range (because the items were all reverse coded) this indicates the participants appeared confident, but not overly so. This seems consistent with the characteristics of freshmen Millennial students, and their expectations of success (Millenbah et al., 2011). Items included: *"When biology activities are too difficult, I give up or only do the easy parts."* along with *"When I find the biology content difficult, I don't try to learn it"*. Self-confidence is people's belief in their own abilities. Specifically utilized here, in regards to learning.

Items related to *Achievement Goals* had a mean of 4.36 and a standard deviation of 0.68, and leaned heavily toward the *strongly agree* side of the range. The items addressed: *"During a biology course, I feel most fulfilled when I attain a good score on a test"* and *"During a biology course, I feel most fulfilled when I am able to solve a difficult problem"*. Achievement goals are intrinsic in nature and deal with the desire to prove something to one's self and accomplish something that holds value to the individual. The goals are achieved because of the beliefs and attributions of the student and through their approach and engagement in learning activities (Ames, 1992). This topic relates less to the extrinsic rewards students expect to receive for their efforts, but focuses more on the personal satisfaction of learning.

This factor corresponds to extrinsic motivation with items related to *Performance Goals.* The mean was 2.75 with a standard deviation of 1.16 and because all of these items had negative wording (but were not reverse coded for the factor analysis), they are toward the *agree* side of the scale. The items asked: *"I participate in biology courses to get a good grade"* and *"I participate in biology courses so that other students think I'm smart"*. Performance goals are extrinsically motivated and value the rewards the students hope to achieve when they complete a learning task. This is usually in the form of a good grade or impressing their instructor or peers.

This factor covers *Self-efficacy,* with a mean of 3.01 and a standard deviation of 1.19. The mean falls in the middle of the scale, in part because two of the four items were negatively worded, but not reverse coded for the factor analysis. Therefore, while they do lean barely toward the *agree* side of the range, they are neutral in their average responses. Items include: *"I am sure that I can do well on biology tests"* and *"No matter* *how much effort I put in, I can't learn biology".* Self-efficacy is defined as a person's confidence in their ability to successfully complete a learning task. While self-efficacy is closely related to self-confidence, these items separated during the factor analysis, the author speculates that this could be because self-confidence is a component of self-efficacy.

Social Validation is a vital part of the existence of most millennials and the mean of 3.68 and standard deviation of 0.80 were on the *agree* side of the range. The two items asked: *"During a biology course, I feel most fulfilled when a teacher accepts my ideas"* and *"During a biology course, I feel most fulfilled when other students accept my ideas"*. Both of the items related to feeling accepted by others. Social validation is the feeling of belonging and being accepted by your peers. Being a part of a social group is vital to Millennials, and it can impact many of the choices they make (Millenbah et al., 2011). It should be noted, that one of the items dealt with acceptance by the instructor, which would have been expected to be included in the next factor, however, it was likely placed with this factor because this set of items focused more on the acceptance of, rather than attention from, an instructor.

The factor for *Instructor Validation* had a mean of 3.45 and a standard deviation of 0.87 with a skew toward the *agree* side of the scale. The items inquired: *"I am willing to participate in this biology course because the teacher doesn't put a lot of pressure on me"* and *"I am willing to participate in this biology course because the teacher pays attention to me".* Instructor validation is the need by a student to feel approval from their instructor. It may include some transference of the desire to seek emotional support from the student's parents and results in the need to impress the instructor.

The final factor, *Connections to Learning* had a mean of 3.90 and a standard deviation of 0.72 with a slant toward *agree*. These items focus on the Application, Analysis, and Synthesis skills of Bloom's Taxonomy (Crowe, Dirks, and Wenderoth, 2008) as well as Constructivist Learning Theory (Cooperstein and Kocevar-Weidinger, 2004). The items asked: *"When learning new biology concepts, I connect them to my previous experiences"* and *"During the learning process, I attempt to make connections between the concepts that I learn"*. Connections to learning can be defined as the consideration by the student of a broader view of how the material they are learning in their courses will apply to their life after school. In other words, the big picture of how the pieces of information connect to each other.

Attitudes towards biology

This part of the survey addressed the fifth research question: How does collaborative group work impact students' attitudes toward biology, perspectives of biology and biologists, and views of science? The Attitudes Toward Biology survey items were adapted by Gardner (2014) from instruments designed by Osborne et al. (2003), Pell & Jarvis (2001), and Usak et al. (2009). A principle component factor analysis (Table 3.3) was completed to verify the validity of the survey and it uncovered seven components (Table 3.4). This is dissimilar from Gardner (2014), who found five factors while also working with non-major undergraduate biology students. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy = 0.906 (anything greater than 0.6 is considered sufficient), Bartlett's Test of Sphericity – X^2 = 4337.284, p <0.0001 (at the

0.05 level), and the Variance Explained = 58.812% of the model. Therefore, this data was appropriate for a factor analysis.

Table 3.3

Attitudes Toward Biology Factor Analysis

Item	Interest in Biology	Enjoyment of Biology	Appreciation of Biology	Application of Biology	Lab Experience	Challenge of Biology	Opinions of Biology
I enjoy biology.	0.456	0.585					
I typically do not do well in classes with biology topics.	0.430						
Doing biology labs are fun.					0.781		
There is little need for biology knowledge in most of today's jobs.				0.465			
Biology is easy for me to understand.	0.557	0.418					
Most people should study at least some biology.			0.419				
No matter how hard I try, I typically cannot fully understand biology concepts.	0.724						
Understanding biology is very important for us to remain competitive in today's global economy.			0.697				

Table 3.3 (Cont.)

Item	Interest in Biology	Enjoyment of Biology	Appreciation of Biology	Application of Biology	Lab Experience	Challenge of Biology	Opinions of Biology
It is important to know at least some biology in order to get a good job.			0.633				
I enjoy talking to other people about biology.		0.779					
I enjoy watching TV programs about biology.		0.676					
I am good at doing lab experiments in biology.					0.698		
You can get along perfectly well in life without any knowledge of biology.				0.653			
I remember most of the things I learn in biology classes.		0.408					
If I do not see how to complete a biology assignment right away, I will probably never understand it.	0.672						
Understanding biology is essential for understanding other coursework.				0.459			
Compared to other courses, biology is important to me.		0.509					

Table 3.3 (Cont.)

Item	Interest in Biology	Enjoyment of Biology	Appreciation of Biology	Application of Biology	Lab Experience	Challenge of Biology	Opinions of Biology
Topics in biology often seem strange to me.	0.597						
I enjoy learning about biology.	0.429	0.622					
When talking about biology I get bored.	0.522						
Biology is hard, but I like making an effort to understand it.						0.615	
I typically find topics in biology interesting.		0.595					
Understanding biology is not that important to me in my daily life.				0.671			
I like learning biology, because it makes me think.						0.535	
I think it is important to understand how biologists think and how they do their jobs.						0.487	
I might like to go into a biology-related field of work some day.		0.582		0.441			
The government should be providing more support for biology research.			0.467				

Table 3.3 (Cont.)

Item	Interest in Biology	Enjoyment of Biology	Appreciation of Biology	Application of Biology	Lab Experience	Challenge of Biology	Opinions of Biology
You have to be smart to be a biologist.							0.884
I often think about issues in biology outside of school.		0.644					
Biology is just too difficult for me to understand.	0.782						
An appreciation for biology has generally made the world a better place.			0.576				
Biology makes me feel uneasy and confused.	0.787						
Biology makes me feel uncomfortable and nervous.	0.800						

Note. Results of the Principal Component Analysis using a Varimax Rotation Method with Kaiser Normalization. The Rotation resulted in 14 iterations.

Table 3.4

Attitude Factor Analysis Means, SD, Range, Significance, and Movement

Factor (#)	Pre-test Mean (SD)	Post-test Mean (SD)	Component Fit Range	p-value	$\bar{g}$-factor
Interest in Biology (9)	3.52 (0.93)	3.40 (0.93)	.430 - .800	< 0.0001	-0.1483
Enjoyment of Biology (9)	3.47 (0.95)	3.41 (0.99)	.408 - .779	0.0491	-0.0699
Appreciation of Biology (5)	3.69 (0.73)	3.78 (0.78)	.419 - .697	0.0003	0.0482
Application of Biology (4)	3.84 (0.92)	3.92 (0.84)	.459 - .671	0.4318	0.0004
Lab Experience (2)	3.52 (0.88)	3.50 (0.78)	.698 - .781[a]	0.8223	-0.0387
Challenge of Biology (3)	3.66 (0.79)	3.62 (0.82)	.487 - .615	0.4038	-0.0379
Opinions of Biology (1)	3.46 (0.98)	3.59 (1.02)	.884[b]	0.0425	0.0618

Note. n = 307 for the pre-test and n = 286 for the post-test. [a] There were only two survey items included in this factor. [b] There was only one survey item in this factor.

As noted by Pell and Jarvis (2001) as well as Russell and Hollander (1975), the attitude of students after a semester of instruction in biology can change significantly. This was observed in some of the Attitude data in this study. For example, the *Interest in Biology* expressed by the students moved toward the *disagree* side of the scale from pre- to post-test. This finding was highly significant (p = < 0.0001). These items included "*Biology is easy for me to understand*" and *"When talking about biology I get bored"* (this item was reverse coded). Interest in biology can be defined as the capability of a student to find the topic of biology compelling and worthy of their attention.

The *Enjoyment of Biology* data was barely significant (p = 0.0491) and it too moved slightly to the *disagree* side of the range. This grouping included items such as: *"I enjoy biology"* and *"I enjoy talking to other people about biology"*. Enjoyment of biology is defined as the ability of the student to find pleasure in learning about biology.

The *Appreciation of Biology* items examined topics such as: *"Most people should study at least some biology"* and *"It is important to understand at least some biology in order to get a good job"*. The results were significant (p = 0.0003) and increased toward the *agree* side of the range. An appreciation of biology occurs when a student understands the intrinsic value of learning about biology.

The *Application of Biology* data was not significant (p = 0.4318). This factor included items like *"You can get along perfectly well in life without knowledge of biology"* and *"Understanding biology is not that important to me in my daily life*". (Both of these items were reverse coded.) The application of biology can be defined as the student's perception of the extrinsic usefulness of biological knowledge.

The *Lab Experience* category was not significant (*p* = 0.8223) and moved very slightly toward *disagree* (but not significantly, which means the movement is likely an artifact of the data). The two items in this factor asked *"Doing biology labs are fun"* and *"I am good at doing experiments in biology"*. Lab experience relates to a student's ability to appreciate and enjoy working in a lab setting. Since there was not a traditional lab for this course (the students instead attended a recitation after class) there was little laboratory exposure for the participants during the semester. This likely explains the lack of significant change in their views of lab work.

The *Challenge of Biology* group was not significant (*p* = 0.4038) and barely moved toward *disagree* (which was once again likely an artifact of the data). Items included: *"Biology is hard, but I like making an effort to understand it"* and *"I like learning biology, because it makes me think"*. The challenge of biology involves the pride and sense of accomplishment a student feels when they are successful in understanding and learning biological concepts.

The final factor *Opinions of* Biology had only one survey item. Even when the author experimented with a forced six-factor analysis, this item remained by itself. The item inquired: *"You have to be smart to be a biologist"*. It was slightly significant (*p* = 0.0425) and moved toward the *agree* side of the range. Opinions of biology are the perceptions of biology and specifically, biologists that a student holds.

Perceptions of biology

The participants' Perceptions of Biology were measured using an adaptation by Gardner (2011) of the Kitchen et al. (2007) *Science Perceptions Survey* (*SPS*). This section of the survey addressed the fifth research question: How does collaborative group work impact students' attitudes toward biology, perspectives of biology and biologists, and views of science? Some of the more significant findings were seen in the change from pre-test to post-test with *Personally Helpful or Personally Harmful, Intriguing or Unappealing, Relevant or Irrelevant, Worthless or Worthwhile, Practical or Theoretical, Empowering or Disempowering, Tentative or Durable, Based on Observation or Based on Ideas, Certain or Adaptable, Understandable or Uncertain, Has Patterns or Chaotic, Answers All Questions or Answers Some Questions, Evidence-based or Does Not Require Evidence, Biased or Unbiased,* and *Ethical or Unethical* (Table 3.5).

Table 3.5

Participants' Perceptions of Biology

Item	Pre-test M (SD)	Post-test M (SD)	Change[a]	p-value	$\bar{g}$-factor
Personally Helpful or Personally Harmful	1.02 (1.22)	1.77 (0.87)	Less Personally Helpful	< 0.0001	0.0858
Intriguing or Unappealing	1.23 (1.22)	2.14 (0.95)	Less Intriguing	< 0.0001	0.1877
Confusing or Enlightening	3.12 (1.35)	2.93 (1.08)	No Change	0.1856	-0.1634
Relevant or Irrelevant	0.98 (1.19)	1.79 (0.89)	Less Relevant	< 0.0001	0.1044
Worthless or Worthwhile	3.95 (1.11)	4.20 (0.85)	More Worthwhile	0.0001	0.2164
Frustrating or Gratifying	2.93 (1.31)	2.99 (1.09)	No Change	0.2054	-0.0414
Impossible or Attainable	3.85 (1.05)	3.89 (0.91)	No Change	0.2926	0.1079
Practical or Theoretical	2.03 (1.38)	2.73 (1.00)	Less Practical	< 0.0001	0.1044

Table 3.5 (Cont.)

Item	Pre-test M (SD)	Post-test M (SD)	Change[a]	p-value	$\bar{g}$-factor
Empowering or Disempowering	1.33 (1.35)	2.28 (0.83)	Less Empowering	< 0.0001	0.1865
Shallow or Meaningful	4.07 (1.03)	4.17 (0.81)	No Change	0.1101	0.1267
Tentative or Durable	2.89 (1.34)	3.28 (0.91)	More Durable	0.0028	0.0707
Based on Observation or Based on Ideas	1.89 (1.29)	2.47 (0.94)	Less Based on Observation	< 0.0001	0.0663
A Single Method or Uses Many Methods	4.00 (1.29)	4.17 (0.86)	No Change	0.4491	0.1470
Certain or Adaptable	3.09 (1.52)	3.61 (1.01)	More Adaptable	< 0.0001	0.1798
Understandable or Uncertain	1.51 (1.25)	2.23 (0.94)	Less Understand-able	< 0.0001	0.1118
Has Patterns or Chaotic	1.70 (1.30)	2.17 (0.91)	Less Has Patterns	< 0.0001	0.0094
Answers All Questions or Answers Some Questions	3.04 (1.41)	3.43 (1.05)	More Answers Some Questions	0.0002	0.1681
Evidence-based or Does Not Require Evidence	0.94 (1.21)	1.70 (0.79)	Less Evidence-based	< 0.0001	0.0807
Biased or Unbiased	2.87 (1.49)	3.25 (0.98)	More Unbiased	< 0.0001	0.1612
Ethical or Unethical	1.44 (1.33)	2.38 (0.90)	Less Ethical	< 0.0001	0.1883

Note. Approximately 307 participants completed this item set for the pre-test and 283 completed it for the post-test. [a] The pre-test scale ranged from 0-5, while the post-test scale ranged from 1-5. The midpoint of the pre-test scale is therefore 2.5, while the midpoint of the post-test is 3.

The participants considered biology to be less personally helpful, less intriguing, less relevant, less practical, less empowering, not as strongly based on observation, less understandable, having fewer patterns, less evidence-based and less ethical. The participants did view biology as more worthwhile, more durable, more adaptable, more unbiased, and that it was more likely to answer some items.

The item asking if *Biology is Confusing or Enlightening* was not found to be significant (p = 0.1856), but there was a decent amount of movement along the Likert scale ($\bar{g}$ = - 0.1634). This was also observed with *Biology is Shallow or Meaningful* with (p = 0.1101, $\bar{g}$ = 0.1267) and with *Biology is A Single Method or Uses Many Methods* with (p = 0.4491, $\bar{g}$ = 0.1470).

Perceptions of biologists

Perceptions of Biologists were measured with a revision by Gardner of the Kitchen et al. (2007) *Science Perceptions Survey* (*SPS*). This component of the survey addressed the fifth research question: How does collaborative group work impact students' attitudes toward biology, perspectives of biology and biologists, and views of science? Statistically significant changes from pre- to post-test were observed with all of the survey items in this section (Table 3.6). Highlights include the perception of biologists as being neat and slightly intelligent, but not very altruistic, humane, ethical, socially responsible, logical, honest, or moral. Apparently, biologists are not great at solving problems. On the plus side, biologists are thought to be an inclusive group.

Table 3.6

Participants' Perceptions of Biologists

	Pre-test	Post-test			
Item	M (SD)	M (SD)	Change[a]	p-value	$\bar{g}$-factor
Sloppy or Neat	3.51 (1.23)	3.85 (0.83)	More Neat	< 0.0001	0.2020
Intelligent or Stupid	0.93 (1.51)	1.50 (0.77)	Less Intelligent	< 0.0001	0.0950

Table 3.6 (Cont.)

