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MOTIVATION AND GENDER DYNAMICS IN HIGH SCHOOL SCIENCE: THE EFFECT OF GENDER COMPOSITION ON MOTIVATION IN SMALL GROUP INQUIRY AND ENGINEERING TASKS

Julie Robinson

MOTIVATION AND GENDER DYNAMICS IN HIGH SCHOOL SCIENCE: THE EFFECT OF GENDER COMPOSITION ON MOTIVATION IN SMALL GROUP INQUIRY AND ENGINEERING TASKS

A Dissertation Presented

by

JULIE R. ROBINSON

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DEDICATION

To my supportive family, who believed in me throughout my entire graduate experience.

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ABSTRACT

MOTIVATION AND GENDER DYNAMICS IN HIGH SCHOOL SCIENCE:
THE EFFECT OF GENDER COMPOSITION ON MOTIVATION IN SMALL GROUP INQUIRY AND ENGINEERING TASKS

FEBRUARY 2018

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While current research shows that the gender gap in science achievement has disappeared (Miller, Blessing, & Schwartz, 2006), girls continue to show declining levels of STEM (science, technology, engineering, and math) engagement in school. Literature shows that various societal and educational factors impact girls' STEM motivation disproportionately to boys (Bennett & Hogarth, 2009; Breakwell & Robertson, 2001; Brotman & Moore, 2008; Campbell & Clewell, 1999; Cokadar & Kulce, 2008; Huebner, 2009; Jovanovic & King, 1998; Lee, 1998; Miller, Blessing, & Schwartz, 2006; Osborne, Simon, & Collins, 2003; Solomon, 1997). The onset of this phenomenon occurs in the middle school years (AAUW, 1994; Bennett & Hogarth, 2009; Brotman & Moore, 2008; Galton, Gray, & Ruddock, 2003; Murphy & Whitelegg, 2006; Scantlebury & Baker, 2007; Solomon, 1997) and is compounded throughout high school and beyond by additional barriers, including societal stereotypes and mismatched values between females and the STEM community (Davis, 2001; Davis, 2002; Hill, Corbett, & St. Rose, 2010; NRC, 2007; Solomon, 1997). Ryan and Deci's Self-Determination Theory (2000a, 2000b) provides a meaningful framework to explore this phenomenon by asserting that

the conditions of relatedness, autonomy, and competence must be present for an individual to experience intrinsic levels of motivation. Science classrooms allowing students to work in cooperative groups on tasks that offer a high level of autonomy and an appropriate level of scaffolding could thus provide an optimum scenario for increased motivation. Yet, individuals must also feel that they are legitimate members of these groups (relatedness) in order for the condition to have a positive effect on motivation. According to the Stereotype Inoculation Model (Dasgupta, 2011a), individuals are more likely to show motivation in a particular domain when they can identify with their in-group peers, especially when those peers are also viewed as experts. This model posits that gender majority may provide this condition for girls in small science groups, allowing them to transcend stereotypes that have inhibited their STEM engagement and creating a scenario in which they are better able to view their possible selves as members of that group, thus increasing their levels of motivation within that context.

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CHAPTER I

GIRLS MOTIVATION IN STEM

Introduction

For over fifty years, researchers and educators have grappled with the issue of achievement, attitude, and gender representation in both science classes and in science fields. Through such research has emerged two critical and consistent trends: an alarming decrease in students' overall interest in science and a significant under-representation of females studying science and pursuing careers in fields of science (Harding, 1998; Hill, Corbett, & St. Rose, 2010; Jones, Howe, & Rua, 2000; NRC, 2007; Osborne, Simon, & Collins, 2003). In other words, not only are all students showing decreased motivation in science over the course of their schooling, but this phenomenon is impacting girls disproportionately. To fully understand this situation, one must explore not only the characteristics of science instruction in our schools today but also the societal, gender, and cultural identities that help shape and determine the choices girls make in their schooling and beyond. Further, as schools and standards shift towards science instruction that is more integrated with technology and engineering and with significant discrepancies between gender interest and participation occurring in these areas as well (Hill, Corbett, & St. Rose, 2010; NSF, 2011) current research and literature must examine females' motivation within the broader context of STEM (science, technology, engineering, and math), not just the traditional sciences, in order to make sense of this continuing phenomenon.

Most students, both boys and girls, enter their first years of school with an innate interest in science and exploring the world around them and both report equally positive attitudes towards science in the world and in the classroom (Vanmali & Abell, 2009). Yet in early adolescence, between the ages of nine and fourteen, children show a notable change in attitude which has been documented over years of research. Both genders begin to view science in a less positive light, with girls showing this trend much more strikingly than boys (Bennett & Hogarth, 2009; Breakwell & Robertson, 2001; Brotman & Moore, 2008; Campbell & Clewell, 1999; Cokadar & Kulce, 2008; Huebner, 2009; Miller, Blessing, & Schwartz, 2006; Jovanovic & King, 1998; Lee, 1998; Osborne, Simon, & Collins, 2003; Solomon, 1997).

Despite this gender disparity in interest, however, STEM achievement, grades, and standardized test scores do not show a significant difference between boys and girls at any grade level. In fact, girls even outperform their male counterparts in some scientific domains (Britner, 2008; Miller, Blessing, & Schwarz, 2006). Yet this balance in achievement does not translate to an overall increase in girls' self-efficacy and interest in science. Even adolescent girls who are considered by their teachers as academically gifted in STEM domains report that their strengths are in verbal areas and do not identify as strong science students (Jacobs, Finken, Griffen, & Wright, 1998; Miller et al., 2006). With self-efficacy as a primary predictor of girls' choosing future science opportunities (Britner, 2008), science achievement would seem to, therefore, provide an impetus for girls to go on to pursue courses or careers in science fields. Yet, research shows that this simply is not the case.

Not only do girls show less confidence and investment in science, but their overall participation, including their behaviors and manner of interacting in science, both in school and out, changes in quality as well (Huebner, 2009; Jones, Howe, & Rua, 2000;

Jovanovic & King, 1998). The onset of this decline can be pinpointed to the transition to the middle school years and continues at an exponential rate throughout high school and beyond (AAUW, 1994; Bennett & Hogarth, 2009; Britner, 2008; Brotman & Moore, 2008; Galton, Gray, & Ruddock, 2003; Murphy & Whitelegg, 2006; Scantlebury & Baker, 2007; Solomon, 1997). By the time girls have entered high school, their science classroom behaviors rarely reflect interest and motivation with science content and processes but are more stereotypically gendered behaviors: participating far less frequently than boys (Shakeshaft, 1995), deferring the hands-on work to their male classmates (Jovanovic & King, 1998), and choosing to pursue "softer" science classes rather than physics, chemistry, or engineering (Britner, 2008; Burkam, Lee, & Smerdon, 1997). Thus, a trend begun in the middle years of schooling can be observed to continue similarly for years beyond, with the ultimate stage of this phenomenon occurring as the under-representation of women in many STEM fields and in the greater scientific community (Bennett & Hogarth, 2009; Brotman & Moore, 2008; Dasgupta & Stout, 2014; Hill, Corbett, & St. Rose, 2010, NRC, 2007).

Women remain an untapped resource in STEM as a whole and represent underutilized reserves of scientific talent (Britner, 2007). One of the most compelling arguments for increasing the number of women scientists is simply that it will enrich the research being conducted in any field when women become integral participants in the work (Campbell & Clewell, 1999). Sandra Harding (1998) argues that the inclusion of women's voices, perspectives, and approaches to scientific research will broaden the scope and quality of the knowledge, research, policies, movements, and initiatives that arise from their contributions. She asserts that women will bring unique perspectives based on their societal roles and experiences that have long since been absent in scientific research projects. Thus, not only will advancing the careers of women scientists increase the number of intelligent and capable of scientists available in any field, it will expand the work being done in those fields by including the female perspective (Harding, 1998). Further, while scientific knowledge may be considered objective and universal, Nancy Brickhouse (2000) draws on the work of feminist research and epistemology to describe how science is in actuality knowledge created within a cultural and societal context. Thus, historically-speaking, much science knowledge and methodology is grounded in a Western masculine orientation, which serves to further marginalize both women and non-Western cultures. There are two equally important assertions, therefore: to include a greater representation of women in the creation of scientific knowledge and to elucidate the perspective and societal context that this knowledge reflects. In this way, the feminist perspective in any scientific research is not only included, it is valued both in terms of its role in the process and in the research's implications.

While it is true that the gender gap in science careers has closed in closed in some areas, this is hardly the case for STEM as a whole, and little change is observed in the statistics over recent years. According to the data from the American Association of University Women (2010), the National Science Foundation (2011), and the National Science Board (2016), only in select fields of STEM, such as psychology, medical sciences, biosciences, and social sciences, do women show comparable representation to men, and this typically represents a combination of a modest increase in women as well as a decrease in men participating in these fields. Across all STEM fields combined, women represent less than thirty percent of the college-educated work force. Further, in fields such as physical sciences, mathematics, computer sciences, and engineering, women remain a dramatic minority, representing less than ten percent of the workforce. These statistics become even starker when intersected with an examination of the minute percentage of minority women in these fields, who represent less than fifteen percent of fields more commonly occupied by women and a scant three percent or less in engineering. Additional reports (NRC, 2007; NSF, 2017) show similar findings in university settings: women hold far fewer faculty positions than men in fields of science. What is more, these women who have broken through the barriers and earned faculty positions in the sciences represent only a small percentage of the women who have degrees in science and are qualified to hold such careers. In other words, of the already small group of women pursuing a science education, even fewer actually go on to fulfill science careers either in the field or in a university. Like passing through a funnel, one might argue, women's access into science decreases over the course of their lives. This phenomenon, in fact, has earned the name, “the leaky pipeline”, which has become a commonplace term in current literature – as girls and women journey through the pipeline of science education and experiences, more and more are lost through leaks along the way with only a fraction remaining at the end.

The issues revolving around girls' and women’s participation in STEM are multi-dimensional, complex, and interdependent. To begin to make sense of these many layers, one should first begin by looking at the various systems that interact to help shape the identities of girls in our society and how this impacts their engagement with science. Knowing that overall science interest shows its first most dramatic decline in early adolescence, most specifically in the middle school grades, an examination of the factors that lead up to this decline as well as those which affect girls' engagement with science during the middle and high school years will provide a longitudinal perspective of this trajectory.

The learning and development of an individual occurs in the context of various systems that co-exist in a “nesting” pattern (Brofenbrenner, 1994), beginning with an individual’s interactions with immediate family and peers and radiating outwards to include influences from society and cultural contexts and their interactions over time. Using this framework, the development, therefore, of girls’ identities occurs not in isolation or at one specific point but rather in relation to their on-going interactions with their families, schools, and peers; with the interactions between these elements; through influences from greater societal and cultural influences; and through the impact of these interdependent systems on the development of girls over time. In addition, girls respond to the feedback and reinforcement provided to them through the various systems and influences in their lives by making choices and demonstrating behaviors and attitudes that most closely match the identities expected of them.

Brotman and Moore (2008), in their review of current literature discussing girls' participation in STEM, have identified four themes that are most prevalent in the research that seeks to make sense of girls' declining engagement: equity and access, curriculum and pedagogy, the nature of science, and identity. Clearly, these themes reflect the previously-discussed systems of family, school, and peers and their impact on a girls' identity. It becomes challenging, however, to dissect these themes and draw lines between them; the reality is that they influence and often reinforce each other in a bidirectional manner. Further, Dasgupta and Stout (2014) assert that the factors contributing to gender disparities in STEM are distinct at different developmental stages of a female's life. This paper will focus on the factors that emerge from these various systems through childhood and adolescence, their effect on a girl's science access and identity development, and their impact on girls' involvement in STEM as a whole. Through this lens, this discussion of girls' science motivation will occur within the framework of "Society and Family" and "Education" and these systems' impact on "Identity Development" rather than as isolated topics, such as is seen in Brotman and Moore's review (2008). This organization of themes more effectively reflects the breadth and truly interdependent nature of these factors and their impact on girls' participation in STEM. Many common factors will emerge across these thematic lines yet also in different contexts. All of these factors in combination, however, impact a girls' sense of identity within the realm of science. As such, the role of stereotypes becomes relevant throughout each larger theme. It becomes critical, therefore, to examine these themes as threads throughout the various systems in a girls' life and the manner in which they result in a girls' self-concept.

Society and Family

One of the most fundamental roots of girls' declining engagement with science comes from the societal expectations that they are facing throughout their whole lives. So ingrained in our psyche is the notion that science is a masculine endeavor that individuals often do not even recognize the stereotypical images and differential treatment to which girls are constantly being exposed. Compounding this issue further is the fact that stereotypes of scientists co-exist with stereotypes of girls and women resulting in two combating societal constructs. A dramatic example of this is the manner in which media and popular culture portray the image of a scientist, both masculine and feminine. The vision of scientists as quirky, obsessive, solitary men (Buldu, 2006; Darbyshire, 2009; Rohn, 2007) has become so commonplace in our societal views that most students, when asked to draw a picture of a scientist, will create a picture that resembles the stereotypical Dr. Frankenstein. The Draw-A-Scientist Test or DAST (Chambers, 1983) has become a replicated tool of research, used for over forty years now in different incarnations and is often also used in science classrooms for uncovering how students view and perceive the identity of a scientist. Time and again, the results of this test show that students' constructs of scientists, especially those created by boys, include characteristics of masculinity, isolation, and eccentricity (Buldu, 2006; Campbell and Clewell, 1999; Darbyshire, 2009; Rohn, 2007). Despite years of attempts to reform this perception, current research still indicates that stereotypical images of scientists among students have persisted and that media representations of scientists often still promotes these traits in popular culture (Bayri, Koksal, & Ertekin, 2016; Christidon, Bonoti, & Konopoulou, 2016; Karacam, 2016).

Historically, when women are portrayed as scientists in the media, their image was often no more attractive. These women were typically loners, spinsters, and considered overly outspoken and demanding (Darbyshire, 2009). The image of a scientist, both male and female, to which many students were being exposed throughout their childhood, therefore, has been one to which few girls would aspire. Recent literature suggests, however, that the portrayal of female scientists in the media and popular culture is perhaps making a shift. In an update to her prior work (Steinke, 2005) examining the representation of female scientists in popular culture, Jocelyn Steinke and her colleagues (2010) found that these images are beginning to present more comparably to that of men. While images of male scientists still far outnumber that of women, fewer stereotypically gendered characteristics are being depicted, with both men and women more often showing equal professional status, intelligence, and family responsibilities. As previously described, however, these images have yet to visibly impact the ingrained perceptions students still maintain of scientists. It may take a great deal of time and continued attention and exposure to these more positive depictions for a change to occur.

Not only does society promote the image of a scientist as masculine, the experiences that children bring to school in terms of toys, family interactions, and trips are often gender-based as well. Because of this, society continues to reinforce, whether consciously or unconsciously, situations that encourage boys to take a greater part in STEM activities than girls. Parents act as additional conduits of societal messages and exert a huge influence over how their children view themselves and their capabilities (Breakwell & Roberston, 2001, Dasgupta & Stout, 2014). Most parents view science and scientific careers as masculine endeavors. They have higher expectations of their male children in domains of science and provide many more STEM-related opportunities for them (Vanmali & Abell, 2009). Therefore, boys much more frequently enter school having been provided with toys and experiences at home that encourage informal science and tinkering, whether it is laboratory equipment, tools, building materials, or model kits. They are more likely than girls to be encouraged to help their parents with hands-on projects and work (Jones, Howe, & Rua; Osborne, Simon, & Collins, 2003; Shakeshaft, 1995; Yanowitz & Vanderpool, 2004). The science experiences many girls do report tend to involve animals, gardening, and other aspects of life science as opposed to physical sciences, technology, or engineering. These greater levels of informal science experience have a strong correlation to feelings of confidence in the realm of formal science, with boys consistently showing higher levels of confidence in science and engineering at the middle school and high school levels. Of great interest is the discovery that, when prior science experience is controlled for in statistical analysis, the difference in confidence means between boys and girls disappears (AAUW, 2010).

A quantitative study done by Kahle and Lakes (1983) aimed to validate this discrepancy by surveying girls and boys about both their interests and background experiences with regard to informal science. They discovered that at age nine, girls still expressed an equal (or greater) desire as boys to engage with scientific experiences and field trips, but reported far fewer of these experiences than did the boys. There was a dramatic discrepancy between the genders in terms of their experiences handling scientific equipment, taking apart and manipulating toys and mechanical objects, making scientific observations, and visiting sites deemed as scientific.

By age thirteen, the girls in this study continued to report fewer of these experiences than boys, but at this point there was another difference. Girls no longer were as interested in being provided with such experiences. They had begun to question their own self-efficacy in science, showed much more negative attitudes towards both educational and extra-curricular science, and had developed a very narrow scope of the nature of science. The authors (Kahle & Lakes, 1983) concluded that their lack of scientific experiences led to a limited perception of science and their role in it. While this study occurred some thirty-four years ago, it remains a relevant to a current study of girls’ participation in science in that it both exemplifies and elucidates the process of girls’ disengagement, which has not disappeared. Further, its relevance and findings continue to be cited by research today.

The impact of parental stereotyping and influence does not end in the early years of schooling, however. At the high school level, familial beliefs and expectations continue to have a strong impact on the choices girls make with regard to academic domains (Dasgupta & Stout, 2014). Solomon (1997) asserts that family culture, particularly the gendered roles that the parents may or may not play within the household, has a significant effect on their daughters’ decision to pursue physics. Further, parents often do not believe that science interest (or lack thereof) at this developmental stage can be changed or increased in females, so they do not tend to try to influence their daughters towards this end. A study by Janis E. Jacobs and her colleagues (1998) exploring the career plans of science-talented high school girls confirmed that mothers’ expectations of women’s roles in science in conjunction with their beliefs about their daughters’ science competencies had a direct correlation to the aspirations of the participants to pursue careers in science.

The interaction, therefore, of societal stereotypes of scientists with societal and familial stereotypes of the girls’ interests and competencies serves to create a lack of congruence that persists from early childhood through adolescence, greatly impacting the choices adolescent girls make in their high school, college, and career plans.

Education

This differential treatment of the genders in realms of STEM outside of the classroom, while perhaps not fully impacting girls' attitudes until the middle school years, is transferred seamlessly into the science classroom and often impacts the teachers' treatment of boys and girls. Copious research has examined the experiences of girls at different ages in the science classroom in terms of engagement, participation, attitude, curriculum, and teacher-interactions.

Perhaps most alarming is the consistent data showing, even in classrooms deemed as exemplary for their science instruction, that girls and boys do not have equal access to STEM education (Bennett & Hogarth, 2009; Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001; Dasgupta & Stout, 2014; Jovanovic & King, 1998; Lee, 1998; Osborne, Simon, & Collins, 2003; Shakeshaft, 1995; Vanmali & Abell, 2009). Stemming once again from stereotypical societal expectations and differing science experiences, girls and boys tend to enter the classroom with different levels of STEM background and are recognized for different traits in the classroom. Boys enter school with a greater sense of confidence in the domains of science and engineering and feel more comfortable manipulating materials, asking questions, and challenging ideas. Because this outgoing behavior is more typical for boys across all areas of the curriculum, with some research saying that "male participation is eight times more than female" (Shakeshaft, 1995, p. 77), it is even more exacerbated in science classrooms where many boys already have the upper hand with greater scientific confidence and prior experiences. Teachers also reinforce this behavior by having higher expectations for deeper levels of thinking and problem-solving in science for boys than girls (Shakeshaft, 1995). The concept, then, of a successful male science student is one who is outspoken, highly involved, and readily questioning and challenging ideas.

This, however, does not match the notion of a successful female STEM student. Research shows that teachers consider girls to be successful in science when they are hardworking, responsible, behaviorally appropriate, and on-task (Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001; Campbell & Clewell, 1999; Robinson, 2012; Shakeshaft, 1995). Girls who question the ideas or tasks presented or who follow their own line of investigation rather than the activity laid out are considered difficult and, at times, annoying (Brickhouse & Potter, 2001; Shapiro, 1994). Despite the apparent engagement that an inquisitive and exploratory girl might exhibit in the science classroom, these often are not the girls that a science teacher considers the highest achievers or best students (Robinson, 2012). As such, and likely due to differences in prior science and engineering experiences, girls are more likely to use materials in strict adherence to the teacher's directions and to the task. Gail Jones and her colleagues (Jones, Brader-Araje, Carboni, Carter, Rua, Banilower, & Hatch, 2000) found significant gender differences in the manner in which boys and girls played and tinkered with tools in the STEM classroom, with boys far more likely to invent and explore and girls highly bound to the parameters of the activity the teacher had provided.

Teachers also reinforce this behavior by having lower expectations for girls in terms of the depth of their understanding and ability to grapple with ideas, by having higher expectations for polite and reticent behavior, and by "letting them off the hook" more frequently when they are struggling with solving problems (Shakeshaft, 1995, p. 77). Girls then see their success in STEM, not as a process by which they explore their world and build meaning and theories out of their own investigation and research, but through their ability to complete their assignments neatly and on time and to please their teacher (Robinson, 2012). They are more apt to “follow the rules rather than invent them” (Brickhouse, Lowery, & Schultz, 2000, p. 441).

Jovanovic and King (1998) examined the participation of middle school-aged boys and girls in a number of highly respected science classrooms in which the primary mode of instruction was hands-on learning, which was considered to be an “equalizer by compensating for the disparities between boys’ and girls’ experiences outside of school” (Jovanovic & King, 1998, p. 478). Through carefully coded classroom observations as well as student interviews, these researchers sought to uncover if girls experienced the science classroom and their science education equally to boys in this model. In this mixed-design study, they learned that both boys and girls showed an equal tendency to take leadership roles in their mixed-gender groupings and that a higher level of leadership correlated strongly with higher levels of self-efficacy and more positive attitudes on the part of both boys and girls by the end of the school year. However, girls overall showed a decrease in self-efficacy and attitude as compared with boys and were consistently shown to manipulate the scientific materials less frequently than the boys in their groups, taking on more passive roles such as note-taker in these situations. While the hands-on experience seemed to allow girls to feel more interested in science in the moment, it did not serve to truly change the notion that science is for boys and did not contribute to an overall increase in the girls’ positive attitude towards science.

Another contributing factor to girls’ declining interest in STEM is the quality and style of the instructional pedagogy. While the classrooms in Jovanovic and King’s (1998) study utilized a hands-on approach, these were carefully selected classrooms considered exemplary for their instruction. Consider those classrooms in which there is even less emphasis on equity and engagement. High stakes testing and existing school structures often lead to a more rigid, teacher-directed classroom environment that does not inherently appeal to girls' learning styles, in which collaboration, discourse, choice, and content-relevance are critical (Osborne, Simon, & Collins, 2003). Some scholars argue that school science instruction actually eliminates any inherent interest girls may have in science by its incongruence with the manner in which many girls (and, often, students in general) best learn (Osborne, Simon, & Collins, 2003).

Science education has been historically a masculine endeavor, and today's science and engineering instruction still bears remnants of its gendered past. Looking back to the context of Western education in the 19^{th} and 20^{th} centuries, science was considered necessary for boys in order to prepare them for their future vocations. It was simultaneously seen, however, as "a threat to a girls' health and her virtue" (Scantlebury & Baker, 2007, p. 259). Girls' education during this time was designed to prepare them for their expected roles in society (bearing in mind that these were specific to girls in the middle and upper classes). Science content that was made available to girls was limited to only that which was considered appropriate for "drawing room conversation", certainly not for future or career purposes, and further limited to only content within the biological sciences (Murphy & Whitelegg, 2006; Scantlebury & Baker, 2007). While girls' participation and achievement in high school science increased for a short period at the turn of the century, this experienced an abrupt halt with the onset of the Great

Depression. Stereotypical gender roles became reinforced and access to science education was limited for girls due to the cost of the educational materials.

Though attempts have been rigorous and varied since the late 20th century to increase all students' access and achievement in STEM, particularly now with many states' adoption of the Next Generation Science Standards (NGSS Lead States, 2013) and its emphasis on an integrated science and engineering curriculum, STEM education still bears remnants of its masculine past. High school classes often continue to present a narrow view of science content and ideas, and pedagogy still favors a dry and disconnected delivery of these concepts, which many girls feel makes science hard and un-engaging (Brotman & Moore, 2007). Further, the role of engineering remains inconsistent in many classrooms, despite the call of NGSS. While it is true that this curricular shift may still novel for both teachers and students, literature indicates that professional development and support for pre-service teachers in the area of engineering education remain limited (Hammack & Ivey, 2017). Many teachers report feeling unprepared and unconfident in their abilities to teach engineering, both in terms of content and pedagogy, with female teachers showing significantly lower engineering self-efficacy than their male counterparts (Hammack & Ivey, 2017). As teacher self-efficacy is found to greatly impact student motivation, success, and classroom behaviors (Cakiroglu, Capa-Aydin, & Woolfolk Hoy, 2012; Mojavezi & Tamiz, 2012), this finding has alarming implications for how girls may experience and respond to engineering instruction in their STEM classrooms.

A wealth of research indicates that girls learn more meaningfully in environments that foster cooperative work, social interaction, and creativity (Bourette, 2005;

Brickhouse & Potter, 2001; Brotman & Moore, 2008; Dasgupta & Stout, 2014; Robinson, 2012; Shakeshaft, 1995; Shanahan & Nieswandt, 2009; Shapiro, 1994; Tucker, Hanuscin, & Bearnes, 2008). While there is no evidence that girls' brain structure is significantly different from boys' (NRC, 2007), studies indicate that they prefer hands-on, inquiry-based learning in which they can develop meaningful understandings as well as meaningful relationships. Unfortunately, many middle and high school science classrooms still rely on mass-produced textbooks with perhaps an occasional teacher-led demonstration. While some girls may be very successful in these environments, and while they may approach this work with the attitude of a responsible, hard-working, and invested student, the lack of social interaction and cooperative work reinforce to girls that science is something that inherently does not match with their own set of values. The competitive edge that boys so often bring to science classes as well, whether it is answering a teacher's questions, completing an experiment, or building an engineering prototype, further raises the level of isolation among the students and further alienates girls from the world of STEM.

When girls reflect on their experiences in the science classroom, they consistently rate group activities, scientific discourse with their peers, and hands-on explorations as the modes of instruction that they enjoy most, while reading textbooks rates among both boys and girls as the activity that they like the least (Burkham & Smerdon, 1997; Robinson, 2012; Shapiro, 1994). However, this unfortunately is not the norm for many middle and high school science classrooms, and so girls' success in these environments is based more on their desire to do well and please the teacher, or others, than to become highly involved in the learning of scientific content. While in the short run, girls tend to do well in science classes for these reasons, this does not necessarily result in these girls pursuing careers in science because their motivation is based in perpetuating the image of the "good student", not the "science student" (Brickhouse & Potter, 2001). They are not developing a passion for scientific inquiry or content; their success in science is education-oriented, not career-oriented (Campbell & Clewell, 1999). Along these lines, girls that continue to pursue science courses beyond what is required in high school frequently do so for educational purposes – to get into better colleges or because it is required for future career choices, such as veterinarian or pharmacist (Miller et al., 2006). Their intention is not ultimately to continue along a science path because their view of this path is a very narrow one.

A final failure of the education system in terms of encouraging girls (and, in reality, all students) to participate more fully in STEM is the lack of connection it provides to real-world contexts and applications in their lives. As girls enter middle school and continue through high school, they place greater value on social justice, societal issues, and the well-being of their world and community. To them, it is vitally important that what they are learning has an application to their lives and to a larger societal picture (Bennett & Hogarth, 2009; Lee, 1998; Shakeshaft, 1995; Solomon, 1997, Yanowitz & Vanderpool, 2004). In reality, this is the core of science and engineering – an enterprise in which knowledge is created and problems are solved in order to improve the plight of humanity and to create greater understandings of humans and their place in the world. Pugh and his colleagues (2009) refer to this phenomenon in relation to school science as "transformational experiences" – those in which science content and concepts are integrated into their everyday relevance, which he asserts is necessary for all students to be engaged deeply. Yet girls do not perceive this grander image of science and engineering due to both a lack of extra-curricular experiences as well as a lack of connection in the STEM classroom. When science concepts and engineering problems are presented in isolation from the people and other social elements they impact, the validity and importance of these domains becomes questionable for girls. By the time these girls have entered middle school, they view science as having little value in helping people and, in fact, as being a great contributor to the problems of the world. By experiencing their science classes as “boring” and “useless”, they lose any faith that scientific research has the potential to impact such societal problems as hunger and disease. Their understanding of the scope of scientific discipline becomes sufficiently narrow as to cause them to regard branches such as medicine and nutrition as outside of the realm of science altogether (Basu & Barton, 2007; Brickhouse, Lowery, & Schultz, 2000; Brotman & Moore, 2008; Farland-Smith, 2009; Jones, Howe, & Rua, 2000; Kahle & Lakes, 1983; Osborne, Simon & Collins, 2003).

This muddled view of various science domains and the phenomenon of school science being disconnected from the real world emerge most prevalently when comparing girls’ experience in different scientific areas (Bennet & Hogarth, 2009; Britner, 2008; Burkham & Smerdon, 1997). In fact, consistent with recent data on women’s representation in science careers, high school girls’ engagement with biology and life sciences now tends to be comparable to that of their male counterparts. This is in large part due to the fact that life sciences incorporate a focus on animals and people and provide girls with the desired connection to helping others that is so critical to their values. While this may additionally reflect stereotypical gendered roles that girls assimilate through their home culture and upbringing (Dasgupta & Stout, 2014), it also represents a trajectory of choice and interest that is consistent from childhood through adulthood. Conversely, however, girls do not see the same intrinsic value in physical sciences or in engineering. Without a transparent connection to the human experience, girls consistently show lower self-efficacy, engagement, and achievement in domains of physical science and engineering as compared with life sciences and with their male peers (Bennet & Hogarth, 2009; Britner, 2008; Burkham & Smerdon, 1997). The physical sciences retain the masculine stereotype; that this area is better suited for boys remains a societal message that continues to be transmitted, causing girls to feel that they are not legitimate participants in such courses and experiences (Burkham & Smerdon, 1997; Murphy & Whitelegg, 2006). In addition, stereotypes also about engineering as a specifically male-dominated domain, in which tools, machines, and an innate aptitude for building are required, perpetuates the myth that girls are less capable in this field (Cheryan, Master, & Meltzoff, 2015). Thus, not only does girls' STEM engagement differ at developmental stages but within domains of STEM as well. This discrepant level of participation for adolescent girls warrants far more attention and research, as it directly aligns with data showing the unequal representation of women in these career fields as well.

This lack of connection between school science and the real-world, human aspect of science is also apparent in how science teachers and classrooms neglect to portray the real lives of scientists and engineers (Bennett & Hogarth, 2009; Buck, 2008; Farland-Smith, 2009; Osborne, Simon, & Collins, 2003; Shakeshaft, 1995; Vanmali & Abell, 2009; Yanowitz & Vanderpool, 2004). Stemming back to the Draw-A-Scientist data, the image of a real, modern scientist is mysterious to many students, boys and girls alike, not only because of media stereotypes but also because little is done to promote these careers in a meaningful and authentic way in classrooms. Science learning tends to be embedded in the work of the many white men who have come before. They are rarely exposed to the real work of scientists today, particularly the work of women and ethnic minorities and how the contributions of these people have helped society or positively impacted the world around us, in any variety of STEM domains (Kitts, 2009).

While many scholars argue for the greater inclusion of scientific role models for girls in the classroom (Kitts, 2009; Yanowitz & Vanderpool, 2004), some research shows that the gender of the science teacher does little to influence the attitude of the female students in that class. Exposure to women scientists alone, therefore, does not necessarily serve to improve girls' interest in STEM (Quinn & Lyons, 2011; Solomon, 1997); rather, it is the ability for these women to act as true role models for girls. When Gail Buck (2008) questioned middle school girls on the characteristics they found most important in a role model (in the domain of science), expertise in science was only one criterion. Equally important was that these women were admirable, good people and that the girls felt like they would be able to make a personal connection with them. This directly reflects the value adolescent girls place on social connections and helping others. Therefore, just because a girl might be in the science classroom headed by a female teacher, this does not mean that the teacher is acting as a role model for that girl, particularly if the quality of her science instruction and equal treatment of boys and girls in her classroom are questionable. Drawing on the work of Bandura (1986), Britner (2008) asserts that one of the greatest influences on girls' self-efficacy in STEM is their exposure to female scientists who possess characteristics and behaviors that are aligned with their own; gender and STEM expertise alone are not enough to create role models for girls. Rather, girls need to observe female scientists with whom they can feel a personal connection and who are similar to themselves – with whom they can move beyond stereotypical images and connect with the human side of a STEM lifestyle and identity (Asgari, Dasgupta, & Stout, 2015; Baker, 2013; Kekelis, Larkin, & Gomes, 2014; Buck, 2008; Kitts, 2009).

In addition to lacking appropriate STEM role models, high school girls often have a negative perception of what a lifestyle or career in a STEM field actually is like and receive little feedback to counteract this (Miller et al., 2006). Career decisions begin to be formed in the early years of high school for both boys and girls. With girls entering high school already showing the more negative attitude towards science and lower self-efficacy than their male classmates, they are already approaching STEM pursuits with more potential barriers in place. While Quinn and Lyons (2011) found that there was a similar perception of STEM careers between adolescent boys and girls as being anti-social and uncreative, boys tended to agree more with statements showing intent to pursue science at the university level and beyond. This was especially apparent, once again, when delineated between life science and physical sciences. Specific interventions have targeted girls' perception of science careers by exposing them to the real life and work of women scientists, such as science workshops (Yanowitz & Vanderpool, 2004) or working side-by-side with scientists (Farland-Smith, 2009). These programs have aimed to address existing stereotypes about the lifestyle of a scientist and by making more relevant their work. In both cases, however, there was no evidence that these experiences had a long-term effect on classroom engagement or career choice. Thus, the stereotype of the lonely scientists persists for all students at a critical educational juncture in the trajectory of their future choices but is compounded for girls by additional factors resulting from years of influence on their identity and self-concept. Quinn and Lyons (2011) posit:

> To 'use the classroom to counteract years of socialization' as suggested by Eccles (1989) seems to be necessary but not sufficient to reduce the underrepresentation of women in science careers. (p.232)

The classroom, therefore, has its own responsibility in shaping the engagement of girls in STEM but cannot be targeted in isolation. Its role in the shaping of girls' identities within the larger societal context must be addressed.

Identity Formation and Group Affiliation

There are many ways in which societal and educational shortcomings regarding girls in science interact so that it becomes difficult to determine which element is affecting which. Truly, there is a transactional process at play, in which society presents girls with particular stereotypical images and kinds of experiences that are reinforced in the classroom, passed along to the students participating in these classrooms, then transmitted back to the society at large, while girls are simultaneously responding to and reinforcing these images and influences. As Brickhouse and Potter (2001) assert,

> Identities are maintained in performances in which one makes a claim on an identity and then judges the viability of that identity against the reactions of others. Thus, individuals have some control over identity yet are also constrained by structure and power relations that may limit the kinds of identities that are viable. (p. 966)

The crux of this dilemma, as mentioned, begins at this middle school level and increases throughout high school due to the values, characteristics, and behaviors that girls in adolescence possess and the manner in which these factors interact with the societal and educational influences these girls are facing.

As girls enter middle school and continue through high school, the issue of identity becomes critically important. They are grappling with their own self-image in terms of their gender, their culture, and their place in a peer group. Individualism becomes less important than does solidarity and identification with other, larger groups (Brickhouse & Potter, 2001; Dasgupta & Stout, 2014; Solomon, 1997). It is then no wonder that when girls are faced with stereotypical images of science and scientists, they find a complete mismatch to their own self-image. For many girls, this image is so far from their own personal identity, that the idea of pursuing a career in science or even continuing their science education beyond what they are required seems an unreasonable and incongruent choice (Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001; Darbyshire, 2009; Farland-Smith, 2009; Lee, 1998; Osborne, Simon, & Collins, 2003; Shakeshaft, 1995). Few girls would aspire to be a white-haired mad scientist. As a result, girls do not perceive themselves as scientists or even as doing science informally, and this has an impact on their investment in STEM most crucially during the adolescent years when their own self-identity is being more carefully and significantly formed.

For both adolescent boys and girls, aspiring to their gendered stereotype allows a comfortable fit between their burgeoning identity and that which is expected of them (Osborne, Simon, & Collins, 2010). As parents, teachers, peers and members of society continue to reinforce the stereotype of STEM as a masculine endeavor and successful female science students as those who are diligent, rule-followers as opposed to risk-takers, the majority of girls will continue to aspire to the identity that is most supported by their society and peer group. While girls no longer necessarily believe the stereotype that “science is for boys” (Kitts, 2009), this phenomenon is, in fact, observed from adolescence through adulthood in multiple group situations.

As Jovanovic and King (1998) observed in their study of hands-on groups, even with exemplary teaching, adolescent boys and girls fell easily into stereotypical roles, with boys taking leadership roles and girls taking more passive roles as the supports or scribes. Carlone (2003) asserts that for high school girls, taking an active leadership role in science, thereby transcending their gendered stereotype, would threaten their “good girl, good student” identity – and really their socially expected identity altogether. Further, Osborne (2010) and her colleagues maintain that rising to fulfill gender stereotypes in such situations is a means to more fully establishing one’s gendered identity. Thus, while these stereotypical behaviors may be unconscious and unrecognized by adolescents, they serve, for better or worse, to help solidify the identities that seem like the “right ones” in a developmental time when this is of critical importance.

Strikingly, Meadows and Sekaquaptewa (2011, 2013) found a similar phenomenon to Jovanovic and King, many years later and with undergraduate students of engineering. When working in small groups to present group projects, the roles of the participating men and women were aligned with gender stereotypes, with men speaking for longer and about more technical aspects of the project than the women who were involved. In fact, the women generally reported acting as the “secretaries” of their groups: in charge of organizing, note-taking, and completing the less technical aspects of the presentation (the introduction, for example). In fact, these gendered roles were even more prominent for both men and women when they represented the smallest percentage of their gender in the group, suggesting that individuals often will take on their stereotypical identities to an even greater degree when they are the minority of a given group. New research on gender composition in STEM small groups from Dasgupta, Scircle, and Hunsinger (2015), however, shows that female majority groups did in fact have a positive effect on women's anxiety and verbal participation in those groups, especially for first-year students who were already less comfortable with the content. While this research is not specific to adolescent girls, it certainly illuminates a trend that appears to remain constant from middle school through college and raises questions about the effect that gender composition has on stereotypical gendered behaviors and student STEM engagement.