Item	Pre-test M (SD)	Post-test M (SD)	Change[a]	p-value	ḡ-factor
Unimaginative or Creative	3.67 (1.25)	3.83 (0.97)	More Creative	0.0133	0.1820
Altruistic or Selfish	1.34 (1.19)	2.43 (0.82)	Less Altruistic	< 0.0001	0.2535
Lazy or Hardworking	4.37 (0.99)	4.44 (0.68)	More Hardworking	0.0252	0.1922
Antisocial or Outgoing	2.96 (1.19)	3.27 (0.90)	More Outgoing	0.0002	0.0921
Boring or Interesting	3.52 (1.15)	3.70 (0.94)	More Interesting	0.0022	0.1674
Humane or Unkind	1.14 (1.11)	2.21 (0.81)	Less Humane	< 0.0001	0.2181
Exclusive or Inclusive	2.33 (1.33)	3.02 (0.80)	More Inclusive	< 0.0001	0.1264
Objective or Subjective	2.07 (1.27)	2.57 (0.81)	Less Objective	0.0004	0.0217
Ethical or Unethical	1.35 (1.23)	2.31 (0.86)	Less Ethical	< 0.0001	0.1823
Socially Responsible or Irresponsible	1.10 (1.20)	1.96 (0.74)	Less Socially Responsible	< 0.0001	0.1761
Moral or Immoral	1.19 (1.23)	2.20 (0.83)	Less Moral	< 0.0001	0.1972
Problem-solvers or Trouble-makers	0.85 (1.01)	1.60 (0.68)	Less Problem-Solvers	< 0.0001	0.1342
Logical or Illogical	0.77 (1.07)	1.56 (0.70)	Less Logical	< 0.0001	0.1356
Honest or Dishonest	0.91 (1.06)	2.02 (0.83)	Less Honest	< 0.0001	0.2045
Skeptical or Gullible	1.20 (1.16)	2.12 (0.82)	Less Skeptical	< 0.0001	0.1686
Spiritual or Atheistic	2.69 (1.37)	3.34 (0.83)	More Atheistic	< 0.0001	0.1625
Patient or Impatient	1.26 (1.29)	2.15 (0.98)	Less Patient	< 0.0001	0.1158
Female or Male	3.08 (1.05)	3.25 (0.57)	Slightly More Male	0.0495	0.0590
Consensus-builders or Cannot Agree	1.86 (1.30)	2.50 (0.82)	Less Consensus-builders	< 0.0001	0.0591

Note. This item set was completed by n = 307 on the pre-test and n = 283 for the post-test. [a] The pre-test scale ranged from 0-5, while the post-test scale ranged from 1-5. The midpoint of the pre-test scale is therefore 2.5, while the midpoint of the post-test is 3.

Perspectives as non-majors

This lone item (which was part of the Knowledge section of the pre-test was also included in the post-test) was based on Gardner's (2011) adaptation of the East Carolina University Biology Department Assessment by Vance-Chalcraft (n.d.). It contributed to the examination of the first research question: Does the construction of collaborative groups based on motivation predict non-major biology students' learning success in a biology course? Since this item stands alone on the pre-test, it was included with the Views of Science (Table 3.7) for the sake of simplicity. Participants moved from a mean of 2.31 with a standard deviation of 0.80 on the pre-test to a mean of 2.45 and a standard deviation of 0.86 on the post-test. This places their answers still between *good* and *okay*, but it moved significantly more toward *okay* (p = 0.0098). This demonstrates a reduction in the confidence of the participants to do well in the course.

Views of science

This part of the study focused on the fifth research question: How does collaborative group work impact students' attitudes toward biology, perspectives of biology and biologists, and views of science? Views of Science items (Table 3.7) were based on Lawson's (2012) online *Biology Attitudes, Skills, & Knowledge Surveys*. One of the interesting findings was a completely non-significant finding (p = 1.0000), which was checked twice for accuracy, for "*A conclusion is a statement of what was observed in an experiment."* the mean did change a small amount from pre- to post-test and the $\bar{g}$-factor also showed some movement, but the author was a bit surprised to see a complete lack of significance. Only half of the items were significant from pre- to post-test. The participants were exposed to basic scientific concepts during the semester, but apparently this did not have a large impact on many of their views.

Table 3.7

Participants' Views of Science and Perspective as a Non-Major

Item	Pre-test M (SD)	Post-test M (SD)	p-value	$\bar{g}$-factor
As a non-science major, how do you rate your ability to be successful in science classes.	2.31 (0.80)	2.45 (0.86)	0.0098	0.0247
The primary goal of modern biology is to explain natural phenomena.	3.54 (0.90)	3.70 (0.82)	0.0823	0.0484
A conclusion is a statement of what was observed in an experiment.	3.95 (0.89)	3.99 (0.83)	1.0000	0.0370
To be scientific, hypotheses must be testable.	4.20 (0.71)	4.48 (0.65)	< 0.0001	0.2675
A well-supported theory becomes a law.	3.58 (1.01)	3.79 (1.08)	0.0030	0.1393
Current scientific theories portray nature more accurately than those they replaced.	3.58 (0.72)	3.72 (0.76)	0.1182	-0.0008
Scientists think atoms exist primarily because they have seen them through powerful microscopes.	3.24 (0.93)	3.28 (0.99)	0.5663	-0.1641
Hypotheses are derived from controlled observations of nature.	3.57 (0.90)	3.77 (0.85)	0.0029	0.0921
A hypothesis is a prediction of what will be observed in the future.	3.68 (0.98)	3.88 (0.94)	0.0406	0.1018
Hypotheses/theories cannot be proved to be true beyond any doubt.	2.79 (1.03)	2.88 (1.12)	0.4094	-0.0478
A well-supported hypothesis becomes a theory.	3.69 (0.87)	3.91 (0.84)	0.0069	0.0901
Explanations that seem reasonable and make intuitive sense need not be tested.	2.25 (1.04)	2.17 (1.05)	0.8323	-0.1493
Coming up with hypotheses requires creative thinking.	3.62 (0.94)	3.82 (0.94)	0.0040	0.0703

Note. This item set was completed by n = 301 on the pre-test and n = 281 for the post-test.

Knowledge

These items examined the first research question: Does the construction of collaborative groups based on motivation predict non-major biology students' learning success in a biology course? Content assessment items were adapted by Gardner (2011) in part from Vance-Chalcraft's (n.d.) departmental assessment and from the *Genetic Literacy Concept Inventory* (*GLCI*) developed by Bowling (2007). The Post-test Knowledge evaluation consisted of the final exam for the course written by the instructor. The pre-test (n = 303) mean Knowledge Score for the course was 30.1% with a standard deviation of 10.7. The mean post-test (n = 297) Knowledge Score was 61.1% with a standard deviation of 14.7. The knowledge grades doubled from pre- to post-test.

Individual motivation, participation, attendance, and final course grades

This collection of data addressed the first research question: Does the construction of collaborative groups based on motivation predict non-major biology students' learning success in a biology course? Attendance (Table 3.8) was taken during every class period through the use of classroom response devices or "clickers". Attendance was a component of the course grade. Not surprisingly, there was a correlation between individual Attendance and Final Course Grades (Figure 3.1) at (r = 0.5029, p = < 0.001).

Participants completed self-evaluations and assessments for the members of their team. The average for an individual student became their Participation Score and was incorporated as part of their Final Course Grade and means were calculated for the teams (Table 3.6). A correlation (*r* = 0.4393, *p* = < 0.001) was found between Final Course Grade and Participation (Figure 3.2). A slight correlation *(r* = 0.0164, *p* = < 0.001) was found between Final Course Grade and Motivation Score at the individual level (Figure 3.3). A strong correlation (*r* = 0.5974, *p* = < 0.001) was found for the relationship between Participation and Attendance. A small, negative correlation was found for Participation compared to Motivation (*r* = - 0.0098, *p* = < 0.001) and for Attendance versus Motivation (*r* = - 0.0198, *p* = < 0.001), respectively.

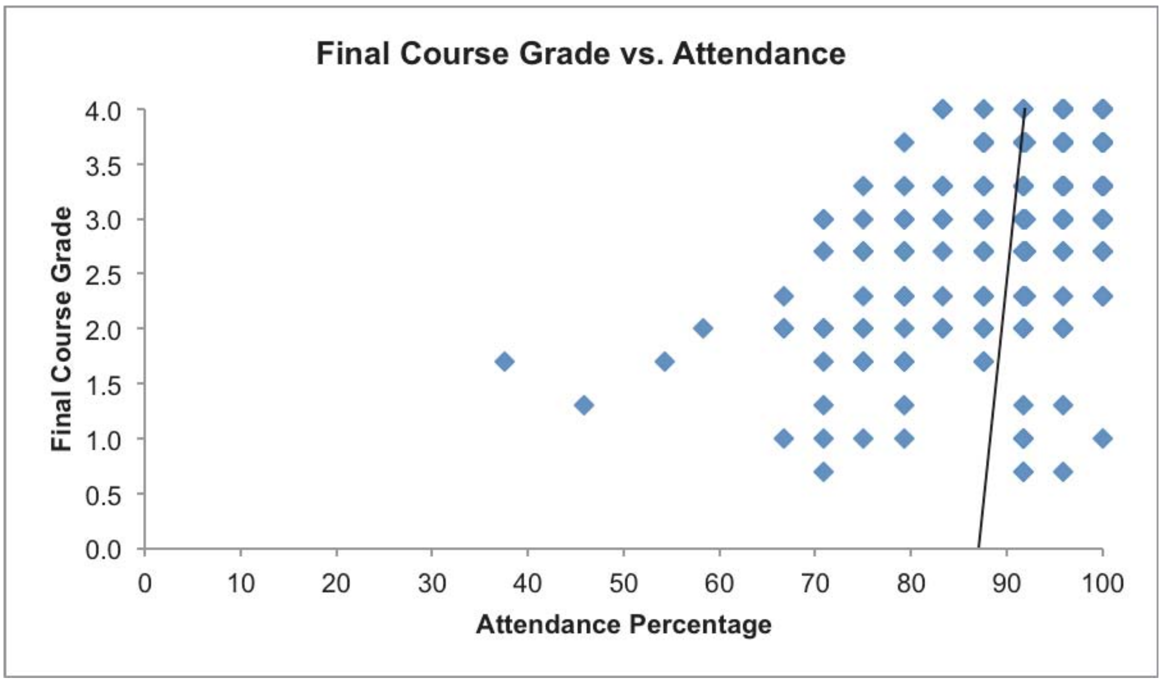

Figure 3.1. Participants' Final Course Grade vs. Attendance. Due to late semester attrition, only 299 students had a final grade for the course and 319 students had attendance data. Participants with a final course grade of 0 were removed from the calculations, as they were outliers. *r* = 0.5029

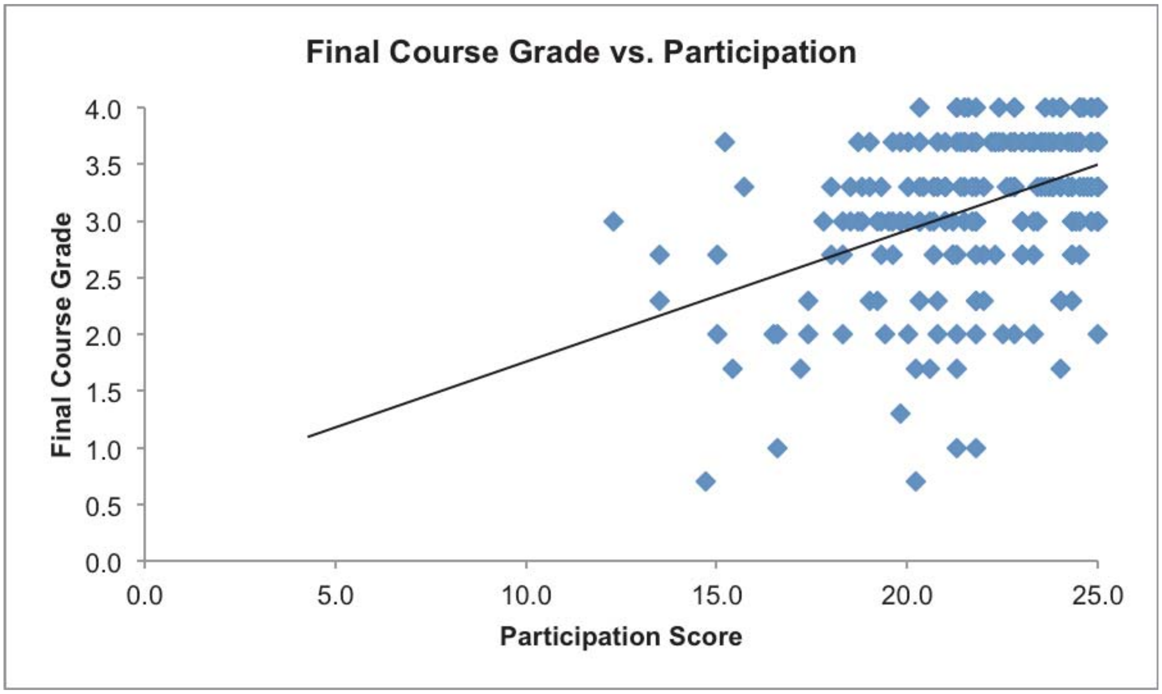

Figure 3.2. Participants' Final Course Grade vs. Participation Score. Only 299 students had a final grade for the course and 303 students had participation scores. Participants with a final course grade of 0 or a participation grade of 0 were removed from the calculations, as they were outliers. $r = 0.4393$

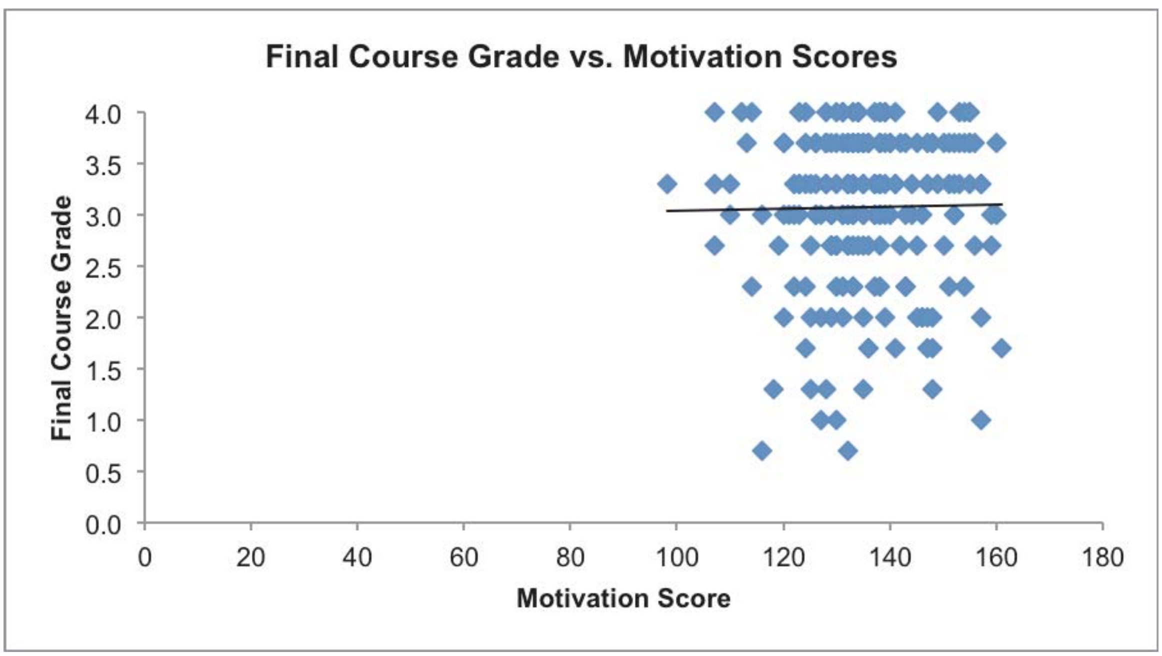

Figure 3.3. Participants' Final Course Grade vs. Motivation Score. Only 236 students completed the motivation survey and 299 had a final grade for the course. $r = 0.0164$. Participants with a final course grade of 0 or a motivation score of 0 were removed from the calculations, as they were outliers.

Group motivation, participation, attendance, and final course grades

This collection of data focused on the group level and relates to the second research question: What group structure (homogeneous or heterogeneous) is associated with the highest learning success and team participation? A comparison of Motivation Scores, Participation Scores, Attendance, and Final Course Grades (Table 3.8) at the group level shows some relationships. A slight, negative correlation (r = - 0.0676, p = < 0.001) was observed for Participation and Motivation (Figure 3.4). Some of the more motivated students had high participation scores, but some also had lower participation scores. There was also a small correlation between Attendance and Motivation (Figure 3.5) at the team level (r = - 0.0251, p = < 0.001). This is surprising, as a more motivated student is more likely to attend class on a regular basis, however, the data at the individual level (r = - 0.0198, p = < 0.001), also had a negative correlation. The highest correlation (r = 0.6511, p = < 0.001) was found between Final Grade and Participation for the groups. Apparently the better the groups worked together, the better the resulting grades for the participants. Correlations were also measured at the group level for Motivation and Final Course Grade (Figure 3.6), (r = -0.0961, p = < 0.001), Participation and Attendance (r = 0.1996, p = < 0.001), and Final Course Grade with Attendance (r = 0.6610, p = < 0.001).