Extensive research has been done to examine the issue of girls' identities in relation to science identities and how such identities coexist. The copious work of Nancy Brickhouse and her colleagues (2000, 2001) explores the identities of girls not just in the science classroom but also in terms of cultural identities in these contexts. Through case studies of girls in urban science classrooms (Brickhouse & Potter, 2001; Brickhouse, Lowery, & Schultz, 2000), the roles of both gender and culture were explored in shaping girls' identities as students of science as well as the quality of instruction that most supported these girls' learning. The results in both studies showed that girls had to push the boundaries of their identities in order to navigate the science classroom in a more meaningful way. As Brickhouse and Potter (2001) state, "When African American girls enter school they are often perceived by their White teachers as 'loud'. In order to do well in schools governed by mainstream European American values, this behavior must be unlearned" (p. 967). In their study, one young African American woman, in order to engage more fully in her computer science class, used the smartest white boys in the class as her role models and resources. Another girl, however, in order to become less visible in her predominantly white science class, adopted the feminine values most respected by her European-American peers: silent and shy. While one recognizes that these girls were seeking success in these settings, one also mourns the notion that, in order to succeed in the world of science, these girls had to abandon aspects of their own cultural and gender identities (Darbyshire, 2009). Meadows and Sekaquaptewa (2013) describe the contradiction that for females to be "successful" in STEM at any developmental stage, they must either abandon their gendered identity all together or become invisible by sinking fully into it – two choices which are both risky and un-equitable. While beyond the scope and context of this study, the interaction between issues of ethnicity and gender within the realm of the science classroom warrants future research.

While parents and teachers exert great influence over girls' identities in adolescence, perhaps even more impacting is the role of the peer group (Jacobs et al., 1998). Much research has shown that there is a strong correlation between academic interests of an individual and the associated peer group. The survey performed in 1987 and subsequently in 1997 by Breakwell and Robertson (2001) found that a peer group reporting to like science strongly correlated to an individual's positive attitude towards science and that a higher level of delinquent behaviors from the peer group correlated to a more negative attitude towards science on the part of the individual. In addition, Britner

(2008) describes that social persuasions, the verbal and nonverbal judgment of one's social group, had the greatest effect on high school girls' self-efficacy in science. Once again, the identity of the peer group largely impacts the identity of the individual. To make decisions contrary to this peer group's values would be to question one's very own self-image.

The work of Joan Solomon (1997) highlights the importance of choice and solidarity on the manner in which adolescent girls experience science. She reiterates that engaging girls with science is much more complicated than making it fun and interesting – issues of familial, cultural, societal, and personal identity all influence a girls' science choice and how disparate from these identities a choice towards science may place her. She also discusses how a choice towards science is "to claim a kind of intellectuality" (Solomon, 1997, p. 414) that by itself places one outside of a more common community. However, she also argues that girls from all-female schools are more likely to pursue all sciences, particularly physical science, than girls from co-educational settings, posing that perhaps that being in a female setting by itself validates the gender identity and leaves room for other choices. Again, gender composition in the pursuit of STEM bears further research.

Davis (2001) argues that the intersection of gender stereotypes, group solidarity, and gaining entrance to the world of STEM provides challenges for girls and women of all ages. In a stereotypically male-dominated arena, girls and women may feel like outsiders to this world, without legitimate right to gain access. She asserts that programs and opportunities for girls must legitimize their participation: in other words, they must rewrite the stereotypes themselves so that girls do not perceive their participation as “beating the odds” but rather expanding the vision of girls’ identities, roles, and the STEM community itself.

Clearly, the interaction among societal, educational, and familial factors provide a commingling of obstacles for girls and their participation a science. Yet stereotypical gendered roles and behaviors on the part of adolescent girls threatens more than just the equity of the situation. In fact, this more passive participation decreases opportunities for girls to develop self-efficacy and transformational experiences in STEM which are requisite for deep learning and engagement (Meadows & Sekaquaptewa, 2013; Pugh, 2009), which in turn influence girls’ future college and career choices. Thus, it will take a multi-faceted and cohesive approach on the part of many contributors; no one “quick fix” will be enough.

Implications for the Classroom

In order for girls to have access to science experiences and education so that they can envision themselves as members of science communities, there must be a change within this complex system of interdependent factors. Returning to the themes identified by Brotman and Moore (2008), girls need to be provided with equal access to science and engineering experiences, a more expansive view of the nature of science, and a STEM education that best suits their learning so that their identities may become more aligned with that of a learner and doer of science. A starting place clearly is the classroom. Yet the question remains, do we need to encourage girls to infiltrate themselves more effectively into the existing world of STEM, or do we need a systemic overhaul of the science world in order to make it more accepting of girls and the way the learn? In other words, do we need to make girls more ready for science or science more ready for girls? In reality, the answer is a balance between these extremes.

Angela Barton (2008) and her colleagues describe the notion of "hybrid spaces" in the middle school science classroom, "spaces" in which girls can merge the multiple aspects of their identities. Girls, and truly all individuals, possess many identities: their home identity, their gender identity, their school identity, their cultural identity, and so on (Barton, 2008; Brickhouse, Lowery, & Schultz, 2000). Pieces of these become more prevalent at different times or may show congruence in certain situations. When the science classroom allows for girls to participate in ways that are consistent with the developing and critical aspects of their identities, then they are able to engage with science at a deeper level. This requires the science teacher to provide opportunities for autonomy in ways that may not be typical of the middle school science classroom. Barton argues that honoring girls' identities means that they are engaging with science on some of their own terms – writing a rap to show what they know about bones, for example, instead of completing a pencil and paper test. In this way, they are able to draw on their own background experience, competence, and values in order to participate in science class in a way that feels consistent with their identities.

When the educational alternatives are considered, clearly a science curriculum that encourages creativity, group problem-solving, and discussion of ideas has more potential to provide quality learning and development of science concepts for every student than does the environment which consists solely of textbook reading and demonstrations. As Bonnie Shapiro asserts, "Students cannot simply be *told* what to understand or what to believe…Learning experiences that are personally meaningful encourage and inspire learners to continue with and enjoy science learning" (Shapiro, 1994). Surely all students, but particularly girls, will engage more profoundly with scientific theories, ideas, and activities when they can see their practical application and ability to help people, particularly in domains such as the physical sciences and in engineering, where girls tend to see the least relevance (Brickhouse, Lowery, & Schulz, 2000; Murphy & Whitelegg, 2006; Tucker, Hanuscin, & Bearnes, 2008; Yanowitz & Vanderpool, 2004). Teachers, therefore, must be given the training necessary to meaningfully and confidently integrate engineering into the science classroom, particularly into domains that will provide a clear connection to the human experience for girls. In addition, students need to debate, question, explore, create, and analyze in a safe, scientific community rather than being directly taught STEM concepts and ideas. A critical element of this shift, however, is that girls are recognized for their active engagement with science, not simply for their "good student" identities. The classroom community needs to be one in which girls feel safe and supported in taking these active roles (Carlone, 2004).

In addition to having an appreciation of opportunities for social interaction and cooperative work in school, girls also tend to learn meaningfully from opportunities to interact with content and concepts through literacy activities, particularly reading (Ford, Brickhouse, Lottero-Perdue, & Kittleson, 2006). However, this does not mean that an ideal scientific environment for girls would be one in which students read textbooks and answer end-of-the-chapter questions. Quality, authentic, non-fiction literature that meaningfully explores scientific concepts would have the potential engage girls with scientific content in a way that appeals both to their identity as strong students of literacy and as learners of science. Further, well-written science books and informational text should be a complementary aspect of any dynamic inquiry-based science classroom. Using literature to back up scientific theories and explore the scientific work that has been done previously in addition to students' own explorations and lines of inquiry more accurately represents the real work of scientists and validates the real scientific investigation that students are doing in the classroom.

Along these same lines, girls should have the opportunity to read more biographies of female scientists and engineers as part of their STEM and literacy classes (Bourette, 2005; Ford, Brickhouse, Lottero-Perdue, & Kittleson, 2006). Once again, through a venue that may appeal to many girls, they could begin to explore role models that may open doors for their perceptions of what real scientists and engineers are like, how they live, and what they do. They may begin to take a second look at their own self-concepts in relation to the portrayal of the women scientists about whom they are reading and perhaps see someone who is not as discrepant from themselves as they once thought. Complementing this would be the thoughtful inclusion of female role models in current fields of science that portray the image that adolescent girls wish to see – women scientists who are intelligent, caring, and involved. Science students from women's colleges or scientists who are members of and working within the girls' own communities would provide an image of science that is more aligned with their personal values and real-life experiences.

Packard and Nguyen (2003) examined the role of mentors and internships on girls' science career paths. They found that when high-school aged girls with a prior interest in science were able to establish meaningful relationships with their mentors, they were more able to envision themselves in science-related careers: their “possible selves”, as Packard and Nguyen explain. Further, participating in relevant internships in which these girls were able to see their science work in the real world and its impact on the community also had a positive impact on their science career trajectories. Thus, these meaningful relationships and real-world connections may serve to provide additional incentive to girls who have a science career plan and help them cross the bridge into their science field.

Yet the expectations and identities of girls in the science classroom must also adapt. Girls must also be held to the same standards for grappling with ideas, questioning, and being vocal in class. They must be encouraged to take risks in the classroom and pursue more hands-on activities both inside and outside of the classroom in order to gain more confidence as a learner of science and more belief in their scientific identity (Shakeshaft, 1995). In addition, the scope of science should be broadened in order for girls to see that science is more than just an enterprise for boys. As Nancy Brickhouse asserts, “What counts as 'doing science' is often justified in terms of how well is matches what professional scientists do. It is often the case that these narrowly defined identities are not what girls aspire to” (2001, p. 287). Science is a part of the questions they ask about the world around them, of their desire to nurture and help others, and of the hands-on projects they pursue with their parents. If they begin to see science and scientists as more than just the stereotypical image they are used to, then perhaps with their increased confidence, the distance between their informal experiences and their image of a geologist, neurologist, or engineer might not be quite so far.

Along these same lines, broadening the image of a scientist will also help girls more readily mesh their own self-image with that of a scientist. To read about and meet female scientists who are both driven and career-oriented as well as those who manage to balance their identities as mothers and family members with the scientific work will allow girls a greater spectrum of choices in which to envision themselves in the scientific world (Buldu, 2006; Rohn, 2007; Shakeshaft, 1995; Wilson, 2005; Yanowitz & Vanderpool, 2004).

The goal, therefore, must neither be to reject all gender stereotypes nor to fully accept them. Rather, we must both celebrate and challenge at the same time the differences between boys and girls in the science classroom and with extra-curricular science experiences. To acknowledge and respect the experiences and strengths that girls can bring to science in a genuine way while still encouraging them to take some risks and push themselves in areas that might seem uncomfortable (or only for boys) at first will serve to broaden girls' perception of what a scientist is and in what ways they are able to interact with science and their scientific community. The hope then is that this is a beginning towards both bringing more women into fields of science over time and altering the societal influences which act as barriers for girls in science.

Conclusion and Implications for Further Research

The implications for further research in this field are both clear and extensive. Much has been done to explore influences, identities, and attitudes in science classrooms and there is a wealth of research tools being used to collect this data. There are also large numbers of intervention programs in place outside of the school setting to attempt to encourage greater participation of girls in science. However, these are often voluntary, so girls entering these programs do so by choice: the assumption being that they have some prior interest in science as well as access to the program itself. Therefore, there are many potential next steps for research in this area in order to retain more girls in science classes and subsequently women in science careers.

A promising direction is the study of gender composition in science groups and its impact on girls' motivation in STEM situations. Ryan and Deci assert in their Theory of Self-Determination (2000a, 2000b), which will be discussed further in greater depth, that three essential conditions must be present in order for an individual to experience motivation in any context. One of these needs is relatedness, or the necessity that individuals function within a supportive community in which they feel a sense of belonging. As issues of identity and group affiliation become paramount during adolescence, creating a scenario in which girls can experience a sense of relatedness through a gender connection may help increase their motivation in a context in which they typically may not feel this sense of belonging: the STEM classroom. While the work of Meadows and Sekaquaptewa (2011, 2013) as well as Dasgupta and her colleagues (2015) have explored this dynamic with adults and in college settings, the results they have found are varied. Also, no research thus far has looked at the effect of gender composition on girls' engagement and participation in high school science groups. Thus, bridging the gap between Jovanovic and King's middle school study (1998) and the current literature from the college level with an examination of high school small group dynamics with regard to gender composition and gendered behaviors is imperative. Further, as engineering now has a fundamental role in the science classroom and was the focus of Dasgupta and her colleagues' recent work (2015), this must be included in current research at the high school level. As such, the *stereotype inoculation model* (Dasgupta, 2011a) helps make greater meaning of the nuances of relatedness in this scenario within the larger picture of motivation and focused specifically within the realm of STEM education.

While it is true that women have made incredible strides in fields of science over the last decades, an examination of the literature shows that the gender gap is by no means closed. The overall attitude of adolescent girls towards both school science and real-world science remains below that of same-aged boys. There clearly is no "quick-fix" to this problem, but with continued systematic research and implementation of a more balanced and flexible approach to science instruction, we may begin to revise this image of scientists and STEM that is so deeply ingrained in our society so that more girls and women may view this image and find it not so far from their own identities.

CHAPTER II

MOTIVATION AND ADOLESCENCE

Introduction

Girls' decline in science engagement, with its vast landscape of factors and influences, exists within an even larger conceptual context. Adolescence for all children is a time marked by incredible transition and, at times, turmoil. Beginning around the age of ten and continuing into the late teen years, adolescence marks immense physical, psychological, emotional, cognitive, and even logistical changes for children. In an educational setting, there is often not an age considered more challenging to teach than the grades occurring during the years of early adolescence, primarily due to a view that many students begin to lose their motivation to succeed in school during the middle school years (Eccles, Buchanan, Flanagan, Fuligni, Midgley, & Yee, 1991; Eccles & Midgley, 1990; Eccles, Midgley, Wigfield, Buchanan, Reuman, Flanagan, & Mac Iver, 1993a; Eccles, Wigfield, Midgley, Reuman, Mac Iver, & Feldlaufer, 1993b; Simmons, Blyth, Van Cleave, & Bush, 1979; Wentzel, 1997; Wentzel, 1998). Further, students continue to function at this lowered motivational level, or worse, well into high school. Despite the fact that this phenomenon is widely researched and lamented, approaches and structures currently existing in middle and high schools do not always provide an environment that ameliorates or acknowledges this challenge with motivation. In order to address educational changes that will motivate adolescent girls to delve meaningfully into science, first a broader understanding is necessary: one that incorporates the developmental characteristics and needs of adolescents over the course of their middle and high school trajectory in various academic domains, and one that is situated in multiple current and relevant theories of motivation.

A wealth of literature has documented that there is a significant decline for all students in motivation and achievement upon the entrance to the middle school years, particularly in the seventh and eighth grades (Eccles et al., 1991; Eccles & Midgley, 1990; Eccles et al., 1993a; Eccles et al., 1993b; Simmons et al., 1979; Wentzel, 1997; Wentzel, 1998). Relevant to this research is a consideration of school structures. While developmental characteristics of early adolescents themselves are certainly associated with this decline, the characteristics of various school structures at both the middle and high school levels may also play a role in this phenomenon. Current literature differentiates between junior high schools and middle schools in that the former tends to be include a more traditional structure with teachers as specialists, while the latter may incorporate more progressive groupings and scheduling. In addition, kindergarten through eighth grade schools also exist, which may present other unique factors from middle and junior high schools. For the purposes of this work, the term "middle school" will refer generally to grades seven and eight, unless otherwise noted, regardless of school structure; however, a comparison of motivational trends across these three different school structures, as well as in international schools that organize differently, is certainly worth future research.

For over thirty years, copious research has sought to identify the roots and manifestations of this decline in adolescent academic motivation (Eccles et al., 1993a; Eccles et al., 1993b; Eccles & Midgley, 1990; Simmons et al., 1979; Wigfield, Roesner, & Schiefele, 2008). For many students, entering the middle school grades is a dramatic transition and change from the elementary school years. Typically, when students begin the middle school grades, they are leaving behind a familiar elementary school and beginning in a new school environment, with the new teachers, peers, and school dynamics that come with it. Then, a mere two years later, students must transition again, this time to high school with a new set of variables to navigate. These multiple turning points in a student's life can become the beginning not only of their secondary schooling but of major upheaval. Issues of behavior, identity, independence, and self-efficacy are only some of the factors that commingle, often resulting in deteriorating student behavior and achievement motivation. Many studies have tried to make sense of this decline in relation to the developmental characteristics of adolescence itself, some suggesting it is caused by the inherent psychological characteristics of the students (Blos, 1965), others positing that it is the cumulative effect of multiple transitions (Simmons et al. 1979), and still others simply condemning the quality of middle and high school education (Eccles et al., 1993b, Eccles & Roeser, 2009). Most compelling, however, is a closer look at the interaction between adolescents, including their needs and traits, and the qualities of the environment provided by middle and high school.

The developmental trajectory of the early adolescent child is riddled with change and transition, even without taking into account the changes occurring in the student's social and academic world. Pubertal affects and identity development that children of this age are facing impacts the manner in which they view themselves and their place among the peers (Simmons et al., 1979). Changes in bodies, emotions, and social expectations cause confusion, discontent, and dissension. Research has shown that there are even neurological changes in the adolescent; loss of neurons in the prefrontal cortex as the brain continues to develop has been theorized to affect reasoning, decision-making, and stimulus-response at this age level (Segalowitz, Santesso, & Jetha, 2010). Further, girls and boys at this age level do not follow the same or even a similar developmental trajectory, meaning that sexual identities and relationships become confused and distracting as well. The combination of these developmental transitions in conjunction with changes in academic and school settings for many students is simply a mountain of change that seems insurmountable. A result in early adolescence is that more delinquent behaviors are observed in middle school students above any other age group, and many students show a marked decline in their grades. Further, the magnitude of this decline has been found to predict subsequent high school failure and dropout rates (Eccles et al., 1993a; Eccles & Midgley, 1990). In other words, these downward trends begun in middle school can be assumed to continue into high school, and students exhibiting an overall lack of academic motivation tend to stay unmotivated throughout subsequent years (Gillet, Vallerand, & Lafreniére, 2012). With motivation significantly correlated to academic achievement in the later secondary years (Uguroglu & Walberg, 1979), high schools must be ready to accommodate students for whom academic success has already begun to lose its allure. Clearly, addressing the motivational needs of students in the various secondary school settings is, therefore, imperative.

Achievement Motivation – Self-Determination Theory and the Stereotype Inoculation Model

To make sense of the literature surrounding adolescent motivation, an understanding motivational theory in general must precede such an analysis. An examination of motivation includes perspectives drawn from a number of domains: educational, psychological, behavioral, social, and developmental. In its most basic sense, motivation is the reason that a human has to act or think in a certain way; a study of motivation aims to understand the characteristics of motivation and the factors influencing people's choices and efforts towards certain actions or tasks (Wigfield, et al., 2008). As motivation is an internal process and psychological construct, it cannot be directly observed. Thus, attempts to measure or describe levels of motivation in individuals typically include cognitive, affective, behavioral, and physiological measures that capture elements such as the amount of effort, persistence, time, interest and attitude given in a particular context, as well as goal-setting and pursuit of those goals (Touré-Tillery & Fishbach, 2014).

While motivation can be described in a vast number of settings, for the purposes of this work, achievement motivation will be the main reference for examining the research. Achievement motivation focuses specifically on the energy and effort that an individual puts forth when standards for academic success are relevant. This is particularly important when exploring issues of student motivation in an educational setting because so much of school success is measured in terms of academic achievement.

There are several areas of study that are typically considered in any research on children's achievement motivation: issues of self-efficacy and perceived competence, students' learning goals and goal orientation, genuine interest in the task or topic, and the value students place on achievement itself (Wigfield, et al., 2008). At times these topics are examined individually and sometimes the interaction among them is observed in order to describe the additive effect of various factors on motivation. Additionally, these domains are examined both longitudinally and at children's specific learning and developmental stages. As might be expected, these issues quickly become muddled by the other elements, such as family, gender, and culture. For the purposes of this study, therefore, in order to meaningfully explore the interaction between achievement motivation and gender dynamics within the specific context of the science classroom, the melding of two motivational theories, which have thus far not been brought together, is required. As will be described in detail, Ryan and Deci's *self-determination theory* (2000a, 2000b) provides the over-arching framework for understanding and describing motivation and its necessary conditions for students in general. Further, Nilanjana Dasgupta's *stereotype inoculation model* (Asgari, Dasgupta, & Stout, 2012; Dasgupta, 2011a; Dasgupta, 2011b; Dasgupta, Scircle, & Hunsinger, 2015; Dasgupta & Stout, 2014) will also be discussed because it connects social context to the behaviors and perceptions manifested in motivation and provides a framework to more fully understand issues of gender in science education, thereby giving meaning to girls' performance in the setting of the science classroom.

Conditions of Motivation

Of the researchers that have expanded current understandings of motivation, the work of Richard Ryan and Edward Deci (2000a, 2000b) has often been used as a theoretical framework to describe motivation across a multitude of settings. Not only have they identified factors that are critical for motivation to be present, they have also described levels and characteristics of motivation as a construct in order to better describe the ways in which students can be motivated. Central to Ryan and Deci's research is their notion that motivation comes from within an individual and arises from the presence of internal factors. They have identified this as S*elf-Determination Theory (SDT)* – that certain conditions will serve to encourage an individual's most optimal performance and self-regulation. There are three conditions that Ryan and Deci have identified as being psychological needs that are critical to the presence of self-motivation: autonomy, competence, and relatedness. When these three conditions are in place, according to SDT, then a student will have greater potential to show motivation and success with a task.

Autonomy, within the context of SDT, refers to the level of choice and control a person has within a particular activity. That this could contribute to greater levels of motivation is hardly surprising. In many contexts, research has shown that children respond most effectively and positively when they are given an appropriate amount of choice in the outcome, and this clearly has the potential to impact their motivation in a variety of settings, from meeting behavioral to educational expectations (Black & Deci, 2000; Eccles et al., 1991; Reeve & Halusic, 2009; Ryan & Deci, 2000a, Ryan & Deci, 2000b). The manner in which autonomy is present in various contexts would certainly look different depending on the circumstances. Clearly, the greatest level of autonomy would occur in a situation in which a person is in complete control of the task; he or she is fully in charge of its design and execution. Yet, autonomy can also exist in cases in which the task comes from an external source. Perhaps an ultimate goal is mandated, but a person has choice in how he or she arrives at that goal. In both situations, and along the continuum of possibilities in between, the presence of some level of autonomy gives greater opportunity for a person to become personally invested in the activity and for his or her ideas and approaches to be validated. In addition, there exists a greater opportunity for creativity and a personal touch to any activity, which allows individuals to capitalize on their own existing interests and talents within an established structure. Autonomy contributes to ownership and accountability to oneself within the task, and with this comes a greater drive to succeed and see choices through to their fruition. Reeve and Halusic (2009) describe that an autonomy-supported environment allows motivation to arise from "vitalizing inner resources" as opposed to existing as a response to behaviorist or social factors. Most succinctly, greater autonomy will lead to greater self-efficacy and consequently greater motivation within a task (Black & Deci, 2000; Eccles et al., 1991; Lavigne, Vallerand, & Miquelon, 2007; Ryan & Deci, 2000a; Ryan & Deci, 2000b).

Jacquelynne S. Eccles and her colleagues have more closely examined the issue of autonomy in both school and family settings (1991). Her work indicated that prior research had often provided conflicting results – some concluding that more structured and controlling classroom environments will provide for greater motivation; others indicating that minimal control and greater freedom will lead to higher levels of motivation. To make sense of the Ryan and Deci's theories in light of this prior research, she chose to study autonomy in different settings and at different developmental stages. Looking longitudinally at a large sample of sixth-graders, she observed both their needs for autonomy as well as the actual presence or lack of autonomy in both their homes and schools. Critical to the data was that all of the student participants transitioned from elementary school to a traditional junior high school during the course of the study.

With regard to decision-making in both a school and family context, Eccles (1991) observed in her young adolescent participants an increased desire for autonomy over time. That is to say, students expressed a greater desire for control in seventh grade than they did in sixth grade. The reality Eccles observed in both settings, however, was that the levels of autonomy and decision-making decreased for these students. This phenomenon will be discussed in greater detail later in this paper to illustrate the experience of middle and high school students. From the results of this study, Eccles and her colleagues concluded that the optimum levels of autonomy necessary for encouraging high motivation are not fixed. Rather, needs for autonomy change over time. Critical for motivation, however, is that there is a match between these needs and the opportunities for autonomy that the students experience. A caveat on Ryan and Deci's description of this condition, therefore, is not simply that autonomy is present, but rather that there is the *right amount* of autonomy for a person's age and development.

Many researchers and theorists describe the setting in which this perfect balance between individual development and autonomy is present as being "autonomy-supported" (Black & Deci, 2000; Gillet, Vallerand, & Lafreniére, 2011; Lavigne, Vallerand, & Miquelon, 2007). In the words of Gillet and his colleagues (2011), "Autonomy support is said to be present when parents or teachers take the children's perspective and provide opportunities for choice and participation in decision-making, while minimizing the use of pressure" (p. 79). Critical to this description is the inclusion of the perspective of the student, thereby making the level and quality of the provided autonomy dependent on the needs of the child, not on the agenda of the adult involved. Thus, an autonomy-supported environment incorporates an individual's input and interests in order to increase their motivation in the learning situation or task. Autonomy-supported does not mean, however, that the environment lacks guidance or is permissive. Reeve and Halusic (2009) argue that, in fact, greater structure is required in an autonomy-supported situation than in a controlling one because it requires clear expectations, frameworks, and feedback for individuals to be successful in their choices and pursuits. Complete permissiveness can impact motivation as negatively as authoritarianism can, which reinforces the need for autonomy support to be directly representative of the developmental and individual needs of those involved. Effectively implemented autonomy support can directly increase individuals' perceptions of competence within a domain, which is a powerful predictor of long-term motivation (Britner, 2008; Lavigne, Villerand, & Miquelon, 2007).

Competence, therefore, is the second factor that Ryan and Deci (2000b) identified as integral in fostering motivation. Competence refers to a person's ability to successfully accomplish a task; breadth of knowledge, efficiency, and accuracy are indicators of one's success within a particular domain. When people perceive themselves as competent, their feelings of confidence serve to encourage greater perseverance and fulfillment with activities. With success comes a desire to continue to succeed, and in areas where people are skilled and able, the chance for success will clearly be greater. Competence can be fostered, however, at varying degrees. Students, for example, may be more motivated in tasks at which they naturally excel or have inherent ability, but structures can also be established which will provide greater opportunity for students to be successful even when the subject or task might ordinarily be challenging. Scaffolds in a task will allow a student to engage meaningfully and push and propel the learning process. In such cases, the opportunity exists for a person to perceive his or herself as competent in a particular context, which may then result in more wide-spread competence in that subject area. The critical components, thus, are that people need the opportunity to first feel competent within some specific aspect within a task structure before greater overall competence can be developed. Continuous incidences of failure and discouragement will have the opposite effect on motivation, causing a person to feel unable to experience success. While a “don't give up” attitude is commendable, incremental successes will have a more consistent impact on overall motivation.

Competence beliefs, or self-efficacy, is another construct that has been widely researched in prior literature, particularly in the context of motivation but also in terms of learning and development. The work of Albert Bandura (1993) has characterized this concept of self-efficacy, defining it as an individual's belief in his or her ability to complete a specific task, problem, or course of action. An individual's self-efficacy plays a large role in his or her performance and persistence in a given setting, thus directly impacting motivation in that context. Self-efficacy as a construct by itself is broad and multi-dimensional. It encompasses many domains, from cognitive to psychological. Bandura asserts that an individual's self-efficacy beliefs arise from several components: prior performance, physiological responses and reactions within the individual, the encouragement and support one receives, and the learning experiences within that context (Bandura, 1993; Wigfield et al., 2008). The importance of competence beliefs within the domain of motivation, therefore, has its roots in a vast amount of research that has come before.

Allen Wigfield and Jacquelynne Eccles also have examined self-efficacy in terms of motivational levels in order to explore their relationship and effect. By further defining how self-efficacy impacts motivation, Eccles and her colleagues developed the *Expectancy-Value of Achievement Motivation* (2000). This theory builds on Bandura's prior work with self-efficacy and gives additional perspective on motivation by further examining the origins and impact of competence beliefs. Expectancy-value theory states that levels of persistence and success with a task can be explained in large part by an individual's beliefs about how well he or she will do as well as by the value he or she places on the task. Through several longitudinal studies, Wigfield and Eccles (2000) formulated a model that described a quantity of factors contributing to self-efficacy, many resonant of Bandura's work, from prior achievement experiences to children's various perceptions and stereotypes. Many of their findings will be discussed further at different points in this paper. Relating to the greater construct of self-efficacy, however, is that these factors, while distinct, are highly interrelated in their cumulative impact on self-efficacy, which in turn impacts motivation. Differentiated competence beliefs were observed in even young elementary school children in these studies, meaning that even at a young age, children understand that there were some things that they were better at than others. These beliefs then impacted the children's task value within specific domains and their overall interest in them. More will be addressed later regarding Eccles' work examining these competence-beliefs over time and through the transition to adolescence.

Ryan and Deci (2000a; Deci, Koestner, & Ryan, 2001) have explored the effects of different reward systems on individuals' autonomy and competence beliefs in order to inform educators on the use of intrinsic and extrinsic rewards in a classroom setting. Called *Cognitive Evaluation Theory* (CET), this sub-theory of SDT asserts that many extrinsic rewards undermine the opportunities for intrinsic motivation by shifting the focus away from fostering feelings of self-efficacy and autonomy, which are so integrally linked to motivation. Ryan and Deci distinguish between two different types of extrinsic rewards: those that are informational and those that are controlling. Informational extrinsic rewards tend to be “verbal rewards” or positive feedback. When the feedback provides meaningful information and enhances a person's feelings of competence within a task or subject, then this can serve to actually increase intrinsic motivation in that area. When the verbal feedback takes the form of superficial praise, however, then this becomes a more controlling scenario in which the person's behavior is modified in order to receive the praise, not because he or she finds the activity itself rewarding. More drastic is the use of tangible rewards, such as food or objects, to motivate or incite certain behavior. Ryan and Deci argue that this type of extrinsic reward actually impedes the opportunity for intrinsic motivation because it often urges people to engage in behaviors that they would perhaps otherwise not do; thus, their behavior is being controlled by the allure of a tangible object as opposed to the activity itself.

In a meta-analysis of prior data, Ryan, Koestner, and Deci (2001) examined the effects of various rewards on free choice behaviors and self-reported interest from students spanning the elementary grades to college age. They found clear evidence that tangible rewards negatively impacted intrinsic interest in the tasks and activities, and these results were seen most dramatically with school-age children, presenting serious implications for how teachers use rewards in their classrooms. A system that uses primarily tangible rewards creates a scenario in which engagement with the tasks and topics becomes about the reward, not about a person's competence or autonomy within that context, and this clearly impedes on the opportunity for intrinsic or self-regulated participation in that area.

These two previously-described components, autonomy and competence, still do not provide the full set of conditions that will lead to optimal motivation, however, according to Ryan and Deci (2000b). The final element is that of relatedness, or the social aspects of the task or activity in which a person is engaged. Stemming from an examination of developmental milestones in infancy (Ryan & Deci, 2000b), studies have shown that interest in a task or motivation to work towards an end arise most optimally when the learner is in a secure and validating environment. A supportive parent, an invested teacher, or a collaborative partner or group all serve to provide social outlets and the human response needed to encourage interest and perseverance in a task. Critical to this condition, however, is that the relationships involved are supportive and trusting. The safety of a caring teacher, for example, will ensure that feedback and guidance are received in a manner that strengthens interest in the task and furthers the learning process. Learners will know that their actions and choices are leading them towards a successful end because they are receiving reinforcement that is timely and trustworthy. On the other hand, an activity pursued in the presence of a challenging (or non-existent) social relationship could serve to eliminate interest in the activity, even if the topic would ordinarily be compelling to the learner. This supportive reinforcement, however, does not need to arise solely from relationships with adults or people in positions of authority in a particular context. Equally important is relatedness in terms of social connections with peers who are also involved in the task or domain. Feeling part of a community that is involved in the same activity or pursuing the same goal also serves to increase a person's interest and motivation within a setting. Feedback, support, trust, safety, and encouragement arising from positive relationships within the context of a task foster a greater level of motivation to continue and to succeed.

Kathryn Wentzel has also closely examined the impact of relationships on student achievement and motivation. In particular, she has focused on how parent-child and teacher-student relationships at the middle school level can predict motivational outcomes. In a longitudinal study of middle school students (1997) between sixth and eighth grades, Wentzel examined the students' perceptions of teacher caring and conducted correlations between this and other academic and social outcomes. She found robust relationships between students' prosocial behaviors and academic effort, particularly when controlled for previous motivation, performance, control beliefs, and distress. In addition, she asked students to describe the qualities that were indicative of a caring teacher and found that students characterized caring teachers in a similar way to caring parents: using a democratic approach, valuing individual differences, modeling a caring attitude, and providing constructive feedback.

In addition to examining teacher-student relationships, Wentzel (1998) also has studied the impact of parent and peer relationships on early adolescent motivation, looking more broadly at student participation in a community to predict academic achievement and positive social behaviors as well as the manner in which these relationships are linked to motivation. From a sample of sixth grade students, she observed that each of these social connections impacted students' performance positively, yet distinctly and independently. Positive relationships and perceived caring from teachers, parents, and peers had an additive effect on student motivation, but the existence of one of these connections did not replace the absence of another. Perceived caring from a teacher was associated with behaviors most directly related to the classroom: following classroom rules and routines, interest in the classroom activities, and pursuit of classroom goals. Peer support was found to be more directly related to prosocial behaviors, including their desire to cooperate and help each other. Finally, perceived support from parents and family cohesion was the strongest predictor of academic goal orientation. While Wentzel acknowledges that it would be easy to assume that highly motivated middle school students are those which experience support and caring in each of these three areas: teacher, family, and peers; she argues that because each of these relationships interacts differently with motivation and types of motivation, the "directions of influence" are much more complex and require much more research. Her work, however, provides more specific evidence to show the significant impact of perceived support and relatedness in distinct aspects of a middle school student's life on varying motivational processes, goals, and behaviors.

In specific contexts, particularly in school settings, the condition of relatedness may manifest in the form of small group work. The work of Nilanjana Dasgupta and her colleagues (Asgari, Dasgupta, & Stout, 2012; Dasgupta, 2011a; Dasgupta, 2011b; Dasgupta, Scircle, & Hunsinger, 2015; Dasgupta & Stout, 2014) provides an additional layer to the concept of relatedness by encompassing a larger learner trajectory and by providing further clarity on the criteria necessary for communities of learners to fulfill this condition. Dasgupta focuses particularly on the role that existing social stereotypes within a particular setting or domain play in individuals' academic performance and achievement in that context. Specifically, she argues, people tend to pursue achievement in domains in which they feel the most comfortable fit, which often is based on group stereotypes (groups such as girls and women in specific contexts, for example). Even despite prior successful performance in a realm that is contrary to group stereotypes, this may not translate to greater self-efficacy in that area if there is a perceived lack of congruence between the stereotype and the achievement. She posits, however, in her *stereotype inoculation model*, that when individuals have ingroup peers and experts with whom they relate and identify in achievement settings, these peers and experts can serve as potential “vaccines” against such stereotypes (2011a).

Dasgupta (2011a; 2011b) bases her model on assumptions encompassed within relatedness – that in order to be motivated in a context that incorporates a larger group element, people need to feel that they are legitimately members of that group and meaningfully connected to the group members. Perceptions of legitimacy are often biased by the stereotypes surrounding the various social, cultural, and gender identities of the groups, the members, and their relationship to the relevant domain. She proposes that when individuals are exposed to ingroup peers and experts, specifically if they are members of a negatively stereotyped group, this will broaden their self-concept, thereby increasing their self-efficacy and motivation within this achievement domain. As such, they will also be able to transcend the stereotypical behaviors and attitudes that exist about them and within them. She also asserts that this is most critical and beneficial for individuals who are in the earlier or transitional stages of a trajectory within that domain because they are better able to envision the pathway toward their ingroup peers. Finally, consistent with prior research on role models, she posits that an individual must feel a personal connection to such ingroup peers and experts in order for this relationship to have a positive effect on perceptions of relatedness and self-efficacy and ultimately on achievement motivation.

To illustrate, this scenario may be described in a classroom setting. For example, if a girl, due to societal stereotypes, feels that she is less capable or competent in the science classroom than her male counterparts, she may enact stereotypical behaviors and attitudes expected of her. If she is placed in a female majority or all-female group in this context, however, she may feel a greater sense of group comfort and belonging initially due to the gender identity. This in itself may allow her to engage more actively because she has accessed group membership on a primary level, as well as there is less immediate exposure to stereotypical behaviors of the dominant group (boys, in this case). Further, if any of these girls in the group are strong and confident science students, thereby modeling non-stereotypical attitudes or behaviors in this setting, then this girl may have the opportunity to broaden her concept of what a female science student might look like and have the potential to thus move beyond her own stereotypical self-concept within the science classroom.

Dasgupta and her colleagues (Asgari, Dasgupta, & Stout, 2012; Dasgupta, 2011a; Dasgupta, Scircle, & Hunsinger, 2015; Dasgupta & Stout, 2014; Stout, Dasgupta, Hunsinger, & McManus, 2011) have explored their predictions regarding the *stereotype inoculation model* in a variety of scenarios, specifically focused on its relevance for girls and women in STEM. Drawing on the claims of their model, they found in multiple cases that, for the females in their studies, gender identification provided the link to greater feelings of group membership; in other words, exposure same-sex peers and experts in STEM had a positive effect on the participants' overall motivation.

In a series of three studies, exposing undergraduate calculus students to same-sex experts via biographies, classroom teachers, and more advanced peer experts, Stout, Dasgupta, Hunsinger, & McManus (2011) aimed to test the *stereotype inoculation model* by examining the effect of these interactions on the female students' self-concept and motivation in STEM. They found that contact with these female experts, while not completely removing negative stereotypes about their gender's participation in STEM, did serve to enhance individuals' self-efficacy and effort on STEM tasks, thereby benefitting their overall STEM identity and motivation.