Table 3.8

Comparison of Group Motivation Scores, Participation Grades, Attendance Percentage, and Final Course Grade Means

Section 1					Section 2				
Group	Mot.	Part.	Attend.	F. Grade	Group	Mot.	Part.	Attend.	F. Grade
1A	150.6	23.1	97.5	3.7	1B	155.4	23.8	87.5	3.7
2A	143.4	20.1	95.0	2.9	2B	148.8	18.5	88.2	2.9
3A	137.5	18.1	90.1	2.7	3B	139.8	23.0	95.0	2.9
4A	138.8	19.2	97.5	3.2	4B	137.0	19.2	86.7	2.9

Table 3.8 (Cont.)

	Section 1					Section 2			
Group	Mot.	Part.	Attend.	F. Grade	Group	Mot.	Part.	Attend.	F. Grade
5A	133.8	22.5	96.7	3.4	5B	134.6	12.6	91.7	3.4
6A	130.6	14.2	92.5	3.1	6B	132.8	11.4	65.3	1.6
7A	127.2	24.4	100.0	3.7	7B	131.4	25.0	75.8	3.7
8A	123.6	17.8	95.0	3.1	8B	129.0	14.9	90.0	3.3
9A	117.0	17.9	96.7	2.9	9B	126.3	24.1	97.9	3.9
10A	151.8	18.2	96.7	2.8	10B	121.8	10.9	47.5	1.3
11A	143.0	12.7	99.2	2.6	11B	155.2	18.9	92.5	3.5
12A	135.2	22.1	88.3	3.2	12B	140.5	15.4	86.1	3.2
13A	131.0	21.9	95.0	2.9	13B	135.8	13.4	85.4	2.1
14A	127.0	22.1	96.6	3.3	14B	135.0	17.6	85.0	2.7
15A	118.2	22.9	95.0	3.1	15B	132.0	21.0	85.0	2.9
16A	135.7	0.0	31.1	0.3	16B	128.6	12.7	95.0	2.9
17A	138.0	18.4	85.0	2.3	17B	119.8	22.1	95.8	3.1
18A	146.0	0.0	70.0	0.4	18B	130.5	23.5	85.0	2.1
19A	142.0	11.8	90.8	2.6	19B	120.5	17.1	80.8	3.1
20A	150.0	21.6	85.5	2.7	20B	142.5	14.4	87.5	2.5
21A	134.0	22.3	81.7	2.8	21B	142.3	22.9	73.3	3.5
22A	137.3	16.2	93.3	3.1	22B	142.0	5.0	95.0	2.4
23A	146.0	7.1	80.8	2.2	23B	135.0	19.2	98.3	3.4
24A	138.0	15.5	87.5	2.3	24B	133.0	17.1	84.2	3.1
25A	146.0	19.8	85.0	2.6	25B	116.0	17.3	95.0	3.2
26A	125.5	20.4	93.3	3.2	26B	135.5	14.2	85.0	2.7
27A	144.0	0.0	79.2	2.3	27B	145.5	22.6	99.0	3.5
28A	131.5	18.8	71.6	2.7	28B	120.0	20.6	91.6	3.2
29A	129.5	24.8	95.0	3.5	29B	0.0	21.6	79.2	3.6
30A	143.0	21.0	79.9	3.1	30B	138.0	17.0	91.7	2.3
					31B	137.0	5.0	90.8	1.8
					32B	132.5	17.4	99.2	2.8
					33B	127.5	20.6	92.7	3.4
					34B	141.5	21.9	92.5	3.2

Note. Group scores are means for all participating members of the group. Motivation scores are based on the *Students' Motivation Toward Science Learning* (*SMTSL*) survey (Tuan et al., 2005). Participation grades are constructed from participants' self and peer assessments. Attendance data was collected daily. Final course grade means are based on a 4.0 scale.

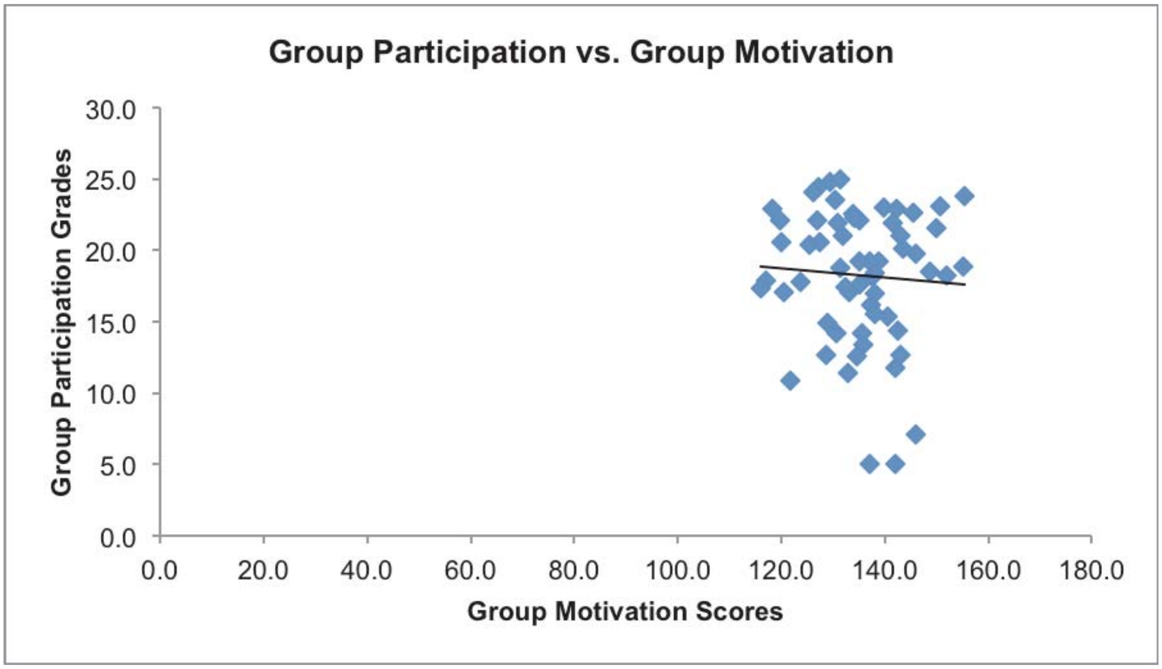

Figure 3.4. Group Participation Grade means vs. Group Motivation Score means. Motivation responses were n = 312 and Participation responses were n = 303. Groups with a 0 motivation or participation score were removed, as they were outliers. *r* = - 0.0676

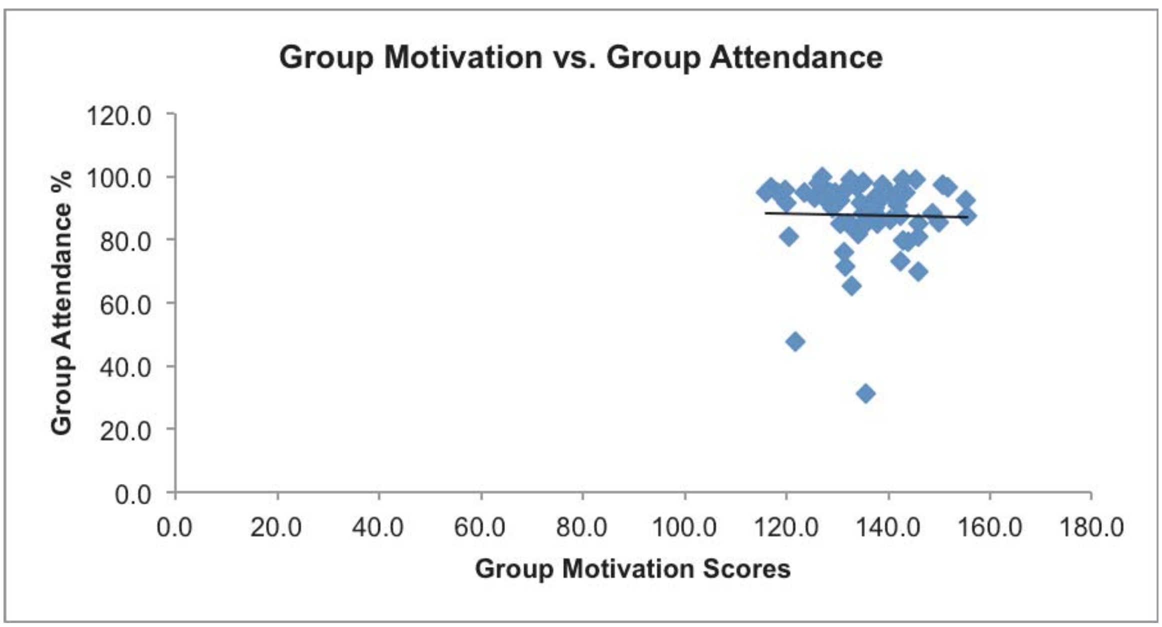

Figure 3.5. Group Attendance means vs. Group Motivation Score means. Motivation responses were n = 312 and Attendance rates varied for each meeting. Groups with a 0 motivation score were removed, as they were outliers. *r* = - 0.0251

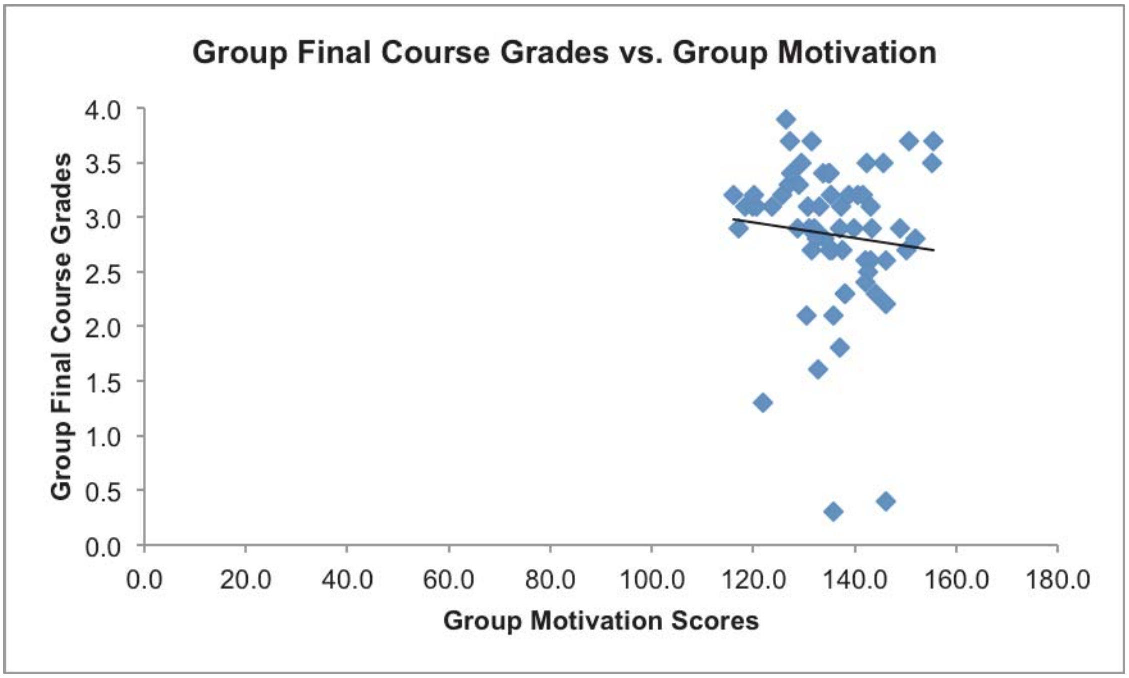

Figure 3.6. Group Final Course Grade vs. Group Motivation Score. Motivation responses were n = 312 and Final Course Grades were received by n = 299. Groups with a 0 motivation score were removed, as they were outliers *r* = - 0.0961

Group size and gender ratios

This subject area considers research question six: How does collaborative group work impact students' attendance, team attrition, and gender ratios? Simple proportions of students were calculated for the beginning and end of the semester for each group. Heterogeneous groups lost the most students due to attrition during the semester, with 34% of the groups either gaining or losing members. Homogeneous middle groups were the most static, with only 8% change in membership (Table 3.9). Overall, only 25% of the teams were impacted by changes in the number of team members. Participation Scores and Final Course Grades appear to be impacted by the attrition rates.

Table 3.9

Comparison of Change in Group Membership, Participation Score, and Final Course Grade

Group type	% Change	Participation Score	Final Course Grade
Homo high	21	22.25	3.06
Homo middle	8	22.10	3.20
Homo low	20	21.24	2.98
Heterogeneous	34	21.43	2.87

Note. Group membership change is the percent of groups for that type of group that experienced a change in membership during the semester. Participation score is based on self and team member evaluation. Final course grade is on a 4.0 scale.

The majority of Homogeneous high teams were skewed toward female memberships, with 12 out of 14 teams having more than 50% women. This was common with all of the homogeneous teams, as 10 out of 13 teams were skewed toward female memberships for Homogeneous middle and 4 out of 5 for Homogeneous low. Heterogeneous teams were skewed toward female participants in 18 of the 32 teams (Table 3.10). However, no correlation was observed between the ratio of female students and Final Course Grade (r = 0.229).

Table 3.10

List of Groups with Female Membership Ratios and Final Course Grade

Group	Group Type	Pre % Female	Post % Female	% Change	Final Course Grade
1A	Homo high	0.8	0.8	0	3.7
2A	Homo high	0.8	0.8	0	2.9
3A	Homo high	0.8	0.8	0	2.7
4A	Homo high	0.8	0.8	0	3.2
5A	Homo mid	0.4	0.4	0	3.4
6A	Homo mid	0.4	0.4	0	3.1
7A	Homo mid	0.8	0.8	0	3.7
8A	Homo low	1	1	0	3.1
9A	Homo low	0.6	0.6	0	2.9
10A	Homo high	0.8	0.8	0	2.8
11A	Homo high	0.4	0.4	0	2.6
12A	Homo high	0.6	0.6	0	3.2
13A	Homo mid	0.8	0.8	0	2.9
14A	Homo mid	0	0	0	3.3

Table 3.10 (Cont.)

Group	Group Type	Pre % Female	Post % Female	% Change	Final Course Grade
15A	Homo low	0.6	0.6	0	3.1
16A	Hetero	0.8	0.67	0.13	0.3
17A	Hetero	0.6	0.6	0	2.3
18A	Hetero	0.4	0	0.4	0.4
19A	Hetero	0.6	0.6	0	2.6
20A	Hetero	0.6	0.6	0	2.7
21A	Hetero	0.4	0.4	0	2.8
22A	Hetero	0.8	0.75	0.05	3.1
23A	Hetero	0.4	0.4	0	2.2
24A	Hetero	0.6	0.6	0	2.3
25A	Hetero	0.6	0.6	0	2.6
26A	Hetero	0.2	0.2	0	3.2
27A	Hetero	0.2	0.33	-0.13	2.3
28A	Hetero	0.4	0.67	-0.27	2.7
29A	Hetero	0.2	0.2	0	3.5
30A	Hetero	0.4	0.5	-0.1	3.1
1B	Homo high	0.6	0.6	0	3.7
2B	Homo high	0.5	0.4	0.1	2.9
3B	Homo high	0.8	0.8	0	2.9
4B	Homo high	0.8	0.8	0	2.9
5B	Homo mid	0.8	0.8	0	3.4
6B	Homo mid	0.6	0.6	0	1.6
7B	Homo mid	1	1	0	3.7
8B	Homo mid	0.8	0.75	0.05	3.3
9B	Homo mid	1	1	0	3.9
10B	Homo low	0.6	0.33	0.27	1.3
11B	Homo high	0.8	0.8	0	3.5
12B	Homo high	0.33	0.25	0.08	3.2
13B	Homo high	0.5	0.4	0.1	2.1
14B	Homo mid	0.6	0.6	0	2.7
15B	Homo mid	0.8	0.8	0	2.9
16B	Homo mid	0.6	0.6	0	2.9
17B	Homo low	0.25	0.25	0	3.1
18B	Hetero	0.6	0.75	-0.15	2.1
19B	Hetero	0.2	0.25	-0.05	3.1
20B	Hetero	0.6	0.6	0	2.5
21B	Hetero	0.6	0.6	0	3.5
22B	Hetero	0.2	0.2	0	2.4
23B	Hetero	0.8	0.8	0	3.4
24B	Hetero	0.6	0.6	0	3.1

Table 3.10 (Cont.)