To further explore the qualities necessary for such ingroup peers and experts to effectively serve as these social "vaccines", Asgari, Dasgupta, & Stout (2012) exposed young women to counterstereotypic ingroup members who were both similar and dissimilar to themselves. Consistent with their predictions regarding the need for individuals to feel a personal connection to their group members, they discovered that same-sex ingroup peers with whom the young women identified had a positive impact on their self-concepts and reduced their self-stereotyping. Dissimilar ingroup members, however, either had no effect or a negative effect on the young women's self-concept: in fact, exposure to same-sex experts with whom the participants did not feel a identity connection in some cases actually increased their gender-stereotypical beliefs and attitudes and reduced their career aspirations. Critical, therefore, is that gender identity alone will not necessarily contribute to perceptions of group membership; a sense of personal connection to these same-sex group members must also be in place for individuals to broaden their vision of "possible selves".

Finally, focusing more on ingroup peers rather than experts, Dasgupta, Scircle, and Hunsinger (2015) examined the effect of gender composition within small undergraduate groups working on engineering tasks. Looking at the effect of percentage of females in a group on the members' motivation and participation, Dasgupta and her colleagues found that for the young women in groups that had a female majority, they felt less anxious, showed more verbal participation, and reported higher confidence and STEM career aspirations than their peers in female minority groups. This was most significantly true for first-year students, confirming their previous prediction that the *stereotype inoculation model* was most relevant for individuals early in their trajectory towards transcending the negative stereotypes of the group. Thus, in addition to gender identity and personal connection within the group, having the ingroup peers represent the majority of the group composition was important for supporting the positive impact of relatedness in this context.

Dasgupta and her colleagues (Asgari, Dasgupta, & Stout, 2012; Dasgupta, 2011a; Dasgupta, Scircle, & Hunsinger, 2015; Dasgupta & Stout, 2014; Stout, Dasgupta, Hunsinger, & McManus, 2011), through the development of the *stereotype inoculation model* and its supporting studies, show that, similar to autonomy, there are layers and qualities to the concept of relatedness. This condition also must exist in the right manner for it to have a positive effect on motivation – simply putting students in groups or exposing them to any kind of experts is not sufficient. Dasgupta highlights the importance of gender identity (particularly with females) as well as the need for personal connection, increased exposure to ingroup peers and experts, and collaboration for individuals to experience feelings of increased group membership, self-efficacy, and, therefore, motivation in that domain. While her work focuses specifically on late adolescence and the early college years, it provides an additional lens that elucidates aspects of relatedness that are critical for consideration and require further research at all developmental stages.

The concepts of autonomy, competence, and relatedness described by Ryan and Deci (2000b) provide a framework for understanding the conditions that humans require to fully realize their potential in a particular domain. True interest and motivation can only exist when these conditions are satisfied, and abundance in one area will not necessarily make up for the lack of another. Motivation in itself, however, is a broad and complex notion that requires further examination. With all three of these elements in place, motivation can still present differently for different people in various contexts. As with many vast ideas, motivation is not only either present or absent: rather, it exists along a continuum that encompasses a full spectrum of gradations, and Dasgupta's *stereotype inoculation model* provides additional nuances within this construct to better inform an interpretation of motivated behaviors.

The Spectrum of Motivation

At the most extreme end of this spectrum exists the notion of a complete lack of motivation, or amotivation. This state exists when a person has no interest or desire to complete a task or participate in an activity for any reason. Not only does the person lack interest in the topic or task itself, but he or she also has no other internal reason for obtaining success within that context; in other words, there is absolutely no internal regulation of the motivation. Typically, such a complete lack of motivation would arise when there is nothing to be gained by a person fulfilling work in that area – for that person, he or she perceives that there is no benefit to the task itself or to the process of engaging with the work, regardless of the content or topic. In some cases, this may not be a reflection on the person as a learner or in terms of his or her overall motivational tendencies. Motivation in particular domains is an individualized state of being, and variations can be dependent on infinite internal and external circumstances. Thus, amotivation for an individual within a particular context may simply be situational; while it may reflect a person's developmental traits in that moment, it is not necessarily indicative of development stages or characteristics themselves. Ryan and Deci (2000a, 2000b) argue that humans are inherently motivated beings from birth, that the desire to succeed is natural. How this phenomenon is manifested in different developmental and contextual settings has much to do with the conditions, both internal and external, that impact a person's engagement.

On the complete opposite end of this spectrum, the other extreme from amotivation is intrinsic motivation. Intrinsic motivation refers to complete personal interest and investment in a topic or task and represents the greatest desire to reach one's full potential. A person shows intrinsic motivation when he or she is engaged with the activity for completely internal reasons, internally regulates his or her own motivation, and pursues the task for his or her own accord. Interest in the task is specific to the domain and content, which takes precedence over the process by which success is achieved. In other words, factors such as getting good grades or pleasing teachers, while perhaps contributing at some level to the existence of motivation, are not the primary influences. Intrinsic motivation in a topic or activity may exist for many reasons within in individual and may be fostered in particular contexts. An individual may show a particular propensity for something: playing soccer, vocal music, studying insects, and these interests may have arisen from various individualized circumstances. Perhaps these interests reflect family values that have been cultivated, or perhaps they emerged from an impacting experience. Whatever the case, these domains reflect areas in which a person excels, pursues for internal reasons, and engages with for the sake of the domain or activity itself.

Intrinsic motivation is not completely outside of external influences, however. Ryan and Deci (2000a, 2000b) assert that supportive conditions must be maintained that will greater enhance the potential for this level of interest. As discussed previously, the conditions of autonomy, competence, and relatedness must be present to allow for intrinsic motivation to ensue. As such, conflicting conditions can serve to undermine intrinsic motivation and shift the focus towards external reasons for pursuing a task or engaging in a domain. When autonomy in a particular context is replaced by external control, when a lack of support is perceived, and when feedback is received in the form of tangible rewards, then success with an activity is pursued for external reasons as opposed to intrinsic interest. This does not necessarily thwart motivation all together, but causes the intent to shift toward external reasons instead of for personal satisfaction. On the other hand, a hostile environment due to excessive pressure and demands or unhealthy relationships will most surely serve to sabotage intrinsic motivation and the opportunity for individuals to fulfill their critical psychological needs.

Amotivation and intrinsic motivation reflect two opposite ends of a complex spectrum, describing the span from a complete lack of motivation to the highest level of internal, personal investment. In between, there are gradations of motivation that reflect the plethora of external factors that can impact a person's interest in a task or topic. These variations of motivational levels are described as extrinsic motivation. Contrary to intrinsic motivation, these states of motivation reflect factors imposed from outside sources which can serve to increase a person's desire for participation and success in a particular context. In addition, these levels, while still labeled extrinsic, more closely approximate intrinsic factors and characteristics as they approach that end of the spectrum. In other words, this continuum reflects the movement towards more internal and personal motivational factors. Extrinsically-motivated behaviors, however, are different from intrinsically-motivated ones in that the pursuance of the outcome is not necessarily for personal satisfaction of the activity itself but for some separable gain.

The level of self-regulation, or self-determination, that an individual shows towards a certain externally motivated behavior determines where along the spectrum his or her extrinsic motivation lies (Ryan & Deci, 2000a, 200b). This, of course is the crux of self-determination theory, that different types of motivation reflect different levels of self-regulation within a domain. Ryan and Deci argue that as humans develop and throughout their lifetimes, many things are in fact externally motivated. Behaviors spawning from true intrinsic motivation are far rarer than those resulting from the existence of various types of external conditions. This does not, however, preclude the need for autonomy, competence, and relatedness at different levels of motivation. In order to carry out extrinsically-motivated tasks or behaviors, certain conditions must still be present that will ensure the fruition of those tasks. As such, according to SDT, the different types of conditions present will impact the amount of self-regulation as well as the value placed on the behavior or task.

As part of their theory of self-determination, Ryan and Deci (2000b) have described four different levels of extrinsic motivation in terms of the amount of self-regulation present: *external regulation, introjected regulation, identified regulation, and integrated regulation*. These levels lie in the middle of the spectrum between amotivation and intrinsic motivation and reflect increasing self-regulation. For example, lying closest to amotivation on the spectrum is *external regulation*, which suggests that a person's motivation comes completely from external conditions and perhaps not positive ones. Punishment, for example, can incite externally-regulated motivation. Moving along the spectrum, *introjected* and *identified regulation* show increasingly more self-determined levels of motivation, with introjected regulation aligned to an individual's feelings of self-worth and identified regulation reflecting an individual's belief in a task's value. Even more autonomous is *integrated regulation*, which shares many commonalities with intrinsic motivation in that there is a match between the task or behavior and an individual's interests and values; there is still, however, an external goal or separable outcome rather than simple enjoyment. Motivation, therefore, spans a complex spectrum from amotivation to extrinsic motivation to intrinsic motivation that is reflective of an individual's level of self-regulation in relation to the existence of the conditions that are in place and the reasons for pursuing a certain task or behavior.

The conditions necessary for motivation to exist (autonomy, competence, and relatedness) align with this continuum of motivational levels. As has been described, the closer one moves along this spectrum towards intrinsic motivation, the more internal regulation of one's motivation within a context can be seen. As such, the level of autonomy increases as well. As prior experiences and continued exposure and practice within certain contexts continues, so can the levels of competence and relatedness. Increased experience with a task or behavior may serve to increase one's abilities in that domain and can also help that individual see his or herself more connected to a community within that context. Therefore, levels of motivation and motivational conditions are not fixed for any particular task or behavior. Rather, they exist within the interdependent and inter-connected system of factors that work together in any situation. Circumstances, experiences, relationships, and changes within any context can serve to positively or negatively influence the motivational levels or conditions for an individual.

With this in mind, it becomes critically important to consider the conditions that are present or absent for an individual when evaluating motivation in any setting. When fostering motivation is necessary, influencing the factors that will contribute to greater levels of internal regulation is crucial. Historically, particularly in many teacher preparation programs, motivation was examined strictly in terms of extrinsic and intrinsic characteristics. In light of the work of Ryan and Deci, however, the importance of recognizing the various manifestations of extrinsic motivation becomes critical, particularly since extrinsic motivation in its various iterations is shown to be more prevalent than intrinsic motivation during the teen years (Gillet, Vallerand, & Lafreniére, 2012). As such, the lofty and perhaps unrealistic goal of fostering solely intrinsic motivation in adolescents can be replaced with a more attainable goal of creating situations in which students are able to develop and fulfill their psychological needs of autonomy, competence, and relatedness, allowing increased internal regulation of their involvement and motivation. Extrinsic motivation is not necessarily an unproductive state. As previously mentioned, much of what humans do arises from external factors and needs. The greater the integration, however, of external values and goals with those of the individual will allow for the conditions that give rise to the highest levels of internal regulation and motivation.

Expectancy-Value Theory

The work of Ryan and Deci (2000a, 2000b) focuses primarily on the conditions that influence regulatory processes and qualities possessed by the individual. Narrowing in further on the quality of tasks themselves yields additional perspective on how individuals show persistence, interest, and achievement motivation in particular contexts. The work of Jacquelynne Eccles and her colleagues (1991, 1993a, 1993b) has extensively examined other elements that give rise to levels of motivation, often framing the work in an educational setting. Wigfield and Eccles' aforementioned Expectancy-Value Theory (2000), while referring to the influence one's ability beliefs and achievement expectancies have on motivation, also includes beliefs about the value of particular tasks. This interaction of self-efficacy with task value beliefs constitutes Expectancy-Value Theory, which complements the ideas put forth by Ryan and Deci (2000, 2000b) as well as Dasgupta (2011) in that it highlights the critical integration self-efficacy and increased motivation. While the focus of this research is on *self-determination theory* and the *stereotype inoculation model* because of their relevance to behaviors in small groups, the inclusion of Expectancy-Value Theory is important in creating a more comprehensive understanding of motivation in general and will be discussed as such.

An additional aspect of the Expectancy-Value model is the inclusion of achievement values, which includes beliefs about particular tasks. According to Wigfield and Eccles (2000), achievement value is related to the level of persistence, choice, and performance individuals exhibit in any particular domain. Achievement value consists of several sub-categories: *attainment value*, *intrinsic value*, *utility value*, and *cost*. The level of value within in each of these domains influences a person's perception of and effort on the task. *Attainment value* refers to the importance of succeeding on a given task. *Intrinsic value* relates specifically to the inherent interest or enjoyment one gets from a task. As has been discussed previously, an individual will show greater motivation if he or she genuinely enjoys engaging in the activity or is interested in the content itself. *Utility value* refers to the usefulness a person perceives a task to have. Often, this specifically relates to an individual's future plans. Motivation on a particular task may be related not necessarily to enjoyment with the activity or a desire for success but rather because it will help that person towards a later goal or move him or her along a chosen path. The final component of achievement value is *cost*. This notion describes a variety of circumstances which may result from engaging in a certain task. In other words, cost is what one sacrifices in order to participate in a task. In contrast to the other components, cost has a more negative connotation in that it indicates what is given up in order to engage in other tasks. The interaction of these elements of achievement value serve to impact the manner in which a student will engage with a task and influence the motivational regulation and decision-making processes around a particular task.

In their reflection of the work surrounding Expectancy-Value Theory, Eccles and Wigfield (2000) determined that the task value students place on the activities they experience are critical predictors of their achievement motivation. Integral to this study and consistent with other findings, however, is that students' self-efficacy and task value beliefs decrease over their school years, particularly beginning at the transition to middle school. This variance differs across domains and across the manner of engagement with the domains. For example, Eccles found that children's subjective valuing of math, reading, music, and sports decreased over a three-year study spanning early to late elementary school years in their beliefs about the usefulness of the subjects. Their actual interest, however, in math and sports remained constant through the upper elementary years. Additional changes were apparent in the transition from upper elementary to middle school as well, with the actual liking of math and reading decreasing during the junior high years. Their utility value of reading, however, increased at this point. Integral to any study of motivational conditions, thus, is an awareness of the levels at which one expresses value of a task. An individual may find an activity to be interesting but not necessarily useful for his or her future plans. The cumulative effect, however, of the overall decline in students' task values over their school years, particularly when viewed in conjunction with similar declines in ability beliefs, points to an impact on achievement motivation during this transition as well.

In sum, an individual's achievement motivation can be described and evaluated by examining the extent to which this motivation is internally regulated. When an environment or set of circumstances supports the conditions of autonomy, relatedness, and competence in the appropriate amounts and with the necessary qualities for a person's developmental levels, then greater levels of self-determined motivation in a particular domain will occur. Critical, therefore, is then using this framework to explore and evaluate the phase in which this motivational decline is shown to be the greatest: during the transition into and throughout the secondary school years.

Achievement Motivation and the Secondary School Environment

A review of the literature describing the characteristics and factors relating to achievement motivation naturally leads to an inquiry of its clearly-documented decline beginning with the transition to early adolescence and into middle school. Students' behavior and attitudes also reflect a shift from greater intrinsic motivation in their schoolwork in elementary school to becoming more extrinsically motivated to pursue their middle and high school academics (Eccles, 1993a; Gillett, Vallerand, & Lafreniére, 2012). With many researchers observing and describing this phenomenon through a variety of measures, the question remains, what are the variables in the interaction between adolescent development and school structures that are leading to this overwhelming trend?

It is tempting to wonder if declines in adolescent achievement motivation are simply a developmental phase or reflective of changes in our societal expectations. While clearly distinct eras and points in time have an impact on students' socialization and expectations, the observed change in adolescent achievement motivation is not a new phenomenon. Research spanning some thirty years has alerted educators to this downward trajectory (Eccles et al., 1991; Eccles & Midgley, 1990; Eccles et al., 1993a; Eccles et al., 1993b; Simmons et al., 1979; Wentzel, 1997; Wentzel, 1998). In order to make sense of the factors involved in this decline, an examination of the developmental characteristics of adolescents, the traits of middle and high schools, and the interaction between these two is necessary for truly understanding achievement motivation at the various adolescent levels.

Adolescent Developmental Characteristics

Adolescents on the brink of and experiencing puberty are undergoing emotional, social, and physical changes that shape their experiences in their educational and family settings. While beyond the scope of this paper to provide an in-depth discussion of adolescent development as a whole, there is a critical need to understand certain characteristics of students at this stage in order to make sense of their presence in the school environment. Most strikingly is the adolescent's need to begin forming his or her identity, and this impacts his or her school and family interactions in many ways. To begin to establish a sense of self, young adolescents start to develop greater independence from their parents and teachers in order to further define themselves on their own terms (Eccles et al., 1993a; Eccles et al., 1993b; Eccles & Midgley, 1990; Simmons et al., 1979). Yet at the same time, the peer group and social dynamic becomes critically important as well (Wentzel, 1998). Middle school students begin to form their identity also within the context of the social group, focusing increasingly on peer and sexual relationships in order to establish their greater self-awareness, and this process continues throughout high school. Young adolescents are highly self-conscious as they embark on this process, consistently aware of how they are viewed and perceived by others, and this certainly becomes heightened as they experience the effects and changes associated with puberty as they progress through their secondary school years. As such, this self-consciousness may be associated with changes in academic motivation in that students may avoid performing in a manner that causes them to be distinguished from their social group.

Not only are adolescents developing physically and emotionally, but they are also expanding cognitively (Eccles et al., 1993b). Their mental ability to engage in abstract and critical thinking becomes more advanced, and they can take on greater intellectual stimulation and demands. They begin to formulate their own opinions, define their belief systems, and express their thinking about issues that they feel are important. This, too, becomes part of the identity-formation process as it helps them assert themselves as individuals yet within a greater community.

The secondary school years have the potential to be an exciting time for students, yet often it becomes a discouraging experience for both students and teachers alike. Beginning in the late 1970's, Ruth Simmons and her colleagues (Simmons et al., 1979) explored and established the negative changes associated with students' transition to middle school. Focusing specifically on self-esteem effects, Simmons consistently found that twelve-year-olds transitioning to traditional junior high school environments showed the greatest level of emotional disturbance, above twelve-year-olds still in a sixth grade elementary school environment. As indicated on a variety of psychological measures, this early adolescent age marked a time of declining self-image and stress and could be identified most prominently in girls who had made the transition to a junior high school. Subsequent work of Simmons and her colleagues sought to more carefully isolate the environmental, social, and biological factors contributing to this phenomenon. A longitudinal study following students moving from sixth to seventh grade in two different types of school systems reaffirmed prior research indicating that the cumulative effect of multiple changes at this age level: transition to a new junior high school, the onset of puberty, and changes in social and dating relationships, caused the greatest stress and emotional disturbance in students. Students who had not yet reached puberty or who were in K – 8 schools in which a transition to a new school environment was not necessary did not present the same intensity of decline in mental health. Moreover, this phenomenon was observed most prominently in girls. While these findings were reported primarily from psychological measures, changes in standardized test scores and behaviors were observed as part of this study as well, indicating that the negative effects associated with these multiple changes impacted not only self-image but school performance as well. This research illustrates how academic achievement motivation is (and has been for many years) negatively impacted by developmental and emotional changes associated with the transition to adolescence and middle school itself.

While this prior work is not focused specifically on adolescent achievement motivation, Simmons and her colleagues (1979) provide background for understanding some of the existing conditions that adolescents are experiencing during this tumultuous time. This creates a more meaningful context in which to explore motivational factors and their interaction with the many changes in an adolescent's life as well as to make sense of the observed decline in school motivation

Stage-Environment Fit

Eccles and her colleagues have sought to describe this phenomenon more specifically with their *Stage-Environment Fit* approach (Eccles et al., 1991; Eccles et al., 1993a; Eccles et al., 1993b; Eccles & Midgley, 1990). Eccles cites David Hunt's 1975

Person-Environment Fit Theory as the foundation for their work, proposing that individual's behaviors are influenced by the interaction between the characteristics they bring to their environment and the qualities of the environment itself. Further, there will be greater successes and positive effects when an environment meets an individual's developmental and psychological needs. To place this in the context of motivational theory in middle and high school settings, students will be more motivated to achieve when an educational environment provides elements and opportunities that are appropriate for their specific developmental and grade level (Eccles, et al., 1991).

Eccles and her colleagues argue that the reverse is also true: if there are appropriate environments for distinct developmental levels, then there are also environments which can be actually detrimental or regressive to a student's motivation and achievement (Eccles et al., 1991; Eccles, et al. 1993a; Eccles et al., 1993b; Eccles & Midgley, 1990, Eccles & Roeser, 2009). In such a case, the fit between the students' needs and what the environment offers is not present. With a marked change in the typical elementary and secondary school environments occurring simultaneously with a documented decline in adolescent motivation, Eccles reasonably questioned the possibility of a correlation between the two as opposed to attributing the decline solely to the characteristics of young adolescents.

Analyzing typical secondary school experiences using the lens of stage-environment fit, Eccles used a variety of prior literature as well as her own research in junior high schools to identify several areas in which the middle school, junior high school, and high school environments are markedly different from that of the elementary schools and to determine their impact on student achievement motivation during adolescence (Eccles et al., 1993a; Eccles & Roeser, 2009). She compiled a list of such characteristics, including greater teacher control and reduced student decision-making, fewer personal teacher-student relationships, increased competition and public comparison, fewer opportunities for collaborative learning experiences, lower teacher self-efficacy, more tasks that require lower-level cognitive skills and creativity, and stricter student evaluation standards. While these features present concerns on their own, the critical question is how they interact with adolescents' developmental and psychological needs as well as how these students respond to these changes in their environment. Not only do these school characteristics pose problems for all adolescent students, they are particularly conflicting for the learning styles of girls and even more so when occurring in STEM domains, in which girls are typically negatively stereotyped.

A useful way to explore this phenomenon and review Eccles' literature regarding school environments with regard to motivation is to return to the framework provided by Ryan and Deci in their Self-Determination Theory (2000b) and to examine the manner in which autonomy, relatedness, and competence are present in the world of the adolescent. While Ryan and Deci's work often discusses motivational characteristics and descriptors without context, the needs for autonomy, relatedness, and competence can be applied rather neatly to create a more comprehensive picture of how secondary school students experience their educational environments and how this interaction impacts their motivation, both overall and in specific domains. In addition, incorporating the overlapping ideas put forth by Dasgupta in her *stereotype inoculation model* (2011a) as appropriate will provide the cohesion to effectively insert the experience of adolescent girls in STEM situations into this overall discussion.

Ryan and Deci describe the need for autonomy in order to facilitate motivation as the converse of control. They assert that students need to feel some sense of choice and creativity in their work so that they are "catalyzed" to be intrinsically motivated (Deci, Koestner, & Ryan, 2001; Ryan & Deci, 2000a, Ryan & Deci, 2000b). As previously discussed, however, autonomy support must reflect the perspective and needs of the child. Eccles and her colleagues corroborate that, "the match between the child's need for autonomy and the amount of adult control exercised is critically important" (Eccles et al., 1991). To examine an environment in terms of the opportunity for autonomy that it offers, it becomes important, therefore, to differentiate between optimal levels of control and autonomy at a given developmental stage as opposed to simply the presence or absence of autonomy.

Drawing from findings in her seminal work, the Michigan Study of Adolescent Life Transitions and using the theory of stage-environment fit, Eccles proposes a mismatch between the level of control exerted in a typical middle school classrooms and the amount of autonomy desired by a typical adolescent (Eccles et al., 1991, Eccles & Midgley, 1990; Eccles et al., 1993b). Using four waves of data collection spanning the transition from sixth to seventh grade, Eccles observed that students expressed an increasing desire and need for decision-making opportunities. They wanted to have more control over their work and over decisions made in the classroom. Further, there was a relationship between this desire for control and the maturational level of the student; in other words, as students progressed through puberty, their desire for autonomy increased as well.

Unfortunately, in many cases the secondary school environment provides the opposite opportunity for these students, as Eccles discovered in her work. As opposed to giving students greater autonomy and chances for decision-making, both students and teachers expressed that instruction included far more teacher control and discipline than in elementary school. In her Michigan study, Eccles found that students perceived fewer chances to contribute to decision-making in the classroom over the course of their seventh grade year (Eccles et al., 1993b). Further, same age-students (particularly females) who were more physically developed had an even more negative perception of their autonomy opportunities when compared with their less mature classmates. These findings suggest that several things: first, as students mature, they desire increased opportunities for autonomy. Second, the school environment does not necessarily follow a trajectory that aligns with adolescents' autonomy needs, therefore resulting in a mismatch between developmental characteristics of the student and the typical school's responsiveness to this. Finally, the issue is posed that there might be multiple perceptions within a classroom of the same environment depending on the individuals' needs and development while at the same time teachers may respond differently to students of distinct maturational and motivational stages (Eccles et al., 1991).

According to the findings of this study, the poor stage-environment fit present in the classroom in terms of autonomy needs coincided with marked declines in students' intrinsic motivation in classroom activities and learning opportunities. Students who felt the greatest sense of mismatch and teacher control also showed the lowest levels of classroom engagement. Lower levels of motivation and extrinsic motivational orientations were also associated with greater occurrences of negative behaviors and poor school conduct, once again emerging particularly strikingly among females.

To frame this phenomenon in the context of self-determination theory, there is much more to contemplate than simply the existence of autonomy in a classroom. Autonomy needs follow a developmental path that must be met by the opportunities afforded by the learning environment (Eccles, 1991, 2009; Gillet, Vallerand, & Lafreniére, 2011; Lavigne, Vallerand, & Miquelon, 2007). When the school environment offers fewer opportunities for autonomy and student decision-making while developmentally these students desire more, then there is a mismatch in the stage-environment fit for these adolescents. The result is more extrinsic motivational orientations, a decline in student engagement in the classroom, and ultimately the risk of negative behavioral and academic outcomes.

The realm of competence becomes a complex issue when examined in the context of the classroom because it encompasses self-efficacy perceptions from both the students and the teachers themselves. Ryan and Deci, as well as Dasgupta, propose that feelings of competence, particularly when coupled with opportunities for autonomy, inspire more internally-regulated motivation and encourage individuals to remain engaged with a task or domain (Dasgupta, 2001a; Deci, Koestner, & Ryan, 2001; Ryan & Deci, 2000a; Ryan & Deci, 2000b). These competence perceptions are developed through a sense of belonging to the group, appropriate challenges, and feedback that is constructive, positive, and inspires the desire to obtain mastery over a task or skill. Ryan and Deci argue that feedback that is demeaning, causes self-consciousness, or is based on external rewards unrelated to the task undermines feelings of competence.

When competence beliefs are examined first within the context of adolescent development, understanding the progression of identity formation is critical in order to provide feedback and evaluation opportunities that are sensitive to these needs. As previously mentioned, adolescents are characterized, as they begin to make sense of who they are, what they are good at, and what they believe, by considerable self-consciousness. They are highly focused on how they appear to their peers and how this relates to their own burgeoning sense of self; they seek a comfortable fit with their various groups' identity expectations and stereotypes. This characteristic is a powerful indicator of the appropriateness of the *stereotype inoculation model* (Dasgupta, 2011a) for this age level. Feelings of competence, thus, become a critical piece of identity-formation for an adolescent: if made to believe that they are not competent in a particular skill or domain, then those areas are quick to be trimmed from an adolescent's perception of his or her identity. Eccles and her colleagues uncovered an overall decline in perceptions of intellectual ability at this age level (Eccles et al., 1993a; Eccles & Midgley, 1990; Eccles et al., 1993b), finding that adolescents tend to be more critical and less confident of their own academic capacities than do students of other developmental levels, particularly when they have experienced difficulty or failure in any specific academic domain. In other words, when students feel incompetent on a task or in a particular subject, or when achievement in that area is in conflict with "comfortable" group stereotypes, they are quick to determine that this does not fit with their identity, and, according to the model set forth by Ryan and Deci and Dasgupta, their motivation will suffer in that area.

With regard to feedback and its role in shaping competency beliefs, one of the most basic and dramatic shifts between elementary and secondary school is simply the method of evaluation. Even in a time when the current emphasis is on the use of assessment data and benchmark goals, students in an elementary setting are evaluated in terms of their individual progress towards mastery. The path is as important as the end result and is tracked and analyzed in order to make educational decisions for that student. In contrast, a hallmark of middle and high schools is the change to letter and percentage grades. The feedback, thus, becomes more fixed and based on a correct end result, even on basic task completion instead of depth of thinking or individual progress. Eccles and Roeser discuss this in terms of mastery-oriented versus performance-oriented goals (2009) and assert that students with mastery-oriented goals remain academically motivated more so than students who are performance-oriented. This is particularly true for adolescent girls, for whom the competition and social comparison associated with performance-oriented goals are in direct contrast with their collaborative and human-oriented learning needs. This by itself has the potential for enormous ramifications adolescent identity and competence beliefs. Competition and comparison become heightened at a time when students are characteristically more self-conscious about their performance and abilities in a group setting. Additionally, these grades have the potential to track students into particular ability groups and classrooms, which are highly evident to the students and reinforce any competence beliefs that they are starting to form about themselves. Eccles argues that once a student is tracked into an ability group, moving beyond that group is nearly impossible (Eccles et al., 1993a), and this continues to solidify a students' level of self-efficacy and identity in that area. Further, these marginalized or lower-performing students will adopt ego-protecting strategies in response, which further reinforce and sustain their amotivation in that area (Eccles & Roeser, 2009).

A "down-to-business" approach as well as large numbers of students in the secondary school classroom can cause not only evaluation but instructional methods as well to become less individualized, which in turn negatively affects competency beliefs. Eccles and her colleagues have observed and researched a marked difference in instructional approach between elementary classrooms and that which occurs in middle and high school classroom settings (Eccles et al., 1993a; Eccles & Midgley, 1990; Eccles et al., 1993b; Eccles & Roeser, 2009). In her Michigan study, while sixth grade teachers incorporated a combination of individual, small group, and whole group instruction throughout the day, seventh grade teachers tended to rely solely on whole group instructional delivery and task organization. All students were observed completing the same assignments from the same textbooks at the same time. Further, based in addition on Eccles' prior literature reviews, she found evidence that many of these tasks incorporated lower-level cognitive skills and did not match adolescents' needs for increased cognitive sophistication, life experiences, differentiation, and integration of individual identities (Eccles et al., 1993a; Eccles & Roeser, 2009). In fact, adolescents often report that they find the academic work and instructional delivery in their secondary classrooms boring and irrelevant (Eccles & Roeser, 2009), which is certainly consistent with additional research on girls' experience in secondary science classrooms. With a lack of individualization and mass instructional approach, students have only way in which to be successful, and therefore only one manner in which to develop a sense of competence in that area. Those students for whom that particular method is ineffective will assimilate this perspective into their developing identity and beliefs of their own competence, or lack thereof. In a scenario in which students are feeling incompetent based on competitive and public evaluation methods as well as developmentally inappropriate tasks, then clearly their motivation in that context will be compromised.

Competence and self-efficacy are critical predictors of adolescent motivation, yet it has an equally important role among middle and high school teachers as well. Low self-efficacy among teachers in their content areas will have a direct impact on the manner in which they instruct, interact with students, and organize a classroom. Clearly, when a teacher perceives herself to have a lack of competence and effectiveness in the classroom, then one can surmise that they she will tend toward the previously-mentioned phenomena: whole group instruction, activities that rely on lower-level cognitive skills, and lack of individualization simply because she will lack the confidence or sense of purpose to delve deeper into the subject matter. As concerning as this scenario may appear, this is precisely what Eccles found in her Michigan study (Eccles et al., 1993a; Eccles & Midgley, 1990; Eccles et al., 1993b). Specifically in the area of mathematics, Eccles and her colleagues found that the instructional conditions middle school teachers faced in their classrooms (large class sizes, greater emphasis on academic achievement, and shortened class periods) made them feel less effective in the classroom (Eccles et al., 1993a; Eccles & Midgley, 1990; Eccles et al., 1993b). Lowered self-efficacy among the teachers translated directly to decreased motivation and academic achievement in the students. As the teachers found the educational situation to be futile, so did the students.

Remaining true to the framework put forth by Ryan and Deci, the final condition of motivation to examine within the framework of middle schools in that of relatedness. Stemming back to John Bowlby's (1979) theories of attachment, Ryan and Deci posit that motivation occurs similarly, thriving where a feeling of security and connectedness is present (Ryan & Deci, 2000b). Once again, looking directly back to the basic structure of the typical middle and high school setting, the opportunity for relatedness is often not there. Large class sizes, shortened class periods, and disciplined approach frequently do not allow the opportunity for students and teachers to develop meaningful, close relationships that would foster greater academic motivation and create the community of learners in which students might perceive themselves as a participant. In addition, as a result of these same factors, the opportunity for students to collaborate and engage in cooperative learning experiences with each other is often absent. A final look at the work of Eccles reveals this to be accurate and only part of the problem. By surveying both the teachers and students between both the sixth and seventh grades in the Michigan study, she found that these conditions led to perceptions that inhibited relatedness on both sides. Students, when asked, described their seventh grade teachers as less friendly, less supportive, and less fair than the teachers these students had one year earlier (Eccles & Midgley, 1990; Eccles et al., 1993b). As already mentioned, a common conception among secondary school teachers is that they need to get more serious and disciplined with the students. This can be seen as a vicious cycle: as teachers are afforded less opportunity to develop relationships with their students, they rely on a stern approach to control them, which leads the students to think of them in a less positive light, which requires the teachers to continue to rely on their stern approach.

While the students may provide a relatively unflattering report of their seventh grade teachers, Eccles found that the teachers described a similar lack of connection with their students. As compared with the sixth grade teachers, they reported “trusting” their students less (Eccles & Midgley, 1990). As a result, they also asserted that the seventh grade students needed significant control and discipline, referencing a belief in students' lower status in the classroom and necessary deference to the teachers. Clearly, this attitude on the part of the teachers would lead to students to feel less connected to them. In Eccles' study, classrooms in which there was a higher reported incidence of low relatedness also exhibited the lower levels of student motivation and decreased academic achievement.

Clearly, this lack of relatedness points directly back to the *stereotype inoculation model* (Dasgupta, 2011a). With no opportunity to develop personal connections with potential ingroup experts (the teachers) or their ingroup peers (classmates in a collaborative scenario), adolescents are not provided with the conditions needed to facilitate envisioning various pathways for themselves, potentially transcending group stereotypes. Rather, this environmental setting promotes taking the least risky courses of action because the personal support, encouragement, and scaffolds to do otherwise are simply not there.

Summary

This combination of factors present in a typical secondary school environment as uncovered by Eccles and her colleagues (Eccles, et al., 1991) presents a scenario that contradicts the developmental needs of adolescents put forth by Simmons (Simmons et al., 1979), the qualities of relatedness and group membership posited by Dasgupta (2011a), as well as the motivational conditions described by Ryan and Deci (2000, 2000b). As such, the stage-environment mismatch, as described by Eccles, provides a rationale for the decreased motivation in secondary schools as observed by the multitude of prior literature. While it may appear based on these combined findings that a restructuring of secondary schools to promote greater student motivation is the clear solution, much remains to be examined. The work of Simmons, while still influential and pertinent to this discussion, occurred some thirty years ago and is focused to a large extent on self-esteem effects. In addition, while Eccles provides seminal data to show how typical middle schools do not serve the developmental and motivational needs of adolescents, her findings arise from a singular study in Michigan. The understanding of adolescent motivational issues would be greatly advanced by replicating this work elsewhere and with other middle and high schools. Further, while Eccles dissected her work among genders and subject areas to a certain extent, focused work in this area that specifically draws on *self-determination theory* and the *stereotype inoculation model* would serve to create a more updated and comprehensive view of the experience of adolescents in specific domains.

A pertinent context in which to examine these motivational theories is in the domain of secondary school science education. With the current under-representation of women in many fields of science pointing back to girls' experiences with science in their secondary schooling and its reported lack of stage-environment fit, an investigation of the interplay between Ryan and Deci's motivational conditions, the *stereotype inoculation model*, and their combined impact on girls' engagement with science in this context is critical. The manifestation of motivational conditions with a specific eye to the experience of girls in science groups provides the opportunity to explore the *stereotype inoculation model* in a different context than has been done thus far. These theories provide a powerful basis for understanding adolescent motivational issues and how much, to what extent, in what form, and when certain motivational conditions might be fulfilled in order to meet the specific needs of adolescent girls in the science classroom.

The study of achievement motivation remains a vital and important area of research, particularly as researchers learn more about unique characteristics and qualities that define motivation at different development levels and in different settings. Critical to this work is its practical application to better meeting the needs of adolescents in secondary schools. As the interaction between adolescents' cognitive and psychological processes and their educational environments is better understood, school structures and instructional approaches should develop to meet these needs. Further research that defines these elements more closely will only serve to ameliorate a scenario that has often discouraged both students and teachers alike.

Research questions

The existing literature on girls' motivation in science is often grounded in issues related to identity, adolescent development, relationships, education, and access. While all of these elements are important to developing a comprehensive understanding of how girls experience the domain of science, far less has situated this phenomenon within the specific framework of *self-determination theory*. Yet the work of Dasgupta as well as of Eccles and her colleagues draw on aspects of motivation theory to support their work, particularly in relation to individuals' motivation within domains of STEM. As suggested, for many girls, female peers and role models have the greatest influence on their actions, decision-making, and subsequent perceptions of self-efficacy, suggesting that gender identification within a STEM group may have the greatest positive effect on their behaviors and attitudes (Dasgupta & Stout, 2014). This scenario alone has the potential to address the conditions of relatedness and competence and their manifestation for girls within such groups. The inclusion of the condition of autonomy as well, however, would provide an even more comprehensive exploration of girls' motivation within such a setting. Therefore, layering the *stereotype inoculation model* over *self-determination theory* offers the potential to determine ways of providing situations that better align girls' group membership and that of a science identity in order to ultimately provide the right conditions for increasing girls' science motivation.

An additional consideration, based on literature indicating girls' preference towards life sciences and inquiry (Bennet & Hogarth, 2009; Britner, 2008; Burkham & Smerdon, 1997) as well as data showing women's drastic underrepresentation in engineering fields (AAUW, 2010; Hill, Corbett, & St. Rose, 2010; NSB, 2016; NSF, 2011), is if group gender composition in the classroom impacts girls' motivation differently in these various STEM domains. While they may already exhibit greater levels of engagement and participation in tasks involving living creatures or the natural world, would any potential benefit be observed in contexts, such as engineering, in which their motivation is typically drastically lower? Further, the work of Dasgupta and her colleagues (2015) focuses on women's motivation while working on engineering tasks; therefore, the inclusion of engineering in this study with high school students creates the necessary connection to the previous literature and findings regarding the *stereotype inoculation model*.