Group	Group Type	Pre % Female	Post % Female	% Change	Final Course Grade
25B	Hetero	0.6	0.6	0	3.2
26B	Hetero	0.6	0.5	0.1	2.7
27B	Hetero	1	1	0	3.5
28B	Hetero	0.8	0.8	0	3.2
29B	Hetero	0.2	0	0.2	3.6
30B	Hetero	0.8	0.8	0	2.3
31B	Hetero	0.6	0.5	0.1	1.8
32B	Hetero	0.4	0.4	0	2.8
33B	Hetero	0.25	0.25	0	3.4
34B	Hetero	0.4	0.4	0	3.2

Note. Negative change values represent an increase in membership for the team. This occurred early in the semester when students accidently joined the incorrect teams.

Linear Regression Analysis

Linear regression analysis was completed to determine if group type could predict Final Course Grade. This related to research question two: What group structure (homogeneous or heterogeneous) is associated with the highest learning success and team participation? The results showed that group type was a significant predictor of Final Course Grade at F (1, 292) = 4.95, p = 0.013. However, the *Adj.* R^2 = 0.013, so only 1.3% of the variance could be explained by the group types. The number of participants that answered an item, along with the mean, standard deviation, and range of their responses by team type for the variables: Motivation Score, Pre-test Knowledge Score, Final Exam Grade, Attendance, Participation Score, Final Course Grade, and Age are shown in Table 3.11.

Table 3.11

Descriptive Statistics of Teams by Type

Variable	n	Mean (SD)	Range
Heterogeneous			
Motivation Score	79	135.81 (12.87)	98 - 161
Pre-test Score	73	30.08 (10.24)	8.0 - 52.0
Final Exam Grade	139	61.74 (10.58)	27 - 87
Attendance	150	0.87 (0.15)	0.20 - 1.00
Participation Score	109	21.43 (3.11)	9.6 - 25.0
Final Course Grade	135	2.87 (0.81)	0.7 - 4.0
Age	77	19.4 (1.17)	18 - 24
Homogeneous High			
Motivation Score	71	143.70 (8.49)	120 - 160
Pre-test Score	71	32.34 (11.71)	12.0 - 68.0
Final Exam Grade	68	63.16 (11.03)	41 - 90
Attendance	73	0.92 (0.10)	0.46 - 1.00
Participation Score	59	22.25 (2.66)	15.0 - 25.0
Final Course Grade	68	3.06 (0.78)	1.0- 4.0
Age	71	18.0 (0.60)	17 - 23
Homogeneous Middle			
Motivation Score	64	130.75 (3.00)	125 -137
Pre-test Score	64	29.06 (11.00)	12.0 - 56.0
Final Exam Grade	60	65.12 (11.06)	46 - 96
Attendance	65	0.89 (0.15)	0.33 - 1.00
Participation Score	53	22.10 (3.40)	4.3 - 25.0
Final Course Grade	60	3.20 (0.70)	0.7 - 4.0
Age	64	18.1 (1.1)	< 17 - > 24
Homogeneous Low			
Motivation Score	24	120.10 (5.11)	110 - 128
Pre-test Score	24	25.67 (9.90)	8.0 - 40.0
Final Exam Grade	21	61.76 (10.78)	41 - 85
Attendance	24	0.86 (0.22)	0.25 - 1.00
Participation Score	20	21.24 (4.75)	4.5 - 25.0
Final Course Grade	21	2.98 (0.81)	1.3 - 4.0
Age	24	18.9 (2.0)	17 - > 24

Note. n is the number of participants that responded to each set of survey items. Final Course Grade is based on 4.0 scale. Motivation Scores had a maximum possible score of 175. Participation Scores had a maximum of 25 points. Pre-test Scores and Final Exam Grades had a maximum of 100 points. Attendance is the percent of classes attended. Age (in years) at the start of the semester.

Assessment scores

Research question two addressed: What group structure (homogeneous or heterogeneous) is associated with the highest learning success and team participation? One-Way ANOVAs were conducted to determine if there were any differences between group type in regards to pre-test Knowledge Scores, Final Exam Grades, and Final Course Grades. Not surprisingly, there were no significant differences between group types for the pre-test Knowledge Scores. At *F* (3, 228) = 2.57, *p* = 0.055. The *Adj.* R^2 = 0.020 indicated that only 2% of the variance in pre-test Knowledge Score could be explained by the group types. For Final Exam Grades, *F* (3, 291) = 0.39, *p* = 0.761, therefore the results were not significant. The *Adj.* R^2 = 0.006 indicated that only 0.6% of the variance in Final Exam Grade could be explained by the group types.

A linear regression was used to test which variables might predict Final Course Grades. A stepwise selection method was utilized to examine multiple variables for significance. The model with the best fit included Final Exam Grade, Participation Score, and Attendance as the predictive variables for Final Course Grade. At *F* (3, 174) = 50.97, *p* = < 0.0001, this is not surprising, since those variables were used to calculate the Final Course Grade. What is more interesting is what was not included in the model. None of the other variables (*e.g.,* motivation, gender, class standing) impacted Final Course Grade. The *Adj.* R^2 = 0.026 suggests that only 2.6% of the variance could be explained by the variables in the model.

A linear regression was also conducted to determine if group type was a significant predictor of Final Course Grade. The results showed *F* (3, 280) = 3.51, *p* = 0.016, with a Mean Square Error (MSE) = 0.61 and *Adj.* R^2 = 0.026. Therefore, the type of group could explain only 2.6% of the variance in the Final Course Grade. When compared to the heterogeneous groups it was determined that only the Homogeneous middle groups were significant predictors of Final Course Grade, *p* = 0.002. Neither Homogeneous high nor Homogeneous low were significant predictors when compared to the Heterogeneous groups (*p* = 0.091 and *p* = 0.549, respectively). The unstandardized coefficient was 0.382, which translates as the Homogeneous middle groups scoring 0.382 points (on a 4.0 scale) higher than the other group types for the Final Course Grade (Table 3.12).

Table 3.12

Coefficients for Group Type as a Predictor of Final Course Grade

Group	B	SE(B)	*B*	*p*
Constant	2.867	0.067		< 0.001
Homo high	0.197	0.116	0.107	0.091
Homo mid	0.382	0.121	0.198	0.002
Homo low	0.11	0.183	0.036	0.549

Note. A comparison of the three homogeneous groups using the heterogeneous groups as a constant.

Finally, a logistic regression was used to determine if group type could be predicted using Final Course Grade. The results showed that Final Course Grade could predict group type ($p = 0.012$, $X^2 = 10.96$). However, only the Homogeneous middle groups could be predicted ($p = 0.003$).

Motivation, attendance, and participation

The next set of analyses examined research question one: Does the construction of collaborative groups based on motivation predict non-major biology students' learning success in a biology course? Another regression was utilized to see if Motivation could predict Final Course Grade. Motivation was found not to be a significant predictor of Final Course Grade, F (1, 221) = 0.496, $p = 0.483$, $MSE = 0.44$ and *Adj.* $R^2 = - 0.002$. Therefore, the Motivation Score could explain only 0.2% of the variance in the final course grade. Motivation may be vital to learning, but it did not forecast grades in this data set.

This set of tests addressed research questions six (How does collaborative group work impact students' attendance, team attrition, and gender ratios?) and two (What group structure (homogeneous or heterogeneous) is associated with the highest learning success and team participation?), respectively. Attendance between the group types was evaluated with ANOVA, F (3, 308) = 2.01, p = 0.112 with the *Adj.* R^2 = 0.010. The results were not significant with only 1% of the variance being explained by the group type. Attendance appears to be independent of group type. Another ANOVA was used to find any differences between the groups for their Participation Scores, F (3, 237) = 1.15, p = 0.330. The results were not significant and *Adj.* R^2 = 0.002 indicates that only 0.2% of the variance could be explained by the group types. Therefore, the groups appear to have similar Participation Scores, regardless of the group type.

Previous science courses

This string of tests examined research question three: How do student demographics impact group structure and learning success? When Gender, Race/Ethnicity, Class Standing, Major, and Age were examined with ANOVA there were no significant differences between the groups. However, it was determined with ANOVA that there was a significant difference between groups with students that had previously taken another science class. F (3, 233) = 4.46, p = 0.005. The *Adj.* R^2 = 0.042 indicates that 4.2% of the variance could be explained by the group types. It should be clarified that this does not reveal that participants who had taken a science course previously performed better in this class, this statistic simply reveals that groups with students that had previous science exposure were significantly different from those who had not taken a previous science course. Post-Hoc analysis was completed using Tukey's Honest Significant Difference (HSD). When all of the group types were compared against each other, a significant difference was observed between Heterogeneous and Homogeneous high (*p* = 0.004) and with Homogeneous high and Homogeneous middle (Table 3.13) participants (*p* = 0.030).

Table 3.13

Comparison of Group Types for Previous Science Class Experience

Group type	p-value	SE
Hetero		
Homo High	0.004	0.076
Homo Mid	0.966	0.078
Homo Low	0.590	0.110
Homo High		
Hetero	0.004	0.076
Homo Mid	0.030	0.080
Homo Low	0.698	0.112
Homo Mid		
Hetero	0.966	0.078
Homo High	0.030	0.080
Homo Low	0.804	0.113
Homo Low		
Hetero	0.590	0.110
Homo High	0.698	0.112
Homo Mid	0.804	0.113

Note. The mean difference is significant at the 0.05 level.

Next, a regression was run to discover if taking a Previous Science course could be useful in a predictive model for the Final Course Grade. The ANOVA results indicted that it was not a useful component of the model with F (1, 213) = 2.91, p = 0.090, *Adj.* R^2 = 0.009. This indicates that 0.9% of the variance could be explained by previous science experience.

Section comparisons

Finally, research question four was addressed: How do classroom characteristics impact learning success? Two independent sample t-tests were used to find differences between the two sections for the variables of: Motivation, pre-test Knowledge Score, Final Exam Grade, Final Course Grade, Participation Score, and Attendance. No significant differences were found between the two sections of BIOL 1150. (Table 3.14) The section similarities were confirmed with an Intraclass Correlation (ICC). The ICC = 0.0072, while > 0.05 is necessary for sufficient variability.

Table 3.14

Comparison of Variables in the Two Sections of BIOL 1150

Variable	t-test	df	p-value
Motivation	-0.04	236	0.969
Pre-test Knowledge Score	0.41	230	0.680
Final Exam Grade	-0.91	293	0.364
Final Course Grade	-0.77	282	0.440
Participation Score	-0.94	239	0.351
Attendance	0.56	310	0.579

Note. None of the comparisons of variables between the two sections were significantly different. Due (in part) to the need to remove students that could not be matched to their pre-test, the number of participants included for the t-tests may be different from those examined for other analyses.

DISCUSSION

The results of the survey item were analyzed using descriptive and inferential statistics, while the participant demographic information, grades, attendance, and group evaluations were examined using linear regression. This discussion focuses on the following research questions:

1. Does the construction of collaborative groups based on motivation predict non-major biology students' learning success in a biology course?
2. What group structure (homogeneous or heterogeneous) is associated with the highest learning success and team participation?
3. How do student demographics impact group structure and learning success?
4. How do classroom characteristics impact learning success?
5. How does collaborative group work impact students' attitudes toward biology, perspectives of biology and biologists, and views of science?
6. How does collaborative group work impact students' attendance, team attrition, and gender ratios?

Item Analysis

Motivation to learn biology

Student motivation is a vital part of the learning experience (Partin et al., 2011). The nine factors of motivation revealed by this study demonstrate the varied influences of this important construct (Table 3.1). The first, *Science Learning Value* relates to the importance a student places on learning biology. It entails the future usefulness that the student plans to receive from participating in the course (Pintrich, 1994). The value a student places on a particular type of assignment (*e.g.,* class discussion, quiz, exam, term paper, final exam) determines how cognitively engaged they will be for that activity. The response for this set of items was agreeable and demonstrates that the participants understood the value of leaning science. Even though these participants were not biology majors, they appear to have made a connection between the usefulness of a basic biology education for their future. In fact, some of the participants actually identified themselves as science majors, even though they were in a different program. It is reassuring as an educator that the students agreed with this item, but the author must also admit that they may have been trying to impress their instructor.

Active Learning Strategies are based on the assumption by students that if they work hard they will be successful, and that any problems they encounter can be corrected by a change in their course of action (Ames, 1992). According to Pintrich (1994), “students who are motivated will study more effectively by using appropriate learning strategies that help them think more deeply about the course material” (p. 27). Students must first possess good study habits and understand how to plan and organize their time. Those without these skills tend to be low-achievers and do not usually want to make the effort to change their behaviors (Ames, 1992). While a few of the participants could be described as low-achievers based on their grades in this course, the majority of students at least understood the merit of working hard and dedicating time and effort to their studies. Also, of interest to a constructivist, is the agreement by students that they must build on pre-existing knowledge and clarify misunderstandings by working with peers.

The mean for *Self-confidence* was on the agree side of the scale. They appear to be confident, but not over confident in their ability to learn biology. That said, the motivation data were only collected at the start of the semester. It would have been interesting to measure the self-confidence of the participants at the end of the semester. Self-confidence can be negatively impacted by feelings of helplessness and amotivation (Kloosterman, 1988). Students may believe they are incompetent and unable to learn the information presented in the course. Gardner, Forrester, Shumaker, Ferzli, and Shea (in press) noted this in a study with biology students, where students actually decreased their confidence in their perceived ability to conduct biology research following an intensive 'reality check' in the field. They view assignments as too challenging to complete and think that no matter what they do, they will not succeed in their studies. This misconception that an external source controls their fate further results in anxiety about learning new information and depression regarding their present situation (Deci and Ryan, 1985). In other words, these negative feeling can reach an apex at the conclusion of the semester when students feel the most stress.

Self-efficacy is a student's belief that they can complete an undertaking (Pintrich, 1994). It is often specific to a certain task and is not a personality trait. A student can express different levels of self-efficacy for different assignments and classes (Pintrich, 1994). Self-efficacy has been shown to predict behaviors, goals, interests, and the desire to major in a STEM field, in addition to contributing to academic performance (Estrada, Woodcock, Hernandez, and Schultz, 2011). Higher degrees of self-efficacy usually result in improved performance (PIntrich, 1994). In other words, if a student thinks they can do it, they will put in the effort to make it happen. Estrada et al. (2011) supported this observation when they described feedback loops of self-efficacy in STEM. When a student performs well, they receive positive feedback from the STEM community. This improves their self-efficacy, reduces barriers and encourages the student to pursue work in the field. The opposite will occur when the student performs poorly. The responses for this factor of items appeared neutral when examined collectively. However, when the responses to the individual items are examined, it becomes clear that the students possess self-efficacy. They are interested in learning the material even when it is difficult and they see the connection between their effort and a positive outcome.

Self-confidence and self-efficacy have a significant impact on a student's achievement behaviors (Pintrich, 1994). *Achievement Goals* are accomplished through constructive choices based on self-regulated learning (Ames, 1992). The learner understands that "effort leads to success" (Ames, 1992, p. 262) and they take pride and satisfaction in their accomplishments or understand that a failure is the result of insufficient effort. Ames (1992) also noted that students with high achievement goals are more likely to accept demanding work, possess an intrinsic interest in learning, and have a more positive attitude related to learning. Of course, students can possess intrinsic and extrinsic motivations for even the same task (Pintrich, 1994). Students with higher intrinsic values and lower extrinsic levels tend to be the most involved in the learning process, but low intrinsic and high extrinsic students can also be cognitively engaged. The only situation to be avoided in a classroom setting is having students who are low for both types of motivation, they may only respond to extrinsic rewards (Pintrich, 1994). The participants seemed to appreciate the motivating influence of achievement goals, with a mean response of 4.36 on the Likert scale. Since these goals are intrinsic in nature, the response appears agreeable. However, this could be an example of the students trying to impress the instructor. Barring this particular bias being introduced into the data, these students appeared to place the value of their learning above the reward of a good grade.

An important component of *Performance Goals* is the need to out-perform peers, to exceed expectations and standards, to receive recognition for the work, and to put in the minimum amount of effort necessary to achieve the goal (Ames, 1992). Learning is therefore not the ultimate goal and it may be viewed as simply a side effect or obligation while achieving a goal. Unfortunately, a learner's sense of self-worth can be tied to their success, and any failure, especially after a large amount of effort was expressed, can result in a negative self-image and a decrease in motivation to persevere. The result can be that performance goals mutate into a "failure-avoiding pattern of motivation" (Ames, 1992, p. 262) as opposed to achievement goals, which are self-sustaining and express a pattern that sustains mastery behaviors. It should also be mentioned that success without a lot of effort can create positive affect and will discourage future efforts (Ames, 1992). This item set exposes the drive that pushes students to succeed in their coursework. It also identifies the value Millennials place on rewards and recognition. This is not surprising, since Millennials have been raised with a reward system and the constant stream of social media places additional pressure upon them to perform (Millenbah et al., 2011).

Millennials are very peer-oriented (Crone and MacKay, 2007), and have a high need for *Social Validation*. The responses to this factor were on the *agree* side of the Likert scale and show the significance of peer justification for college students (especially members of this generation). A sense of belonging is essential for students and is a component of the social support they require to reduce stress, anxiety, depression, and fatigue (McGrath, 1999). Additionally, when students feel more socially validated, they can more easily adjust to college life and are more likely to remain in school (McGrath, 1999).

The instructor can directly influence a student's motivation during a course. If the instructor is well liked, dynamic, and presents interesting information then the student may have more interest in the class (Pintrich, 1994). Additionally, students may try to impress the instructor with their work (Ryan and Deci, 2000). This need for *Instructor Validation* is common with Millennials who may assume their instructors will take on a parenting role (especially in the case of the children of *helicopter parents*) while they are in school (Crone and MacKay, 2007). That said, it is interesting to consider that students with supportive parents have a G.P.A. that is 5% higher than non-supportive parents (McGrath, 1999). Therefore, if an instructor acts as a surrogate parent for students it may improve their grades. Also, Millennials desire and assume they will be recognized for their efforts since they have been told they were "special" their entire lives (Millenbah et al., 2011). It can create challenges for them in an academic setting if they do not feel they are receiving the extra attention and praise they expect from an instructor (Millenbah et al., 2011).

Connections to Learning was identified as significant to the participants with a mean of 3.90 on the Likert scale. The students understood the need to make connections between the material they were leaning in the classroom and the real world. This demonstrates the utilization of higher order skills from Bloom's Taxonomy (Crowe, Dirks, and Wenderoth, 2008) and the application of Constructivist Learning

Theory (Cooperstein and Kocevar-Weidinger, 2004). In other words, the students were willing to apply and merge information from a biology classroom to their own lives.

In conclusion, the nine factors that contribute to the construct of motivation (identified by this research) not only help define the construct, but provide clarity and a better understanding of how the components interact with each other to facilitate learning. Deconstructing motivation (which is a huge concept) will hopefully aid educators in addressing the motivational needs of their students within the classroom.

Attitudes towards biology

Interest tends to be static and is a part of an individual's personal traits (Pintrich, 1994). This suggests that it does not change frequently. However, the *Interest in Biology* factor had the most significant change at p = < 0.0001 of all of the Attitude factors and the greatest range along the Likert scale with ($\bar{g}$ = - 0.1483). It moved toward the *disagree* side of the scale, demonstrating a reduction of interest over the course of the semester. One possible explanation for the decrease in interest could be that as incoming freshman, students were still transitioning to university level coursework and while they had considered biology to be an easy subject in high school, they no longer held that view at the conclusion of their first semester (Millenbah et al., 2011). The greater volume of work and the need for more independent study time may have surprised some students. There was likely a transitional period as they discovered they needed to take more responsibility for their own learning than in the past (Millenbah et al., 2011). Also, the participants were likely exposed to more difficult biological concepts (than in high school) and had to work harder to understand the new material. In addition to causes related to being freshman, the results could be related to the participants' status as non-majors. A student's interest in biology can be impacted by a their major, especially if it is another field. They may perceive biology topics as boring or not applicable to their lives (Pintrich, 1994).

It should be noted, that while the topic of *Interest in Biology* may be included with the Attitude data, it is also related to Motivation. A student may have interest in a subject, but if they lack self-efficacy or self-confidence, they may not engage in the activity. Alternately, if a student possesses self-efficacy and self-confidence, but lacks interest, they may avoid the task (Pintrich, 1994). This could have contributed to some of this study's findings (*i.e.*, the lack of a correlation between motivation and achievement).

The participants' *Enjoyment of Biology* likely had many influences. Participants were probably exhausted by the time they took the final exam, and this could have impacted their overall ability to enjoy biology. As noted by Balogun, Pellegrini, Miller, and Katz (1999) student burnout is the result of mental and physical exhaustion in addition to frustration and a sense of personal failure. Balogun et al. (1999) also observed that students might develop negative habits regarding their studies as their level of stress increases. This could have impacted their enjoyment of the course. Also, it is the opinion of the author that the participants may have associated the rigors of studying biology with the actually practice of biological science. In other words, the participants may have still enjoyed biology if they had not just spent a semester learning it. This idea is supported by the work of Russell and Hollander (1975). Who also noted a decrease in positive attitudes by students during the semester.

As for the *Appreciation of Biology*, the results moved more toward the *agree* side of the scale. Therefore, the author can only assume the instructor imparted the value of learning biology or the participants came to this conclusion on their own. This is an important accomplishment, as this course may be the last biology class many of the participants take during their undergraduate experience. According to Fowler (2012), it is vital that non-majors make the connection between their coursework and society. They need to develop a scientific literacy that will enable them to make informed decisions later in life. Gaining an appreciation for the field of biology is the first step in accomplishing these goals.

When considering the *Application of Biology*, (and the lack of significant results) it is important to recall that the majority of the participants were freshman and it would be interesting to ask this item again when they were seniors. Would their views on the value of biological knowledge in the workplace change as they were preparing to enter it? It would be interesting to see if four years of undergraduate coursework impacted their attitude. Also, it is not unusual for Millennials to only place value on subjects that they consider to be directly related to their future careers (Millenbah et al., 2011).

Lab Experience also lacked statistical significance for the results. As mentioned in Chapter 3, this was likely connected to the omission of a laboratory section for this course. Without any lab experience to impact their attitudes, it is not surprising that there was no significant change.

For the *Challenge of Biology*, the participants had an insignificant decrease in their confidence to perform well in a biology class from pre- to post-test. It may have been impacted by some of the same causes as the decrease in their enjoyment of biology. The participants may have been more optimistic at the beginning of the semester, before they were exposed to the challenges of college level science.

Lastly, with *Opinions of Biology* the change in attitude for this item is rather interesting. How did the instructor convince the participants that you had to be smart to be a biologist? Was it based upon their observations of his intelligence or from their lessons that cited the work of past biologists? Perhaps it was the volume of information that had to be assimilated during the course and the students deduced that one would have to be smart to learn it all? Whatever the cause, the participants gained an appreciation for the intellectual abilities of biologists.

As freshmen begin their first year of college, they possess a set of attitudes related to their ability to succeed based upon personal experiences (Partin et al., 2011). These attitudes can be static and unchanging regardless of the challenges presented during the first semester (Kitchen et al., 2007). However, these attitudes can change during that initial year and have an impact on the students' motivation, performance and retention. Additionally, research suggests that attitudes may have a strong correlation with retention (Besterfield-Sacre, Atman, and Shuman, 1997). Therefore, monitoring and utilizing attitude data could be a useful tool in retaining students in STEM programs. Students who chose to leave STEM fields, even when in good academic standing, tend to have less positive attitudes toward math and science and reduced self-efficacy at the beginning of their academic career (Besterfield-Sacre, Atman, and Shuman, 1997). These attitudes appear to intensify during the first year and contribute to their decision to exit the program.

Finally, it is important to consider that the post-test was a part of the final exam and (well known) feelings of frustration are often experienced during finals (Balogun et al., 1999). Perhaps if the survey had been taken a week or two earlier, the Attitude results may have been different. Also, during the end of the semester there is a greater volume of work (in all courses) and an increase in the difficulty of the biological concepts the students are learning. This may have discouraged the participants and impacted their attitude.

Perceptions of biology

Is biology boring? Prokop, Prokop, and Tunnicliffe (2010) pose the question as part of the title of their journal article, where they discuss the unfortunate perception that biology is too challenging and no longer relevant. This study also examined participants' Perceptions of Biology. Of the twenty items examined in this part of the survey, five items showed no significant change from pre- to post-test (*e.g., Confusing or Enlightening, Frustrating or Gratifying, Impossible or Attainable, Shallow or Meaningful,* and *A Single Method or Uses Many Methods*). Apparently, biology continued to be confusing, gratifying, attainable, meaningful, and it uses many methods. However, the remaining items were highly significant and demonstrated the changing perceptions of the participants by the conclusion of the semester.

Participants remained on the *Personally Helpful* side of the scale, but were less agreeable about their perceptions of this item. What is occurring during instruction that creates this impression? Is it connected to a generally disagreeable perspective held by students at the end of the semester (Balogun et al., 1999)? The timing of the survey and the exhaustion felt by the participants could have impacted the perceptions of biology held by the students. These include: biology is less *Intriguing*, less *Relevant*, less *Empowering*, less *Understandable*, less *Ethical*, and more *Biased* (Table 3.5).

The participants may have felt that biology was less *Intriguing*, because it was no longer novel. They had just had a semester of exposure to college level biology. Perhaps it simply lost its newness? The feeling that biology was less *Relevant* may be related to the participants being non-majors. The idea that this course did not apply to them and that it was simply another requirement of their program may have impacted the participants' perspectives of the relevance of biology. The response of biology being less *Empowering* may have also been prompted by the participants' non-major status. They lacked a connection to the field and did not gain a sense of strength (empowerment) from the course work.

The perception that biology was less *Understandable* may in part be connected to being non-majors, as students with an interest in a subject tend to understand the material better since they are motivated to do so (Schibeci and Riley, 1986). The origin of the less *Ethical* perspective of biology is less clear. It may pertain to learning about past experiments that involved living subjects. However, since there was no lab component for this course, the students did not perform any dissections or other procedures in class that could potentially be viewed as ethics violations for some participants. It is interesting to note that the participants' view of biologists also became less *Ethical* at the end of the semester. Were the students combining the two perspectives?

Participants also considered biology to be less *Based on Observation* and moved along the scale toward the *Based on Ideas* side. While research in biology certainly requires ideas, it is primarily based upon observation. This appears to indicate that the students lacked an understanding of the scientific method. Alternately, participants may believe that scientists do not follow the scientific method. The participants' perception that biology *Has Patterns* moved toward the *Chaotic* side of the scale. Biological research *can* be chaotic and even messy at times. Perhaps this is actually a reflection of a more realistic view held by the participants. In other words, biology *Has Patterns*, but research is *Chaotic*. The view that biology was less *Practical* may have occurred for a similar reason (*i.e.,* the students understood more about the *Theoretical* side of biology, and placed more value on that side of the scale). The instructor for this course spent a lot of time talking about the Nature of Science and how scientists develop theories and ideas, and how they do not just use one method to develop those ideas, this could explain the data patterns observed.

Students showed an increase in the perception that biology *Answers Some Questions*. This could be interpreted in multiple ways. Did the participants come to understand that there is still much to be discovered in the field of biology and that is why it only *Answers Some Questions*, because we have so much more to learn? Or is this item being viewed through a philosophical lens and biology cannot, by its nature, answer the meaning of life types of questions? Or do the students feel that biology leaves a lot of questions un-answered and we should be attempting to answer more of those questions through research? In other words, the intention of this item may have been unclear to participants and they answered it from multiple perspectives.

Participants considered biology to be *more Worthwhile.* As non-majors, it would not have been surprising for them to have considered biology to be *Worthless.* Especially considering that they found it *less Relevant* and *less Intriguing*. Apparently students comprehended the value of biology. They also considered it *more Durable*. The author assumes this relates to the perception of the permanence of biology as an institution. They deemed it to be a stable field, but they also appreciated the flexibility of biology and saw it as *more Adaptable*. This likely is related to the regular revolutions in biology as new discoveries replace old ideas.

Participants expressed the belief that biology was *more Unbiased*. The instructor stressed the importance of being unbiased in the sciences, and apparently participants responded to this component of the course. However, the learning objective about biology being *Evidence-based* did not impact the participants as strongly and the participants viewed biology as *less Evidence-based*. Perhaps the students took the instructor's word for it and this ethos was all that was required for them. In other words, they did *Not Require Evidence* and for some reason did not recall the true nature of biology.

This data provides evidence that at least some of the messages educators are attempting to convey to their students are being received. When shown these results, the instructor for this course concluded that a lot of the results might have to do with the significant amount of time he spent in class talking about the *Nature of Science* as opposed to just reviewing the old-school *Scientific Method* as occurs in most classes. He introduced topics such as: how science is a process and a worldview, how the process works, how theories are developed, creative aspects of science, the tentative but rigorous nature of ideas in science, as well as the social and ethical impacts of science. He determined that this could impact a lot of student impressions about the perceptions of biology as well as biologists, and perhaps not in the way he intended.

Perceptions of biologists

Decades of research on students' (usually K-12) perceptions of scientists have used writing prompts, questionnaires, drawings, illustrations, and structured interviews to measure this construct (Laubach, Crofford, & Marek, 2012). A number of these studies have examined college students with results frequently being comparable to younger students (Beardslee & O'Dowd, 1961; Bovina & Dragul'skaia, 2008; Brush, 1979). Finson (2002) describes the connection between student attitudes and self-efficacy when they "draw a scientist", which is a classical methodological means for measuring student perceptions of scientists. Students with stronger and more positive self-efficacy tend to also have more optimistic attitudes and when they draw a scientist they include fewer stereotypical components.

There is little research into understanding why these misperceptions exist, let alone how (and if) we should correct them (Finson, 2002). Mead & Métraux (1957) offer some interesting suggestions, such as early interventions and the utilization of mass media. The image of a scientist is so common a stereotype in popular culture, that it is consistent despite the background and experience of the student (Beardslee & O'Dowd, 1961; Boylan, Hill, & Wallace, 1992; Brush, 1979; Song & Kim, 1999). Cakmakci et al. (2011) describe the seven stereotypes of scientists: the evil experimenter, the gallant hero, the fool, the insensitive researcher, the adventurer, the mad scientist, and the powerless scientist unable to control his own experiments. According to Beardslee & O'Dowd (1961), when college students were asked to describe a scientist, they perceived them as "unsociable, introverted, and possessing few, if any, friends" (p. 997). Thankfully, they also noted that students who were planning on entering a STEM field viewed scientists as more colorful and interesting when compared to other programs. It should be noted that perceptions of a *biologist* are usually a bit more favorable than those of a *scientist*, with the biologist being perceived as more well rounded and normal in appearance (Beardslee & O'Dowd, 1961). However, the two terms will be used interchangeably here, as a biologist is a scientist.

The lone figure of an older white male in a white lab coat surrounded by beakers and test tubes of colorful liquids is a long-standing and difficult one to modify (Mead & Métraux, 1957). The challenge associated with this meme is that students who might consider enrolling in science courses or entering the sciences are hesitant to do so because 1) they may not perceive themselves as the cliché image of a scientist or 2) they do not want others to view them in that light (Beardslee & O'Dowd, 1961; Finson, 2002). Therefore, students may avoid STEM fields in order to avoid being labeled with a perceived negative self-image. What seems like an innocuous misconception could actually be harmful for developing future scientists.

It is interesting to consider that many incoming freshmen have yet to meet a scientist, yet they still have a strong impression of a scientist as being intelligent, but cold and logical (Brush, 1979). This "Spock Effect" (in reference to the *Star Trek* character) likely originates from television and movies (Cakmakci et al., 2011; Mead & Métraux, 1957). In this study, the students also seemed to view biologists as logical

(Table 3.6). For the survey item: *Biologists are Logical or Illogical?* the pre-test mean = 0.77. This item was skewed heavily toward to *Logical* side of the scale and the post-test mean = 1.56, which was still on the *Logical* side, but moving toward center. Student perceptions became *less Logical* during the semester. Presumably, as participants had the opportunity to learn about and meet actual scientists, they realized scientists were not purely logical, but were instead human. Student perceptions do not only focus on the personality of scientists, they also viewed the home life of a scientist to be less then ideal, with their career overshadowing their personal life (Beardslee & O'Dowd, 1961; Mead & Métraux, 1957). This perception is problematic as it could push away potential recruits to STEM fields, especially women and underrepresented groups who may place more value in home-life over work

The results demonstrate a number of statistically significant changes in the perceptions of the students from pre-test to post-test (Table 2). The most significant changes were observed in the students' perception of a biologist's intelligence, selfishness, humanity, inclusive nature, ethics, social responsibility, morality, problem solving ability, logic, honesty, skepticism, spiritual beliefs, patience, and ability to agree. There was no significant difference in the perception of biologists being female versus male or in the hardworking ability of biologists. These results are similar, but not identical to Gardner's (2010) findings.

While the effect of some of the course topics (*i.e.,* natural selection, human evolution) on the students must be considered since it can be a popular subject (Gardner, 2010) or controversial issue (Donnelly, Kazempour, & Amirshokoohi, 2009). Some of the other changes in the students' perceptions are likely from other sources in addition to their classroom experiences (*e.g.,* media and popular culture). On an individual scale, a student's personal experiences (*e.g.,* failing a quiz, not completing an assignment, group interactions) in the class might have an impact on their perceptions (and mood when completing the survey), but the course wide changes are not so easily influenced.