This current study is embedded within and utilizes data collected for the larger NSF project of Dr. Martina Nieswandt and Dr. Elizabeth McEneaney, entitled *Managing Small Groups to Meet the Social and Psychological Demands of Scientific and Engineering Practices in High School*. The purpose of this study within the NSF project is to explore the motivated behaviors of students throughout a series of three science inquiry and three engineering design tasks. Situated in motivational theory and using the *stereotype inoculation model* as an additional layer, this project explores the role that gender composition plays in the manifestation of motivation, specifically in relation to the conditions of autonomy, competence, and relatedness. To address this topic, students were places in small groups of four (one with three) representing varying gender compositions: some with gender equity and some with a gender majority (greater than half of a specific gender). Using an a priori set of codes that combined Jovanic and King's (1998) behavioral indicators with Ryan and Deci's motivational conditions (2000a, 2000b), student behaviors as well as reflections on their experiences were analyzed in order to determine how these factors represented or enacted the various motivational conditions. Patterns in the data between genders as well as between groups of varying gender composition were compared. Further, as research on girls' participation in science and women's participation in STEM fields indicates a strong difference between life science fields and engineering pursuits (Hill, Corbett, & St. Rose, 2010; NSF, 2011), the data was also examined by comparing the behaviors and reflections between these two distinct domains, as provided by the biology and engineering tasks from the NSF study.

Dr. Nieswandt and Dr. McEneaney's study provides the ideal setting to explore the manifestation of these conditions in that they are established through the very structure of the study. In other words, an appropriate *stage-environment fit* (Eccles et al., 1991; Eccles et al., 1993a; Eccles et al., 1993b; Eccles & Midgley, 1990) should be present because the scenario provided should meet the developmental and psychological needs of the students in this particular developmental stage, which allows for greater emphasis to be placed on aspects of motivation not directly related to development. Autonomy, thus, should be present in that the inquiry and engineering tasks require the students to plan and execute their own solutions to the questions, which are provided within a developmentally-appropriate framework. The condition of relatedness is established through the focus on small group structure, and competence is addressed in that these tasks occur within units of study in the classroom in which students are receiving the background knowledge and prior content to understand the ideas and parameters outlined in the tasks. The following research questions will guide this project:

1. How is motivation manifested in small groups of high school students as they engage in science activities?

- ***How do these groups manifest autonomy, competence, and relatedness in their group interactions?***
- ***Within the group, how do boys and girls differ in their manifestation of autonomy, competence, and relatedness?***

- ***How are these patterns different between groups of varying gender composition and across different science tasks (science inquiry versus engineering)?***

2. How do participants of these small groups perceive their experiences of motivation?

- ***What are the group participants' perceptions of their small group experiences with regard to autonomy, competence, and relatedness?***
- ***How are these patterns in perceptions different between groups of varying gender composition and across different science tasks (science inquiry versus engineering)?***

Prior studies have sought to identify behaviors that indicate motivation in a general sense and others have described manners of engaging with tasks, but none have specifically delineated behaviors or perceptions of experiences among the conditions of *self-determination theory* and with the additional layer of the *stereotype inoculation model*. For this reason, the most appropriate method of analysis must be qualitative. Because patterns and themes are being sought in this context for the first time, an approach that is exploratory in nature but based in the themes arising from prior theoretical findings is most applicable.

CHAPTER III

METHODS

Purpose and Significance of the Study

While current research shows that the gender gap in science achievement has disappeared, girls continue to show declining levels of science engagement in school: decreased participation, interest, self-efficacy, and motivation. Literature shows that societal stereotypes, family dynamics, and educational structures and pedagogy are at the root of this issue, impacting girls' self-perceptions, access and motivation in science. The purpose of this study is to explore the motivated behavior of students in small science groups within the context of *self-determination theory* and how the conditions of autonomy, competence, and relatedness are manifested in the students' behaviors. In addition, the *stereotype inoculation model* provides an additional layer to explore gender patterns within these manifested behaviors, particularly in relation to varying group gender composition. Further, an examination of these motivated behaviors between biology inquiry and engineering tasks is considered.

Philosophy of Research

A phenomenological approach to qualitative research seeks to understand events and interactions through the perspectives of the various human beings involved (Bogden & Biklen, 1998). While not completely disregarding some level of objectivity, phenomenology focuses more on people's behaviors and perspectives with regard to certain situations and phenomenon. Phenomenologists aim to better understand these behaviors and perspectives and the interpretation of specific "realities" they convey. The goal, thus, is to look “through the eyes of the subject group” (Morrell & Carroll, 2010, p. 15) within the qualitative study and understand the distinct experiences of the individuals involved.

Grounded theory, also aiming to make meaning of a situation or phenomena and possibly to explore the participants’ feelings about it, has the additional goal of developing a theory from the themes and patterns that are present in the data (Morrell & Carroll, 2010). Thus, in this case of the grounded theory approach, there are not pre-existing theories that apply to this particular situation or phenomena, and the researcher aims to begin the process of developing theories to explain it from the moment the data collection process begins (Merriam, 2009). Thus, the manner of developing understanding is inductive in that a potential theory is developed from the specific case that serves to inform a broader realm or domain, in contrast to phenomenology, which remains more closely tied to the subjects within the study.

Both phenomenology and grounded theory are methodologies that are influenced by a social constructivist viewpoint to research because they both assume that knowledge and “reality” are constructed by the participants involved (Charmaz, 2008; Morrell & Carroll, 2010). Both seek commonalities among the data in order to derive meaning from the situations. The aim of this study is to similarly examine the experience of the participants in their small science groups in order to make meaning of their behaviors, perceptions, and reflections by seeking commonalities and patterns within the data. This study, however, is situated in theories of motivation which have already been widely researched and have become somewhat mainstream. Further, it layers multiple models on top of each other, in a sense, in order to examine certain aspects of a phenomenon within a specific context: specifically, the manifestation of the conditions of *self-determination theory* within the context of small groups in science class, focusing on the role that the *stereotype inoculation model* may also play in this scenario. Thus, while still maintaining a constructivist approach, a focus on “contextual constructivism” (Madill, Jordan, & Shirley, 2009) that acknowledges the specific conditions within this study as well as the researcher’s theoretical position, is most appropriate (Brooks, McCluskey, Turley, & King, 2014). Further, this specificity of context and prior conditions make neither grounded theory nor phenomenology in their purest sense appropriate choices for methods in this case, either. A research method that is thematic in nature, yet explicitly acknowledges the framework imposed by the literature and the researcher’s stance is necessary.

Thematic analysis is directly related to both phenomenology and grounded theory due to its analysis of commonalities and patterns in the data in order to derive meaning and understanding of human experiences and events. Gaining increasing acceptance as a method in its own right, as opposed to being a tool for conducting grounded theory or phenomenology (Braun & Clark, 2006), thematic analysis provides the flexibility to be pursued within any theoretical framework and from any philosophical research stance. Thematic analysis, however, does follow a prescribed six-step manner of analysis in order to identify and describe the underlying themes. These steps, as described by Braun and Clark (2006) are as follows:

1. Become familiar with data.
2. Generate initial codes.
3. Search for themes.

4. Review themes.
5. Define and name themes.
6. Produce the report.

This process, while often presented as linear, is in reality an iterative, recursive process in which the steps are repeated and moved between as many times as needed in order for the themes that have been identified to be refined so that they sufficiently support and represent the data and serve to tell its cohesive story (Braun & Clark, 2006).

Because this study includes specific *a priori* themes, in the form of the conditions of *self-determination* theory, this research will follow a theoretical thematic analysis, deductive in that these themes are drawn from prior research on motivation. While other themes and patterns may emerge through the analysis process, the initial coding focus will be on how the autonomy, relatedness, and competence play out across the data. Further, since these conditions are not explicit and must be explored in terms of their behavioral and attitudinal presentations, a latent or inferential analysis of these themes will be necessary to make meaning of these evident behavioral factors within the context of the unobservable conditions. In other words, deeper interpretation of specific behaviors beyond their superficial presentation will be necessary in order to determine their significance within the context of the research questions (Braun & Clark, 2006).

While studies have sought to observe and measure indicators of motivation, both in subjects' behaviors and perceptions, none have specifically placed these indicators within the context of *self-determination theory* and its requisite conditions. Jovanovic and King (1998), in their study of middle school behaviors in science groups, identified specific behaviors that were indicative of manners of engaging with the science tasks and content. Drawing on this approach and placing it within the framework of SDT, observable behavioral indicators have been previously identified that will serve to represent the manifestations of autonomy, competence, and relatedness. These behaviors are delineated in the Table 1 below. This further refines the research method and analysis process in this study to template analysis, in that it includes an a priori template or "codebook" that guides the initial engagement with the data (Brooks et al., 2014). According to Brooks and her colleagues:

> Template analysis is a form of thematic analysis which emphasises the use of hierarchical coding but balances a relatively high degree of structure in the process of analysing textual data with the flexibility to adapt it to the needs of a particular study (p. 203).

Fundamental to template analysis is this use of the aforementioned codebook, or a priori coding themes, which are based on previous research and theories. As this study draws on themes elicited from the work of Jovanovic and King (1998), Dasgupta and her colleagues (Asgari, Dasgupta, & Stout, 2012; Dasgupta, 2011a; Dasgupta, 2011b; Dasgupta, Scircle, & Hunsinger, 2015; Dasgupta & Stout, 2014), and Meadows and Sekaquaptewa (2011, 2013) yet within the context of SDT, template analysis is the most appropriate approach because it provides the established theoretical context and framework yet allows for refinement as part of the analysis process. As motivational behaviors and perceptions have not in prior literature been analyzed in terms of their manifestation of and relationship to SDT's conditions, the balance between previously-outlined codes and potential revisions through the iterative process is imperative. Thus, template analysis aligns neatly with and follows the same process and Braun and Clark's description of thematic analysis (2006). Retaining the same features of flexibility and independence of a guiding philosophical or epistemological framework, as well as the iterative and open nature of the analysis process, it simply further delineates the researcher's theoretical stance and research focus from the onset of the study, in contrast to pure grounded theory or phenomenological approaches.

Table 1: Behavioral manifestation of autonomy, competence, and relatedness

	Autonomy	Competence	Relatedness
Active	***Directing*** • Instructing group members • Making decisions	***Explaining*** • Explaining a scientific concept or idea to the group	***Working interactively*** • Collaborating with other members of the group • Discussing, talking with peers about the task • Seeking agreement
Passive	• Following another student's directions	• Listening to explanations • Expressing lack of understanding, "I don't know" or "I don't get it" types of comments	• Working independently • Not interacting with peers
Active	***Manipulating*** • Handling materials and equipment	***Suggesting*** • Offering suggestions regarding the execution of the activity • Increased frequency/duration of speaking time	***Assisting*** • Helping another student with equal ownership
Passive	• Observing the activity • Record-keeping, note-taking only	• Lack of suggestions or contributions • Limited frequency/duration of speaking time	• Helping a student who is directing
Active	***On task*** • Engaged in activity, not distracted	***Requesting explanation from peers*** • Rethinking issues by asking for clarification from peers	***Reading directions*** • Reading/listening to directions as whole group
Passiv	• Off-task, distracted, unengaged in activity	• Immediately asking for teacher's help • Copying without intent to understand	• Reading directions and beginning task individually

The original set of indicators, as outline by Jovanovic and King (1998) is presented as simply a list of behaviors with their description. (See Appendix A). This list incorporates both active performing and passive behaviors as distinct items, such as “directing” and “following”. However, not each indicator on this list is given a counterpart; for example, “on task” appears as an item on the list, but “off-task” does not, even though off-task or distracted behaviors are coded and identified in their findings. Further, Jovanovic and King do use the language “active” and “passive” in their quantitative findings and discussion, but these descriptors do not appear on their original set of codes. For the sake of clarity, the coding template for this study was updated to include the objective indicator and subsequently the active and passive versions and descriptions of each. This modification and expansion of the codes was initially based solely on the findings of Jovanovic and King and appear in their original form in Table 1. During the first stage of analysis, gaining familiarity with the data, some of these definitions were refined further, through the iterative process, based on observations from the data sources. While no indicators were fundamentally changed, added, or omitted, their definitions in some cases were expanded to include various additional nuances seen, and these modifications are described further in their relevant sections.

This study, in sum, utilizes the template analysis form of thematic analysis, taking the overarching guiding constructivist principles of grounded theory and phenomenology but placing them within the existing framework of motivational theory. The unit of analysis is the group, taking into account, however, that while behaviors are enacted by individuals and experiences perceived by individuals, they are received, interpreted, and responded to within the context of the whole group. Behaviors that are observed and recorded for the purposes of this study do not represent an individual's behaviors in a vacuum but rather the manifestation of the whole groups' dynamics and interactions. Further, when examining these behaviors, not only is their occurrence and frequency noted but also the number of participants exhibiting these behaviors at a given time and in what way the other group members react, respond, or eventually reflect on these behaviors.

The foci of this study, therefore, are the science content (inquiry versus engineering), the group composition (male majority, equal male-female composition, or female majority), and the manifestations of motivation within the student groups and between the genders. These factors allow an investigation of the interplay between STEM content (acknowledging the discrepant participation of females between life sciences and engineering), social context, and *self-determination theory* in order to make greater sense of the contexts which may further elucidate the phenomenon of girls' experience and motivation in science and STEM activities.

NSF Study – Managing Small Groups to Meet the Social and Psychological Demands of Scientific and Engineering Practices in High School

This study occurred within a larger NSF project, led by Dr. Martina Nieswandt and Dr. Elizabeth McEneaney, examining the role and dynamics of small groups working on science inquiry and engineering design tasks in their high school biology class. This larger study took place in four high schools, two in Vermont and two in Massachusetts. The teachers from the Vermont schools were recruited specifically by this researcher in order to add to the sample size of the NSF study, but also because prior collegial connections made this an accessible source of data for this study as well. Among these four schools, classrooms from five different teachers were used, with a total of six videotaped groups from the Vermont schools and twelve from the Massachusetts schools, two from each classroom block or section. These eighteen groups in total were formed collaboratively between the teachers and Dr.'s Nieswandt and McEneaney based on the results of a biology interest inventory given to the students prior to creating the groups: students with similar interest levels were grouped together. In the Vermont schools, because this study was using data from these two schools exclusively, teachers also then incorporated various gender compositions as well. Due to this constraint, as well as student consent and some teacher preferences for students to work together, several changes were made from the original interest-based groupings prior to the start of the study, but an intent was made in each case to maintain similar interest levels within the change.

As part of the NSF study, six tasks were given to these five teachers, three science inquiry and three engineering, yet all tied to the biology curriculum, and teachers received professional development in the administration of these tasks. (See Appendix B for a more detailed description of the tasks.) These tasks were given to students over the course of their biology term as part of their regular classroom curriculum, and the videotaped student groups remained consistent over all six tasks.

NSF researchers from the project contributed to many aspects of the data collection and analysis process in each of the four schools, including videotaping the small groups working on the tasks, conducting focus group and teacher interviews, writing Elaborated Running Records (ERR's), and participating in the first round of the coding the data through the ERR's. These initial codes flagged the presence of social, cognitive, and affective behaviors as seen through the students' behaviors and interactions. While these data collection methods as well as the Vermont subset of the data itself from the NSF project were utilized for the purposes of this current study, the subsequent coding and analysis processes were distinct to address its specific research questions.

The structure and format of this NSF study provided the optimum scenario for conducting a secondary analysis using a subset of its data for several reasons. First, the NSF study also was situated in theories of motivation and, therefore, in its inherent design aimed to incorporate the conditions of autonomy, competence, and relatedness in the tasks. Second, the emphasis on small groups allowed for an appropriate venue for examining the *stereotype inoculation model*, including within and across group gender dynamics. Finally, the equal inclusion of both inquiry and engineering tasks provided a means for comparing girls' enactments of motivation in different STEM domains.

Research Design

Setting and participants

This study took place in two rural public high schools. Each school was located in southern Vermont, both in close proximity to their town centers. These schools provided ideal settings for this study for several reasons. First, both schools were already involved in the NSF study, and the participating teachers, administrators, and students had already given consent. Second, this researcher had prior collegial relationships with the teachers and many students involved in the study and, therefore, was a familiar and known entity within the school buildings and classrooms. Finally, as this study does not directly address issues of ethnicity and social class within its scope, these schools provided a relatively homogeneous setting. School 1, which will be called Mountain High from this point, had an enrollment of approximately 850 students in grades nine through twelve with a thirty-four percent free and reduced lunch rate. The population was primarily Caucasian, with less than ten percent of the students representing Hispanic, African American, Asian, Pacific Islander, Native American, and multi-racial ethnicities. The graduation rate was aligned with the national average at eighty-three percent, and fifty-seven percent of the students were proficient in reading and math, according to state standards.

School 2, referred to now as Cascade High, was considerably smaller, with a total enrollment of approximately 350 students. Of these students, more than half qualified for free and reduced lunch. Similar to Mountain High, there was little racial diversity, with ninety-five percent of the population being Caucasian. The graduation rate was substantially below the national average at sixty-two percent, and approximately fifty-two percent of the students demonstrated proficiency in relation to the state math and reading standards.

A total of twenty-three students from three different semester-long Biology classes participated in this study: fifteen from two different blocks in Mountain High and eight from one Biology block in Cascade High. Both schools used block scheduling, meaning that one biology class spanned two periods, approximately ninety minutes. The students were put into small groups of three and four by their biology teacher, and the groups remained constant over the course of the semester for these three science inquiry and three engineering design tasks. While there were two STEM disciplines represented in these tasks, science inquiry and engineering design, all six related to the classroom biology content and curriculum. The integration of engineering into the science curriculum is a fundamental pedagogical shift presented in the Next Generation Science Standards (NGSS Lead States, 2013) that was relevant to the goals of the NSF study. In this case, additionally, it also allowed for an examination of girls' experiences within these two distinct and often discrepant STEM domains, yet still within a science content area that they most typically showed a higher level of interest and participation.

The participating biology teacher in each school formed the groups of three to four students in conjunction with the NSF researchers based on several factors. First, students were grouped initially based on results from a biology interest instrument that was modified for the NSF study from a questionnaire developed by Marsh and his colleagues (Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005). This instrument asked students a series of questions in which they rated their interest in biology on a five-point Likert scale as well as their interest in biology class with various questions on a four-point Likert scale. Students were matched with classmates who shared a similar level of interest in biology as indicated by their survey scores: in other words, students who indicated a high interest were grouped together (mean scores of 3.5 to 5.0), and those with low interest were as well (mean scores of less than 3.5). This manner of creating initial groups was a response to prior literature, on the part of the NSF researchers, suggesting benefits for students in triggering and maintaining their interest in new contexts when they are grouped with others who share a similar interest level in that particular context (Durik, Hulleman, & Harackiewicz, 2015). Next, teachers used these initial groupings but reorganized some students in order to create different gender compositions across the classroom to provide a means of comparison for the purposes of this project, while still maintaining these similar interest levels. Finally, teachers used their prior knowledge of the students to make any final adjustments for any remaining needs without disrupting either the interest or gender factors. Of the small groups in the classes, they then chose the groups that would be videotaped based on one hundred percent parental consent as well as those that showed different gender composition from each other. In each block, these groups were named "Group 1" or "Group 2". Table 2 shows the composition of the groups included.

Table 2: Group compositions

	Group 1	**Group 2**
Mountain, Block 1	3 males	3 females, 1 male
Mountain, Block 2	2 males, 2 females	3 females, 1 male
Cascade, Block 2	2 males, 2 females	3 females, 1 male

Thus, Block One from Mountain contained a group of three boys as well as a group of three girls and one boy that were videotaped. This particular class had only four girls total, and one did not receive consent for the study; therefore, it was not possible to create another group that included females. In Block Two, there was a group with two boys and two girls and a three girl, one boy group. In School Two, one videotaped group had three girls and one boy and the other was equally divided with two girls and two boys.

Both teachers participating in the study received professional development training by Dr. Nieswandt and Dr. McEneaney in the administration of the six tasks prior to the start of the spring semester and received the same standardized lesson plan for each of the tasks. Table 3 further describes these tasks, and more information is given in Appendix B.

Table 3: Overview of tasks

Content	Name of Task	Concepts Addressed	Task description
Inquiry	Naked Egg	Osmosis and diffusion	Design an experiment to change the volume of de-shelled egg by immersing it a liquid that will cause it either absorb or exude water
Inquiry	Snails and Elodea	Photosynthesis and cellular respiration	Design an experiment to show that all organisms respire using snails and elodea in an aquatic environment
Inquiry	Pill Bugs	Animal behavior	Develop and test a question about pill bug behavior based on prior observations and knowledge
Engineering Design	Oil Spill	Engineering design process and ecosystem dynamics	Design an effective system within cost parameters for cleaning up spilled oil
Engineering Design	Heart Valve	Engineering design process and the circulatory system	Design an artificial heart valve that will allows blood to pass through in one direction only
Engineering Design	Pill Coating	Engineering design process and the digestive system	Design a coating that will adhere to a pill and can withstand a simulated stomach environment

As this table shows, each task fits within the curricular framework of a high school biology class in terms of content and objectives. Thus, students were experiencing these tasks within already established units of study within their classrooms, thereby supporting the condition of competence because they were receiving requisite background knowledge and information in order to access the tasks. In addition, as the "task description" column of the table indicates, each activity posed a question or challenge to the students that required them to design and execute their own solutions based on their ideas, interests, and decisions. In no case was the procedure of the task outlined formulaically for the students towards a singular end because the solutions were open-ended. This task characteristic potentially contributed further to the development of competence, in that it allowed for multiple entry points and opportunities for feelings of success, and it also allowed for autonomy due to the manner in which the tasks were designed and in the expectations placed on the students for their completion. Finally, the condition of relatedness was inherent in the group structure of the activities. The level of complexity and materials involved in the tasks required many hands and multi-tasking, thereby making the small groups have a meaningful purpose for the task completion.

While all within the realm of biology, the inquiry and engineering tasks provided two different types of STEM content reflecting the discrepancies noted in the literature regarding females' greater involvement and representation in life science fields as opposed to engineering domains (Bennet & Hogarth, 2009; Britner, 2008; Burkham & Smerdon, 1997). While all three science inquiry tasks involved some aspect of living creatures or materials (pill bugs, snails, eggs, elodea), the three engineering tasks incorporated a more systematic use of materials to create prototypes of systems or mechanisms. Further, the inquiry tasks inherently allowed an authentic question or challenge to be answered, while the engineering tasks had the different purpose of presenting a specified problem to be solved. Despite these distinctions in task purpose and design, their open-ended structure supported students' autonomous approaches to answering their research questions and creating and testing their engineering designs.

The structure and implementation of these tasks, therefore, provided the ideal setting for exploring the manifestations of motivation within the context of self-determination theory in that they potentially provided the conditions of autonomy, competence, and relatedness. Additionally, the STEM content of science inquiry and engineering design allowed the opportunity to investigate manifestations of motivation between these two domains yet within one over-arching content area.

Gaining entry and informed consent

As a community member and fellow educator within the region of each of the schools, this researcher had prior professional relationships with each of the biology teachers participating in the study. The researcher approached each teacher verbally with a description of the NSF project as well as of this study and secondary analysis and then followed up by providing the NSF Small Groups Project overview and description as outlined by Dr. Nieswandt and Dr. McEneaney. In addition, the principals of each of the schools received this information and were asked to give their permission for their teachers to participate. All of the students in all biology blocks from both schools were given a short presentation in class by both the researcher and by Drs. Nieswandt and McEneaney, at which time the students were also given a project description and an Informed Consent Form for the NSF study to share with their parents. In Mountain High, all but one student from both blocks received parental consent to participate in the study. In Cascade High, fifteen out of twenty-one students received parental consent to participate. As mentioned, groups that were chosen to be videotaped all contained students with parental consent given. All research design methods were developed and parental consent was given according to the University of Massachusetts' Institutional Review Board (IRB) guidelines. Because this study utilized this subset of the NSF data collected for its analysis and did not require any further measures or modifications, no additional consent was required beyond that for the NSF study.

Data Collection

Table 4 outlines the data collection process and timeline for this study. Data were collected over the spring semester, beginning in January and ending in June. The data used for this study comes from secondary sources, originally gathered for the purposes of Dr. Nieswandt and Dr. McEneaney's NSF project. The theoretical and methodological frameworks for the analysis, however, are distinct from those used in the NSF study, allowing for a novel interpretation of these small groups' experiences, as explored through the lens of *self-determination theory* and the *stereotype inoculation model*.

Table 4: Data collection outline

Jan. to June 2015	January	February	March	April	May	June
School 1 Mountain	Jan. 28 – 30 – Pill Bug lab		March 25 – Heart Valve March 26 – Pill Coating	April 28 – Student Focus Group Interviews April 29 – 30 - Snails and Elodea	May 22 and 26 – Naked Egg	June 3 – Oil Spill June 11 – Student Focus Group Interviews
School 2 Cascade		Feb. 4 – 5 – Pill Bug lab Feb. 26 – Naked Egg		April 2 – 3 – Snails and Elodea April 16 – Student Focus Group Interviews April 29 – Student Focus Group Make-up	May 18 – 19 – Heart Valve May 20 – 21 – Pill Coating	June 8 – 9 – Oil Spill June 10 – Student Focus Group Interviews

Classroom observations, which consisted of collecting videotaped footage, audio footage, and field notes occurred for the duration of each of the inquiry and engineering tasks. Typically, these labs and tasks occurred over one to three class periods, and, in both schools, the teachers chose to complete the tasks over the course of the entire semester, with one or two being completed each month, depending on their classroom schedule and other curricular demands. In addition to observations of the students working on the tasks in their small groups, focus group interviews were also conducted midway through the semester and in June to collect data on how the students themselves perceived and described their small group experiences.

Observations

Classroom observations occurred for each of the six tasks and were conducted by this researcher (approximately fifty percent of the data across the six groups) as well as by other members of the NSF research committee. The observations involved videotaping the students in the two small groups within each classroom and science block that were decided upon at the beginning of the semester. The groups were videotaped during the small group portion of their tasks; in other words, the cameras were turned on when the students met in their groups and began to work on their tasks. Whole class observations were not included. For the majority of the tasks, the small group portion of the class lasted for between forty-five and sixty minutes. As indicated in Table 3, some tasks were completed in one class period, while others required continued work over two or even three days. In all cases, the students were videotaped for all occurrences in which they met in their small groups for these specific tasks, regardless of the stage of their process.

The intent of the videotaping was to capture the behaviors of the group members as well as their conversations and interactions during the small group portion of the tasks. Thus, each group was taped using two cameras showing different angles of the group so that all four students were captured between the two cameras. If the group changed locations or moved collectively to gather materials, every effort was made to move the cameras to capture this as well. Further, audio pens were used, one per group, to supplement the capture of the audio data in case the students' conversations were difficult to hear from simply the videotapes. This ensured that both the visual data (what the groups did) and audio data (what the groups said) were collected with equal attention. In this way, the videotaped observations (and audiotaped recordings) captured data about how the small groups engaged with the process and completion of the tasks, including planning, decision-making, recording, executing their design, and sharing their results. From the video footage, the additional NSF researchers and I created Elaborated Running Records (Rogat & Adams-Wiggins, 2014) of the fulle set of data to give an initial overview of the experience and provide specific time stamps for further review. These ERR's were created for the whole NSF project and did not incorporate any initial coding using the template from this study. Rather, they were written as objective records of the videotaped data that then included indicators specific to the NSF study as a way to provide "flags" and time stamps for later review. These indicators, however, were not utilized in any way when then ERR's were reviewed for this study. From this full set of ERR's, only those from the two schools involved in this study were examined. Additionally, only the descriptions and transcripts were used to relate specifically to the coding template for this study and to provide the source for analysis for these independent research questions.

Interviews

In addition to the classroom observations of the small group work during the tasks, twice during the semester, each videotaped group from the full NSF study was part of a focus group interview conducted by this researcher and other members of the NSF research committee. The questions were designed by Dr. Nieswandt and Dr. McEneaney and were intended to gather students' perceptions of their small group experience after three tasks were completed and then again after all six tasks were completed at the culmination of the data collection phase (See Table 3 for the timing of these interviews in the two schools.). While these questions were geared towards the small group dynamic, they, too, are situated in motivational theory, so they elicited commentary in relation to the conditions of autonomy, competence, and relatedness. Table 5 shows a sampling of the questions included in the focus group interviews which most align with the motivational manifestations described in this study. The full set of interview questions, which were used for both the mid-semester and end-of-semester interviews, can be found in the appendix.

Table 5: Interview questions for student focus groups

Interview Questions for Student Focus Groups
• How did you like the different hands-on activities and labs? Was there one you like more than others? One you didn't like at all? • What do you think you learned from the lab and activities? • Did you notice anything different when working on the inquiry labs in comparison to the engineering design activities? • Do you think the jobs in the labs were divided evenly among you? • How did you like working in a group with your peers? • Did you see yourself having a particular role throughout the labs and activities? • Do you think your peers took your comments seriously? • Do you think you knew what you should do for the different labs? • When you got stuck on a task, what did you do?

The focus group interviews were conducted privately from the rest of the class and the teacher, one group at a time, in a separate room. As mentioned, only the videotaped groups participated in the focus group interviews, and only the groups from the two schools involved in this study were analyzed according to the coding template. All four students were interviewed in a group with either one or two NSF researchers asking the questions. This researcher was involved in all of the interviews in these two schools, with an additional NSF research co-conducting some of the interviews or conducting interviews simultaneously with a videotaped group from the same class. The focus group interviews were videotaped with two cameras trained on the group in order to capture all of the students for the duration of the interview. The interviews themselves lasted on average between twenty and thirty minutes. In one case, one of the groups at Cascade had two students absent on the day that the interviews were scheduled in April; thus, the interview was done once with the two students who were present and then repeated later in the month with the other two students who had been absent previously. In all other cases, the focus interviews were only done twice total with each videotaped group. Again, data were collected from the interviews in the form of both visual (group behaviors during the interviews) and audio (group commentary in response to the questions) in order to gain insight into the manifestation of motivation within the groups' perceptions of their collective and individual work. Members of the NSF committee transcribed the student focus group interviews from the video footage for subsequent analysis so that thorough transcriptions of the groups' responses could be utilized.

Field notes:

Field notes were collected informally, only as a supplemental tool for anything notable that occurred outside of the scope of the video cameras or required further explanation. Field notes were collected by the NSF researcher who was present to videotape the small student groups and did not necessarily follow a specific format or protocol. The purpose of the field notes was simply to capture any other data that would not appear on the videotapes or that may have an effect on the groups' behavior or work: explanations of student absences (One student in School 1 did not complete the final task, for example, because he literally joined the circus.), classroom experiences that were out of the ordinary (a fire drill occurring during a task in School 2), or experiences by other small groups not being videotaped that either had an impact on the other groups or were notable for future review in their own right. These field notes were not intended necessarily to be included in the formal data analysis but rather to provide a greater context and bigger picture for making sense of the data. Table 6 below summarizes these sources of data.

Table 6: Summary of data sources

Data Source	**Purpose**
Classroom Observations	To capture small group interactions and conversations while working on tasks
Focus Group Interviews	To capture participants' perceptions of their small group experience
Field Notes	To supplement other data sources and explain/indicate any notable occurrences

Data Analysis Process

The data collection phase yielded data in several forms: videos of the six small groups working on the assigned tasks, Elaborated Running Records of these videos, video and transcribed data from two separate focus group interviews for each group, and informal field notes to provide any supplementary information.

The videotapes of the classroom work summed approximately fifty-four hours in total across all six groups. Each group required about two hours per inquiry task and one hour per engineering task. Thus, for each of the six groups, nine hours of videotape of small group work were analyzed. In addition, each focus group interview lasted no more than thirty minutes; therefore, a total of one hour per group. One additional thirty-minute interview block was allotted for the gender majority Cascade group because two of their group members were absent for the initial focus group interview. This interview was then conducted in two separate thirty minute sessions to allow all students in the group to participate. The total number of interview hours, therefore, equaled approximately six and one-half hours, combining with the small group video data to equal sixty and one-half hours of recorded data in all.

As described previously, a six-step process for analyzing these two sets of data separately was employed in accordance with the definition of Thematic Analysis given by Braun and Clark (2006). These steps, while being described and outlined as linear process, were in reality highly recursive, with repetition of steps occurring throughout the analysis. This process is illustrated in the illustration below. The purpose of each of these steps was to identify at increasing levels of detail and distinction, manifestations and student perceptions of motivation as defined by the a priori codes in the template. From these coded pieces of data, further analysis examining overarching themes and patterns in relation to the research questions was then conducted, comparing themes between gender and among group gender composition. This process will be briefly described in terms of the outlined steps below.

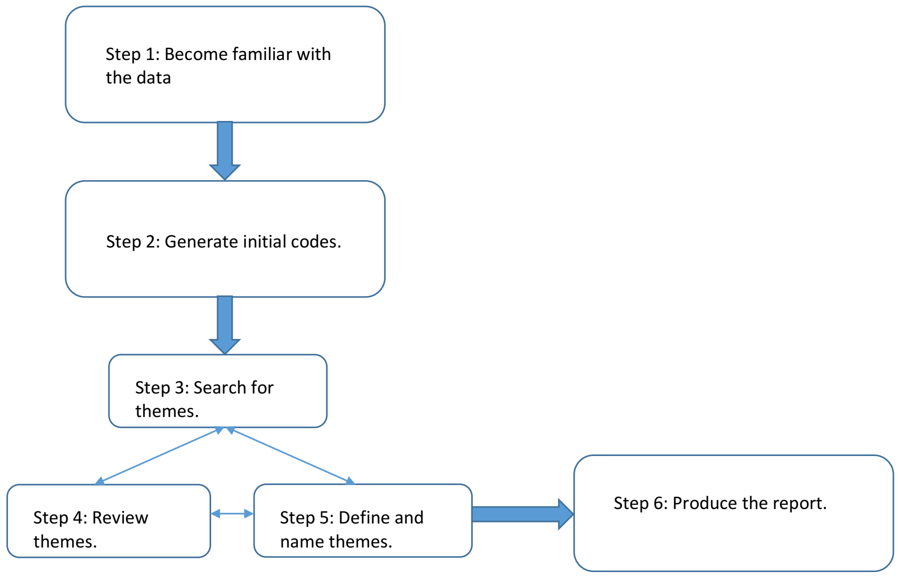


Figure 1: Six-step procedure for thematic analysis

Step 1: Become familiar with the data

Familiarity with the videotaped data occurred in two ways: by viewing the tapes and by creating written documentation of them. From the videotaped data of the small group work, Elaborated Running Records (Rogat & Linnenbrink-Garcia, 2011) were created in order to provide a written document of each group's tasks. These Elaborated Running Records (ERR's) were produced for the full set of NSF videotapes, but only those involving the two Vermont schools were utilized for the purposes of this study. ERR's differ from transcripts in that they document not just the conversations and dialogue among the student participants but capture their actions as well. They provide an overall description of the interactions and behaviors seen among the students as well as verbatim transcriptions for much of the verbal exchanges included, thereby creating a comprehensive record of each task. These ERR's were intended to provide an objective illustration of the groups' work on the tasks without interpretation by the researcher at this point. This researcher produced approximately one-third of the ERR's from the Vermont schools; the remaining ones were completed by other researchers on the NSF team. Familiarity with this additional two-thirds of the video data occurred through watching the videos, reading the completed ERR's, and taking notes on observations prior to coding.

As part of the NSF study, direct transcripts were created from the videotapes of the focus group interviews for each session. These transcripts were created by another researcher from the NSF project team, and these did directly record both the interviewer's and students' questions, answers, and dialogue verbatim as seen in the videotapes without additional reference to actions or behaviors observed in the videotapes and without the researcher's stance included. From this full set of transcripts, those from the Vermont groups were utilized and reviewed for this study by this researcher.

During this first step of the analysis process, while gaining familiarity with the data, aspects of some behaviors previously identified in the template and according to Jovanovic and King's original definitions (1998) emerged that showed another layer or element of that behavior. While these new features did not change the basic definitions themselves, in some cases, they added further distinctions to the behaviors, and the definitions were expanded to include some of these emergent characteristics. For example, while the basic definition of directing did not change, manners of directing or directing for different purposes emerged as an aspect of this behavior previously undistinguished. These more detailed definitions are described in greater detail later in this chapter.

Step 2: Generate initial codes

Initial codes were created a priori, in advance of the analysis process, in order to directly acknowledge the researcher's stance and theoretical framework. Using the three motivational conditions described by Ryan and Deci, as well as an adaptation of Jovanovic and King's behavioral indicators, a codebook was created the placed these behaviors within the categories of the motivational conditions of autonomy, competence, and relatedness (see Table 1). The overall purpose of the codebook, therefore, was to identify student behaviors that manifested the existence of these conditions in order to create an overall picture of motivation within the lens of the research questions.

As the codes were already created, applying them to the data was a multi-step process that preceded the search for themes and patterns. For the classroom data, the ERR's were used to initially flag occurrences of autonomy, competence, and relatedness without further distinction at that point. From these initial flagged occurrences, excel spreadsheets were created that organized and further described the data. For each task and for each group, these spreadsheets showed the conditional category for each behavior (autonomy, competence, or relatedness), the specific behavior as defined in the codebook, whether it was the active or passive version of this behavior, who performed the behavior (student name and gender), and any further description, notes, or characteristics to further describe the behavior. Thirty-six of these spreadsheets were created, one per task for each group.

These spreadsheets were then used to further examine and analyze the data. Additional spreadsheets were created that reorganized the behaviors across behavioral indicators rather than within the groups. Nine of these spreadsheets were created, one for each behavior as identified in the codebook. These spreadsheets showed, for each behavior, who did them, whether it was the active or passive version, and in what type of task (inquiry or engineering). This allowed patterns, frequencies, and other notable trends to emerge in terms of the behaviors themselves.

Finally, simple counts of the behaviors were conducted. Tables that showed the groups, specific students themselves, and frequency of both active and passive versions of specific behaviors were indicated in order to elucidate patterns across the groups. In this way, the frequency and type of behavior could be examined across all six groups of varying gender configuration as well as in terms of gender.

From these forms and levels of coding, from broadest to most discrete, and in these three manners of organization, the research questions were applied to make meaning of the patterns and trends observed in the data for the classroom small group work.

Focus group interview transcripts were also coded using the a priori set of codes from the template. In a similar manner to the process used with the ERR's, the focus group interview transcripts were first coded broadly using only the autonomy, competence, and relatedness categories to flag incidences in which students described their perception or reflection on one of these elements.

Further, the next level of coding in terms of behaviors, was performed more simply and holistically with the focus group interviews than with the ERR's of class work because not all behaviors were described or referenced by the students or pursued by the interview questions themselves. For example, no specific mention was made by the students nor could be inferred regarding reading directions or explaining concepts. In some cases, even if a behavior was identified by a student or group, this may not have been done in any other group or was sufficiently limited as to not indicate any underlying theme. As such, patterns and trends in the data were observed anecdotally by first examining responses between genders throughout all six groups and then subsequently by comparing the characteristics of responses given between gender dyad groups (meaning two boys and two girls in the group) and gender majority groups (more than half of the group members of the same gender, in this case three boys or three girls).