Students often assume the typical scientist is similar to their instructor (Boylan et al., 1992). This could have created some bias when the participants completed the survey. According to student opinion surveys, the instructor for the course is well liked and respected by the majority of the students, so what might be the origin of the more negative perceptions of biologists at the conclusion of the course? Does studying biology and the history of biological discoveries create a negative view of biologists? Are instructors unintentionally portraying the accomplishments of other biologists in a negative light? Mead & Métraux (1957) remind us that most of the scientists that are studied while in school are dead. This could be impacting the sense of connection that might otherwise be felt by students. Additionally, many textbooks can be dry and students may associate the lack of excitement with the scientific community (Brush, 1979).

Beardslee & O'Dowd (1961) noted that incoming students have more agreeable perceptions of scientists and by the second semester their views become less favorable. This observation is supported by this project, as the scores for intelligence moved toward the *stupid* side of the scale, as did perceptions for *selfish*, *unkind*, and *immoral* among others. It should be noted that students also perceived biologists as more *interesting* and *outgoing* by the end of the semester.

The perception that scientists are atheistic as noted by Mead & Métraux, (1957) was also observed in this study. Item 18 asked if *Biologists are Spiritual or* Atheistic, and had a pre-test mean of 2.69 with a standard deviation of 1.37 and a post-test mean of 3.34 with a standard deviation of 0.83 and the result was significant (p = < 0.0001). On the pre-test, the mean response was on the atheistic side of the scale, but just barely. By the end of the semester, the mean response had increased significantly ($\bar{g}$ = 0.1625) toward the atheistic end. One participant even went so far as to write in "evolution" next to their selection of a 5 (*atheistic*) for this item. Obviously, this participant wanted to make it clear that because the theory of evolution was presented in this course, that student viewed the instructor (and presumably biologists in general) as atheists. It should also be noted that the same student rated biologists as a 3 (*neutral*) for Spiritual-Atheistic on the pre-test. This data demonstrates how a student's perception of biologists is influenced by their current instructor and course (Boylan et al., 1992). The instructor's introduction of the subject of evolution likely impacted the participants' perceptions of a biologist's spirituality.

Student aversion to learning about evolution is not limited to conservative Christian groups, certain geographical regions, or even the United States of America (Jones and Reiss, 2007). Religious beliefs are a delicate issue and can become polarizing very quickly. Some students arrive at school prejudiced against evolution and are determined to not accept the theory (Bryant and Calver, 2009). They may be fearful or even hostile when the subject is presented; therefore, the material needs to be presented with 'philosophical neutrality' according to Bryant and Calver (2007). This abhorrence (by some) to evolution may be connected to the notion by students that acceptance of the theory requires them to become atheists or that scientists will try to dissuade them from believing in God's involvement in creation (Jones and Reiss, 2007). As stated by Dobzhansky (1973), "education is not to be used to promote obscurantism" (p. 125) and a student's personal views (or societal pressures) should not interfere with their education.

There is an assumption by the public that since evolution is a scientific theory that it must be atheistic in nature and acceptance of the theory requires the rejection of religious views (Jones and Reiss, 2007). Moderate points of view that incorporate both versions of creation exist (Dobzhansky, 1973), but are often overlooked, since most of the individuals that hold such views do not feel compelled to advertise them in the same way as those on the other ends of the debate (Jones and Reiss, 2007). This assessment likely also contributed to the view that biologists are atheists.

As with the Perceptions of Biology, at least some of the take-home messages about actual biologists that are being transmitted in classrooms are being accepted. However, there are still a number of inaccurate perceptions that need to be addressed in order to provide a more realistic and human view of biologists to the public.

Issues in identifying as non-majors

Participants were less confident in their ability to succeed in the course by the end of the semester. This was revealed when participants were asked: "As a non-science major, how do you rate your ability to be successful in science classes?" with choices including 1 (*very good*), 2 (*good*), 3 (*okay*), 4 (*fair*), and 5 (*not good*) on a Likert scale. The pre-test mean was 2.31 with a standard deviation of 0.80 and the post-test mean was 2.45 with a standard deviation of 0.86. The result was significant (p = 0.0098, $\bar{g}$-factor = 0.0247) with a fair amount of change in the normalized gains (Table 3.7). While the responses remained between (*good*) and (*okay*); they did became less secure by the end of the semester. This reduction of confidence by the participants may be of concern to educators, as self-confidence is linked with developing competence in a program of study (Chesser-Smyth and Long, 2013). In other words, if a student believes they will do well in a course, they are more likely to actually do well. The majority of participants (>75%) earned a B- or greater in the course and there was a 49% improvement from the pre-test to the post-test knowledge score. Yet, so many participants still thought they would just do *okay*. The links between self-efficacy, academic motivation, and achievement are well documented (Chesser-Smyth and Long, 2013). The participants performed well overall and appeared to benefit from working in teams (Farias, Farias, and Fairfield, 2010), yet this survey item demonstrates a lack in participant confidence. When compared to the self-confidence results seen in the Motivation data, this is more puzzling. The participants were relatively confident, but when directly asked about their confidence to do well in a biology course, that confidence faded. Perhaps the more you learn; the more you realize you need to learn more.

It should be noted that two of the participants identified themselves as being science majors and did not answer the post-test item. The two participants were actually Exercise Physiology majors. Therefore, this item needs to be reworded in future studies to say: “As a non-major in biology, how do you rate your ability to be successful in biology classes?". Also, one participant wrote "B to C+" next to their post-test selection. The author assumes the participant equates success in a science class with their grade.

Equating success with good grades is not uncommon, as many students believe success in a course is only demonstrated with a high grade, as opposed to a complete understanding of the material (Farias et al., 2010). This perspective is also impacted by the need to maintain higher grades if the student has a scholarship, wishes to avoid being placed on academic probation, and hopes to find a job someday (since many employers screen candidates based upon grade point average). For previously high achieving students, grades can also be tied to their self-worth (Honken and Ralston, 2013). The participants' agreement with the Performance Goal items in the Motivation part of the survey also corresponds with these results. The students placed value on good grades and impressing their instructor.

While this section only deals with a single item, it has a number of implications for instructors. How can we help students maintain the confidence to succeed in our courses that they possess at the beginning of the semester? More importantly, what is occurring that diminishes this confidence in our students?

Views of science

This group of items dealt with basic scientific concepts (*i.e.*, The Nature of Science). Only half of the responses were significantly different from pre- to post-test (Table 3.7). The participants were taught basic scientific concepts, but apparently this did not alter many of their views of how biology operates. No changes were noted for the following items: *The primary goal of modern biology is to explain natural* *phenomena. A conclusion is a statement of what was observed in an experiment. Current scientific theories portray nature more accurately than those they replaced. Scientists think atoms exist primarily because they have seen them through powerful microscopes. Hypotheses/theories cannot be proved to be true beyond any doubt. Explanations that seem reasonable and make intuitive sense need not be tested.*

The first significant item asked: *To be scientific, hypotheses must be testable.* The item moved further toward *strongly agree* on the post-test. This response demonstrates that the participants improved their understanding of the scientific method. The next item asked: *A well-supported theory becomes a law*. This item moved more toward the *agree* side of the scale. The students apparently understood the difference between theory and law. Item seven inquired: *Hypotheses are derived from controlled observations of nature*. As with the previous item, this one remained in the *agree* range, but that may have to do with the students' thoughts on when a hypothesis is formed. The author believes they may be responding to the wording of the item, that the hypothesis comes after the controlled observations (or experiment), while many students were taught that the hypothesis is formed first. The next item: *A hypothesis is a prediction of what will be observed in the future*, was barely significant in the *agree* range. Since this item also relates to hypotheses, the author was surprised that it was not closer to the *strongly agree* side. This item appears straightforward, but could the wording be an issue again? Perhaps the terms *future* or *prediction* are problematic and confused the participants in some way?

The item: *A well-supported hypothesis becomes a theory*, is similar to *A well-supported theory becomes a law* and this item also moved toward the *agree* side of the scale, with very similar results. The responses were likely similar because the items were related. The final item inquires: *Coming up with hypotheses requires creative thinking.* This item connects to the Perceptions of Biologists item *Biologists are Unimaginative or Creative.* The participants considered biologists to be *more Creative* by the end of the semester. This is not surprising, since they also thought a hypothesis required a creative thinker.

Knowledge

The results of the pre-test Knowledge items were unimpressive overall, but this is not surprising. The students were primarily incoming freshmen who had just began their college experience after a summer break. Academics were likely not their main focus. The instructor reassured the students that their performance did not matter and would not contribute to their final grade. This presumably removed any pressure they may have felt about the knowledge items, but it also implies they may not have taken the assessment as seriously. The mean score was 30.1% with a standard deviation of 10.7. The post-test Knowledge assessment showed a great deal of improvement. The mean was 61.1% with a standard deviation of 14.7.

McNeill et al. (2013) noted that since existing knowledge impacts learning, students who do well on knowledge pre-tests, tend to do well on post-tests. This phenomenon was also observed with this project ($r = 0.3320$, $p = < 0.0001$). Students with higher pre-test Knowledge Scores tended to perform better on the Final Exam. The take home message is that even though the overall scores were low, the students increased their knowledge of biology (more than doubling their mean scores) during the semester.

Individual motivation, participation, attendance, and final course grades

Correlations were examined between Motivation, Participation, Attendance, and Final Course Grade at the individual level. A significant positive correlation was found between attendance and grades. This is to be expected, as Gardner (2014) also identified a connection between grades and attendance. It is not a surprise that students who attend classes regularly tend to perform better. They take their education more seriously, have an interest in the subject, or want to learn the material (Ames, 1992; Pintrich, 1994).

Participation and Final Course Grade showed a slight correlation as well. For similar reasons as seen with the Attendance results, students who choose to participate in their group work demonstrated a higher level of interest to do well in the course. It is to be expected that they would earn higher grades. A very small correlation was found between Motivation Scores and Final Course Grade. This result is surprising, since motivation is one of the key components to success in the classroom (French et al., 2005; Graham et al., 2013; Yoshida et al., 2008). Devadoss and Foltz (1996) saw an increase of 0.42 points (on a 4.0 scale) in grade for the more highly motivated students in their study. However, that study was conducted almost 20 years ago, and there may be some different educational perspectives with the current generation of undergraduates.

A strong correlation was observed between Participation and Attendance, which was also to be expected. The two variables are similar in their demonstration of commitment by a student to their studies. Conversely, a slight correlation was found between Participation and individual Motivation. Once again, this was unexpected. Motivation scores seem to be separating from the rest of the variables. Since participation can be an indicator of motivation, the author expected to find a better connection between the two variables. A small, negative correlation was detected for Attendance and Motivation. Since these two variables should be similar, these results seem counterintuitive. Devadoss and Foltz (1996) observed a strong positive correlation between Attendance and Motivation. It would seem logical that more highly motivated students would attend classes more often. However, that was not observed with this study. Once again, part of the answer may have to do with the generation of the participants of this particular study. Millennials are a unique group of students and express behaviors that differ from past generations (Crone and MacKay, 2007). They simply may not possess the same motivation to attend classes as previous generations.

Motivation review

According to Tuan et al. (2005), motivation is a stable construct in regards to student achievement. In fact, learning achievement is often used to predict the motivation level of the student. Millennials have a different motivational foundation than previous generations. They consider their college experience to simply be another stop on their path to a successful career and professors are providing a service stop along that road. Their education is a commodity and because they are paying for it, they expect a return on their financial investment and are not necessarily willing to devote time and energy to something for which they are already paying (Crone and MacKay, 2007). This is revealed by the poor correlation between Motivation and the other variables (*e.g.,* Attendance, Participation, and Final Course Grade).

Participation review

According to observations by Trackey (2013), students tend to complete self-evaluations that are closely aligned with how their teammates perceive their contribution to the group. While he did note some exceptions to this rule, the Participation Scores were deemed accurate in his investigation. While many of the individual Participation Scores in this study reflect successful team interactions, there were also a large number of single digit values (including 0 ratings). These lower scores did tend to cluster in the groups that had lower scores for other variables. Luckily, the converse was also true. Participants with better personal Participations Scores were frequently in groups with higher mean scores, and these individuals tended to perform better on other measured variables. That said, there were also a number of exceptions. Students who had high Participation Scores, but then barely passed the course and students with low Participation Scores who earned A’s. Apparently, a student could be very good at group work, but not be able to translate those efforts into a decent grade. While others may have had problems participating with the teams, but were able to be successful by studying independently.

Participant evaluations revealed generally positive experiences. However, there were also challenges and frustrations encountered during the semester. In order to provide some context for the discussion of participation, a sample of responses are listed below. Highlights are in italics and are the addition of the author. Names of participants have been reduced to a single letter.

Heterogeneous representative group comments

> "Overall my group worked well together and no problem occurred over the semester."
>
> "I thought T and A helped me the most in my group but it was very hard to keep my group on task and complete the assignment in a timely manner. For almost all of the classes I had to write down all the questions and answers and keep my group on task to get the assignment done. At times *this was very frustrating for me because I felt like I was trying the hardest and making the most effort to complete the assignment when my other group members were talking or on their phones and did not care about the group work*."
>
> "I really enjoyed working with this group this semester. If someone did not understand the topic clearly, *we all had a way of making each other feel comfortable with asking questions*. We were all respectful to each other and we all did what it took to get the work done and done correctly. *If I had a choice, I would definitely pick this group to work with again.*"

Homogeneous high representative group comments

> "Overall, great group. We worked well together."
>
> "D was great at including everyone in the group work and always did his best to answer the questions."
>
> "We worked very well as a group. *Everyone individual contributed in their own way.*"
>
> *"Every time I spoke up, my ideas or questions were shot down*. I tried to participate and look up helpful information that would assist in answering the group questions."
>
> "Everyone was basically wonderful in group 4. The only reason I gave C a lower score on a couple was because *he would argue with us a lot and be difficult* when we were trying to get him to do something, so needless to say we didn't exactly get along. But he did work for the group and he put forth a lot of effort so I

don't think he should be graded too harshly on this :)"

"I was in a very good and helpful group. Everyone did their part and contributed."

Homogeneous middle representative group comments

"At first I wasn't sure how our group would work out, but in my case I think your survey to create group's worked out well. *It was weird at first, but we all ended up having similar ideas and worked together great!*"

"M was very quiet most of the time. *When she was not on her phone she only contributed when directly asked for input*. She was not exactly a bother to have in the group, and I think she was a little shy, but we could not get much out of her."

"At first, J did not contribute much, but as the semester went on he started helping the group out."

"Minus D, I thought the rest of the group worked well with each other. No one was extremely enthusiastic about doing the work, but we got the work done on time and without any conflict."

Homogeneous low representative group comments

"There were 3 other people originally in the group. T was the only one who told us that she dropped the class, but the other two group members stopped coming and never let A or I know where they were. A was frequently absent, but when he was in class he was a very good partner who understood the material."

"I did literally all of the writing this whole semester because "girls have neat hand writing" but they were all very helpful most of the time and never made me figure out any of the answers on my own and never took me for granted or did their own thing while I was writing. They all contributed at least something during the group activities. *I was hesitant to work with 3 older dudes at first but they were very helpful.*"

Attendance review

Student Attendance appears to be the most significant component to academic success (Devadoss and Foltz, 1996; Snyder, Forbus, and Cistulli, 2012; Stripling, Roberts, and Israel, 2013), yet attendance rates range from 20% to 40% of students not attending on a daily basis (Stripling et al., 2013). Even though higher rates of absenteeism usually result in lower grades (Devadoss and Foltz, 1996). Several studies (discussed below) have examined the problem, and some have attempted to find unique and innovative methods for getting students into their seats.

Snyder et al. (2012) utilized *The Principle of Social Proof* in their experiment. The principle is related to the persuasive impact of peers (*i.e.,* if a peer follows a certain behavior or rule, then it is easier for the next student to adhere to it too). This principle has been applied to a number of situations (*e.g.,* charitable donations, investments, and even littering) and most people are familiar with the idea of *Peer Pressure*. Essentially, they were trying to use peer pressure to encourage attendance. Cooperative teams can have the same impact. When one team member does not attend meetings, the other members may apply pressure and encouragement, or at the very least notice the absentee since they are working in a small group (Devadoss and Foltz, 1998). Snyder et al. (2012) observed that when their participants were exposed to peer pressure it resulted in higher attendance rates.

Devadoss and Foltz (1996) recommended an attendance requirement, as they saw a 12.7% increase in attendance rates when the policy was in place. Also of interest, Devadoss and Foltz (1996) observed an increase in attendance rates (6.4%) for classes held on Monday, Wednesday, and Friday. Their students preferred the shorter class periods and were willing to attend more frequently. This preference could have impacted the current study, since that course was offered on Tuesday and Thursday. Devadoss and Foltz (1996) also remind us that a talented instructor can make students more willing to attend class.

St. Claire (1999) states that compulsory attendance policies are ineffective because there is not a link between attendance and grade, and therefore St. Claire believed that mandatory attendance impacted students' sense of control and actually made them regret enrolling in college. St. Claire's (1999) research also noted that student attendance improved when they perceived a benefit. Therefore, it was recommended that the students' grade be linked to attendance. The current study did find a correlation between grade and attendance, and the author understands the value of student attendance. St. Claire (1999) offers valid points, but her recommendation to offer a reward for attendance by tying it to grade, but not make it mandatory because it negatively impacts student's sense of control seems contradictory. Devadoss and Foltz (1996) offer an alternative, they recommend explaining to students at the beginning of the semester the connection between grades and attendance, but then not enforcing a requirement, since attendance alone does not indicate learning. That said, Stripling et al. (2013) noted that the number one reason students did not attend a class was because attendance was not taken (93.4% of the students polled).

Final course grades review

Final Course Grades were correlated with Attendance and Participation, but not with Motivation at the individual level. The connection with Attendance and Participation is not surprising, as they were used to calculate the Final Course Grade. As will be discussed below, the linear regression also revealed that Motivation was not predictive of Final Course Grade for this set of participants. As these variables are usually closely related, it would be interesting to further investigate what made this data different from what is generally reported in the literature (as discussed extensively in Chapter 1).

Group motivation, participation, attendance, and final course grades

Correlations were calculated for comparisons between Motivation, Participation, Attendance, and Final Course Grades at the group level. A negative, but negligible correlation was found between Participation and Motivation. This is not surprising, as there was also a slight negative correlation at the individual level. Apparently, there was no group effect to alter this part of the data. Attendance and Motivation had a trivial negative correlation, similar to the individual correlation. Motivation and Final Course Grade were negatively correlated (the individual values were positive, and also inconsequential). Once again, Motivation did not have a strong connection to the other variables.

Final Course Grade and Participation featured a strong correlation at the group level, just as it did at the individual level. This supports the argument that more effective teams performed better. They were able to use collaborative learning methods to facilitate the transmission of knowledge. Participation and Attendance, as well as Attendance and Final Course Grade featured robust correlations at the individual level. However, only Final Course Grade and Attendance remained highly correlated at the group level. Participation and Attendance only had a slight correlation. This may be due to an effect from the group (*i.e.,* participants that did not complete their peer and self evaluations and therefore did not receive a Participation Score).

Overall, the group and individual results were similar, which offers support for the reliability of the data. However, the continued lack of a correlation with Motivation and the other measured variables is not consistent with the literature. The mystery of what makes this group of participants different from other studies needs further examination.

Group size and gender ratios

The group environment can have an influence on student performance and retention (Choi and Rhee, 2014). Changes in team membership can have a negative impact on a group, as they have lost one of the members of their team. While overall group attrition rates were only 25%, some types of groups were more affected than others (Table 3.9). The Heterogeneous groups had the most changes in membership with 34% of the groups either gaining or loosing members of the team. Interestingly, these groups also had the lowest Final Course Grades and one of the lower Participation Scores. Alternately, the Homogeneous middle groups had only 8% attrition and they had the highest Final Course Grades and one of the higher Participation Scores. The author proposes that this loss of teammates had a detrimental impact on the group function and resulted in lower grades and collaboration within the teams.

The gender ratios for the course were skewed toward the female participants (58.7%) and this was reflected in most of the teams. However, there was no correlation between these gender ratios and Final Course Grade. That said, teams with all female members had group Final Course Grades ranging from 3.1 to 3.9, while the single all male team had a group Final Course Grade of 3.3. The overall mean for the course-wide Final Course Grade was 2.9. The literature does offer some support for homogeneous teams based on gender (Ro and Choi, 2011). On a small scale, the gender homogeneous teams were successful and the all female teams were the most successful. Obviously all female groups cannot be utilized in all classrooms (excluding all female colleges). The comfort level from working with similar teammates may have contributed to the achievement of the single gender teams.

Linear Regression

Predictions of variables

It was determined that group type (heterogeneous vs. homogeneous) could predict Final Course Grade, but only a small fraction of the variance was explained by the type of group, therefore, this was not a useful component to the model. To seek clarification, an additional test was run with all four group types to determine if a specific group type might be predictive. The heterogeneous groups were used as a control and it was verified that the homogeneous middle groups were predictive of Final Course Grade. Conversely, a logistic regression was used to determine if the Final Course Grade could predict the type of group. It was discovered that group type could be predicted, but it only worked with the homogeneous middle teams, therefore, it was not useful as a whole.

Next, the four group types were examined to see if there were any differences between the members for pre-test Knowledge Scores, Final Exam Scores, and Final Course Grades. Not surprisingly, the groups were equivalent for the pre-test Knowledge Score, as this was prior to the start of the semester and before the educational intervention had occurred. The results for the Final Exam Grades were insignificant and the model showed that only 0.6% of the variation for Final Course Grade could be explained by the group types. Once, again this was not useful for a predictive model.

Since group type was not predictive in a beneficial way, a stepwise selection method was chosen to determine if any of the other variables could predict Final Course Grades at the individual level. The best fit for the model included Final Exam Grade, Participation Score, and Attendance. Unfortunately, this was not very useful information, as these variables were used to calculate the Final Course Grade. The significance here instead, is what was *not* included in the model. None of the other variables (especially Motivation) effected Final Course Grade, and those that were predictive only accounted for 2.6% of the variance. The literature (Dolmans et al., 1998) is full of references supporting the significance of motivation in the improvement of knowledge content; however, this was not observed in this data set. Obviously something else is impacting the results.

Self-efficacy has been shown to be positively correlated with academic success and can be used to predict grades (Chemers, Li-tze, and Garcia, 2001). A confident student will work harder and devote more time to their studies, additionally; they will be more likely to persevere when faced with a challenge and will use more efficient problem-solving and learning approaches (Chemers, Li-tze, and Garcia, 2001). However, simple correlations and more advanced linear regressions showed no connection with motivation and grades for this data set.

Motivation, attendance, and participation

Just to be sure, Motivation was specifically used to determine if it could predict individual Final Course Grade. Only 0.2% of the variance was explained by this construct. Similar to previous results, Motivation again was not predictive of Final Course Grade. Next Attendance and Participation were tested to determine if there were any differences in the scores between the groups. It was discovered that Attendance was independent of group type, as it lacked statistical significance. Participation also lacked statistical significance. Therefore, the Attendance and Participation scores were not related to the group types.

Previous science courses

The final group feature to be analyzed with linear regression was the demographic data of the participants. Gender, Race/Ethnicity, Class Standing, Major, and Age were all analyzed and none were found to be statistical significant from each other. In other words, the various demographic groups performed and responded in a similar fashion to the instrument. The only difference in demographic data was discovered for participants that had taken a Previous Science Course. These students were found to be statistically different from those participants who had not taken a Previous Science Course. When additional tests were preformed, it was revealed that this difference only applied when comparing heterogeneous and homogeneous high groups, or homogeneous high with homogeneous middle groups. A final regression was used to discover if Previous Science Course could be used in a predictive model, but as only 0.9% of the variance could be explained by the previous course, it was not useful.

Section comparisons

There were no significant differences in the two sections for Motivation Scores, pre-test Knowledge Score, Final Exam Grade, Final Course Grade, Team Participation Scores, and Attendance. The author hypothesized prior to the start of the project that there might some differences between the students because of the class times (*i.e.,* the morning section would have more motivated and higher performing students, because afternoon sections are *sometimes* selected to allow the student to sleep late). However, this was not the case and the two sections had similar results.

Conclusions and Implications

Considerations of the affective responses of Millennials to biology

In the 1980's at Purdue University, researchers asked students in an introductory chemistry class "what makes a subject so 'difficult' that some students drop out or fail?" (Seymour and Hewitt, 1997, p. 10). The students possessed a "democratic theory of education" (Seymour and Hewitt, 1997, p. 10) and thought that it should be possible for faculty to teach chemistry is such a way that any student who was prepared and put in sufficient effort would earn good grades in the course. The students emphasized that their success was within their control. This perspective has changed considerably with the Millennial generation. Many students now believe that professors should give them good grades, regardless of the effort they put into the class (Millenbah et al., 2011). Today's students have a consumerist view of education (Millenbah et al., 2011; Seymour and Hewitt, 1997). They expect to receive a degree as a result of their financial investment, and not necessarily because of their efforts.

Could the discrepancies found in this research, when compared to other (often older works) be related to Millennials? Do they perceive and use motivation to learn biology differently when compared to previous generations? Are our current instruments for measuring motivation not as effective with this group? Or are Millennials more extrinsically motivated, but express a pseudo-intrinsic motivation in an attempt to impress or please their instructors? Further research examining the differences between Millennials and other generations could be useful in identifying more successful ways to instruct these students.

Limitations

The two sections of the course were statistically similar and the two categories of groups (*i.e.,* heterogeneous and homogeneous) in each section were nearly identical since they were created by splitting the sections in half and randomly assigning students to one of the two group types. In other words, while the groups of students were different from each other on a small scale, they were similar on a larger scale. Future research methods may need to use a different technique to create the groups.

The pre-test component of the survey was taken at the start of the Fall Semester. At that time, the majority of the students (85.9%) were incoming freshman and were still acclimating to college life. Part of this acclimation included learning their student identification number. Of the 312 students who completed the pre-test, 79 (approximately 25% of the participants) did not use their student number. While this created a few difficulties when managing the data, it may have also impacted the analysis. A participant who was not motivated enough to go look up their student number, may have also been lacking in motivation to do other tasks, such as learning biology. All of the students enrolled in the class who either did not complete the pre-test or did not use their student number were placed (out of necessity) in heterogeneous groups. Therefore, we may have skewed the motivation levels of the heterogeneous groups toward less motivated students.

The pre-test was made available to students prior to the start of the Fall Semester, but in order to accommodate students during the add-drop period, the survey remained available during the first 10 days of class. The second day of lecture covered the topic of the Nature of Science. Some of the participants completed the pre-test *after* that lecture, and it may have impacted how they answered some of the pre-test items. In particular, the Views of Science items that related to the Nature of Science.

Future directions and research questions

The information obtained from the study on student perceptions of biologists could be useful in designing learning and social interventions for STEM students. If we can better understand how students perceive biologists and biology (and what drives these perceptions), then perhaps we can address the negative views and hopefully correct these perceptions while we encourage and promote the positive views. For example, much of the current literature attributes student perceptions to popular media reinforced by stereotypes perpetrated in most science classrooms. What are the "hidden" curricular aspects that drive shifts in negative perceptions? The ultimate goal is to create in students an interest and appreciation for biology and hopefully aid in the retention of promising students in STEM fields.

Inaccurate views of scientists appear to form during childhood (Cakmakci et al., 2011; Finson, 2002) and may contribute to problems interacting with the community. If people believe the scientist stereotypes, they may be less willing to listen to and work with scientists. This could be especially problematic when dealing with conservation issues, but it could also impact the community and economy (Cakmakci et al., 2011).

It would be interesting to include an item on a future survey that identifies participants with “helicopter parents”. This could offer some interesting insights regarding the success and attitudes of students. Also, the amount of financial support a student receives can impact their self-efficacy (Estrada et al., 2011). A future item that delicately inquires about the student’s level of independence could be useful during motivational analysis.

In considering the survey item that asks *You have to be smart to be a biologist*, the author wondered what the question might reveal about the person answering it. Would a smart person be more likely to agree or disagree with the statement? What about a less intelligent person? How much is the answer impacted by spending time with actual biologists? How would a biologist answer the question? It would be interesting to find a group of biologists who would be willing to take the Perceptions of Biology and Biologists part of the survey. How do they perceive themselves and their work?

The majority of the data collected for this thesis was quantitative. A qualitative examination of students’ views and perceptions would be insightful. It would also provide a better understanding of why participants selected their responses to certain items and may help explain the discrepancies between this research and the motivation literature. A better understanding of how to teach biology to Millennials is the ultimate goal of this thesis.

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APPENDIX A: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

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

Notification of Exempt Certification

From: Social/Behavioral IRB
To: Kristi Walters
CC:
Grant Gardner
Date: 6/20/2012
Re: UMCIRB 12-001112
Motivation Based Groups

I am pleased to inform you that your research submission has been certified as exempt on 6/20/2012. This study is eligible for Exempt Certification under category #1.

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

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

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

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

APPENDIX B: PARTICIPANT PERMISSION LETTER

Principle Investigator:
Grant E. Gardner, Ph.D.
Department of Biology, N403 Howell Science Complex
Greenville, NC 27858-4353
252.328.9842 (office)
252.328.4178 (fax)
gardnerg@ecu.edu

Title of Study: *The impact of collaborative group organization on biology students' affective perceptions of science and scientists*

Participation:

We are inviting you to participate in an educational research study as a part of your enrollment in BIOL1150 this semester. The purpose of this study is to exam the impact of the structure of collaborative group work on your motivations in science classes, your perceptions of science and scientists, and your academic achievement. The goal is to use this information to refine future classroom instruction.

You participation within collaborative groups both in and out of class and your responsibilities to your other group members are spelled out in the course syllabus and are a required part of this class. However, taking the survey instruments is optional as it is part of the research study and refusing to participate will not impact your grade in any way. Survey instruments that are optional will be clearly marked and you have the right to choose not to participate or to stop participation at any time without penalty. In addition, by signing this consent form you agree to release your final course grade as a data source for use in the study.

If you do not understand any aspect of this document, it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided for your records. If at any time you have questions about your participation, do not hesitate to contact Dr. Grant Gardner (contact information at the top of the page).

Risks and Benefits:

There are no anticipated risks involved in participating in this study. Information from this study may provide insights into best practices in biology teaching. Participation in the research components of this course is not a course requirement and your participation or lack thereof will not affect your class standing or grades. You may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is complete your data will be returned to you or destroyed at your request.

Confidentiality:

No names will be used in the study and your responses will be anonymous and reported as aggregates. The information in the study records will be kept strictly confidential. Data will be stored securely in a locked filing cabinet. No reference will be made in oral or written reports that could link you personally to the study.

Contact:

If you have questions at any time about the study or the procedures, you may contact the researcher, Grant Gardner using the information above. If you feel you have not been treated according to the description in this form, or your rights as a participant in research have been violated during this course of this project, you may contact the University & Medical Center Institutional Review Board, phone: 252.744.2914, fax: 252.744.2284, email: umcirb@ecu.edu, website: www.ecu.edu/rgs/irb.

Title of Study: *The impact of collaborative group organization on biology students' affective perceptions of science and scientists*

“I have read and understand the above information. I have received a copy of this form for my records. I agree to participate in this study with the understanding that I may withdraw at any time.”

Subject’s Signature:____
Date:________________________

Subject’s Printed Name: ____

APPENDIX C: PARTICIPANT GROUP EVALUATION

GROUP EVALUATION DOCUMENT

INSTRUCTIONS: *Please completely fill out the following document as honestly as possible for ALL THE INDIVIDUALS in your group INCLUDING YOURSELF. You DO NOT work as a group on this and individual results WILL NOT BE SHARED with other group members (only an aggregate score for each individual). EACH PERSON needs to hand in a copy to get credit. If you do not hand it in, you will receive a "0" on your self-evaluation scores. You only have to put an "x" in the box that best describes each individual's role. It is due by FRIDAY, NOVEMBER 30 @ 5:00pm as a digital document in my email. NO LATE EVALUATIONS WILL BE ACCEPTED.*

EXAMPLE QUESTION*:*
Question X*:* How well did this individual write?

	Sloppy, like a doctor	Ok, I guess	Well enough to read	Very clearly and concise
Joe Smith	X			
Jane Doe				X
John Brown			X	

WHAT IS YOUR NAME? ____

WHAT IS YOUR GROUP NUMBER? ____________________________________

Question 1: How was this individual's attendance at in- and out-of-class meetings?

Write/Type Group Member Names Here ↓	They were habitually absent	They missed more than two group meetings during the semester	They only missed one or two group meetings during the semester	They attended all group meetings

Question 2: How well did this individual participate in discussion and/or listen actively to other group members at in- and out-of-class meetings (including over emails)?

Write/Type Group Member Names Here ↓	They were inconsiderate of others' ideas. They frequently interrupted, ignored or dismissed others views.	They paid attention. They occasionally asked questions and built on others' comments. They sometimes needed encouraging.	Their body and verbal responses always indicated active listening. They often asked questions and built on others' comments.	They showed respect for and actively engaged others. They listened attentively. They consistently asked questions, asked for clarifications, and built on others' comments

Question 3: How well did this individual contribute to the group?

Write/Type Group Member Names Here ↓	They rarely provided useful ideas. They often refused to participate. They were rarely prepared for group work.	The sometimes provided useful ideas. They mostly did what was required, but sometimes did not participate. They were occasionally prepared for group work.	They usually provided useful ideas and asked questions. The demonstrated an effort to accomplish group work.	They routinely provided useful ideas and questions. They were a consistently active member of the group and always helped the group achieve its works goals.

Question 4: How was this individual's on-task behavior and time management skills?