Steps 3, 4, and 5: Search for themes, Review themes, Define and name themes

The process of searching for, reviewing, and identifying themes was highly recursive and iterative in that emerging patterns were compared, evaluated, revised, and reviewed multiple times while data analysis occurred. In reality, these three steps were performed in conjunction rather than as separate or distinct stages of the process. Once the spreadsheets and tables were created, as described in step 2, each of the six groups was examined as a whole via the ERR's and the within-group tables as a whole in order to uncover the underlying personality and story of the group throughout this study. The ERR's were analyzed first, looking at the overall whole group function as described via the behavioral indicators, as well as in terms of the participation and performance of each individual group member. When these overall group pictures were established, they were compared through the lens of the research questions. The patterns for each behavior, including frequency and quality, were compared first between genders in order to uncover commonalities in the presence of these behaviors between the boys and girls in the study. Next, these trends were examined between groups of varying gender configuration, with an intent to uncover commonalities and differences between gender dyad groups and gender majority groups. Finally, any patterns distinguishing the types of task, inquiry or engineering, either between genders or among the differently-configured groups, was examined. These comparisons were used to draw generalizations and conjectures about the manifestations of motivation exhibited by boys and girls in the six different groups in relation to the research questions. These findings will be described in greater detail further in the chapter.

A similar, yet less involved, process was used to find and review themes in the focus group interview data as well. Using the initial autonomy, competence, and relatedness codes identified from the interview transcripts, these flagged responses were analyzed to determine an overall theme within each category that best characterized the perceptions presented by both boys and girls and by the various groups. Because the behavioral indicator codes were created specifically for observable actions performed within the groups, they did not all have the same relevance when searched for within student responses regarding their experiences. Not all behaviors were referenced, so a more over-arching thematic approach was utilized in order to make meaning of the students' perceptions regarding their motivation, identifying just one significant trend that emerged under each motivational condition, both between genders and across the differently-configured groups. Some of these themes emerged as significant differences between genders or between groups, but in other cases they presented as commonalities in perceptions with regard to that motivational condition, regardless of gender or group. These findings are discussed in detail later in this chapter.

Step 6: Produce the report

This chapter, which discusses the findings from this study, focuses first on patterns and trends observed within each group, between genders, and across these groups of varying gender composition in terms of the behaviors observed within each motivational condition. Manifestations of motivational behaviors are presented separately from perceptions elucidated through the focus group interviews, which are discussed subsequently. Beyond the scope of this study is a comprehensive comparison between these two, analyzing the difference between behaviors exhibited and student perceptions, although it has been referenced when most significant. The research questions provide the over-arching framework for presenting these findings, and the proceeding chapter is organized as such.

Inter-rater reliability

Trustworthiness of the coding and findings was established using inter-rater reliability. As part of the NSF study, each of the researchers and I completed training in the purpose and production of Elaborated Running Records (Rogat & Linnenbrink-Garcia, 2011). We examined and read Elaborated Running Records (ERR's) that were completed by Dr. Nieswandt and Dr. McEneaney to become familiar with their specific structure and format. Then, in order to establish reliability, we each independently watched the same three videotapes of classroom observations and completed ERR's for these videos. Finally, we reunited as a group to compare and establish agreement among all of our ERR's in terms of how we objectively captured the behaviors and interactions among the students, how we coded these incidences according to the codes outlined for the NSF study, and the level of detail we included in our writing. This reliability measure was completed all researchers for the purposes of the NSF study.

For this study, a further measure of reliability was utilized in order to establish trustworthiness with its specific codes. An objective researcher independent of the study, but involved in the full NSF-project, was trained in the definitions of the motivational conditions and behavioral indicators outlined in this study's codebook, as well as the use of these indicators to code the data. The researcher coded four of the thirty-six ERR's utilized in this study (or just over ten percent), using the same system of flagging and identifying initial behaviors in terms of how they aligned with the categories of autonomy, competence, and relatedness. This coded data was then compared with the original codes established in the study. Percentage of agreement was calculated by finding the ratio of ERR sections (defined by time stamps) in which agreement was reached versus total sections. In all cases, inter-rater agreement exceeded eighty percent and, in many cases, was one hundred percent. Behaviors were then further discussed between the raters in order to establish understanding and agreement about the qualities and nuances of these behaviors and interactions in terms of the template definitions.

In sum, the two primary sources of data for thematic analysis in this study were the classroom observations and the focus group interviews, with the field notes serving to supplement as needed. Analysis of the videotaped classroom observations provided data for the first category of research questions:

1. How is motivation manifested in small groups of high school students as they engage in science activities?
    a. How do these groups manifest autonomy, competence, and relatedness in their group interactions?
    b. Within the group, how do boys and girls differ in their manifestation of autonomy, competence, and relatedness?
    c. How are these patterns different between groups of varying gender composition and across different science tasks (inquiry versus engineering)?

This source of data provides the groups' outward exhibitions and behaviors that can be described as indicated in Table 1 and examined through the lens of the conditions of motivation. Further, the focus group interviews provide data to explore the second category of research questions, which relate to more specifically to the participants' perceptions:

2. How do participants of these small groups perceive their experiences of motivation?
    a. What are the group participants' perceptions of their small group experiences with regard to autonomy, competence, and relatedness?
    b. How are these patterns in perceptions different between groups of varying gender composition and across different science tasks (inquiry versus engineering)?

The focus group interviews allowed the participants to describe their experiences and express their feelings in relation to the small group work, providing information on the internal aspect of these phenomena. Finally, as previously described, the combined theoretical frameworks of *self-determination theory* and the *stereotype inoculation model* provide the structure with which to make meaning of the results of the analysis.

Codes/Definitions

As described, through the process of gaining familiarity with the data, new aspects of some behaviors emerged as modifications or expansions of their original definitions. While they did not change the fundamental coding of the behaviors themselves, they did offer further insight in some cases into the quality or characteristics of these behaviors, at times significantly along gender lines. As such, these modifications were added to the original codebook in order to further distinguish these aspects and are represented in red in Table 7. These modifications and the reasoning behind them are discussed in greater detail in the following definition sections.

Table 7: Updated behavioral manifestation of autonomy, competence, and relatedness

	Autonomy	Competence	Relatedness

Active	***Directing***
	• Instructing group members
	  ○ Task directing
	  ○ Discrete directing
	  ○ Refocusing
	• Making decisions
		Explaining
		• Explaining a scientific concept or idea to the group
		• Explaining a scientific concept or idea to teacher
			Working interactively
			• Collaborating with other members of the group
			• Hands-on collaboration
			• Discussing, talking with peers about the task
			• Seeking agreement
			• Inviting collaboration

Passive	• Following another student's directions	• Listening to explanations • Expressing lack of understanding, "I don't know" or "I don't get it" types of comments	• Working independently • Not interacting with peers

Active	***Manipulating***
	• Handling materials/equipment
		Suggesting
		• Offering suggestions regarding the execution of the activity
		  ○ Global suggestions
		  ○ Discrete suggestions
		• Increased frequency/duration of speaking time
			Assisting
			• Helping another student with equal ownership

Passive	• Observing the activity • Hands-on playing • Record-keeping, note-taking only	• Lack of suggestions or contributions • Limited frequency/duration of speaking time	• Helping a student who is directing
Active	***On task*** • Engaged in activity, not distracted	***Requesting explanation from peers*** • Rethinking issues by asking for clarification from peers	***Reading directions*** • Reading/listening to directions as whole group

Passive	• Off task, distracted, unengaged in activity
	  ○ Social conversations within group
	  ○ Social conversations with other groups
	  ○ Playing with non-task items
	  ○ Unengaged in task
		• Immediately asking for teacher's help
		• Copying without intent to understand
			• Reading directions and beginning task individually

Autonomy

Autonomy, as described by Ryan and Deci (2000a, 2000b), is the condition in which individuals have appropriate levels of choice and control within a given context, contributing to increased motivation within that setting. For the purposes of this study, and based on the variables explored by Jovanovich and King (1998), three behavioral indicators were used to identify the enactment of autonomy: directing, handling materials and equipment for the purpose of the task, and on-task behaviors. Each of these indicators exemplifies not only active engagement with the task but represents the students' ability to have ownership over its execution. For each active indicator, passive counterparts are defined in order to fully describe the spectrum of behaviors observed, as well as to explore how these active and passive behaviors exist in relation and in response to each other.

Directing

According to the definition provided by Jovonovic and King (1998), directing behaviors are those in which a student is “instructing other group members on the procedure and execution of the activity”. This may present as situations in which students are ordering or demanding that their groupmates to undertake a particular task-related action, larger directions that guide the task’s approach, or those in which they are making decisions for the group. In some instances among the participants of the study, this behavior also presented as being the “voice” of the group in response to the teacher or to written questions in which the other group members may or may not have contributed their thinking also. Further, directing also at times took the form of a student orally dictating elements of the task, such as the steps of the procedure or the materials list, to the other members of the group, perhaps without allowing for additional input or perhaps by restating and formalizing the ideas presented. In each case, these behaviors indicated that individual was taking control, or attempting to take control, of the group’s work, situation, and overall functioning.

The passive form of directing simply appeared when students were observed following the directions of another student without equal contribution. In some cases, this was simply going along with a dictated decision without comment or completing the task or action asked of them. Not all directing behaviors resulted in a passive response, however: among all groups, the incidences of active directing far outnumbered those of passive directing, simply because sometimes no response occurred or was required.

These directing and decision-making behaviors appeared to occur within three distinct domains among the groups in this study: towards the overall planning, execution, and completion of the task; in order to involve or otherwise guide the actions of another student in a discrete action or step of the task; or with the intent of refocusing or modifying the behavior of either the whole group or its individual members towards task-orientation. For the purposes of further referencing, these three behaviors will be described as such: task directing, discrete directing, and refocusing. These three types of directing behaviors aligned with the overall trajectory of the lessons and activities, following the course of planning and strategizing through task-execution.

Task directing most often occurred in the beginning stages of the task as the group was developing their design and approach to the task. Directing behaviors at this stage of the activity often involved decision-making for the group or declaring one's intent in a tone or manner that was distinct from "suggesting". For example, when exploring the scenario presented about the transplant patient in the Heart Valve task before beginning the engineering process itself, Parker immediately describes the scenario to her group and then declares that a biological heart should be used. She follows up with, "Do you all agree?", which does not open up a conversation among the group members but rather causes them all to simply nod. Tricia, in another example, tells the members of her group at the beginning of the Oil Spill task, "Okay, once she puts the oil in, me and Abigail, I'm going to stretch this out and then we're going to lay this on it because it picks up some of the oil. And then Abigail will go over it with the cotton ball." This declaration of intent, again, does not leave room with the other group members to contribute or share different ideas. In such cases, these task directions guide the group to decisions about the next steps or overall picture of the task.

Discrete directing typically occurred during construction or execution stages of the task, often when students were eliciting help or support with what they were trying to accomplish in the moment. Examples include such directions as, "When I say go, start the timer," or "Put some tape right there." While these directions may not dramatically alter the direction of the task, they indicate that the student directing is in charge of what is happening in that moment.

Refocusing, however, could be discerned at varying stages over the course of the lesson and task. At times, refocusing directions coincided with the beginning of the task when students in the group had not yet fully engaged with the activity, and at other times a student may have refocused the group when they had gotten stuck in the middle of a task. Such refocusing directions took the form of rereading aloud questions from the task, asking the group if they had heard the teacher's directions, or simply saying, "Guys, we have to start." Not all groups presented examples of refocusing behaviors; this was most common in the groups in which the students seemed to have a high level of comfort with each other. For example, Diana and Timothy, in one of Mountain's female majority groups, refocus their group multiple times over the course of the six tasks, primarily in response to the group members engaging socially with each other and losing task-focus. Refocusing behaviors are not seen at all in Cascade's gender dyad group or in Mountain's other female majority group, in which the students have less comfort with each other socially. As such, the phenomenon of refocusing directions appears to have a connection to the group's potential to become socially distracted, reflecting perhaps an element of the group's relatedness as well.

Hands-on behaviors and manipulating equipment

Each of the six tasks provided in this study included a hands-on component, whether it be a biological material, scientific tools and equipment, or construction of a prototype. As such, students were presented with the need to balance the different requirements of each task, including not only cognitive participation and a written assignment but the manipulation of the various materials, equipment, and elements that were necessary for its completion.

Jovanovic and King (1998) explored hands-on behaviors in terms of the frequency with which students handled the materials and equipment involved in the task with specific attention to whether the boys or girls were performing this behavior more frequently. They did not, however, examine the quality of the hands-on behavior; in other words, was the manipulation of equipment for the purpose of pursuing the task or simply for exploration and play outside of the task's requirement and expectations? As such, this study further delineates and describes these handling behaviors. This distinction allows for a deeper understanding of the nature of hands-on behaviors and their gendered presentation, which speaks more directly to the research question regarding enactments of motivation between genders. Active handling or manipulating involves any instance in which a student gathers materials, constructs, collects, touches, or examines by picking up any of the physical elements involved in the task, specifically of their own accord.

Assisting in a hands-on manner is not incorporated in this measure but rather in the relatedness section and will be discussed later. Passive versions of these handling behaviors, therefore, include instances in which a student is simply observing, is writing or note-taking rather than involved in the hands-on aspect of the task, or is handling the materials but with the purpose of playing, not task pursuance. This definition differs from “tinkering”, in the context of engineering design, in that the intent of the hands-on play is not to explore the materials, improve upon them, or to work towards greater understanding about the problem posed but rather simply for amusement and diversion from any expectations aligned to the task or the nature of the materials. Examples of this may include mixing liquids from the oil spill kit just for fun, spinning the test tubes around for play rather than to set up the cellular respiration experiment, or using the paper involved in one of the tasks to play “basketball” across the table.

On and off-task behavior

The final category of behaviors within the conditional construct of Autonomy is that of *on and off-task behavior*. Jovanovic and King describe on task behaviors as being “engaged not distracted in the activity”. On task behavior encompasses and overlaps with many of the other behaviors described within this study’s overall codebook. For example, setting up an experiment is *on task*, but falls within actively handling equipment in this case. Additionally, a group discussion about design ideas is *on task*, but for the purposes of this study falls within the category of *relatedness* and *working collaboratively*. As a result, off-task behaviors emerge more prevalently and are more easily flagged, as on task behaviors include indicators that tend to have been designated in another category. If the code, therefore, could be applied directly elsewhere, then that indicator or category took precedence. If the group was engaged in the activity but the behaviors were not clearly outlined somewhere else in the codebook, then it was coded as *on task*. Thus, in order to describe the groups' enactment of on and off-task behaviors, focusing on who is off-task and when often emerged as more descriptive and elucidating approach than the reverse.

Across the six groups, a variety of off-task behaviors were presented and observed. Most common were simply conversations among the group members that were not related to the task at hand: about school, friends, sports, or other classes. This occurred in every group at some point and with every group member to some extent. Additionally, off-task behaviors included social conversations that occurred not just within the group but between students from other groups. In these cases, a student might leave their group and work on the task in order to interact with other students elsewhere in the room.

In these instances, the individual exhibited not only off-task behavior but a lack of relatedness as well. The boundary between this distinction is drawn based on the impact on the whole group. If one student is off-task, but then rest of the group is working collaboratively, then the off-task code is given to the individual. If the entire group is off-task but socially engaged, then the off-task code is assigned to all of the group members. If, however, the whole group is not only off-task but also not interacting as a group, then they are each assigned a passive code for relatedness. In this manner, the nesting of the behaviors emerges more clearly in terms of the individual in relation to the group and how the culminating effect of behaviors at times results in an over-arching group effect.

Additional off-task behaviors that students presented involved the use of items that were not related to the task and resulted in distraction from the work: hand lotion, phone cases, hair accessories, and headphones are all such examples. Particularly prevalent among some students was the use of their phones to text or use the internet. These behaviors were often more individual rather socially enacted but at times could draw the attention of other group members or support the off-task socializing that was already occurring. For the most part, off-task behaviors were enacted positively among the group members, meaning that they did not involve negative social interactions, arguing, or otherwise deviant behaviors. At times, the off-task behavior resulted in a refocusing direction from other group members, as described previously, but was not a major source of conflict.

Competence

Competence, the second of Ryan and Deci's (2000a, 2000b) three basic psychological needs required for motivation, refers to an individual's ability to successfully accomplish a task, to experience mastery within a particular activity or domain, and to perceive some control in the outcome of the task due to a sense of efficacy. Critical within the description of this condition is that requisite skills and understandings are in place sufficient to support an individual's work towards the desired goal. Three behavioral indicators outlined in Jovanovic and King's (1998) study have been designated for the purposes of this research to evidence the presence of perceived competence within the groups and their members: explaining, suggesting, and requesting explanations. These indicators serve to not only represent the perceptions of competence sensed by the individuals but contained within the group as a whole. Explaining concepts and suggesting ideas and strategies both exemplify an individual's confidence in his or her own potential towards a specific end, yet also indicate a confidence in the group's collective competence to receive and respond productively to what is being offered. Requesting explanations and the manner in which this behavior is executed further exemplifies both individual and group perceptions of competence. As with the autonomy, each of the indicators above will be further described in terms of its active and passive manifestations and its representation within the six student groups.

Explaining – vocal participation

Explaining behaviors, as described in this study's template, refer to instances in which a student expresses his or her understanding of a scientific concept, outlines the reasoning behind an idea, states a specific observation that contains a scientific connection, or further outlines a parameter or expectation of the task. These active manifestations of explaining indicate that the student is using a sense of perceived competence in a particular area in order to further the group's work towards the goals and expectations of the task. While Jovanovic and King (1998) include solely explanations that are provided to other students, this study expands this definition to include explanations provided in response to teacher intervention and questioning because this behavior was observed and noted in the videos and ERR's, during the gaining familiarity with the data stage. Inherent, or perhaps implied, in these actions is underlying background knowledge or understanding of content in the area being addressed. Each of these behaviors is related specifically to content, whether it be the scientific principles or concepts central to the task or the skills and methodological understandings required to execute it. The accuracy of the explanations and specific reflection of prior knowledge, however, are not within the scope of this study to include as part of the analysis.

As the described behaviors represent the active portrayal of competence in terms of explaining, there also exist the passive counterparts. In this case, simply listening to explanations rather than offering one's own suggests a passive version of this behavior. While this may seem amorphous in that explanations in some regard must be listened to initially by the other members of the group, the absence of a response or of an additional explanation that builds on that which is being offered in this context illustrates that there may be a lack of perceived competence sufficient to support furthering the explanation. This may be taken a step further, however, to include not only a lack of explanation but negative declaration of understanding or content knowledge. In such cases, statements like, "I don't get it," or "I'm not good at this," are more dramatic examples within the passive explanation category. As such, they do not simply reflect a lack of confidence in attempting to provide an explanation but actually assert an inability to perform this behavior or, more critically, some aspect of the task, impeding the journey towards mastery and task completion.

Suggesting behaviors

The six tasks administered to the student groups in this study all included open-endedness and required some level of group problem-solving in order to complete them. Research questions, experimental design, and engineering prototypes all allowed for multiple approaches based on the groups' interests, ideas, and decisions. Therefore, each task necessitated at various points some group discussion around how they were going to strategize and execute the task based on the expectations and challenges set forth.

Suggesting behaviors manifest perceived competence similarly to explaining behaviors in that they represent some level of confidence with the content involved in the task sufficient for a student to feel comfortable offering a possible approach or solution. In order to make a suggestion for the activity, a student must first feel that he or she has an entry point for accessing the parameters of the task, and this inherently involves some level of understanding about the concepts and skills in which it is grounded. Thus, suggesting behaviors, while distinct from explaining in their intent, enact perceived competence with the same fundamental purpose of transmitting one's understanding of relevant content but in this case with the additional purpose of connecting it to the task at hand.

Jovanovic and King (1998) outline the definition of suggesting as "offering suggestions regarding the execution of the activity or part of the activity". In this study, suggesting encompasses such ideas offered at any stage of the task, whether it is initial idea offered about experimental or engineering design or if it is incorporated into the execution of the task as a suggestion about a more discrete or specific step or action. A more introductory, global suggestion may guide the group towards actively beginning the task, such as when Timothy suggests a starting point for the cellular respiration lab, "I think one test tube should have both snails and elodea because the snails will give off carbon dioxide." In this manner, he is offering a way for the group to start thinking about the design of their experiment, and it is grounded in an existing conceptual understanding that he is using to justify his suggestion. In contrast, a discrete suggestion is exemplified when Abigail, in the midst of working with materials during the oil spill lab, says to Tricia, “Maybe we should cut this coffee filter.” While it manifests perceived competence in that she is actively engaged with the task and pursuit of its completion, these types of suggestions may require and show less conceptual background with the over-arching scientific content.

Both global and discrete suggestions such as these, however, are considered active suggesting behaviors for the purposes of this study in that they indicate motivation towards the task execution and completion. Passive versions of suggesting behaviors are simply reflected in a lack of suggesting or talking time; in other words, similarly to explaining, passive suggesting as described by this study’s template is simply a lack of suggestions, of contributions towards planning and carrying out the tasks, and of building on or responding to the suggestions of others.

While active explaining behaviors aligned to the directing behaviors observed in the six student groups, this pattern does not hold true for suggesting. Interestingly, suggesting and explaining behaviors present differently; while directing and explaining seemed more related to the group’s hierarchical distribution, suggesting behaviors appeared less consistently so among all of the groups.

Requesting explanations and seeking clarification

In all instances of group work and collaboration, times occur in which explanations, support, or clarification is required in order to continue towards task pursuance. These moments reflect a broad range of needs, both individually and collectively in the group. At times, one student may have questions about the parameters of the task or may request clarification about a relevant scientific concept. Challenges or confusion about how to best approach an experimental or engineering design, about the expectations of the task, or even about explanations or suggestions offered by a groupmate all may incur the need for some level of assistance. How a student or group of students address this need reflects a particular aspect of their perceived competence and, as such, their level of overall motivation. While the need for support may seem contrary to competence in the most basic sense, pursuing understanding is indicative of motivation towards competence. Further, the level of independence with which this competence is sought is indicative of underlying confidence and the distinction between simply getting and answer and consolidating understanding.

As with the other behavioral indicators described thus far, there are both active and passive manifestations of how students request explanations or clarification while engaged in one of the inquiry or engineering tasks. When students actively request explanations, they do so within the group. They look towards their peers or towards a collaborative discussion in order to come to understanding. This is considered an active behavior in this case because it indicates a sense of perceived competence at the group level, that the group is considered capable and dependable to resolve a question or confusion by itself. While at the individual level it may appear that this is showing a lack of competence, the trust in the group's ability indicates an underlying sense of prior knowledge upon which the collective knowledge is building.

The passive manifestation, therefore, of requesting explanations appears in two ways: by immediately seeking the help of the teacher and by copying another student's work without any intent to understand. Both of these behaviors reflect the desire to get to an answer quickly rather than try to build an understanding. In this manner, the motivation is not towards competence and does not indicate a sense of underlying competence but rather just getting the task completed in the most efficient way possible. Jovanovic and King (1998) indicate the difference in these active and passive behaviors simply by drawing the distinction between requesting explanations from a teacher or from a peer; this study broadens the definition to include copying another student's work without intent to understand. Not only was this a behavior observed during the first step of the analysis, while gaining familiarity with the data, it also directly reflects motivation, or a lack thereof, towards understanding. It further delineates between the actions of requesting an explanation from peers in a manner that seeks understanding and collaborative knowledge as opposed to simply getting an answer to complete the task.

Relatedness

The last of the three basic needs required for more internalized motivation, as described by Ryan and Deci (2000a, 2000b), is relatedness. This construct arises from a human's need to interact with other individuals, to function within a social context, and to make sense of one's own self within a community of others. Further, there must exist some sense of caring and connectedness within this condition, which contributes to an overall sense of belonging and group membership. This sense of relatedness serves to legitimize one's own identity and presence within a particular context thereby increasing an individual's motivation to pursue that domain. Building on this concept is Dasgupta's *stereotype inoculation model* (2011a), asserting that this sense of belonging, of identifying meaningfully with one's in-group peers, is fundamental in creating a sense of relatedness and thus intrinsic motivation, particularly for those who may be functioning within a realm in which they are most typically marginalized or facing stereotypes.

For the purposes of this study and drawing on the behaviors identified by Jovanovic and King (1998), three indicators were used to indicate the presence of a sense of relatedness, both by individual group members and by the group as a whole: working interactively, assisting, and reading material aloud to the group. These behaviors were all specific to the task so that they were related solely to motivation within the context of the science and engineering activities, not as observed in a strictly social presentation. Distinct from the other conditions of autonomy and competence, relatedness at its core is a group construct; it is not an individual behavior in its most basic definition. It is almost contradictory to look at relatedness at any other level than that of the group. Individuals in the groups, however, may still manifest a sense of relatedness, or an intent to create relatedness, by exhibiting certain behaviors, and this, in combination with the response given by other group members, can elucidate the overall existence of relatedness.

A further distinguishing factor of relatedness in the context of this study is that, as it specifically relates to the work on the tasks, autonomy and competence become inherent in the presence of relatedness. In other words, when a group is seen to be working collaboratively, very likely the group members are also exhibiting the active behaviors described within autonomy and competence: being on task, suggesting ideas, handling materials, and explaining their thinking, for example. Therefore, in some cases, the sense of relatedness arises out of autonomous and competent behaviors: they are contained within it, and the line at which the behaviors meld into relatedness can be amorphous.

Finally, working interactively is an incredibly broad category that encompasses a variety of behaviors. While Jovanovic and King (1998) identify this as "working cooperatively with others in the group", discussing, collaborating, and seeking agreement were only some of the behaviors that emerged from the data as indicating interactive, cooperative work. For example, many hands-on occurrences in which students were manipulating materials and equipment became instances of relatedness when they began to do so together. Further, inviting a group member to become involved was another behavior that was not previously identified in the code book but was observed in multiple cases. As such, distinguishing the behaviors of assisting and reading directions from working interactively almost became moot after the range and breadth of relatedness behaviors that arose. For this reason, relatedness findings will be described more globally because the individual discrete behaviors represent the relatedness overall rather than having significance by themselves.

To further describe the active and passive versions of these behaviors for future reference, active occasions of working interactively are any moments in which the group or its members discuss, collaborate, come to an agreement together, involve each other in the decision-making process, or work together in a hands-on task. Passive occurrences of working interactively would simply be moments in which the group or members of the group are working independently, those in which an attempt to create collaboration is not acknowledged within the group, where an action intentionally does not involve all group members, or in which certain members disengage from the collaborative effort. Assisting involves actively helping someone with equal ownership – assisting due to equal investment in the specific step or action. Passive assisting occurs when a student helps another in response to a direction, not due to equal ownership over what is being accomplished. Finally, reading directions aloud, while a very specific behavior, indicates a group's intent to start and engage with the task collaboratively. Reading directions and questions aloud to the group at the start of a task, or throughout the task, is the active version of this behavior in that it indicates a students' intent to organize the group's work and approach and to create consistency in their effort. When groups begin the tasks independently by reading and responding to the pre-lab questions or directions on their own, this is considered the passive version because it manifests a lack of relatedness in their approach and pursuance of the task.

CHAPTER IV

FINDINGS

Introduction

The purpose of this study was to explore how high school students manifest motivated behaviors when working in collaborative groups of varying gender composition on inquiry and engineering tasks in their biology classrooms. The research questions address themes relevant to the conditions of motivation (autonomy, competence, and relatedness) and how the enactment and receipt of these conditions may vary between genders, within groups, and between groups when the groups' gender configurations differ. While a comparison of groups can be focused relative to such gender constellation, the personality of these unique groups must also be taken into account when pursuing patterns and themes within this context. As such, this chapter will begin with a description of the groups themselves in order to provide greater meaning and context to the description of the findings. These profiles were compiled anecdotally through the process of gaining familiarity with the data when watching the full set of videotapes and both creating and reading the ERR's. This initial step allowed this researcher to develop an overall sense of the groups and their overt characteristics over the course of the six tasks.

Group Profiles

In order to distinguish between the groups described in this study, pseudonyms will be used that indicate the school, block, and gender configuration of the group. The number 1 or 2 describes the block as appropriate, and the letters “F” and “M” will be used to represent the genders included in the group.

Table 8: Group pseudonyms

School	Group 1 Pseudonym	Group 2 Pseudonym
Mountain High	Mountain 1MMM	Mountain 1FFFM
Mountain High	Mountain 2MMFF	Mountain 2FFFM
Cascade High	Cascade MMFF	Cascade FFFM

Cascade MMFF and Cascade FFFM are from the same classroom in a rural, regional high school in southern Vermont. Cascade MMFF was comprised of two girls, Tricia and Abigail, and two boys, Robert and Daniel, all Caucasian. This lively group seemed to generally have positive rapport with each other, as indicated by frequent joking and laughter throughout their experiences together. In fact, the group members could be seen “playing” together at times by making up games with materials or teasing each other. At times, this teasing could take a slightly negative and off-task turn, but overall tone of the group was one of relative friendship and comfort with each other. They seemed to know each other outside of the class in that they frequently talked about common experiences or friendships. This was particularly evident between the gender pairs. Daniel and Robert, for example, exhibited a high level of camaraderie in their social conversations, chatting about such things as sports and driver’s licenses. Several absences among group members over the course of the six tasks, however, had a noticeable impact on group’s cohesion. As Tricia often guided the group, her absence resulted in an observable lack of direction among the group members. Similarly, on the occasion that Robert was absent, Daniel showed almost no interaction with the girls. The overall dynamic in the group, therefore, showed the most positivity and collaboration when all group members were present.

Cascade FFFM, alternatively, contained a female gender majority with three girls and one boy. Of the three girls, two (Taylor and Tina) were Caucasian and one (Anna) was Latina. The boy, Andrew was also Caucasian. This group showed a very different social dynamic from Cascade MMFF. There was far less visible comfort. While not negative, these students showed no indication of being friends outside of the class. In fact, Anna was often observed to leave her group to chat socially with other classmates. They did not joke with each other or chat socially at any point. The teacher of this classroom indicated further that Tina was frequently absent and often socially disconnected because of this. Her hope was that this combination of students might provide Tina with some positive social connections. Andrew was the most disconnected from the group, becoming increasingly solitary and non-communicative over the course of the six tasks. Taylor often guided the group's work with frequent directions, decision-making, and questions posed to her peers, and Tina and Anna, in particular, were very polite in their interactions with her and in response to her direction. The personality of this group, therefore, was often quiet and subdued.

The remaining four groups were Mountain High, a different rural high school in southern Vermont. While similar in demographics to Cascade, it had a higher overall enrollment and larger downtown area. Mountain also offered a greater variety of class choice and both academic and athletic opportunities than Cascade.

Mountain 1MMM was the only group in the study that was homogeneous, with only three males. Originally, this group was intended to have three boys and one girl, but the girl chose to terminate her participation in the study before the tasks had begun and was, therefore, placed in a different group that was not included. Two boys in the group, Zeke and Steven, were Caucasian, and Rahim was of Indian descent. At the beginning of the study, Zeke and Steven clearly had a preexisting friendship. They appeared very socially comfortable with each other, as evidenced by their frequent chatting and apparent knowledge of each other's situations outside of the classroom. Rahim, however, seemed more task-oriented, drawn to his computer screen, and not participatory in their social conversations. He often, at first, seemed to lead the group's work with consistent task-focus and decision-making. Over the course of the six tasks, however, Rahim gradually seemed to gain comfort with his group members, resulting in a positive dynamic and very friendly rapport among all three by the end. They were often heard conversing together about such topics as cars, girls, beards, and jobs. Further, this increased comfort seemed to coincide with more equitable participation and leadership among the three boys with regard to the tasks themselves.

Mountain 1FFFM was another female majority configuration, with three girls and one boy as members. The boy, Brian, was Caucasian. Of the three girls, two were Caucasian, Parker and Sophie. The third, Talia, was of Hawaiian/Pacific Island descent. A notable variable in this group was that Sophie was selectively mute, therefore was not observed to participate or contribute verbally throughout any of the tasks. While she was present and attentive to the work of the group, the lack of speech limited the appearance of certain motivational behaviors as outlined by the study and, therefore, resulted in more passive than active behaviors being exhibited for her. This did not dramatically affect the group's overall frequency of passive behaviors, though; hers, in reality, were comparable to her groupmates. While it may have perhaps lowered the active behaviors seen for the group if she had not been selectively mute, it was not significant enough to affect the group's overall data. However, the other students in the group expressed at the end of the study, in the format of a writing prompt provided to all participants, that this scenario posed challenges for them in that they did not know how to engage her in the work and felt like she was not equally contributing to the completion of the task. While it may not have shown an outward effect in the data from an objective stance, it certainly was noted by the group members.

Aside from this clearly unusual circumstance, the group had a very productive and task-oriented dynamic throughout the study as evidenced by their consistent attention to the activities and their completion. Parker was the clear leader of the group, with Brian often taking a collaborative role with her. There appeared to be a positive social dynamic, and the students were friendly, polite, and respectful of each other. They indicated that they had some classes together previously but felt that this group work had brought them closer together as friends. A final note of interest with these particular students is that Brian was not present for the final focus group interview, although he did complete all six tasks with his group. His teacher stated that he had left the school year early, remarkably, to join a youth circus troupe.

Mountain 2MMFF was a gender dyad group, comprised of two girls and two boys. All four group members were Caucasian. The two girls, Catherine and Elizabeth, presented very different profiles from each other. Catherine was much more socially engaged and distracted, often seen chatting with members of other groups and talking about extra-curricular issues and activities with her peers. Elizabeth was quieter and more reserved in the group, although her comfort level seemed to increase over the course of the six tasks. At times, she and the boys would joke or have a discussion that was tangential to the task. The two boys, Adam and Gavin, were also both rather reserved. In every video, Gavin is wearing a hood on his head and seats himself in the same corner of the table. While there was some social conversation between the two boys, the group overall had a rather neutral, though certainly not negative, dynamic with minimal overall conversation or energy.

Mountain 2FFFM, the final group in the study, is also a female gender majority group with three girls and a boy, all Caucasian. The dynamic in this group was often unfocused towards the task and socially-driven. All three girls, Diana, Bryn, and Natalie, seem to have pre-existing friendships as evidenced by apparent comfort with each other. They were often seen playing with each other's hair, having social conversations about sports, extra-curricular activities, and clothes. Natalie appeared very distracted by social dynamics, often chatting with members of other groups and disappearing from the task. Her energy in the group was unpredictable – sometimes sleeping at the table and other times singing, talking to the camera, or just making noises. Bryn was absent from portions of many of the tasks, arriving late to class, leaving for long periods of time, or missing class all together. Thus, when she was present, she often was unclear on aspects of the task, and her participation was limited or superficial. Diana, however, seemed the most task-driven and least distracted by social interactions. As such, she often led the work of the group by directing, questioning, and trying to engage her groupmates, frequently with Timothy's collaboration. This again was a lively group with a great deal of laughter and social interaction, as well as off-task behaviors. Frequent coming and going by some of the group members seemed to impact, however, a sense of overall consistent cohesion and was noted (specifically about Bryn) in their final focus group interviews.

As described, these six groups of students, while representing aligned gender configurations and similar demographic backgrounds and educational settings, present unique personalities and profiles that impact the manner in which they may present motivated behaviors, respond to each other, and evolve over the course of their group experiences. The patterns and themes in the data relevant to the preexisting codes are delineated and described, as with any qualitative study, within the holistic view of the students and groups: they do not exist within a void. They arise empirically from the groups' complex networks of actions and interactions.

Results and Findings – Videotaped Group Work

Table 9: Autonomy table of results

	Between Genders	Across Groups	Inquiry versus Engineering
Themes	• Hierarchy and leadership • Directing – facilitating and demanding • Hands-on behaviors – playing versus constructing • On and off task		
Findings	**GIRLS:** • Frequent female leadership • Frequent directing and decision-making • Facilitative quality of directing • Hands-on behaviors related to task • Overall adherence to pursuit of task **BOYS:** • Some male directing • Demanding quality of directing • More hands-on for play and exploration • Less attention than girls to task adherence and writing	**GENDER DYADS versus GENDER MAJORITY:** • No trend observed in hierarchy or leadership between groups • Gender divide for hands-on behaviors in dyads – girls and boys performing separately • No gender divide in hands-on in gender majority groups – more even distribution across genders • No trend observed in on and off task behaviors relative to group	**INQUIRY versus ENGINEERING:** • More frequent occurrences of discrete directing and following directions in engineering tasks across genders and groups • Boy's off-task behaviors reduced during engineering tasks • More active hands-on behaviors regardless of gender and group during engineering tasks than inquiry • More passive hands-on behaviors (observing, writing) during inquiry

Autonomy Table of Results

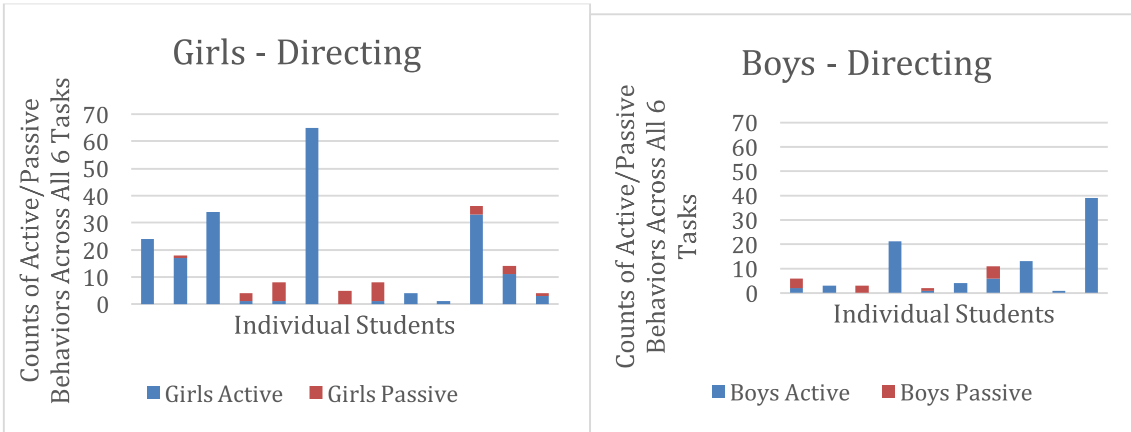


Figure 2: Frequency of directing behaviors observed between girls and boys

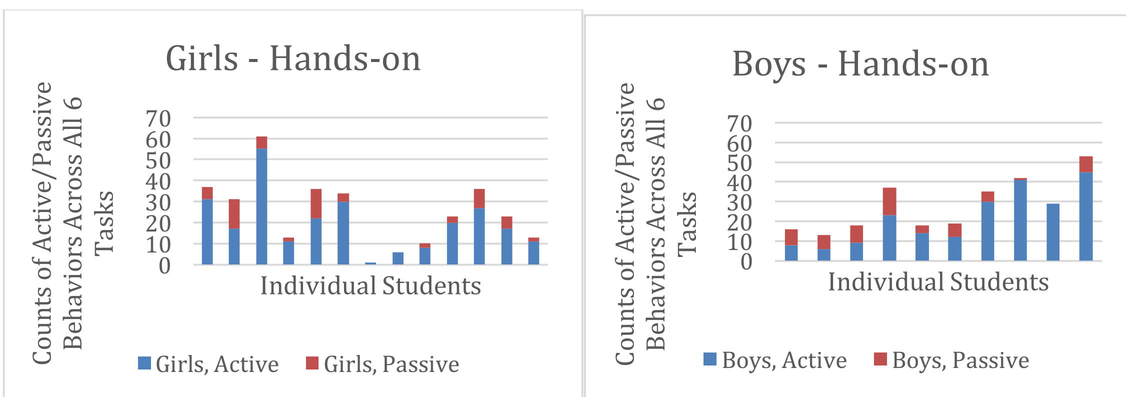


Figure 3: Frequency of hands-on behaviors observed between girls and boys

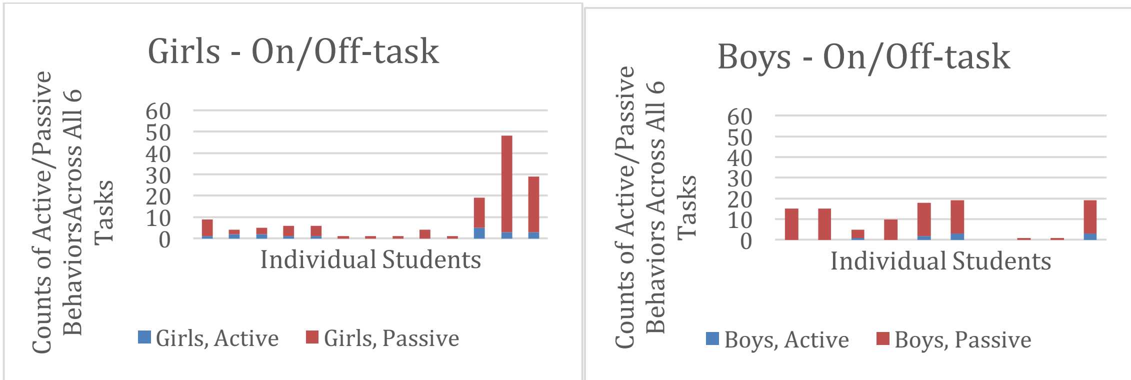


Figure 4: Frequency of on and off-task behaviors observed between girls and boys

Figures two through four show the frequency of the various behaviors associated with autonomy (directing, hands-on manipulating equipment, and on/off-task behaviors), as compared between girls and boys. Both active and passive enactments are included, and the columns indicate counts per student. These tables illustrate the relative gender distinction between these behaviors, as will be discussed by behavioral indicator in the following sections.