Write/Type Group Member Names Here ↓	They consistently distracted the group with off-task behavior.	They exhibited on-task behavior some of the time, but were often off-task.	They exhibited on-task behavior most of the time.	They were always on task, and focused on efficiently completing the groups' work.

Question 5: In general, how effective was this individual in working with a group?

Write/Type Group Member Names Here ↓	Very ineffective.	Somewhat ineffective.	Somewhat effective.	Very effective.

Question 6: How well did this individual take up a particular role within the group?

Write/Type Group Member Names Here ↓	They did not engage in the performance of any productive group role.	When a role was assigned to them, they did the minimal task associated with that role.	They performed some roles well, but needed improvement with others.	They effectively and enthusiastically performed multiple roles within the group.

Please use this space to provide any other additional comments that will help me evaluate specific individuals within your group.

APPENDIX D: PRE-TEST INSTRUMENT*

Thank you in advance for taking this survey.

This survey is a critical part of this course as well as our University Foundations assessment. Please complete all questions to the best of your ability. If you do not know the answer to some of the biology content questions right away, THAT IS OK, just provide your best guess.

This survey is part of a large body of research. Your feedback will be used to help you and future students to learn more effectively in biology courses here at ECU. By taking the survey you agree to allow me to use this data to help you structure our class to maximize learning.

Please provide your ECU Banner ID. This survey is anonymous. This will only be used for us to help track pre- and post-survey scores at the end of the semester.

Which section of BIOL1150 are you currently enrolled?

- Section 001 9:30-10:45am
- Section 002 12:30-1:45pm

What is your gender?

Male	Female
○	○

With which group do you most identify?

- Caucasian
- African American/ Black
- Native American
- Hispanic/ Latino
- Asian
- Middle Eastern
- Pacific Islander
- Other or Mixed background

Your class standing?

- Freshman
- Sophomore
- Junior
- Senior
- Graduate

Have your taken or are you currently taking a college science course other than BIOL1150?

Yes	No
○	○

If so, which class(es) are you now taking or have previously taken? [Please list the course prefix and number; for example, this class is BIOL1150]

What is your major? If undeclared, please just type "undeclared"

What is your age?

Under 17	17	18	19	20	21	22	23	24	Over 24
○	○	○	○	○	○	○	○	○	○

This survey contains statements about your willingness to participate in this biology class. You will be asked to express your agreement on each statement. There are no "right" or "wrong" answers. Your opinion is what is wanted. Please be sure to answer each question (even if it is similar to another question).

	Strongly disagree	Disagree	No opinion	Agree	Strongly Agree
Whether the biology content is difficult or easy, I am sure that I can understand it.	○	○	○	○	○
I am not confident about understanding difficult biology concepts.	○	○	○	○	○
I am sure that I can do well on biology tests.	○	○	○	○	○
No matter how much effort I put in, I can't learn biology.	○	○	○	○	○
When biology activities are too difficult, I give up or only do the easy parts.	○	○	○	○	○
During biology activities, I prefer to ask other people for the answer rather than think for myself.	○	○	○	○	○
When I find the biology content difficult, I don't try to learn it.	○	○	○	○	○
When learning new biology concepts, I attempt to understand them.	○	○	○	○	○
When learning new biology concepts, I connect them to my previous experiences.	○	○	○	○	○
When I don't understand a biology concept, I find relevant resources that will help me.	○	○	○	○	○
When I don't understand a biology concept, I'd discuss with the teacher or other students to clarify my understanding.	○	○	○	○	○
During the learning process, I attempt to make connections between the concepts that I learn.	○	○	○	○	○
When I make a mistake, I try to find out why.	○	○	○	○	○
When I meet biology concepts that I don't understand, I still try to learn them.	○	○	○	○	○
When new biology concepts that I have learned conflict with my previous understanding, I try to understand why.	○	○	○	○	○
I think that learning biology is important because I can use it in my daily life.	○	○	○	○	○
I think that learning biology is important because it stimulates my thinking.	○	○	○	○	○
In biology, I think that it's important to learn to solve problems.	○	○	○	○	○
In biology, I think it's important to participate in inquiry	○	○	○	○	○

activities.					
It's important to have the opportunity to satisfy my own curiosity when learning biology.	○	○	○	○	○
I participate in biology courses to get a good grade.	○	○	○	○	○
I participate in biology courses to preform better than other students.	○	○	○	○	○
I participate in biology courses so that other students think I'm smart.	○	○	○	○	○
I participate in biology courses so the teacher pays attention to me.	○	○	○	○	○
During a biology course, I feel most fulfilled when I attain a good score on a test.	○	○	○	○	○
I feel most fulfilled when I feel confident about the content in a biology course.	○	○	○	○	○
During a biology course, I feel most fulfilled when I am able to solve a difficult problem.	○	○	○	○	○
During a biology course, I feel most fulfilled when a teacher accepts my ideas.	○	○	○	○	○
During a biology course, I feel most fulfilled when other students accept my ideas.	○	○	○	○	○
I am willing to participate in this biology course because the content is exciting and changeable.	○	○	○	○	○
I am willing to participate in this biology course because the teacher uses a variety of teaching methods.	○	○	○	○	○
I am willing to participate in this biology course because the teacher doesn't put a lot of pressure on me.	○	○	○	○	○
I am willing to participate in this biology course because the teacher pays attention to me.	○	○	○	○	○
I am willing to participate in this biology course because it's challenging.	○	○	○	○	○
I am willing to participate in this biology course because the students are involved in discussions.	○	○	○	○	○

Default Question Block

Please select the answer below that best describes your feeling toward the study of biology. There are no right or wrong answers.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I enjoy biology.	○	○	○	○	○
I typically do not do well in classes with biology topics.	○	○	○	○	○
Doing biology labs are fun.	○	○	○	○	○
There is little need for biology knowledge in most of today's jobs.	○	○	○	○	○
Biology is easy for me to understand.	○	○	○	○	○

Most people should study at least some biology.					
No matter how hard I try, I typically cannot fully understand biology concepts.					
Understanding biology is very important for us to remain competitive in today's global economy.					
It is important to know at least some biology in order to get a good job.					
I enjoy talking to other people about biology.					
I enjoy watching TV programs about biology.					
I am good at doing lab experiments in biology.					
You can get along perfectly well in life without any knowledge of biology.					
I remember most of the things I learn in biology classes.					
If I do not see how to complete a biology assignment right away, I will probably never understand it.					
Understanding biology is essential for understanding other coursework.					
Compared to other courses, biology is important to me.					
Topics in biology often seem strange to me.					
I enjoy learning about biology.					
When talking about biology I get bored.					
Biology is hard, but I like making an effort to understand it.					
I typically find topics in biology interesting.					
Understanding biology is not that important to me in my daily life.					
I like learning biology, because it makes me think.					
I think it is important to understand how biologists think and how they do their jobs.					
I might like to go into a biology-related field of work some day.					
The government should be providing more support for biology research.					
You have to be smart to be a biologist.					
I often think about issues in biology outside of school.					
Biology is just too difficult for me to understand.					
An appreciation for biology has generally made the world a better place.					
Biology makes me feel uneasy and confused.					
Biology makes me feel					

uncomfortable and nervous.

For the following adjectives, please slide the slider to indicate what you believe knowledge of biology to be to you personally. There are no right or wrong answers. KNOWLEDGE OF BIOLOGY IS:

	0	1	2	3	4	5
Personally Helpful (0) or Personally Harmful (5)						
Intriguing (0) or Unappealing (5)						
Confusing (0) or Enlightening (5)						
Relevant (0) or Irrelevant (5)						
Worthless (0) or Worthwhile (5)						
Frustrating (0) or Gratifying (5)						
Impossible (0) or Attainable (5)						
Practical (0) or Theoretical (5)						
Empowering (0) or Disempowering (5)						
Shallow (0) or Meaningful (5)						
Tentative (0) or Durable (5)						
Based on observation (0) or Based on ideas						
A single method (0) or Uses many methods (5)						
Certain (0) or Adaptable (0)						
Understandable (0) or Uncertain (5)						

Has patterns (0) or Chaotic (5)					
Answers all questions (0) or Answers some questions (5)					
Evidence-based (0) or Does not require evidence (5)					
Biased (0) or Unbiased (5)					
Ethical (0) or Unethical (5)					

For the following adjectives, please slide the slider to indicate what you believe knowledge of biology to be to you personally. There are no right or wrong answers. BIOLOGISTS ARE:

	0	1	2	3	4	5
Sloppy (0) or Neat (5)						
Intelligent (0) or Stupid (5)						
Unimaginative (0) or Creative (5)						
Altruistic (0) or Selfish (5)						
Lazy (0) or Hardworking (5)						
Antisocial (0) or Outgoing (5)						
Boring (0) or Interesting (5)						
Humane (0) or Unkind (5)						
Exclusive (0) or Inclusive (5)						
Objective (0) or Subjective (5)						
Ethical (0) or Unethical (5)						

Socially Responsible (0) or Irresponsible (5)					
Moral (0) or Immoral (5)					
Problem-solvers (0) or Trouble-makers (5)					
Logical (0) or Illogical (5)					
Honest (0) or Dishonest (5)					
Skeptical (0) or Gullible (5)					
Spiritual (0) or Atheistic (5)					
Patient (0) or Impatient (5)					
Female (0) or Male (5)					
Consensus-builders (0) or Cannot Agree (5)					

As a non-science major, how do you rate your ability to be successful in science classes.

- Very good
- Good
- Okay
- Fair
- Not good

What is the relationship among genes, DNA, and chromosomes?

- Genes are composed of DNA and lie within chromosomes.
- Genes are separate entries from either DNA or chromosomes.
- Genes are found only in chromosomes and not DNA.
- Genes are found only in DNA and not chromosomes.
- Genes are composed of chromosomes and lie within DNA

Adult height in humans is partially determined by our genes. When environmental conditions are held constant, humans have a wide variety of heights (not just short, medium, and tall). Height is probably influenced by:

- one gene with two alleles.
- a single recessive gene.
- a single dominant gene.
- several genes.
- only paternal genes.

Our understanding of how genes function indicates that:

- different species of organisms use different genetic mechanisms for producing individuals traits.
- there are no interactions among genes in producing individuals traits.
- gene products can be carbohydrates, fats, or proteins.
- genes do not produce specific products, but code directly for individual traits.
- genes code for proteins, which in turn produce individual traits.

Which of the following is INCORRECT regarding meiosis?

- It occurs only in species of organisms that have sexual reproduction.
- It halves the chromosome number in reproductive cells.
- It provides for genetic variation in the offspring.
- It occurs in most body cells at some time during the life of the individual.
- It keeps the chromosome number constant from generation to generation.

Sometimes a trait seems to disappear in a family and then reappear in later generations. If neither parent has the trait, but some of the offspring do, what would you conclude about the inheritance of the trait?

- Both parents are carriers of the recessive form of the gene.
- Only one parent has two copies of the recessive form of the gene.
- Only one of the parents has a dominant form of the gene.
- Only one of the parents has a copy of the recessive form of the gene.
- It is most likely the result of new mutations in each parent.

Mutations in DNA occur in genomes of most organisms, including humans. What is the most important result of these mutations?

- They produce new genes for the individual.
- They produce new enzymes for the individual.
- They provide a source of new cells for the individual.
- They provide a fundamental source of genetic variation for future generations.
- They produce new chromosomes for future generations.

Many geneticists study the genetic material of organisms such as mice, fruit flies, and yeast. They are able to apply what they learn from these organisms to humans because virtually all different types of organisms:

- have DNA as their genetic material.
- have the same genetic code.
- have the same amount of genetic material.
- answer choice 1 & 2 are correct
- all of the above are correct

Which of the following is a characteristic of mutations in DNA?

- They are usually expressed and result in positive changes for the individual.

- They are usually expressed and cause significant problems for the individual.
- Those that occur in the body cells of a parent are usually passed on to their children.
- They usually occur at very high rated in most genes.
- They result in different versions of a gene within the population.

What is the relationship between DNA and chromosomes in higher organisms?

- Chromosomes are found within DNA.
- DNA is found within chromosomes.
- There is no difference between DNA and chromosomes.
- DNA and chromosomes are completely separate structures.
- Chromosomes produce DNA.

How is the expression of genes regulated or controlled?

- The expression of genes is not regulated or controlled.
- Genes are turned on during development and stay on throughout ones life.
- Genes are only turned on and off during development.
- Genes are turned on and off at appropriate times throughout one's life.
- The expression of genes is only controlled by external factors.

What effect, if any, does an individual's environment have on the development of his or her traits?

- It has little or no effect on most traits in an individual.
- it sets the potential for the development of most traits in an individual.
- It affects to varying degrees most traits in an individual.
- It is a dominant factor for determining most traits in an individual.
- It does not have any effect on an individual's traits, but can have an effect on the traits of an individuals offspring.

Your muscle cells, nerve cells, and skin cells have different functions because each kind of cell:

- contains different kinds of genes.
- is located in different areas of the body.
- activates different numbers of genes.
- contains different number of genes.
- has experienced different mutations.

What is the relationship between genes and traits expressed in individuals?

- Genes code for DNA, which is responsible for individual traits.
- Genes code for proteins, which are responsible for individual traits.
- Genes code for chromosomes, which are responsible for individual traits.
- Genes code for carbohydrates, which are responsible for individual traits.
- The environment rather than genes is primarily responsible for individual traits.

The muscle cells of humans contain 46 chromosomes. How many chromosomes do unfertilized human egg cells contain?

- 11
- 22
- 23
- 46
- 92

Please select an option to indicate your thoughts regarding the following statements.

	Strongly disagree	Disagree	Don't know	Agree	Strongly Agree
The primary goal of modern biology is to explain natural phenomena.	○	○	○	○	○
A conclusion is a statement of what was observed in an experiment.	○	○	○	○	○
To be scientific, hypotheses must be testable.	○	○	○	○	○
A well-supported theory becomes a law.	○	○	○	○	○
Current scientific theories portray nature more accurately than those they replaced.	○	○	○	○	○
Scientists think atoms exist primarily because they have seen them through powerful microscopes.	○	○	○	○	○
Hypotheses are derived from controlled observations of nature.	○	○	○	○	○
A hypothesis is a prediction of what will be observed in the future.	○	○	○	○	○
Hypotheses/theories can not be proved to be true beyond any doubt.	○	○	○	○	○
A well-supported hypothesis becomes a theory.	○	○	○	○	○
Explanations that seem reasonable and make intuitive sense need not be tested.	○	○	○	○	○
Coming up with hypotheses requires creative thinking.	○	○	○	○	○

Biological communities:

- ○ have distinct and well-defined borders.
- ○ are relatively simple biological systems.
- ○ exist in terrestrial but not aquatic habitats.
- ○ usually do not include bacteria and fungi.
- ○ are groups of organisms that rely on each other for food and nutrients.

Photosynthesis:

- ○ is carried out by green plants, fungi, and cyanobacteria.
- ○ actively transports glucose molecules into cell chloroplasts.
- ○ is a process that occurs in leaves, stems, and roots of green plants.
- ○ uses solar energy to combine CO2 and H2O molecules.
- ○ produces products similar to cellular respiration.

All but which of the following statements are true about biogeochemical cycles?

- ○ They include biotic and abiotic components.
- ○ They can influence many ecosystems.
- ○ They involve the recycling of biologically important atoms and molecules.
- ○ They are limited primarily to plant-soil interactions.
- ○ They can illustrate pathways that energy and elements take as they pass through biological systems.

When a tree grows bigger, most of the new tree material comes from

- the sun.
- the soil.
- the air.
- the seed.

Food chains:

- seldom include herbivores.
- typically start with plants.
- typically end with an omnivore.
- are usually more complex than food webs.
- usually include predators but not prey.

Animal species:

- usually refers to individual organisms.
- typically can breed with other species in nature.
- refers to organisms similar enough to produce fertile offspring.
- have binomial names that are usually written in French
- are diverse and number from 10 to 12 thousand.

* Six of the knowledge questions adapted by Gardner from Vance-Chalcraft's assessment have been removed for publication, as they may have been from a copyrighted test bank.

BIOGRAPHICAL SKETCH

I was born in a small town in rural Massachusetts, and even though the coast was hours away, I fell in love with the ocean at an early age. In 1994, I received my Bachelor of Science in Marine Biology from Roger Williams University in Bristol, Rhode Island. After graduation I worked as a naturalist at a variety of nature centers, aquariums, and environmental education camps. When that path was no longer paying the bills, I accepted a position with a software company and began teaching their programs as a travelling instructor. I met my future husband on an airplane during a business trip, and we eventually moved to Greenville, North Carolina. As the coast was once again hours away, I decided to return to school and earn a more applicable degree for my new city. I enrolled part time at East Carolina University in 2007. After a couple program changes, I finally found my home in the Department of Biology in 2011. Graduate school has been a long journey with a number of stops along the way (*e.g.,* marriage, two kids, two dogs, a cat, and a goldfish), but I am excited to reach the end.