An examination of the overall trends of directing behaviors among all six groups over all six tasks present an interesting picture. Regardless of gender composition, in three of the five groups containing girls, one female in each group exhibited far more leadership behaviors of any sort than by all of the remaining group members combined. Thus, in each case, one particular girl took on a distinct role in terms of directing and deciding about elements of the task towards its completion. In the remaining two mixed-gender groups, this role also existed but was shared with one of boys in the group as well. In other words, the leadership appeared to be more of a shared position between a specific male and female group member in terms of their combined directing and decision-making behaviors and the groups' responses to this.

This phenomenon of female leadership, specifically in terms of directing, was independent of group gender composition and appears more a function of gender itself. Tricia in Cascade MMFF, a gender dyad group, exhibited an almost equal number of directing behaviors as Taylor in Cascade FFFM, with a female majority. Parker in Mountain 1FFFM, a female majority group, showed a dramatic number of directing behaviors, almost twice that of any of the other female leaders in any of the groups. While it appears that a hierarchical structure with a clear leader emerged in each of these groups according to the disparity in directing behaviors among members, this was a shared role in Mountain 2FFFM and Mountain 2MMFF. Consistent, however, was that a female in every group, no matter the composition, rose to this status, even if in conjunction with a male member. Further, in the all-male group, Rahim exhibited the same trend as the female leaders, in that his occurrence of directing behaviors far outnumbered those of Zeke or Steven. This indicates the persistence of hierarchical structures, regardless of gender and group composition, but suggests that, in groups with girls, it is likely one female will take on this role.

While leadership in itself often showed female participation, a distinct gender contrast emerged with regard to type and manner of directing and leading the group. Girls appeared overall more likely to perform task-related directions and behavioral refocusing than boys. In other words, their directions often maintained an intent towards task pursuance. Diana, for example, guides her groupmates towards a specific lab question they need to finish by saying, “Hey, listen!” and reading aloud a section of text that she thinks is funny. When their attention is back on the work, she reminds them they only have five minutes to finish. In this way, she refocuses them back to the task but without a sense of demanding. She is also heard to say at other points, "Guys, we have to get going." With the exception of Timothy, no other boy in any group refocused their groupmates at any point: boys' directing most often took the form of commands and decision-making rather than intents to organize or refocus their peers.

Further, the girls in each group, particularly those who assumed the leadership roles, were more likely than the boys to start the group off with more facilitation-type directions that organized their group's work around the task. These directions were often framed with an inclusive tone, even if the intent was adherence to her idea. For example, Parker in Mountain 1FFFM starts the group off brainstorming during the pill bug task by saying, "Let's think about light and dark." While this is still a directive, it invites a whole group approach towards beginning the task. Taylor, in Cascade FFFM, similarly leads and facilitates the group's launch of the task by saying, "I'll show you what I'm thinking once we've got the stuff," and "You can add some pictures of snails if you want." Again, her leadership is apparent but without an intent to order her groupmates towards certain behaviors. Even for girls that did not necessarily assume leadership roles, manner of directing still retained the same tone of inclusion. Abigail, in Cascade MMFF, at one point asks Tricia to "read it out loud so we can all hear". While this is a slightly more commanding direction, its intent is to facilitate the group's work rather than her own specific agenda.

In contrast to the girls' manner of directing, the boys in each group often did not did not even contribute at this more holistic planning stage and thus provided very few task-related directions at all. Even in the all-male group, little evidence of any task-directing is observed, with the beginning of the task being framed more by discrete directions, such as “We have to write a hypothesis,” or by simply developing their own independent ideas first, which precluded such types of directions. Overall, boys’ directing and manner of leadership, when apparent, was far more demanding than that of the girls. They were more likely to command their peers with discrete directions than to facilitate the whole group’s work. Timothy’s directions, for example, often contain this commanding tone, such as “Try more soap,” or “Bring me some scissors.” Similarly, Rahim says to his group, “I need another test tube,” in expectation that someone will bring it to him. These directions do not necessarily guide the group’s work; rather, they command another individual’s behavior towards a specific agenda or end. In this way, leadership and directing differ significantly between the genders, regardless of group composition and more reflect the gender of the student doing the directing.

Directing behaviors, in sum, reflect the gender and leadership quality of the individuals performing the directing as well as the trajectory of the task. In all cases but one, directing behaviors were dominated by one particular group member. Further, the opportunity for female leadership in a group was not dependent on its composition, either, and occurred with greater frequency than male leadership among the groups.

Hands-on behaviors, similar to directing, did not necessarily exhibit a consistent frequency pattern with regard to genders but rather varied with quality and presentation between boys and girls. While the individuals in leadership roles tended to actively handle equipment and materials more frequently than the other members of their groups, a further gender distinction emerged as well. Girls in general, despite differences in quantity of hands-on behaviors, manipulated equipment and materials specifically towards pursuance of the task. Consistent with task-oriented directing behaviors, when girls did perform hands-on actions during activities, these were aligned with the over-arching goals of the activity. While boys also performed task-oriented hands-on behaviors, the greatest distinction in this area between the genders is the passive form: simply writing (as opposed to engaging in manipulating materials) or handling equipment in ways not aligned to the task (playing with the materials). In this domain, boys provided a distinct presentation from girls.

In all instances of such passive handling behaviors (writing versus playing), when these behaviors did occur, playing with the materials was seen almost exclusively with the boys, and writing was observed primarily in the girls. This is not to say that all boys simply played with the materials, more specifically that when materials were being used in a playful or exploratory manner, it was most likely to be performed by a boy. The most dramatic example of this was shown with Robert and Daniel and Cascade MMFF. In this case, their passive behaviors even outnumbered their active handling behaviors. In other words, they were more likely to play with the materials than use them as intended for the task.

This behavior, however, is also observed frequently in Andrew, as compared with his female groupmates. While the girls in the group actively work on the construction phases of the tasks, he was more likely to play with materials in manners not aligned to the tasks' intents or goals. It is worth noting that, over the course of the six tasks, his participation in the group and in the class waned dramatically. In some cases, he was actually not present for the majority of the class time, therefore having less opportunity for active involvement. No more information is available to explain his decreasing involvement in the group, but this fact does affect emerging trends among the data.

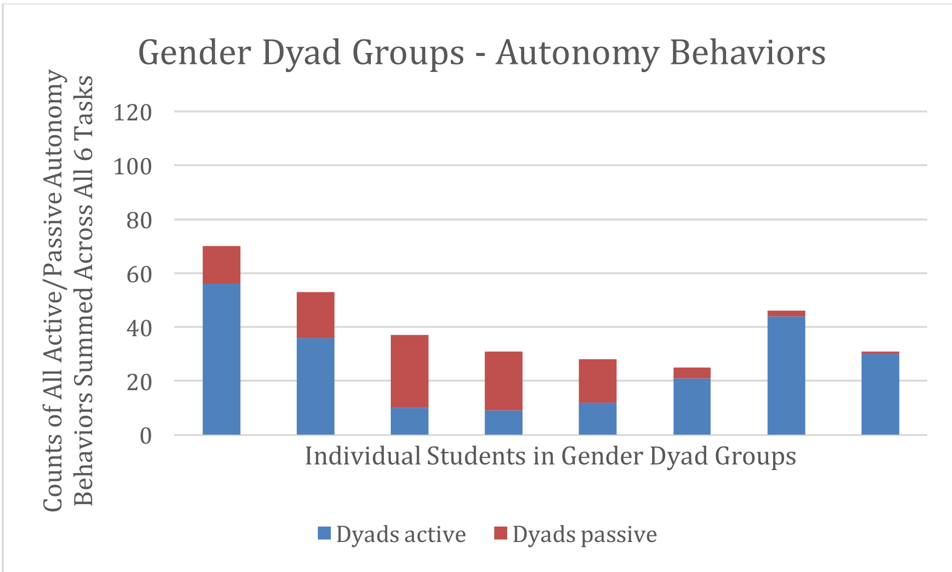
Timothy also is observed to play with materials outside the parameters of the task, particularly when he is engaged socially with his group members. This is true within the all-male group as well, with Zeke and Steven frequently passively handling the materials while chatting and socializing. In contrast to the boys mentioned, playful handling of materials is observed literally only once with Tricia in Cascade MMFF, when she joins the boys in a game they have created out of the materials, and on only a couple of occasions when Natalie joins Timothy. A further distinction, therefore, is that in the very few instances that girls do engage in handling materials for playful or exploratory purposes rather than task-directed ones, they are joining in socially with the actions of the boys in their groups. On no occasion are girls observed to engage in this behavior amongst themselves.

Girls do, however, engage with each other in socially off-task behaviors in almost equal frequency as boys. In this regard, little gender distinction is noted in either quantity or quality of the off-task behaviors. Both genders, both between and among themselves, are observed to chat about topics unrelated to the task with no apparent distinction. The only gender difference noted is simply that boys off-task behaviors and social distractions are more likely to be linked to their passive hands-on behaviors as well. In other words, these two behaviors more often coincide with boys, but girls' off-task behavior falls more specifically in the realm of simply chatting and socializing. While some students exhibit this behavior more than others, it does not fall along gender lines but rather seems more related to the student's comfort and existing friendships with their groupmates and with other members of the class. For example, Diana and Bryn in Mountain 2FFFM explain that they were good friends outside of the class, and much of their off-task behavior involves talking about sports, plans outside of school, and their other classes. In contrast, the students in Mountain 1FFFM, who did not know each other as well outside of class, and show few off-task behaviors as to be inconsequential.

On and off-task behaviors, therefore, show little gender distinction. While the girls in various groups did tend to show mostly social distractibility, the boys were more variable in the manner and type of their off-task behavior, with some passive hands-on behaviors included. Despite this, overall frequency of off-task behaviors appears to be more relative to the individual students and their existing relationships.

Autonomy manifests within the group first by the emergence of a consistent hierarchical structure. Enactments of autonomy show a gender distinction within the realm of leadership and directing in that a singular female in each takes on this role, although it is shared with a male in some cases. Manner of leadership and directing varies along gender lines, with girls facilitating and guiding the group's work and boys more likely to demand specific actions towards their own agenda. Both boys and girls handle the materials and equipment readily, but girls more frequently do so within the parameters of the task and are less likely to explore and play with them than boys. This contributes to some of the males' off-task behaviors, while girls more likely to engage socially when they are off-task.

Autonomy and Group Composition



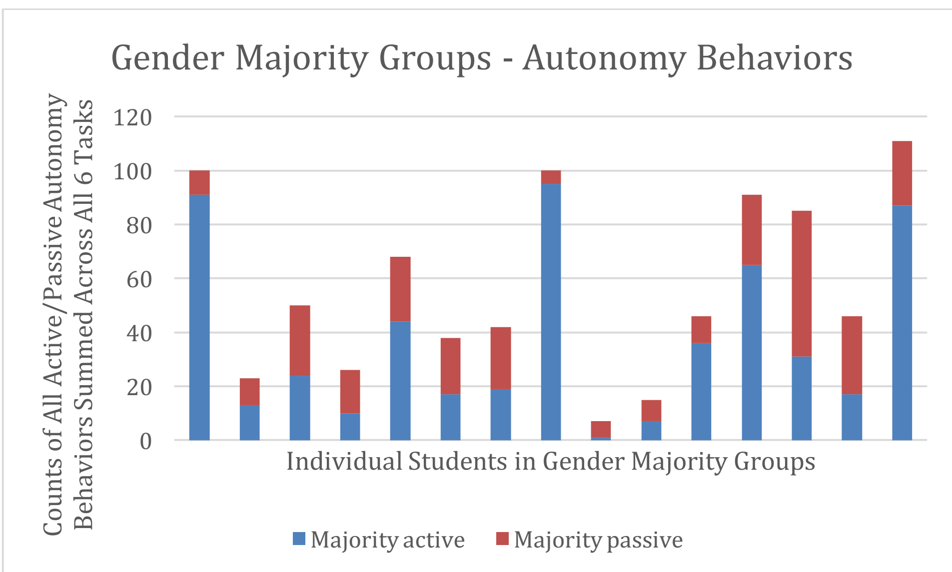


Figure 5: Frequency of autonomy behaviors manifested across groups

Figure 5 shows the frequency counts of the sum of the behaviors associated with autonomy for each student but organized to show all counts by group composition instead of by gender. Columns represent the sum of all autonomous behaviors observed by individual students, colored to show the portion of active and passive behaviors, and from which group composition the student comes. This table, therefore, does not distinguish the specific indicator nor the gender of the student but rather the overall frequency of active and passive enactments of autonomy observed between groups of varying gender composition.

Enactments of autonomy, while showing clear gender distinctions in their manifestations, appeared to be less directly linked to group composition. Directing, for example showed almost no connection or difference in presentation among the groups of varying gender composition, with the observable trend relative to the hierarchical structures established in each group, and often with female leaders emerging. The existence of some shared leadership between Diana and Timothy in Mountain 2FFFM and Gavin and Catherine in Mountain 2MMFF in terms of their directing and decision-making, however, did not represent any difference in group composition, as one was a gender dyad group and the other a female majority. As such, little can be said with regard to directing and leadership among the groups relative to their composition.

Hands-on behaviors showed a connection to group composition in some slight and subtle ways, but not with overall consistency. The gender dyad groups, for example, showed little parallel to each other. In Cascade MMFF, Tricia, who also assumed the leadership role in the group, exhibited more active hands-on behaviors than any other group member. Further, the combined hands-on behaviors of the two girls in the group far outnumbered that of the boys. Therefore, despite the gender parity, the girls outperformed the boys in terms of their willingness and frequency of manipulating the equipment necessary for the task. Passive handling behaviors, however, were divided more equally among all four group members, regardless of gender, with all students showing a relatively similar number.

This profile was not consistent with the other gender dyad group, Mountain 2MMFF, however. In contrast, the boys exhibited more than twice as many active hands-on behaviors as the girls. Gavin, in particular, dominated the manipulation and construction of the elements related to each task, with Adam still performing far more hands-on behaviors than either Catherine or Elizabeth. Interestingly, while the passive writing behaviors were once again observed only among the girls (with Adam and Gavin often leaving this aspect of the task undone), no playing behaviors were observed at all. Robert and Daniel from Cascade MMFF often played with materials while socializing in a manner unrelated to the task, but this same level of friendship outside of the class and social cohesion was not observed in Mountain 2MMFF.

Elizabeth presented an interesting dynamic in this group. In most cases, she became involved in the hands-on work only after it was already initiated by the boys, so while she was not necessarily assisting, her behaviors still followed their lead. In almost every lab, she did not become actively hands-on until the task was fully underway. Further, she also became more involved in a hands-on manner during the pill bug lab and cellular respiration labs, which involved live creatures. In the pill bug lab, her primary hands-on involvement was “rescuing” the pill bugs when they started to escape from their choice chambers. She was also instrumental in carefully placing the snails in their appropriate test tubes. In these cases, she did not exhibit the stereotypically-gendered response to the bugs and snails that were observed among some of the girls in other groups, and, while her handling of the creatures was task-oriented, it held the more prominent intent of taking care of them: at times, she was even observed to speak directly to them to explain that she was "rescuing" them.

The manner in which group composition did present distinctly in terms of these hands-on behaviors is simply in this gender divide in the dyad groups. While hands –on behaviors were observed more frequently among the girls in one group and the boys in the other, the fact that the partitioning occurred is distinct from the gender majority groups, both male and female. In these majority groups, the overall presentation was consistent among them, with a generally similar distribution of hands-on behaviors among the students in the groups, even if some students were observed to perform them more frequently than others. Overall, everyone was involved in a hands-on way in some manner, with no predictable divide as noted in the gender dyads groups. Even more definitively, active handling behaviors were distributed very similarly among all three boys in the group with no one member standing out in terms of being more actively hands-on.

The leadership was more consistently aligned with the hands-on behaviors in the gender majority groups as well. Notably, the female leader in each of the three female majority groups still showed a greater frequency of such behaviors than the other two girls in these groups, even though there was involvement among all students in these groups. Further, in two of these groups (Mountain 1FFFM and Mountain 2FFFM), the single male in each group performed as many or more active handling behaviors than the female leader. In other words, while all of the group members were involved in hands-on work, the female leader and male still emerged as leaders in this area as well.

Passive handling behaviors were also similarly distributed among the students in the female majority groups, with little dramatic distinction presented. However, in the majority of these cases, the passive behavior noted is simply writing. No playing behaviors were observed in groups Cascade FFFM or Mountain 1FFFM at all, and very few occurred in Mountain 2FFFM. The relative equal distribution of such passive behaviors, particularly around the act of writing, indicate that among these female gender majority groups, no one member was the sole note-taker or writer and that it did not occur along gender lines but equally among the members.

Each of the six groups presented a very different profile in terms of their on and off-task behavior, and little pattern emerges relative to group gender composition. A minimal comparison can be drawn between the two gender dyad groups, Cascade MMFF and Mountain 2MMFF, in that both exhibited a high frequency of off-task behaviors as compared with some of the other gender majority groups. The perpetrators of these off-task behaviors, however, was not aligned in any predictable way between these two dyad groups. In Cascade MMFF, off-task behaviors were aligned with the passive handling of materials behavior described previously by the Robert and Daniel in the group. As they were the principal perpetrators of this, they also exhibited several times as many off-task behaviors as either Abigail or Tricia. Not only did they use the scientific equipment and materials for off-task distractions, they also spent substantial amounts of time playing with other non-classroom objects. During the pill bug lab, Robert, although consistently interested in handling the creatures, asserts to the girls as they are planning their investigation, “You go do that, we’ll play around with bugs.” The boys also engaged in many conversations around driver’s licenses, sports, and other topics unrelated to the task while the girls were setting up investigations, performing trials, writing down observations and answer to questions, and making collaborative decisions, reflecting back on the gender divide with regard to on and off-task behaviors. While both Tricia and Abigail do get drawn into the distractions and conversations from time to time, they consistently return to the task and attempt to redirect or re-engage the boys. There is no discernible trend over the course of an individual task, either; the boys are equally distracted throughout, not showing more on task behavior, for example, during the construction or investigation phases of the tasks.

The second gender dyad group, Mountain 2MMFF, however, presents a very different profile. While occurrences of off-task behavior are comparable to that of Cascade MMFF, these behaviors are performed almost exclusively by Catherine, with only one instance noted with any of the other members. In contrast to Robert and Daniel, Adam and Gavin remain on task almost without fail during all six tasks. Catherine's off-task behaviors are purely social in this case, and they often involve students in other groups. Therefore, she often leaves her own group to chat with friends elsewhere in the room or will disengage from the activity in order to talk across the room to other students. In these moments, the distraction causes her to miss work being conducted by her own group, and she will have to copy or seek help to re-engage. While the occurrence of off-task behaviors may appear similar among the gender dyad groups, the actual individuals doing so and their quality of behaviors are not necessarily so.

In some cases, female majority groups show fewer instances of off-task behavior. Two of the female majority groups, Cascade FFFM and Mountain 1FFFM, showed fewer than half of the off-task behaviors as the gender dyad groups. Both of these groups exhibit such a low frequency of off-task behaviors as to be easily missed. In Mountain 1FFFM, the group is so fundamentally on task, that the only moments in which they can be considered off-task occur once when Parker asks Talia how her sister is doing, and another time when Sophie simply just appears to be staring off into space for some time. Over all six tasks, these are the only times when any off-task behavior among any of the members can be noted.

In Cascade FFFM, the other remaining female-majority group, the instances of off-task behavior occur most frequently with Andrew. As previously noted, his participation in the group decreases dramatically over the course of the six tasks. No further information is available to indicate if this phenomenon is true only for this particular class or if it is more systemic for him personally. From the first inquiry lab, in which he participates with great frequency and apparent investment, to the final engineering task, he becomes almost non-communicative, despite multiple attempts by the girls in the group to involve him. Although he does often appear to listen and attend while he is in the group, his decreased participation results in several off-task behaviors noted. The majority of Andrew's off-task behaviors occurred during their final lab, which was an oil spill engineering design challenge conducted in June.

Also in this group, Anna and Taylor exhibit very minimal off-task behaviors, but they are very short and do not result in a greater distraction from the task. These most typically were checking their phones or a quick socially-related question. Despite this, combined with Andrew's behavior, this group still showed fewer off-task behaviors than the most of the other groups. Further, these behaviors were generally individual and short-lived, meaning that the entire group itself remained predominately on task.

This pattern does not hold true, however, for the other two gender majority groups: the third female majority group, Mountain 2FFFM, which exhibited off-task behaviors many times more than that any of the other six groups and the all-male group. In both of these cases, the off-task behaviors were primarily social. In the all-male group, their off-task behaviors tend to be far more conversational than related to items or objects. Zeke and Steve, in the all-male group, spend large portions of their class time discussing girls, cars, sports, and jobs. Rahim becomes increasingly more involved in these conversations as his apparent comfort increases. Similarly, in the female majority group, Mountain 2FFFM, all three girls show a high level of social comfort with each other. Thus, much of their distraction involves socialization, talking about clothes and upcoming sporting events, and being caring towards each other, demonstrating mutual affection through such actions as doing each other's hair. In stark contrast to the behaviors of Robert and Daniel, who are indiscriminately off-task, the girls are easily re-engaged during the construction and execution stages of the tasks. They readily join in and assume roles towards its completion. Their off-task behaviors tend to occur when there is a transition, confusion about the next step of the task, or when there is a lull in the activity, specifically towards the beginnings and ends of the class period.

As such, frequency of off-task behaviors does not appear to consistently or conclusively related to the gender composition of the groups, but could perhaps be linked to other social factors or student personalities.

To return to the *stereotype inoculation model*, behaviors associated with autonomy, according to these findings, do not appear to be greatly impacted by groups gender composition. In other words, stereotypically gendered behaviors related to autonomy, such as girls potentially writing as opposed to manipulating equipment or more frequently following the directions of others, does not appear to be linked in any significant way to the gender composition of the group. Rather, these behaviors seem more inherently based on the group's hierarchical structure the genders of the individuals.

Autonomy - Inquiry versus Engineering

A subtle trend appears in the directing behaviors between inquiry and engineering tasks. While the same group leader (or leaders, in the case of Mountain 2FFFM) remains constant for each group among all six tasks, greater frequency of occurrences of passive direction (following directions, in other words) emerge in the engineering tasks as compared with the inquiry tasks for most groups. These occurrences coincide with increased discrete directing in these cases, possibly because the engineering tasks involved a greater amount of hands-on construction and materials that often required more than one set of students' hands. This trend, however, was not equally visible in Cascade FFFM, with constant passive directing behaviors emerging at regular intervals throughout all for all six of the tasks, regardless of whether they were inquiry or engineering design. The majority of instances of following directions, however, were conducted by Anna in this group, indicating perhaps her willingness to acknowledge and help Taylor: rather, a characteristic inherent in Anna rather than in the type of task.

A subtle distinction appears between inquiry and engineering design tasks in terms of the trends in handling behaviors as well. In the majority of cases, more passive behaviors are observed overall in the inquiry tasks than in the engineering design tasks, regardless of group composition. This may simply be aligned to need for building and construction within the engineering design tasks. However, no observable pattern is detected with regard to the individual genders and the type of task nor with the type of passive behavior within different types of tasks. In other words, while there most certainly appear to be gender dynamics at play with regard to behaviors involving handling materials and equipment among these groups, these dynamics are not further impacted in any observable way between inquiry and engineering design tasks. Individual gender, group gender composition, and group social dynamics may comingle in a variety of ways to impact the frequency and manner with which students enact these behaviors.

The most dramatic trend in terms of manifestations of autonomy is seen in on and off-task behaviors. While not consistent among all six groups, in the all-male group, not one single instance of off-task behavior is observed during the engineering design tasks for this group; every off-task occurrence noted happens during an inquiry task. Interesting also is that they exhibit a high level of off-task behaviors overall throughout the course of the six tasks when compare to the other five groups. When considered in combination with their high frequency of off-task behaviors overall, this trend is even more startling in that this very high number is concentrated in only three inquiry tasks.

This is not the only group from the six in which the males' off-task behaviors diminish during the engineering design challenges. While the female majority group, Mountain 2FFFM, shows the highest frequency of off-task behaviors among the groups overall, with Timothy representing a large portion of them during the inquiry tasks, he does not exhibit one single off-task behavior during any of the three engineering tasks. In fact, the overall number of off-task behaviors in the group are fewer during the engineering tasks than the inquiry tasks. Natalie and Bryn exclusively exhibit these behaviors during the engineering tasks and also show the highest frequency of off-task behaviors of any of the students across all six groups.

While most prevalently seen in these two groups and specifically among the males, a slight decline in off-task behaviors during engineering challenges does generally occur for all of the groups. Among the remaining groups, however, there is less of a gender distinction in terms of occurrences, and it seems to be related overall more to the task than predictably to either boys or girls.

Autonomy Summary

Autonomous behavior was examined in this study with regard to three specific enactments: directing and decision-making, hands-on manipulation of materials and equipment, and on and off-task behaviors. While the individuals within the groups and the groups themselves presented a variety of profiles and variability in these categories, some over-arching observations can be made. First, within each group, a hierarchy developed that remained constant throughout the duration of the six tasks. In other words, a student leader (or leaders) emerged who maintained this status. In all five groups that contained females, one girl was shown to assume a leadership role, even if it was shared with the another boy in the group. Consistent with this female leadership were the autonomous behaviors associated with it. Regardless of group composition, the female leaders in the group showed more directing and decision-making behaviors than the other group members, often facilitating decisions, refocusing the group, or taking control of the next steps of the task. In the all-male group, Rahim assumed this leadership role, exhibiting the same frequency of directing behaviors as the leaders in the other groups.

Type of directing behavior is also related to genders and to the trajectory of the task, unrelated to group composition. For example, more task directing and refocusing seems to occur at the beginning and ending stages of the activity, while more discrete directions happen during the construction and execution stages of the task, indicating perhaps the times in which the group members are more hands-on, engaged with the task, and requiring more discrete and immediate actions to take place. Along gender lines, females are observed to perform these more facilitative and organizing directing behaviors than boys, who more frequently exhibit directing behaviors that are demanding and discrete.

Little generalization can be drawn regarding hands-on behaviors with regard to group composition. Notable, however, is that in each gender dyad group, the hands-on behavior within the groups themselves was distinct between the boys and girls. In other words, in one group the boys showed far more active hands-on behaviors than the girls. In the other group, the girls performed more active hands-on behaviors, but the boys showed almost exclusively passive playing behaviors with the materials and equipment. While the presentation was different between these two groups, a gender separation did occur with regard to this indicator.

Consistent across all groups, however, is the gender divide that occurred with regard to passive handling behaviors. Girls, in the majority of cases, exhibited passive behaviors in the form of writing. In contrast, boys exhibited both playing and writing behaviors, with a greater occurrence of playing. Girls' hands-on behaviors, therefore tend to remain more task-driven and towards task completion than that of the boys.

On and off-task behaviors appear unrelated and inconsistent not only between genders but also between groups of varying gender composition. On and off-task behavior cannot be generalized at this point based on any factor related to gender, only that both gender dyad groups exhibited relatively more off-task behaviors than some, but not all, of the gender majority groups. More impactful seems to be the social cohesion of the group and its members, as well as the type and trajectory of the task, with a general reduction in off-task behaviors during the construction phases of the engineering tasks.

Enactments of autonomy, in sum, appear to vary more predictably along gender lines than between groups of varying gender composition. Further, not all manifestations of these behaviors show a gendered manifestation. Some behaviors appear to have little relation to gender at all but to the plethora of other factors existing within a small group of high school students.

Table 10: Competence table of results

	Between Genders	Across Groups	Inquiry versus Engineering
Themes	• Explaining concepts and ideas – vocal participation • Expressions of confusion • Suggesting – global versus discrete suggestions • Seeking clarification – problem-solving and teacher support		
Findings	**GIRLS versus BOYS:** • Same group leaders (often girls) who exhibited most directing offer most frequent explanations and suggestions • Girls more likely to make discrete suggestions about next steps • Boys more likely to make global suggestions about task design • All-male group seeks help from teacher most frequently. • Girls seek support, both active and passive, more towards task completion than to understand content.	**GENDER DYADS:** • More frequent expressions of lack of understanding • Less overall vocal participation of group members **GENDER MAJORITY:** • More vocal participation overall, especially with girls in leadership roles • More equal distribution of suggesting among group members • Little trend noted in terms of group composition between female majority and gender dyads in terms of seeking clarification.	**INQUIRY:** • More active explaining • Increased overall vocal participation • More teacher support sought **ENGINEERING:** • Fewer instances of active explaining • More frequent expressions of confusion • But fewer instances of seeking help from teacher

Competence Table of Results

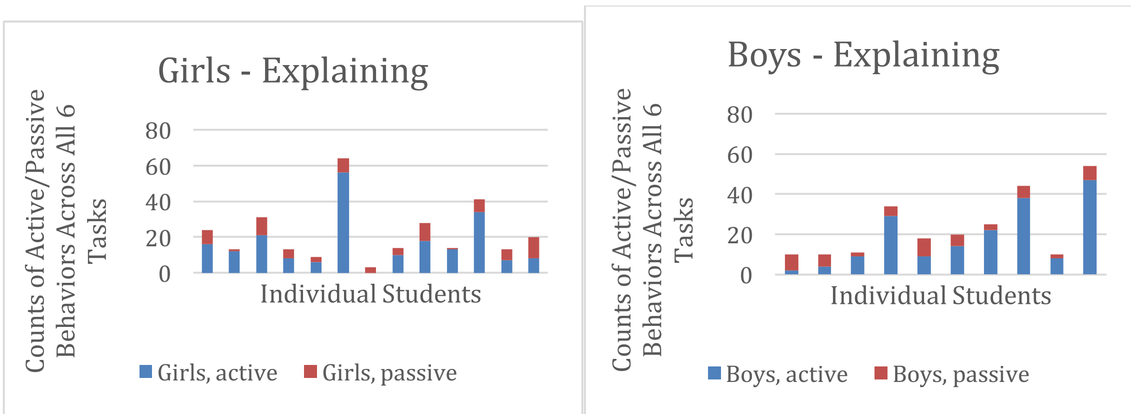


Figure 6: Frequency of explaining behaviors observed between girls and boys

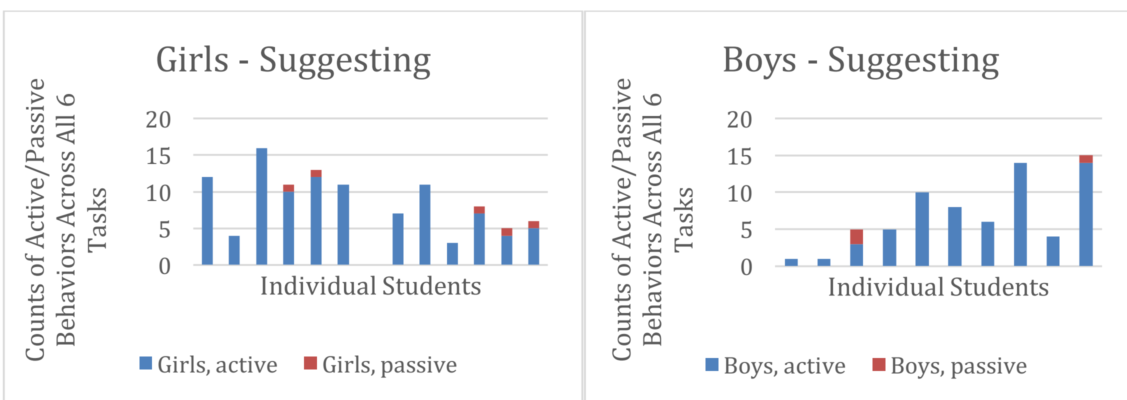


Figure 7: Frequency of suggesting behaviors observed between girls and boys

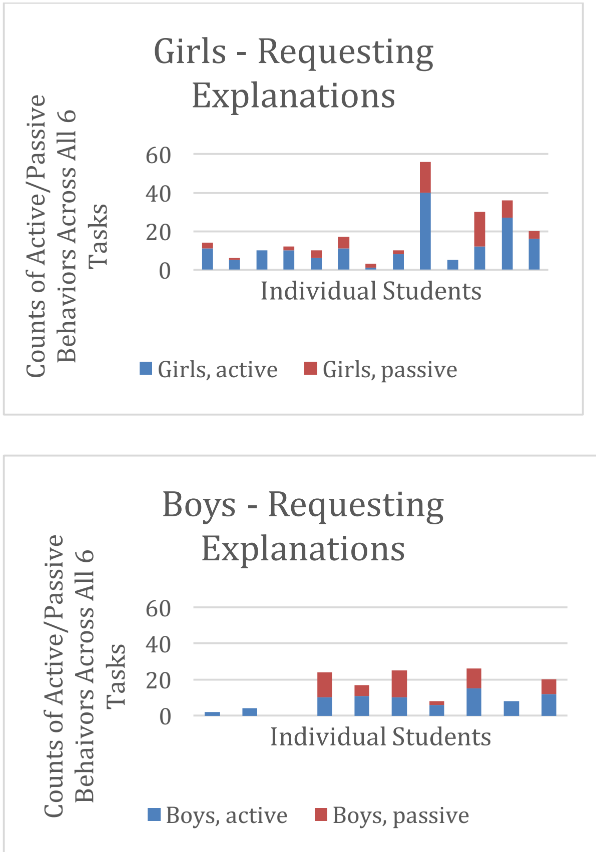


Figure 8: Frequency of requesting explanations behaviors observed between girls and boys

Organized similarly to the autonomy, figures six through eight show the frequency of each specific behavior by student, distinguishing whether the behavior is active or passive as well as the gender of the student. Columns represent the total number of those behaviors observed in an individual student.

Across all six groups, a clear trend emerges, which initially appears unrelated to gender. The same students who exhibit the greatest frequency of directing behaviors also provide the greatest quantity of explanations within their groups. Further, the distribution of explaining behaviors appears similar to that of the directing behaviors, with most of the students presenting the same profile as they did in the category of directing. For example, in the female majority group, Mountain 2FFFM, Diana and Timothy share the majority of the directing behaviors, each exhibiting a great deal more than either Bryn or Natalie. This same pattern remains constant within the realm of explaining behaviors as well. Diana and Timothy provide far more active explanations than either Natalie or Bryn and also show a similar frequency as each other, much like in their directing profile. This striking phenomenon is true for every student in each of the six groups: while the actual numbers are different, their relativity to the other group members is exactly the same in these two categories. In other words, the student with least number of directing behaviors in a group did the least amount of explaining as well. This suggests a strong relationship between students' confidence with directing and instructing their peers and a potential connection between their perceived knowledge about a topic and their willingness to take a leadership role within that domain.

Because there was an observed gender trend in relation to directing behaviors and leadership, with a female often taking on this role in groups with girls, this presents similarly in terms of explaining as well. The result is that the females who have assumed this sense of leadership and group guidance, even if it is a shared role, also exhibit the most frequent explanations to their groups. Parker and Taylor, for example, very much female leaders of their groups, offer many times more explanations of their thinking and of scientific content than any of their group mates. This is true of Tricia and Catherine in their groups as well, with Gavin also often sharing explanations in his group with Catherine and in light of their shared leadership. Active explaining, therefore, is aligned to the gender trends relative to the hierarchical structures of the group as opposed to any more stereotypically gendered behaviors.

Passive explaining, or rather expressions of lack of competence, does not follow the same trend as with active and passive directing. For many of the girls in the study who exhibited high levels of explaining, this did not necessarily predict fewer passive explanations. In fact, these girls in leadership roles typically exhibited a similar number of passive explanations, or expressions of confusion, as their active explanations and as their groupmates. Tricia in Cascade MMFF, for example, has an almost equal number of passive explaining behaviors as active explanations. This lack of disparity between active and passive explaining can be observed also with Catherine in Mountain 2MMFF, however, in the other gender dyad group. As willing as she is to share her thinking and ideas about the task or its data, she is also equally likely to say that she is "confused" or "doesn't get it". This pattern remains true for Parker, Diana, and Taylor: each of these girls also exhibits notable and multiple expressions of confusion and lack of understanding, although not with the same frequency as their positive assertions, but more similar or even exceeding that of their groupmates.

This interesting trend suggests that these girls' leadership qualities and sense of confidence with content did not preclude them from admitting that some aspect of a task felt hard or challenging or that they were not sure what to do next. In fact, they actually even showed a higher frequency of such expressions than their group mates as well. What this appears to suggest is that in each group, the more dominant females were likely to provide explanations and also to express a lack of understanding. However, the female leaders in each group provided a far greater number of explanations than expressions of confusion. Their overall vocal participation in this area, both active and passive, is greater than their groupmates. Beyond the scope of this study is to look more deeply into the roots of this phenomenon – if it represents simply increased vocal participation on the part of these girls or a more deeply-rooted stereotypically gendered lack of confidence that must be expressed, despite other assertions of understanding.

The other group members presented a different profile from the female leaders, regardless of gender. They were less likely to contribute in either way, whether it be an active explanation of a scientific concept or a passive expression of confusion. Their overall participation in this way was less frequent than that of the leaders in the group. Further, for many of these individuals, their active and passive explaining behaviors were very similar in count. This indicates that, for these students, their explaining behaviors were perhaps more reflective of their overall willingness to be a vocal participant in the group rather than indicative of a gender pattern.

The all-male group follows this same hierarchical trend, with Rahim exhibiting far more active explanations than either Zeke or Steven, and with their active and passive explanations more similarly distributed. This may indicate that, while a gender distinction can be identified with regard to explaining behaviors, these dynamics are also intertwined with hierarchical factors.

While explaining behaviors did follow a gender trend in terms of frequency, quantity of suggesting did not appear aligned to gender in the same manner, when separated from group composition. Rather, manner and type of suggesting seemed to differ more predictably between boys and girls. As previously described, different types of suggesting behaviors are exhibited at various points during the tasks. These suggestions may be more global in that their purpose is to guide the over-arching design or plan of the task: these suggestions tend to be more connected to scientific content and incorporate a broader vision. In contrast, discrete suggestions are less concept-driven and tend to be more directed towards a specific step during the task's execution. In general, and as would be expected, global suggestions tend to occur at the beginning stages of the activity when the planning stage is underway, while discrete suggestions are more likely to be offered while the group is actively engaged in the construction or hands-on stage of the activity. With regard to this distinction in suggesting behaviors, girls and boys do appear to differ in the manner with which they suggest. Regardless of type of task, inquiry or engineering, or of group composition, boys tend to make more global suggestions, while many of the girls' suggestions are more discrete and related to very specific actions embedded within the task. While some of the girls in more leadership roles, like Parker or Taylor may offer more global task-design suggestions as well, across all girls, particularly those in more supportive roles in their group, suggestions are more likely to be limited to finite actions or steps.

Bryn is an illustrative example of one of these such girls. Showing very few behaviors in other areas that indicate active participation with the task, such as explaining, she actually makes as many suggestions as her groupmates. Yet her suggestions are small and geared towards a specific action. "Why don't we use the stick?" or "Should we make the holes bigger?" are examples of her manner of suggesting a further action later during the execution stage of the task. Talia also contributes suggestions to her group in this way. Even if she is contributing during the planning or design-stages of the task, she still limits her suggestions to finite steps, such as "drawing a line to show if the bugs move in a different direction" or "We could put soap on the felt and use that." This trend continues among all girls across the groups.

In contrast, suggestions made by boys like Brian, Timothy, or Gavin tend to include an overall picture of the design and often occur during the planning stages. Brian begins many of the tasks with a global idea that he explains or sketches to the group, often with Parker's collaboration. Timothy as well focuses more on an approach rather than specific steps. Beginning the oil spill task, for example, he describes an idea for creating a barrier between the water and the shoreline rather than focusing on the more specific and isolated use of materials, as is seen with Bryn. Similarly, Gavin often combines scientific explanations with suggestions for the task, such as describing independent and dependent variables in the cellular respiration task to support his design idea, while Catherine focuses her suggestions more on the specifics of the materials and where to put the snails.

Separating the suggesting behaviors in this way sheds some light on the discrepancy between explaining and suggesting as exhibited in some students, however. While global suggestions may have more in common with explaining, discrete suggestions may be a more comfortable and less risky entry point for some students' participation. Worth further consideration is that the quality and type of suggestions may still reflect an unbalanced gender effect, with many of the girls' manner of suggesting perhaps indicating an existing lack of perceived competence. They may not feel comfortable or competent, for a wide variety of reasons, taking on the responsibility of making a more over-arching suggestion about task in its complexity in the same manner as the boys, and their small, isolated suggestions may reflect a more subordinate manner of engaging with the completion of the task in this manner.

Manner of requesting explanations and support also follows a gender pattern in terms of its quality and characteristics, but not necessarily in terms of frequency. Across the groups, girls and boys did not necessarily differ in how often they requested explanations either in general or from their peers as opposed to from the teacher. For the most part, all students sought the support of their peers more often than that of the teacher. What did show a distinction was the type of question both boys and girls asked when they required such support.

In most cases, girls sought support, from both their groupmates and their teacher, for reasons that were related to the completion of the task. Their questions and behaviors were most often geared towards specific logistics or task-related clarification rather than about over-arching content. While this initially appears to conflict with earlier findings in the realm of autonomy indicating girls' concern with learning for the class as opposed to exploration, in fact, it remains ultimately consistent with an intent to be successful, both in the class and in future areas in which they need to master the material. This still differs from a more intrinsic motivational approach to the content in that it places the learning priorities in the context of the external controls of the class rather than within the students' individual learning interests and goals.

Catherine is a clear example of this. She shows active clarification behaviors more than three times as frequently as anyone else in her group. She constantly asks her group mates to explain concepts associated with prelab questions ("What should our hypothesis be?"), to define vocabulary and terminology ("What is the independent variable?"), and to clarify their next steps ("How are we doing the data table?"). While some of her questions result from her being off-task and then needing to catch back up with the group, many appear highly task-driven and oriented to accuracy in the written work. They do not, however, appear to be motivated by developing understanding, but rather, as evidenced by the example questions provided, seem intended to support her completion of the assignment.

This same trend can be observed in many of the other girls as well. In another illustrative instance, Taylor and Tina find that their group's cellular respiration lab did not produce the results they were expecting. They indicate that they have "no clue" why this happened. Rather than try to answer their questions through discussion, research, or asking the teacher, however, they clarify with each other the logistics of their Powerpoint slides and agree on an explanation they could use in terms of completion of the project. Diana, also, when consulting the teacher is more likely to ask "is this right?". While there is some intent to seek clarification and understand the content of their work, it is within the realm of task completion, answering the lab questions, and finishing their slides.

Parker, also, a strong group leader and extremely conscientious about her group's work, also follows this trend and most often seeks clarification within the parameters of the work required from the assignment. Almost never consulting a teacher for support, she clarifies with her peers many times in terms of confirming data, the ideas of others, and the wording of their written responses. While she is heard to wonder at times about the reasoning for results or the behaviors of the living creatures, for example, she does not at any point consult anyone specifically with the intent of making sense of the content, rather, her questions address specific parameters of the tasks: "Can we do two controls?" or "How did we change the quantities in this experiment?"

Along these same lines, with regard to more passive manifestations of requesting clarification, only girls in the study are found to copy the work of their groupmates without an overt attempt to understand the material. This behavior is not observed in any case among the boys. Catherine, for example, exhibits these behaviors most frequently in response to missing aspects of the group work due to being off-task and needing to reorient herself in the progress the group has made. Bryn and Natalie also show frequent copying behaviors in their group. Similar to Catherine in the gender dyad group, frequent absences during the class time or off-task behaviors result in them missing aspects of the group work with which they must then catch up. Both girls, therefore, show a greater intent towards task completion with regard to their requesting clarification behaviors than with seeking overall conceptual understanding.

More frequently seen among the boys, however, when they do consult with their peers or teacher for clarifications or explanations, is an intent for a more open-ended, deeper understanding of the content, regardless of the task itself. Andrew is a very interesting example of this. Over the course of the six tasks, his engagement with his group and the tasks wanes dramatically. However, he willingly talks with the teacher about other ideas he has for the experiments, such as exploring the “heat point” for the pill bugs, the temperature at which it becomes uncomfortable for them. This conversation is strictly between Andrew and the teacher – something that strikes his interest outside the parameters of the task and his group’s intent.

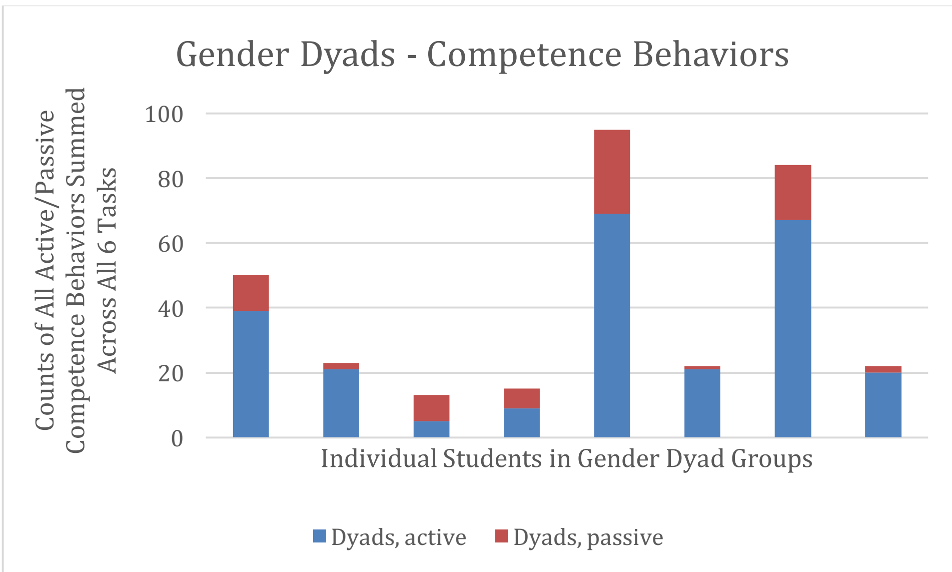
This same trend is observed with Gavin, in that he frequently engages his teacher in conversations that bring the content to a level beyond what the group is addressing, asking about effect of BTB on the pH of a substance, for example. Much of the time, the questions he asks of both his peers and the teacher tend to be far more content-driven and less technical or logistical than Catherine's, in the same group. In other words, they appear more geared towards the purpose of understanding content rather than simply completing the task. Brian in Mountain 1FFFM and Rahim in the all-male group show similar clarification and questioning behaviors. Brian spends a great deal of time chatting with his teacher about the content beyond the task, about how to tell the gender of the pill bugs, for example. Rahim also becomes involved in several conversations with teachers that connect the content of the task to larger science content, pill bug characteristics related to other creatures and insects, in one instance. In other words, the boys show far more instances of asking their teachers questions that are outside the realm of the task and make more far-reaching connections than do the girls.

The group that shows the most interesting profile among all six with regard to requesting explanations is the all-male group. They are the only group in which teacher support is sought at a higher rate than within the group. In every other case besides with this particular set of students, at least on this most superficial level, clarification sought within the group outnumbers any form of passive requesting of explanations. Yet, despite gender stereotypes to the contrary, these three boys exhibit the lowest level of confidence with their approaches and understandings in this category than any other group. Even more notable, however, is that the vast majority of these passive behaviors occur during the inquiry tasks. In a similar trend to the on and off-task behaviors with this group, their need for teacher support dramatically decreases when they are engaged with the engineering tasks. This pattern suggests an emerging relationship between this group of boys and their motivation specifically within the engineering tasks.

Competence shows a gender dynamic in several ways. Relative to the hierarchical status established, directing behaviors are closely aligned to explaining behaviors in that the relative frequency remains constant for students in each group between these two indicators. As specific girls have been shown to present more directing behaviors in their groups, so do they offer more explanations. Expressions of confusion do not follow the same pattern with passive directing, however, in that these same girls are also equally or more likely than their groupmates to state that they do not understand. Suggesting behaviors does not follow a gender trend in quantity but rather in quality with girls making smaller, more discrete suggestions and boys making more global suggestion about the task design or approach itself. Finally, distinctions emerge in terms of how girls and boy seek support – rather than contrasting in quantity or from whom (with the interesting exception of the all-male group), girls' requests for clarification are aimed more frequently at what they need to do or know to be successful on the task, while boys may also ask questions of the teacher that represent less concern with the task and more a desire to explore content or ideas.

This distinction in quality of all three behavioral indicators related to competence does seem to suggest that boys and girls manifest competence differently. Consistent in many ways with observations made regarding autonomy, success on the task and in the class appears to be an underlying factor of girls' actions. There are also appears to be, despite an apparent lack of difference in quantities of these behaviors between boys and girls, an overall contrast in the quality and presentation of them, with girls exhibiting almost "safer" manifestations of these behaviors – more discrete suggestions and more task-aligned participation and questioning. While an outward presentation in competence behaviors many not at first glance appear significantly different in terms of performance between the genders, a close look at the characteristics of them seems to indicate that an underlying difference in perceptions of competence or comfort still exists between boys and girls in the science classroom.

Competence and Group Composition



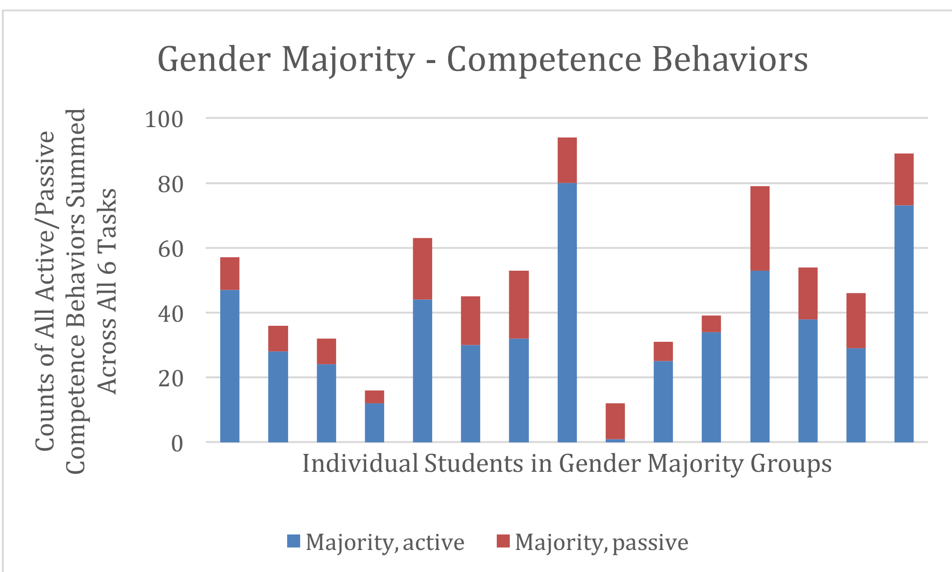


Figure 9: Frequency of competence behaviors manifested across groups

Figure nine shows the frequency of the sum of all three competence behavioral indicators for each student across all six groups. Again, columns show the sum of both active and passive behaviors for each student, but without distinguishing between the specific indicator or student's gender. The relative comparison of active and passive behaviors enacted by the students in gender dyad versus gender majority groups is illustrated, comparing group composition in this manner.

While manifestations of competence do differ along gender lines in some significant ways, even more notable is the distinction among groups of varying gender composition with regard to this particular set of behavioral indicators.

The gender dyad groups, Cascade MMFF and Mountain 2MMFF, in general show fewer instances of active explaining overall than do the gender majority groups, with less overall participation in this way among the group members. While this is due to the behavior of various individuals, the dynamic itself remains constant. In the gender dyad group, BF 1, Robert and Daniel continue their trend of minimal task engagement by exhibiting far more expressions of lack of competence ("I don't get it.") than explaining any concept or idea. In fact, Daniel does not show one single instance of active explaining in any of the tasks. This group in particular shows the least amount of explaining among all six groups and the lowest margin between active and passive explaining, meaning that they were almost equally likely to assert an idea as they were to express a lack of understanding. This seems to indicate an overall lack of perceived content competence with this group and that perhaps Tricia, with her more frequent explaining behaviors, is doing her best to take the lead with providing explanations in order to move the task ahead.

The other gender dyad group, Mountain 2MMFF, while exhibiting a higher number of active explanations and a somewhat smaller discrepancy between active and passive, still shows an overall lack of group participation in this manner. Much of their explaining occurrences are largely due to Gavin's input, who very frequently offers explanations regarding scientific content and concepts. Elizabeth, Catherine, and Adam are less participatory in both regards, offering fewer explanations of either sort, indicating that the assertions of competence within the realm of scientific ideas and thinking are arising primarily from one individual in the group rather than from a collective understanding, similar to Tricia's group.

In this instance, the three female majority groups and all-male group present a very similar profile to each other in terms of the occurrence of explanations. Within each group, there is a far greater number of active versus passive explanations or declarations, with much greater discrepancies observed between these two types of explaining than is seen in the gender dyad groups. In other words, the gender majority groups, more assertions of competence and understanding are being offered than instances of expressing a lack of understanding.

A caveat of this observation, however, is that the majority of these active explanations were offered by the same female leaders in each group who had also shown dominance in directing, as well as by Rahim in the all-male group. The reliance on one member of the group for explaining, therefore, shows similarity to the gender dyad groups, but not consistently with regard to gender. For the other students across all six groups, their overall explaining was lower than that of their leaders, with passive expressions of explaining either meeting or exceeding the occurrences of active explaining, with little pattern noted between genders. Group gender composition, therefore, appears to most positively impact the females who have already taken on the leadership roles in their groups. For the remaining group members, little consistent affect is noted.

The gender dyad groups, Cascade MMFF and Mountain 2MMFF, actually did follow the same trends observed in both directing and explaining. In Cascade MMFF, Tricia continued to show the greatest frequency of vocal participation in her suggesting behaviors as well, offering more than twice the suggestions as Abigail in the group, while Robert and Daniel provided virtually no suggestions whatsoever during all six tasks, which remains consistent with their overall lack of active participation. In Mountain 2MMFF, Gavin and Catherine, similarly to both of their explaining and directing behaviors, offer more suggestions than either Adam or Elizabeth in the same group, with Gavin exhibiting slightly more active participation than Catherine. As such, the patterns in behaviors that are related to the active vocal participation indicated by directing, explaining, and suggesting remain constant for these two groups. While these behaviors reflect different motivational constructs, for these two groups, their patterns of manifestation remain constant for each, although distinct between the two.

The female majority and all-male group present a different picture with regard to suggesting, however. In all four of these groups, the distribution of suggesting is far more equally represented that was seen in either the directing or explaining behaviors. While the perceived group leaders still exhibited slightly more suggestions that their groupmates, the discrepancy was far less than what was seen in other behaviors. This seems to indicate that, while still considered within the realm of competence, that explaining and suggesting behaviors are, in fact, not consistently aligned in terms of their presentation. While suggesting still requires a sense of perceived competence in terms of connecting task pursuance to concepts and content, students appear far more likely to take this risk and initiative in the group than perhaps with other behaviors.

However, this is most specifically the case in the gender majority groups. While Rahim in the all-male group is so clearly the leader in many other areas, in the realm of suggesting, not only do all of the group members contribute frequently in this way, Zeke actually offers the most suggestions over the course of the six tasks. Similarly, while Diana is typically the most vocal member of her female majority group, with Timothy often sharing this role as well, in terms of suggesting, all three girls in this group offer suggestions in almost equal measure. This is particularly notable in the case of Bryn, who in all other categories thus far has shown the least motivated behaviors, with the lowest directing, explaining, and hands-on occurrences as well as the highest off-task behaviors exhibited in her group. However, in the case of making suggestions, she appears similar to not only the other two girls in her group but to the other girls in the female majority groups as well. The only student in a female majority group who really does not follow this pattern is Sophie, yet this is to be expected as her selective mutism clearly impacts her representation in any data that involves vocal participation and behaviors. Suggesting behaviors, therefore, appear to be more clearly and directly linked to group gender composition than explaining.

The groups show additional interesting, yet inconclusive, trends in terms of requesting explanation behaviors. The gender dyad group, Cascade MMFF, shows very little requesting behaviors whatsoever, active or passive. There are so few instances, in fact, that it is difficult to discern any noticeable trend between the group members in this case. This profile is similar, actually, to two of the female majority groups, Cascade FFFM and Mountain 1FFFM. In general, these groups simply do not exhibit significant or corresponding instances in which they request explanations or clarification throughout the tasks. As this is discrepant from their explaining and suggesting profiles, it may perhaps indicate that much of the discussion in these groups was declarative or proactive in terms of the task; or that the group leaders pushed the productivity of the task forward without need for the rest of the group to question or clarify. Even the perceived group leaders in these cases do not show a noticeable difference in requesting behaviors than their groupmates, suggesting that neither hierarchical status nor gender plays a significant role but perhaps more the overall group identity.

Conversely, the two remaining groups, representing different gender compositions, showed an even different presentation in terms of requesting explanations than the other groups. Despite this varying configuration, groups Mountain 2MMFF, a gender dyad group, and Mountain 2FFFM, a female majority, exhibited the highest numbers of requesting explanations behaviors, both active and passive, among all six groups. Even so, the patterns within these two groups remain even more distinct in terms of the individual behaviors among group members, reflective more, perhaps, of the individual’s genders as previously described than of any impact by the group’s composition.

In the female majority group, Mountain 2FFFM, in contrast the gender dyad group Mountain 2MMFF, shows requesting explanations behaviors, both active and passive, that are much more evenly distributed among all group members than in any other group. The quantity does not show any apparent gender trend or difference but remains fairly constant among the members over all six tasks, both inquiry and engineering. All four group members, thus, appear comparable in their willingness to seek out support and have their questions answered within the group, with no one member showing more participation than the others.

As previously described, these all differ from the profile presented by the all-male group, who seeks teacher support at a rate higher than any other group and more frequently than they do within their group. Because of the confounding factors for this group specifically between gender and group composition, it is difficult to discern which of these variables is responsible for this phenomenon in their case.

Group composition, therefore, has the greatest distinction for explaining and suggesting behaviors, with female leaders in the majority groups showing a more positive impact than in the groups with dyads. Their overall rate of active explaining exceeded that of the females in the dyad groups specifically. Suggesting behaviors, while differing in quality between the genders, were more equally distributed among group members in gender majority groups, with a greater participation among all members than is seen in the groups with gender dyads. Little effect is noted, however, with regard to group composition and intent to seek clarification or request explanations. No discernible pattern is identified between the gender dyad and the gender majority groups, with each group presenting its own distinct profile.

These findings directly support the *stereotype inoculation model* in that girls in the female majority groups showed an overall greater willingness to participate vocally than those in the gender dyad groups. While maintaining a connection to group hierarchy in some aspects, female gender majority still appeared to have a positive impact on all of the girls in these groups, with overall active explaining behaviors more frequent among girls in female majority groups as well as increased contributions observed among some of the more reticent girls. Suggesting next steps in the task, for example, appeared to be a safe entry point for these more passive girls in the female majority groups that was not observed in the gender dyad groups. In sum, female gender majority appeared to support the participation of all of the girls in these groups, but most importantly those who showed more passive behaviors in other areas, supporting previous research on the *stereotype inoculation model* (Dasgupta, Scircle, & Hunsinger, 2015) that female gender majority promotes confidence and increased vocal participation of the women in the group during STEM tasks.

Competence - Inquiry versus Engineering

Some interesting differences still emerge when behaviors indicating a perception of competence are compared between inquiry and engineering tasks. While these do not necessarily further relate to gender or group composition, they present trends in their own right. First, in all groups, more overall explaining behaviors occur in the inquiry tasks, with active explanations consistently outnumbering the passive explaining in these types of tasks. In the engineering tasks, there are fewer occurrences of either sort but with much less discrepancy between active and passive behaviors. Put most simply, students just seemed to have more content-related discussion in the inquiry tasks and had more positive and confident assertions about what they were doing. In the engineering tasks, there was not only less apparent content-focused talk but a relative increase in passive explanation, or lack of understanding, as well.

Interestingly, both groups in Cascade High showed a greater frequency of passive than active explaining behaviors, meaning in this case that students in both gender composition groups showed more confusion and lack of perceived competence with the engineering tasks. This seems to suggest that all students exhibit less perceived competence as shown through the types of explanations they offer, but that this is more prevalent as Cascade, perhaps indicating a more systemic lack of exposure to engineering than students at Mountain High.

Seemingly in contradiction to this finding, however, is how occurrences of requesting explanations and clarification are exhibited between inquiry and engineering. Despite this seeming decrease in a sense of competence during the engineering tasks observed through the explaining behaviors, the groups' passive requests, or seeking teacher support, also generally decrease during the engineering tasks, regardless of group composition. Only the female majority group, Cascade FFFM, shows slightly more passive requesting during the engineering tasks, yet the occurrences are low enough as to make this observation limited in its scope or relevance. In general, for five of the six groups, the passive requesting of explanations decreases noticeably during the engineering versus inquiry tasks.

In sum, students in general expressed lower confidence with engineering tasks than inquiry yet sought teacher support less frequently during these engineering tasks as well. While such a comparison of competence and support-related issues between inquiry and engineering would be a potential avenue for further research, it is beyond the scope of this study to speculate the reasoning behind this finding at this point.

Competence Summary

Within the realm of competence, gender and gender composition do appear to have some role in the manifestation of the various behaviors - explaining, suggesting, and requesting clarification – although this manifestation is not necessarily consistent across all behaviors. Most prevalent is the effect within explaining and suggesting, with a positive impact noted for the girls in these groups. In terms of explaining, the girls who exhibited leadership behaviors across other categories, particularly directing, appeared far more likely to explain their thinking and understanding of scientific concepts to their peers. This trend was not observed in the same manner in the gender dyad groups. Gender composition also seemed to impact suggesting behaviors, with more equal distribution among all group members of suggesting occurring in the female majority groups. Gender does appear to play a different role, however, in that, regardless of group composition, girls appeared to make more discrete suggestions about specific next steps in a task while boys seemed to make more global suggestions that were related to over-arching content or design of the activity.

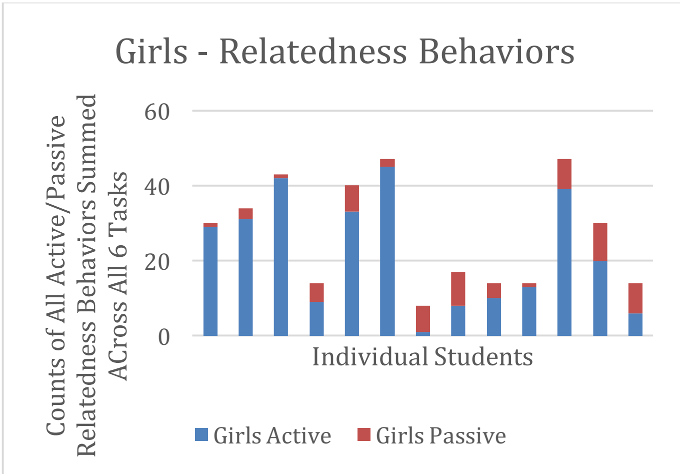
Requesting explanations, however, shows a gender or group composition effect mainly in the sense that the all-male group showed the highest frequency of seeking teacher support rather than attempting to resolve confusion or questions among themselves. Aside from this phenomenon, little consistent pattern is noted among the other groups with regard to either gender or group composition, with some groups exhibiting so few as to make generalizations impossible to discern. Quality rather than frequency of questioning behaviors, rather, is the manner in which gender distinctions emerge, with girls seeking clarification more towards task completion and accuracy than the boys. Further, only in female participants is the copying without intent to understand behavior noted. This suggests, perhaps, that task adherence is still a critical consideration for girls, more so than boys, despite other instances of off-task or unengaged behavior on their part. Active requests for clarification, however, show little effect from group composition, with each group's profile showing unique patterns and distinctions. In the realm of competence, therefore, more assertive behaviors like explaining and suggesting appear to be positively impacted by group gender composition, but within-group problem-solving and clarification seems more related to the overall group's personality and cohesion.

Table 11: Relatedness table of results

	Between Genders	Across Groups	Inquiry versus Engineering
Themes	• Fostering relatedness, inviting collaboration • Working collaboratively • Assisting • Reading directions aloud, starting an activity		
Findings	**GIRLS:** • More frequent intent to foster collaboration and agreement • More equal distribution of relatedness among all girls in contrast to other behaviors • Independent work still related to task • Frequent assisting, both active and passive • More likely to read directions, questions aloud **BOYS:** • Higher frequency of independent behaviors • Independent behaviors more likely to be off task than girls • Only assisting with equal ownership • Few instances of reading directions/questions aloud	**GENDER DYADS:** • Fewer instances of fostering relatedness • Fewer occurrences of working interactively • Gender partitioning into same-sex pairs • Fewer assisting behaviors of any type **GENDER MAJORITY:** • More frequent occurrences of behaviors intending to foster collaborative work • Boys and girls in female majority groups engaged more frequently in collaborative work • More frequent assisting of all types, passive and active	**INQUIRY versus ENGINEERING:** • Gendered behaviors remained constant despite type of task • More occurrences of independent work during engineering tasks, especially with gender dyads and all-male group • More frequent reading directions and questions aloud during inquiry tasks • More discernible intent to start inquiry tasks collaboratively than engineering tasks

Relatedness Table of Results

Gendered Manifestations of Relatedness



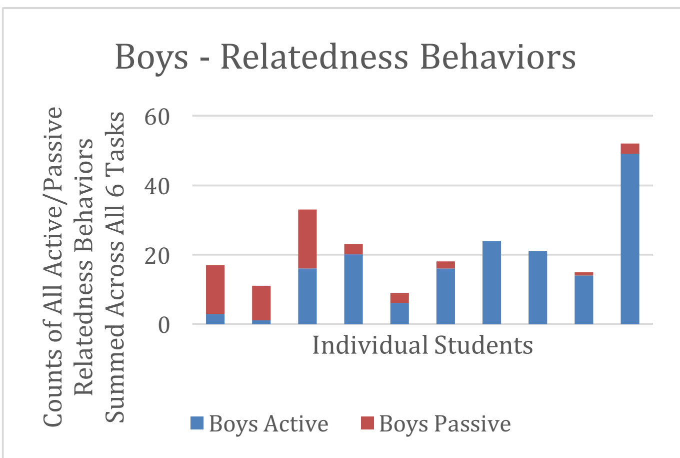


Figure 10: Frequency of manifestations of relatedness observed between girls and boys

Figure 10 illustrates the total number of relatedness behaviors enacted by individual students, with a comparison of girls and boys. Columns, in this case, represent the sum of all active and passive indicators observed for each individual student. A comparison is made, therefore, between the frequency of all active and passive relatedness behaviors observed between genders.

Within the six groups in this study, boys and girls manifested the behaviors associated with relatedness in many distinct ways. Most notable is that girls in general, across all relatedness behaviors, tended to show more intent towards relatedness than the boys. Consistent with other behaviors in this study, the group leaders continued to show the most frequent occurrences of working interactively behaviors. These types of behaviors included simple moments of organizing the group towards collaboration, seeking agreement among the group members before beginning a next step or making a collaborative decision, or inviting a group member to join in in an active manner with the task. Parker, for example, seeks agreement amongst her group members by asking, "Should we use three or four snails, and then should we use the same with the elodea?" Similarly, Taylor asks her group, "Should we test it now and then fix the flaps tomorrow?" In all cases, these behaviors showed a distinction from the more autonomous directing behaviors also exhibited by group leaders in that they attempted to move the group's progress as a whole. These did include some element of directing the group towards an end, but elicited more potential feedback from the other group members. However, they were still focused on pursuance of the task and productivity, as the other behaviors also indicated.

In all groups, this leadership quality remained constant among the same students as seen prior: Tricia, Taylor, Rahim, Parker, Diana, and Timothy. These particular students showed high numbers of working interactively instances consistent with their directing, decision-making, and explaining behaviors. However, notable is that other students in the groups also rose to this level in terms of these types of behaviors. Students who had previously shown relatively fewer autonomous or competence-related behaviors were observed to show a high number of behaviors that elicited relatedness among the group members. Further, these students who rose to this level of occurrence were most often other female group members. Abigail, for example, in group Cascade MMFF, who previously did not match Tricia's instances of autonomous behaviors, actually exceeds Tricia's working interactively behaviors by one. She is observed to frequently try to get her group members' input when answering the written questions on their lab report or to ask the group's opinion on how to organize their experimental design. Anna is another example, in Cascade FFFM, who shows little autonomous behavior but frequent active attempts to work interactively with her group. She is heard to ask her group members questions like, "Do you think this method worked better than the other one?" or "Do you have any ideas of how to start?" This phenomenon suggests that a greater range of students may feel comfortable taking on leadership qualities when they are able to involve the other group members; in other words, whereas directing or decision-making may fall into more of a hierarchical pattern, fostering collaboration actively may appeal to a broader range of female participants and may draw more reticent girls into active participation within the group.

Instances of not working interactively are most commonly seen among the male group members. While female members of groups do show some occurrences of not working interactively, these most often are seen in terms of writing independently or working on the written part of the task by themselves. In frequent cases, it does not necessarily reflect a lack of desire to work collaboratively but rather a specific aspect of the task that the girls may be approaching in a more methodical manner. With girls, this almost never occurs at hands-on stages of the task but during those times in which they might be more concerned with task completion and accuracy, as has been seen among other behavioral indicators. In the cases of the boys, these "not working interactively" occurrences are typically off-task behaviors that involve other actions besides working with the group on the assigned task. Andrew in Cascade FFFM, for example, is often observed during these times to leave the group and do other things around the room while the other three girls are working collaboratively. In contrast, Parker, a highly collaborative group member, shows passive actions in this area simply in those moments when she has gotten started on the written aspect of a lab report on her own, but will often update her peers on what she has written and seek their input then. This suggests again that girls' behaviors within the group are more driven by an intent towards task completion and that this confounds – or at least informs – an examination of stereotypically gendered behaviors in that they must be considered within this task-pursuance lens.

Consistent with many behaviors that manifest an intent to work interactively, girls also show more frequent occurrences, both active and passive, of assisting the members within their groups. They are observed to be equally likely to assist someone with equal ownership or to assist someone who is directing and show far more occurrences of this than do the boys. As such, assisting behaviors appear to fall along gender lines within the group, with girls more willing to help out with the task as needed.

The manner of assisting, however, appears to follow the same hierarchical patterns observed among other behaviors. Those students who have assumed leadership roles from the beginning continue to manifest this role in their assisting behaviors in terms of taking on more active assisting. These group leaders are more likely to assist with equal ownership and showed almost no passive assisting behaviors whatsoever. This is consistent with their directing and decision-making behaviors in that most likely these students are acting up on ideas or strategies that were theirs or that they developed collaboratively. Taylor, Parker, and Gavin, for example, show only active assisting behaviors in their groups, while students like Bryn and Tina show only passive assisting.

Also consistent as seen with manifestations of working interactively, assisting behaviors allowed some girls who did not show as high frequencies of autonomous behaviors to contribute more actively in their group in this manner. Anna in Cascade FFFM again shows the highest number of assisting behaviors, both active and passive combined, of anyone in her group. This was a similar phenomenon to her working interactively profile in that, through a collaborative effort, she took on a more active role in the group. Elizabeth in Mountain 2MMFF, who is typically a very passive member of her group in other ways, actively assists Gavin on multiple occasions. Natalie in Mountain 2FFFM as well shows more active and passive assisting behaviors combined than anyone else in her group, actively assisting both Timothy and Diana on multiple occasions.

An interesting trend in terms of gender with regard to assisting behaviors, however, is the case with Mountain 1MMM, the all-male group. These three boys exhibited no occurrences at all of passive assisting. At no point did any of these boys assist another who was directing them as such. In all cases of assisting, they were helping each other with equal ownership and investment towards that particular action or step. In some cases, this took the appearance of hands-on collaboration. In other instances, however, these behaviors appeared as almost negotiations of how to collaboratively get the work done. Steven, for example, at one point during the Naked Egg lab offers to Rahim, "I'll take the eggs out of the beakers if you go get them." This followed a discussion of the next steps they needed to take in the task and how to best proceed and thus indicates an intent to divide the work equally to make progress. Among the other five groups, only one boy is seen to passively assist any other boy, and this is Adam in Mountain 2MMFF with Gavin. Of the very few other instances in which boys exhibit passive assisting behaviors, they are done only with other girls. This raises an interesting question, which is beyond the scope of this study, about the manner in which boys collaborate and their willingness to help and support each other.

The final behavioral indicator within relatedness is reading directions or questions aloud to the group. As described previously, this behavior manifests an intent to perhaps get the group started collaboratively and with all members on the same page. This behavior is noted most specifically at the beginnings and endings of labs when more attention is being paid to the lab's directions, initial written components, and final write-up: in other words, when written document and assignment itself is determining the group's work.

In this final manifestation of relatedness, girls once again show a higher frequency of active behaviors than do the boys. In all but the case of Timothy, girls are more likely to read directions and questions aloud to the group at the onset and culmination of activities than boys, as well as to elicit the group's feedback when trying to answer questions and organize the beginning stages of the lab, such as writing the hypothesis and research questions. As such, girls consistently show a more active intent to create a cohesive group approach than the boys. Further, when girls do read directions aloud, they consistently read them to the whole group. Aside from Timothy, in the only other observed case of a boy reading directions aloud, it was in group Mountain 2MMFF, done by Gavin. He, however, only read the directions to the other male in the group, Adam, rather than to everyone. This, thus, raises the question if his intent is towards group collaboration or if he is only attempting to engage Adam, as well as how this relates back to relatedness within a gender context.

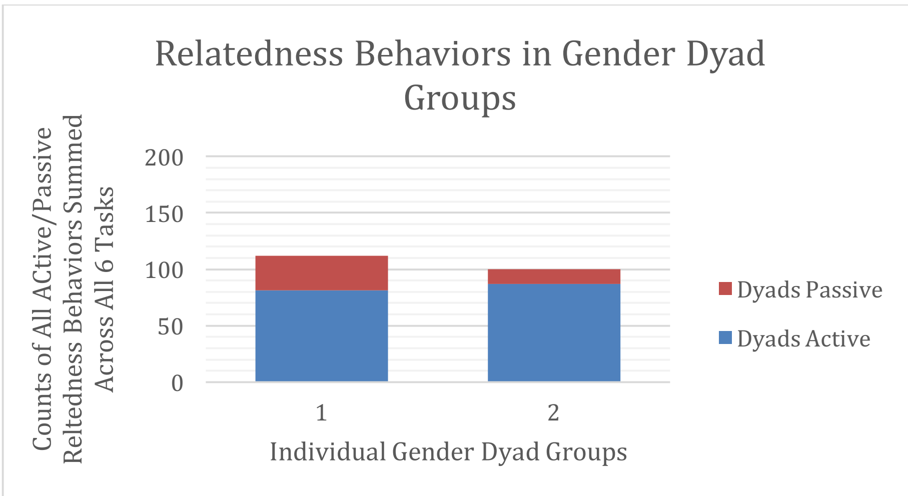
While boys and girls clearly exhibit distinct behaviors with regard to reading directions aloud, the hierarchical organization in the group also plays a role. Of the girls that are shown to read directions aloud, all are those that have shown leadership qualities in the group. Instances of reading aloud are not, as with other behavioral indicators, distributed among the girls in the various groups but are specific to certain group leaders: Parker, Taylor, Catherine, and Tricia, for example. While some of the other girls also are observed to read directions aloud on fewer occasions, like Abigail and Anna, some of the remaining girls show no instances of this behavior whatsoever: Talia, Elizabeth, and Bryn, for example. This indicates that, while reading directions aloud is a gendered behavior in that it is more often exhibited by the girls in the groups, it also has a connection to more autonomous behaviors in the sense that female group leaders are the most likely to do it.

The all-male group once again presents an interesting twist to this scenario. Not only do they exhibit more occurrences of the passive version of this behavior, starting a task independently, than any other group, they also show no instances of reading directions aloud whatsoever. Rahim, again, consistently a more autonomous member of the group in terms of directing and decision-making, also is the only member of this group to show any reading aloud behaviors. However, he is distinct from any other student in this category in that his only instances involve simply reading measurements or repeating observations back that other students in the group have shared. In no instance does he read directions or questions aloud with the intent to organize collaboration among the group members; rather, he is simply transmitting information. While coded in the reading aloud category, it blurs the line of directing in that it appears intended more to tell the other group members what is going on rather than to foster their equal participation in the task. Again, this shows a different quality or way of manifesting relatedness than is seen among the girls.

An outlier in this category is Timothy. He is the only male that reads aloud to his whole group on as many occasions as most of the girls. The other girls in this female majority group (Diana, Natalie, and Bryn) in contrast show far fewer instances. This pattern is distinct from the other groups in this shift in roles, simply in this one category. As Timothy takes on a similar leadership role as Rahim in the all-male group, this anomaly may indicate, similarly to Rahim, that the action of reading directions aloud may have a more directive rather than collaborative nature for Timothy.

Behaviors that manifest relatedness, overall, show a distinction among the boys and girls within the groups and follow in some part as well a hierarchical status. Girls in general were more likely to exhibit behaviors that fostered relatedness than boys: from actions that elicited working interactively, like inviting other group members or seeking agreement among groupmates to assisting and reading directions aloud to the group. While these behaviors were also most frequently seen among the leaders in the groups, other girls who were typically more passive showed greater active participation in these categories as well. Boys were more likely than girls to exhibit instances of not working interactively and rarely showed more passive relatedness behaviors. In fact, in some cases, their relatedness efforts bordered more on directing. Further, while boys' instances of not working interactively included off-task or unengaged behaviors, girls consistently were still pursuing task completion, even if they were not working interactively.

Relatedness and Group Composition



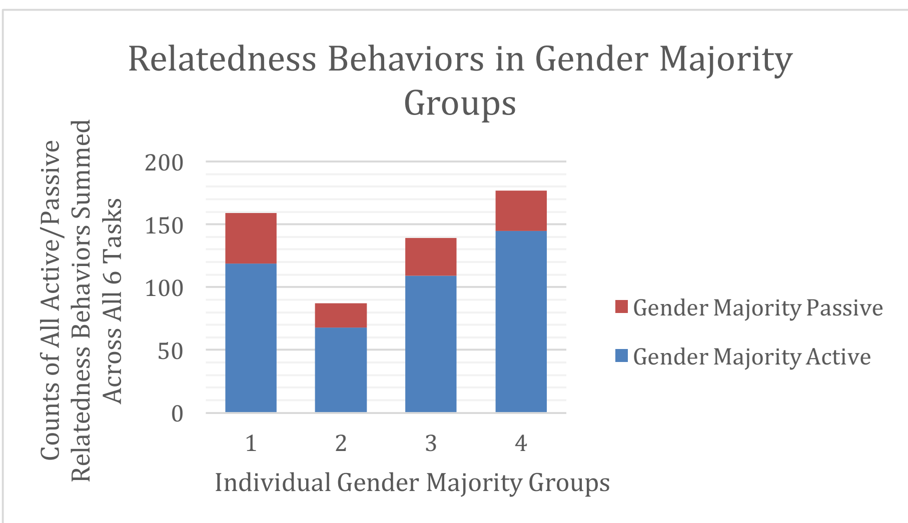


Figure 11: Frequency of manifestations of relatedness across groups

Figure 11 shows the sums of all relatedness behaviors observed for each individual group. Each column is the total number of relatedness behaviors, both active and passive, summed for all students in a particular group. Each graph is separated by group composition and together compare the total frequencies of active and passive relatedness behaviors seen across groups of varying gender composition.

While relatedness behaviors are distinct along gender lines, group composition also appears to have an impact on its manifestation and presence. At first glance, little distinction was noted among the groups when examining whole group instances of working interactively. Group composition did not seem to notable impact the frequency of each group's ability to work together as a whole, nor was there any discernible pattern observed between groups of similar and different gender composition. Gender dyad groups appeared to work together productively as a whole about as often as groups that had a gender majority, either male or female. When relatedness was examined more globally however, a striking trend emerged.

As described previously, working interactively encompasses a broad range of behaviors. Not only are instances in which the entire group is engaged in the task included, but individual efforts that seek group agreement and foster inclusiveness are also incorporated into this category. When all of these behaviors, both whole group and individual are combined, the female majority groups showed a significantly greater number of occurrences of working interactively than either the gender dyad groups or the all-male group. In fact, the female majority groups showed almost twice as many of these types of behaviors. This is consistent with the findings in relation to gender in this manner: if girls are more likely to exhibit behaviors that manifest an intent towards creating relatedness, then the groups with more girls will show a greater number of such behaviors.

Worth noting, however, is that the males in the female majority groups also exhibited more instances of behaviors aligned with working interactively than did the males in any of the other groups. In other words, not only did girls, regardless of group gender composition, show more frequent instances of working interactively efforts, all members of the female majority groups showed more of these behaviors as well. This seems to suggest that working interactively behaviors were increased for everyone in the female majority groups – that overall, in those groups, there was a greater sense of relatedness as seen in terms of working interactively behaviors.

The gender dyad groups, while showing fewer instances of overall working interactively behaviors, did differ from each other in terms of the division of these behaviors across all groups members. In Cascade MMFF, the two males, Robert and Daniel, exhibited almost no intent to work interactively. All of these such behaviors were seen only among the two girls, Tricia and Abigail. In the other gender dyad group, Mountain 2MMFF, however, the behaviors were more equally distributed among all group members, regardless of gender, but still showed similarly low numbers in total to that of Cascade MMFF. While the individual members of these gender dyad groups presented somewhat different profiles, the overall effect on the group itself was similar in that these two gender dyad groups showed lower numbers of working interactively behaviors in total.

The all-male group, Mountain 1MMM, in fact, showed the fewest occurrences of working interactively behaviors of any of the six groups in the study. While their whole group instances of working collaboratively together did not differ significantly from the other groups, when taken in conjunction with their individual intents to foster collaboration, they showed far fewer of such behaviors than any other group. This phenomenon further shows that the girls and female majority groups show the greatest intent towards collaboration, even if the whole group outcome is relatively similar among groups.

Assisting behaviors followed a similar trend as those seen in the working interactively category. While taken individually, comparing the active and passive versions of this behavior, the instances seem insignificant across groups of varying gender configuration. Aside from the all-male group, previously described to have shown no instances of passive assisting at all, all remaining five groups showed both, with no particular group standing out in terms of exhibiting dramatically more active or passive assisting behaviors. Gender composition, thus, did not seem to have an effect on the type of assisting students were more likely to exhibit. When all occurrences of assisting, both active and passive, are taken in conjunction, however, a more observable pattern becomes apparent. The female majority groups showed more assisting behaviors in total than the gender dyad or all-male groups. Particularly in Cascade MMFF, only a few assisting instances were observed at all among the group members. While the total number of assisting behaviors were higher in the gender dyad group Mountain 2MMFF than in Cascade MMFF, interestingly these followed a distinct trend of their own. Only once in Cascade MMFF does a male (Daniel) do any assisting whatsoever, while in Mountain 2MMFF, the boys are more likely to only assist each other. Of these assisting examples, Gavin and Adam on several occasions assist each other with equal ownership, while only once does Adam assist Gavin while he is directing. In contrast, Elizabeth and Catherine also tend to assist each other and show more examples of passive assisting, with Catherine more likely to assist Elizabeth.

The distinction in assisting between the gender dyad groups and female majority groups, therefore, is that fewer assisting behaviors are observed overall in the dyad groups and that there is less equitable and even distribution of these behaviors across group members of varying gender. The assisting in these gender dyad groups appears less likely to reflect whole group collaboration or a common approach among the members and more individualized agendas or lack of engagement overall.

The final behavior described under the relatedness condition is that of reading directions aloud. While this specific behavior did appear distinct between genders in the groups, with the females doing the most reading aloud to the whole group, no pattern is noted between the groups based on gender composition. Group composition does not appear to greatly affect the students' willingness, either male or female, to attempt to get their group started together by reading the directions and questions out loud. Girls were equally likely to perform this action no matter which group.

To reiterate findings related to gender, however, the all-male group showed the only instances noted across all group of beginning the tasks independently without reading the directions together, or the passive version of this behavior. While this can be described as a gender distinction, it also becomes critical when looked at in terms of group composition. As the boys across all groups were less likely to read directions aloud, when examined in relation to other groups with varying composition, this does have an overall effect on its manifestation. With no girls in the group who are more likely to exhibit this action, the action does not occur, resulting in a less collaborative start on tasks for this all-male group. Thus, for the boys, group composition can impact this aspect of relatedness.

When all relatedness behaviors are considered together to create an overall profile with which to compare the groups of varying gender composition, some generalizations can be drawn. Group composition does appear to have an effect on the presence and quality of the relatedness observed within the various groups, as well as the individual students' intents to foster and pursue collaboration. While girls exhibited the behaviors of relatedness more frequently in general than the boys, they did so even more, and with greater participation of all girls, in the female majority groups. This suggests that a quality inherent in girls anyway was able to develop and thrive even more for them in the groups where there was a female majority, that this was particularly positive and supportive to the female group members.

Further, relatedness and attempts to create collaboration were overall more prevalent in female majority groups; they simply pursued relatedness more often, even if their instances of actual whole group collaboration were not specifically more numerous compared with other groups. This indicates a more inclusive tone in the female majority groups overall, with a greater intent to involve the participation of all members.

One of the greatest differences noted in both of the gender dyad groups, within the construct of relatedness, is that, across all behaviors, boys and girls frequently partitioned into gender pairs, and this had an effect on the quality of the relatedness that was present, regardless of the actual numbers of occurrences. In both groups, instances of working interactively and collaboration were often divided along the gender lines rather than among all of the group members. Tricia and Abigail in Cascade MMFF consistently worked together towards task completion, with Robert and Daniel frequently pairing off (to pursue off-task endeavors, in many cases). Similarly, Gavin and Adam in Mountain 2MMFF were far more actively involved in collaborating between themselves, with Catherine and Elizabeth often comparing written work and answers with each other. In both groups, assisting behaviors occurred most frequently between same-sex pairs as well, with attempts to support and help occurring between female and male partnerships separately.

This phenomenon of gender partitioning reflects back to the presentation of the other motivational constructs as well. Behaviors assigned to autonomy and competence, such as decision-making and hands-on work, were, therefore also seen to take on a distinct quality in the gender dyad groups when examined also through the lens of relatedness. Much of this work occurred, rather than among all group members, within these gender pairs. Decisions were solidified, for example, between Tricia and Abigail rather than including Robert and Daniel. Gavin and Adam, similarly, often collaborated on the tasks' designs and set-up, while the girls worked on the written aspects of the tasks together. In this manner, while working interactively counts may appear similar regardless of gender composition, the manner in which the group members collaborate is distinct.

Further, as the members of the gender dyads break into these same-sex pairs, stereotypical gendered behaviors and unequal workloads emerge. Tricia and Abigail, while exhibiting frequent autonomous behaviors, also are more task-focused and attentive to accurately completing the steps of the activity. In contrast, Robert and Daniel show little attention to the task's expectations and are more likely pair off in order to play with materials together and have off-task social conversations, which leaves much of the task's work to the girls to complete. Similarly, Gavin and Adam, while more task-focused than Robert and Daniel, still focus together on the hands-on and decision-making aspects of the task, while Catherine and Elizabeth are more likely to work together on checking their written answers and filling out the lab's questions. This again results in unequal and stereotypical work division.

This partitioning phenomenon is not observed in the gender majority groups at all. In fact, collaborative partnerships are far more fluid when they occur, emerging between varying members of these groups based on circumstance and need rather than gender. In Mountain 2FFFM, Timothy is equally likely to work on written or hands-on tasks with any other member of his group. Brian in Mountain 1FFFM presents a similar profile, showing collaboration with each of his female groupmates at some point. This allows some of these gender stereotypes to dissipate in the female majority groups as well. While certainly some gender trends still emerge regardless of group composition, they are noticeably fewer among these groups with more opportunity for varying roles and workloads among all group members. Without opportunity for gender pairs to partition off, actions and behaviors appear more related to the needs of the task rather than on expectations of genders and also allows the single male of these female majority groups to function more similarly within the group to his female groupmates rather than along stereotypically gendered lines.

These findings speak directly in support of the *stereotype inoculation model*. When students do not have the opportunity to partition into gender pairs and when there is more opportunity provided, as afforded in the female majority groups, for whole group collaboration and dynamic working relationships, students are less likely to fall in stereotypically gendered roles. As a result, many of the behaviors and group roles appear to equalize and become more task-focused, allowing the female majority to more actively engage in the various requirements needed to complete the activity and the single male in the group to match and support this effort, rather than usurp it.

Relatedness, therefore, manifests distinctly between boys and girls in many ways, and is thus further distinguished between groups of varying gender composition. Female majority groups, when all relatedness behaviors are considered in conjunction, allow greater collaboration among all group members and reduced stereotypically gendered roles, encompassing many of the behaviors noted in terms of autonomy and competence as well.

Relatedness – Inquiry versus Engineering

While different genders and groups of varying gender composition do appear to significantly manifest behaviors associated with the relatedness condition distinctly, differences between the type of task – inquiry or engineering – are far less obvious. In fact, little distinct pattern or trend is noted either with boys and girls or across groups when comparing these two types of tasks. The profiles presented in terms of gender remained constant regardless of the task, and this was equally true when examining the effect of group gender composition. In other words, when behaviors were analyzed distinctly between the two types of tasks, girls still showed higher incidences of behaviors manifesting relatedness than boys, and this remained more prevalent in the female majority groups.

Still, some interesting findings emerged while comparing relatedness behaviors between inquiry and engineering tasks in a more general sense. First, while the gender dyad groups and the all-male group showed the least amount of working interactively behaviors across all six groups, these numbers were even lower during the engineering tasks: the discrepancy when compared with the female majority groups was even greater when broken down by inquiry versus engineering.

In addition, the engineering tasks showed more instances of groups not working interactively overall than the inquiry tasks did. This indicates that, while the gender dyad groups and all-male group were even less collaborative during the engineering tasks as compared with their female majority counterparts, all six groups, in fact, exhibited more independent behaviors during the engineering tasks.

This trend continues when looking at the behavior of reading aloud. Far more instances of reading aloud occurred during the inquiry tasks than engineering tasks – more than three times as many. This perhaps suggests that the inquiry activities required more of an intentional and unified approach, that more content and structured answers to pre-lab questions were required in the inquiry tasks, while the engineering tasks may have allowed students to begin with less need for getting everyone in the group on the same page with directions and questions.

Assisting behaviors, however, strayed from this pattern, with more instances of both active and passive assisting occurring during the engineering tasks than the inquiry tasks. In both types of tasks, more passive assisting occurred than active, or assisting with equal ownership, but no additional trend is observed with regard to gender or gender composition between the two types of tasks in this manner. This increase in assisting during engineering tasks may reflect the increased demand for construction and design involved in these tasks. In contrast to the reading directions behaviors observed during inquiry, this discrepancy may be more related to the characteristics and demands of the types of tasks rather than to the group members themselves.

To sum, relatedness manifests differently among genders and groups with varying gender composition but not necessarily to a greater or different degree when this comparison is made between inquiry and engineering tasks as well. These comparisons may reflect more the distinct qualities between the different types of tasks rather than relative to any gender dynamics.

Results and Findings – Focus Group Interviews

Twice during the semester, focus group interviews were conducted with the individual student groups to gain their insight on the experience of working with the tasks and within their specific group. The first interview was conducted after the students had completed three of the six tasks, and the final interview occurred at the end of the semester and culmination of all six tasks.

The questions remained the same for both interviews. While these questions were designed as part of the larger NSF study, they guided the students to think about their underlying motivational approaches and behaviors, both within themselves and within the group. Further, student responses to all questions were coded within these three specific categories, regardless of the intent of the original question. In other words, some responses to specific questions included elements of all three categories and, thus, the different parts were coded separately among various conditions. The table below shows examples of questions that related specifically to the conditions of autonomy, competence, and relatedness.

Table 12: Sample interview questions aligned to motivation conditions

Condition	Example questions
Autonomy	How did you like the different labs/design activities you did over the past few weeks? Did you see yourself as having a particular task or role throughout these tasks/activities?
Competence	What do you think you learned from these tasks/design activities? When you got stuck at a task, what did you do?
Relatedness	How did you like working in a group with your peers? Do you think the tasks of the labs/design activities were divided evenly among you all?

Responses, as read via the written transcripts, were coded only using the initial flags of autonomy, competence, and relatedness. Only student responses, not behaviors exhibited during the interviews, were considered in that the research questions in this area were aimed at examining student perceptions of motivation, not behavioral indicators during the interviews. Because the interview questions, as written for the NSF study, were not directly related to the codebook for this study, transcripts were coded only using the over-arching categories of autonomy, competence, and relatedness. Patterns and themes were analyzed more holistically, with an intent to uncover which kinds of behaviors from the codebook students referenced in their responses as opposed to attempting to identify the presence of each one. Responses from the full transcripts were analyzed first looking at gender patterns within and across groups and then looking at a comparison of groups in light of varying gender composition. As a comparison of inquiry versus engineering is directly addressed in the interview questions, how students of different genders and between groups of varying gender composition reflect on these different tasks provides information related to existing literature on females' under-representation in engineering domains as well as to the *stereotype inoculation model's* emphasis in this particular area.

Table 13: Focus group interview results

		Between Genders	Across Groups
Autonomy	**Themes**	• Leadership and directing • Hands-on behaviors • On and off task	
	Findings	• Female leadership style recognized and appreciated by group members • Male directing recognized and considered more demanding • Both boys and girls equally positive about hands-on activities • Girls connected hands-on to content • Boys connected hands-on to intrinsic enjoyment • Females' off task behaviors identified more readily than that of boys	• Gender partitioning recognized in dyads • Static hierarchy perceived in dyads • Perception of leadership dispersing and equalizing in female majority groups, all male group
Competence	**Themes**	• Perceptions of competence with tasks • Perceptions of competence with science in general • Seeking clarification	
	Findings	• Girls expressed greater sense of competence with inquiry • Boys expressed greater sense of competence with engineering • Girls expressed less confidence and enjoyment of science in general than boys • Girls described connection of science class to future career plans, boys expressed more in terms of interest	• Gender dyads more likely to express needing teacher for support • Female majority and all male groups perceived no help sought from teacher • Group perceptions not necessarily consistent with observations
Relatedness	**Themes**	• Group work – sharing work and ideas • Group comfort • Task roles and collaboration	
	Findings	• Both boys and girls positive about group work • Benefits described similarly by both boys and girls – ideas improved, work shared • Both boys and girls described more collaboration yet more conflict in engineering • Girls more intrinsically interested in group work • Boys expressed increasing comfort over time	• Assertions of groups' collaboration consistently positive across whole groups • Single males in female majority only individuals to express any negativity about group work

Focus Group Interviews Results Table

Perceptions of Motivation through the Lens of Gender

Autonomy

The themes that emerged from student responses with regard to Autonomy aligned directly with the specific behavioral indicators defined in the codebook: leadership (directing/deciding), hands-on activity, and on and off-task participation. Overall, students in all groups recognized and identified the students in the groups that acted as leaders, and these identified leaders were consistent with those observed in the videotapes: Tricia, Taylor, Parker, Gavin, and the Diana/Timothy co-leadership pair. Regardless of gender, the members of the groups seemed to appreciate the existence of some element of leadership and spoke favorably, for the most part, about having someone who was willing to guide and finalize next steps, but they did not necessarily see it as dominance. While Parker in Mountain 1FFFM was clearly identified as the group's leader, both Brian and Talia agreed at different points during the interviews that, "No one dominated the group," and that "There was no real authority, and it wasn't taken with opposition." Similarly, in Cascade FFFM, Tina explained that having Taylor as the leader allowed the group to be more "calm and organized" in their work together. In Mountain 2MMFF, Elizabeth explained that Gavin was "good at moving the group forward". In each of these cases, the group spoke positively about the identified student's leadership skills in terms of the helping foster the effectiveness and productivity of the work.

Only in Mountain 2FFFM was the leadership behavior described in a less favorable manner. Natalie and Bryn, while calling Diana and Timothy their "team captains", also describe Timothy as being "bossy" and "controlling". They were highly critical in the interviews, to the point of conflict, of his manner of directing, even going so far as to mock him in front of the interviewer: “Do this, stop touching it, do it my way.” Further, Bryn at one point in the interview actually encouraged Diana to take a “higher role” in her leadership in order for the group to function more smoothly. Natalie explained that the students in the group are “not teachers and can’t just tell someone what to do”. However, Bryn and Natalie also both identify themselves as being willing to “go with the flow” and follow the ideas of others. In this manner, they seem to also appreciate and want leadership, they just did not respond to Timothy’s more authoritarian manner of doing so and were seeking out Diana’s perhaps more facilitative way of guiding the group.

While the groups identified their own hierarchical structures, the group leaders seemed to also recognize their status as such. Taylor in Cascade FFFM indicated that this was partly her personality, saying, “I take charge,” and described how she kept things moving forward in her group. Parker in Mountain 1FFFM said of her leadership role, “I’m the overseer.” Tricia also in Cascade MMFF seemed to connect her status partly to her leadership personality as well, indicating that she took on this role because she was good at it. In the case of these three female leaders, they all responded to this identification as something they were inherently capable of and that they did for the benefit of the group.

Distinct between the female and male leaders, however, was the manner of directing that not only they described about themselves but was identified by their group mates. In all cases, a pattern of female leadership that was geared towards organization and facilitation emerged. For example, in Cascade FFFM, Andrew says of Taylor (similarly to how Tina described her as well), “I’d chip in, and she organized my idea.”

As Parker described herself as an overseer, she also said that she helped organize the group, that she did not try to be a leader, it just happened because of this quality. In Cascade MMFF, both Tricia and the other members in the group described a scenario in which Tricia would develop a plan with Abigail, which they would then present to the boys for feedback before making a final decision. While still directing and making the final decision, Tricia again showed that her leadership incorporated the input and participation of everyone.

In stark contrast is the presentation of leadership described both by and about the males in the groups. As has already been described about Timothy in Mountain 2FFFM, the girls in his group felt he was overly controlling. His response to their criticism was, "I have the best ideas. We had to get it done, and I had an idea of how." Rather than fostering a group approach, his leadership reflected a sense of authority rather than facilitation or organization. This is true of Gavin as well. While his group seemed to have a greater appreciation of his leadership, he described his role as simply doing what he saw had to be done. "Okay, this is what we're doing." Again, this description reflects a more take-charge sense of leadership than was seen among the girls.

Even in cases in which the boys were not considered in a leadership role, their sense of autonomy is manifested in more authoritarian ways as well. In Mountain 1FFFM, in which Parker is considered more of the leader, Brian is often seen to assume a sense of autonomy when participating in tasks. Parker, however, describes him as such: "Brian just did whatever he wanted. He did lots of building and then would have to write later." Similarly, while Rahim often exhibited the most directing and decision-making behaviors in the all-male group, Steven described a phenomenon among all of them: "If anyone had a better idea, they just took over and showed everyone what to do." Again, this reflects among the boys a far more authoritarian sense of directing the group than the organizational qualities described by and about the female leaders.

This gendered approach to and perception of leadership and directing is consistent with that observed in the videotapes and also aligns to the hands-on behaviors described by the group members.

All students, regardless of gender, responded that they enjoyed hands-on labs and activities far more than other types of science and engineering classwork. This feedback was consistent across all groups with all students. However, reflections on why this approach was favorable as well as reports of the types of hands-on work that individuals performed did show subtle differences along gender lines.

Girls described the benefit of hands-on learning more in terms of its connection to content, learning, and achievement in the class. Tricia in Cascade MMFF appreciated this quality of the tasks because she described herself as a "hands-on learner", while Abigail in the same group discussed how it helped her see the real-life connection to what they had been reading about in class. Catherine and Elizabeth in Mountain 2MMFF also reported that they tended to get more confused while sitting and listening to content being explained by their teacher but that they felt more successful and that they understood more when the tasks were hands-on.

Natalie, however, expressed an interesting distinction, which continues to be aligned to the focus on learning achievement. While she responded positively to the hands-on activities, expressing that they were more fun, she also explained that they did not actually help her answer test questions more accurately or help her improve her test grades. While not consistent with the opinion of some of the other girls in different groups, Natalie still reflects on the tasks in terms of their connection to her overall learning and success in the classroom.

This is distinct from the manner in which the boys describe their experience with the hands-on tasks. In contrast from the girls, none describe their enjoyment of them in terms of their connection to learning; rather, for the boys the greater factor is the intrinsic pleasure in building and constructing. Robert and Daniel in Cascade MMFF describe that "Hands-on is more fun," and that they liked "messing around with materials". The boys in Mountain 1MMM all agreed that they just liked activities in which they could "build, make, and actually do stuff" because it was more "fun". Timothy in Mountain 2FFFM also describes enjoying the opportunity to construct, especially with the engineering tasks. In all cases, while girls also expressed enjoyment with the hands-on quality of the tasks, for the boys, the enjoyment was purely in building and construction with little recognition of any greater benefit for their understanding.

Not all students described their hands-on participation similarly, however, and this took on a gendered quality as well. In some cases, the girls across various groups described their hands-on involvement as differing depending on the type of task. Catherine in Mountain 2MMFF described that she was not able to be fully hands-on in some tasks because they just did not require everyone to be involved in that way. Elizabeth, in the same group, described that in some cases she ended up cleaning during tasks when there was not another hands-on task for her to complete. Bryn in Mountain 2FFFM described her hands-on behavior as trying to help Timothy with his construction efforts in many cases. Parker also described that, as she knew that the written component of the tasks needed to also be completed, she took on this role with Sophie frequently so that others could copy from her. The boys provided no responses related to feeling that the hands-on tasks were unequitable or different between various tasks; in other words, only girls discussed in the interviews that there were times in which they had to choose other responsibilities besides actively building or constructing. This suggests that for the boys, they either did not recognize or simply did not take on other responsibilities when the hands-on manipulation of materials was not an option for them – or, further, that it always was.

The opportunity for hands-on work affected some groups' perceptions of on and off-task behaviors. While many groups felt overall that their members were on task most of the time, in some cases where there was a discrepancy, this appears to also indicate a gender dynamic. In Mountain 2MMFF, as previously described, Catherine and Elizabeth felt at times that they were not able to be as actively involved in the task due to insufficient hands-on tasks for them. This made them feel like they "did not do as much" during these tasks. However, this same perception was not corroborated by the boys in the group. Adam, in fact, said that everyone was always focused and involved in the tasks, thus sharing a different perception of the group members' involvement.

Similarly, in Mountain 2FFFM, Timothy vehemently "calls out" Bryn and Natalie on not having a "work ethic" and "not doing anything". He also expressed that Natalie purposefully disrupted the group's progress at times. When Bryn retorted that she tried to help him, but he would not let her, Timothy's response was, "You would mess it up." Again, unequal hands-on opportunities for the girls disrupted the group's overall sense of on-task behavior, although in this case the male of the group had a negative perception of the on and off-task behavior, while the males in Mountain 2MMFF had no perception of any difference at all.

Interestingly, in Cascade MMFF, Robert and Daniel (as observed) show the most off-task behavior of any students across all six groups. Yet everyone in this group describes the success of their work together, that they “all cared, which made the work go faster”. No perceptions of off-task behavior are described in this group during either interview, despite the unequal distribution of work that was observed. Perhaps similarly to Mountain 2MMFF, the students more actively involved in the hands-on work seem less inclined to notice those students who are not.

Gendered perceptions of autonomy are reflected in the how group leaders are described and describe themselves, in their discussion of hands-on work, and in how on and off-task behaviors are considered. In all cases, the girls describe autonomy with greater emphasis on collaboration and learning, while boys are more focused on doing for the sake of doing, with less consideration of the overall group functioning.

Competence

Behaviors described under the category of competence in the codebook were not identified as directly within student responses in the focus group interviews as those in the autonomy category were. However, several distinct themes emerged that suggested distinct gender patterns in terms of students’ perceptions around their participation in the tasks.

The most prevalent and consistent trend that emerged in the student responses in terms of feelings of competence was the difference between how the girls and boys viewed the inquiry and engineering tasks. Without exception, the girls all described the engineering tasks as “frustrating”, while the boys said they were “easy” or that they liked them best. This gender trend was so consistent that almost every student had the same feedback according to their gender.

The girls consistently explained that the engineering tasks were too open-ended, without one right answer. Parker in Mountain 1FFFM described that there were so many possible ideas involved in the engineering tasks that it became guessing, without a specific place to start. Taylor in Cascade FFFM said she felt like the engineering tasks were simply “guess and check” and that she became extremely frustrated by their attempts that failed. Tricia and Abigail in Cascade MMFF both asked, “What is the right answer in an engineering task?”, indicating that there just was not one. They also both described feeling like the engineering tasks came out of nowhere and were not tied into their curriculum, thus not serving a greater purpose toward their learning in the class. They both also, like Taylor, expressed frustration with the guess and check nature of the engineering tasks. Diana from Mountain 2FFFM said specifically about the Pill Coating task that they had to just “wing it” and did not put much more thought into it. Finally, both Catherine and Elizabeth in Mountain 2MMFF said that were “clueless” about how to start the task and also felt frustration by their repeated failed attempts.

Consistent messages in the girls’ feedback about the engineering tasks, therefore, was the feeling that they did not have a specific starting place because the tasks were either not tied into their curriculum, had such a range of possible approaches that it was difficult to know how to begin, or that they were trying to balance and accommodate many different ideas from the group. Further, they found what they described as the “guess and check nature”, with its multiple instances of design failure, frustrating and unrewarding because at times “nothing worked”. They consistently reported that they preferred the inquiry tasks because they felt they had the background and content knowledge to approach them and that the inquiry tasks were based on information they were learning and were tied to real life, which is consistent with existing literature on girls’ preference towards life sciences.

In stark contrast were the boys’ comments about the different types of tasks. While some boys reported that they liked working with the pill bugs (“because I like bugs”), they overwhelmingly preferred the engineering tasks to the inquiry ones. When the girls described finding the engineering tasks hard, in many cases, the boys in the group would respond that they found them easy, as Daniel did about the heart valve task that Tricia found so challenging. For some of the same reasons that the girls did not like these tasks, the boys actually preferred them. For example, Timothy said that he like not knowing the answer to the engineering tasks ahead of time. He described the cellular respiration inquiry task, for example, as “boring” because he already knew the results and that everyone’s experiment was the same. He differentiated between the inquiry and engineering by saying that the inquiry tasks were more about an overall plan and conducting trials, but that the engineering tasks involved more thinking and strategizing.

Many boys also described not liking some of the inquiry tasks that involved live creatures because there were variables that they simply could not control. Both Steven in the all-male group and Timothy explained that they found the pill bug lab frustrating because they could not control what the pill bugs did. Timothy said that this unpredictability “took away from the experiment”. On the other hand, Zeke in the all-male group described feeling like the engineering tasks actually had more of a specific "right answer", unlike many of the girls' perceptions. He explained feeling like the heart valve task, for example, had an ultimate correct result in that they needed to keep the marbles from coming back through the flap, but that he enjoyed this process of figuring it out because he liked working with his hands. The all-male group, instead of describing frustration with failed designs as many of the girls did, rather said that they "learned from their mistakes" and "took it one step at a time". Thus, their overall attitude towards the engineering tasks was more open to its inherent structures and challenges.

It would be impossible to not hypothesize about the reasons why boys and girls differed so dramatically in their perceptions of the inquiry and engineering tasks. While it was clear that the girls felt more competent in conducting inquiry labs and the boys preferred the engineering design tasks, their reflections indicate different priorities in terms of the purposes of these tasks as well as perhaps a difference in prior experiences. For the girls, drawing on knowledge learned in the class allowed them to more confidently approach the inquiry tasks. However, as a vast body of literature describes the more plentiful experiences boys have with tinkering and building outside of school, this may have served to provide the background knowledge they needed to more confidently approach the engineering tasks. Further, as girls prioritize activities with their connection to learning and class achievement, the boys were comfortable conducting the activities for their own sake. While the girls were frustrated that they weren't getting to the "right" answer, the boys enjoyed the process intrinsically. Although beyond the scope of this study to investigate more deeply, this speaks greatly to the factors that contribute to a sense of competence and how gender dynamics and prior experiences have a profound effect on girls' and boys' perceived competence in different domains.

Another trend that emerged from boys' and girls' responses during the focus group interviews was a distinct difference in sense of competence in science in general. While not absolute, girls were more likely than boys to say that "science isn't my thing" or that they didn't enjoy the class. Interestingly, however, is that many of the girls' and boys' future career choices incorporated some aspect of science education. Many girls expressed an interest in pursuing medical sciences and recognized the need to take more science classes to this end, despite not feeling competent in science in general. Many of the boys described enjoying science classes to a greater extent than the girls, even if their future career choices did not necessarily include a STEM field. In sum, girls seemed less confident in their science abilities but acknowledged that they may need to pursue further classes in order to meet their future educational and career goals. In contrast, the boys were more likely to enjoy the class regardless of the future career choices or plans to pursue additional science courses.

The greatest gender dynamic observed in the category of competence, therefore, is that of the differing view of inquiry and engineering tasks expressed by boys and girls and the underlying priorities and experiences that this suggests between the genders. Girls are more likely to prefer inquiry tasks that provide a narrower scope which is more directly aligned to concrete concepts they are learning in class. Boys, however, enjoy the open-ended challenge of the engineering tasks and rely, perhaps, on the experiences they have had in other areas of their life to provide a sense of competence when dealing with the multiple iterations and potential failures involved in an engineering design challenge. This speaks to the over-arching construct of motivation in that girls are being driven more by a sense of class success and connection to learning and understanding. In contrast in this area, boys' motivation is driven more by an inherent interest in problem-solving and meeting the specific demands of the task.

Relatedness

The most interesting phenomenon when examining the groups' reflections on relatedness is that, while common trends emerged from the interviews, there was little gender divide observed in this particular category. Both boys and girls presented the same reflections on their group work.

Initially significant, is that all groups – and all group members, male or female – adamantly declared that they preferred working in a group for STEM tasks such as these. While the relationships within the group varied, with some members being friends ahead of time and others barely knowing each other, all expressed a sense of camaraderie that increased over the course of the six tasks. Many groups indicated that they felt awkward at first, but that growing to know each other over the semester had a positive impact on their collaboration. While this message is consistent across groups, Daniel and Abigail explain it succinctly.

> Daniel, "I think at first it was just kind of like weird at first, but then like after doing more of the days of working together, it got better."
> Abigail, "Yeah, we all learned each other's personalities a little bit better, I think."

This same sentiment is echoed by the members of Cascade FFFM, who described how it got easier to share ideas over the course of the semester, as well as by Mountain 1FFFM, in which Parker described how they made an effort to include more input from each group member as their relationships in the group got closer. Even in Mountain 2FFFM, the group in which Timothy was deemed controlling and bossy, the members described feeling that they worked together more collaboratively during the three later tasks than in the first three. This sense of increasing collaboration and cohesion in the group was consistently described across all groups and all group members, regardless of gender.

Another consistency among all groups was a sense of appreciation in having multiple ideas when working together on the tasks. Frequently repeated by both boys and girls was the sentiment that collectively they were able to develop better ideas than they could have individually. Tina in Cascade FFFM explained that the different opinions were actually welcome in the group because they led to more learning. Both Rahim and Zeke discussed the importance of not being set on your own idea but allowing for multiple ideas to help figure out the solution together. Brian in Mountain 1FFFM described the importance of multiple brains providing a collective approach, and Elizabeth in Mountain 2MMFF described how having group mates with whom to share your thinking helped you see the "holes in your ideas". No gender distinction emerged in these descriptions and reflections upon collaborative thinking, with all students positively describing the strengthened approach and thinking this collaborative effort provided.

Further, both male and female students described a sense of feeling their ideas were heard and improved upon by the collective nature of their groups. Zeke in the all-male group explained that he felt his ideas were "taken up and made better". Andrew in Cascade FFFM described how his ideas were heard and considered but sometimes changed. Tina in this same group described the phenomenon of "feeding off of each other's ideas". These examples all reflect a sense of how the individuals in the groups felt progressively better able to share their ideas but also recognized that these ideas may be changed or built upon for the greater good of the group, and that this was a positive and appreciated occurrence.

Another consistency among the individuals and groups was the reflection that the engineering tasks provided greater opportunity for increased collaboration than did the inquiry tasks. Despite the fact that this may have provided greater frustration for the girls in its open-endedness, both boys and girls agreed that the because the engineering activities required more jobs and tasks, it was easier for everyone to collaborate and be involved. Parker described how there was just simply more for everyone to do in the engineering tasks, while some of the inquiry ones involved a lot of watching. Daniel and Robert in Cascade MMFF explained also that the inquiry tasks allowed for more independence within them, resulting in less overall collaboration. Similarly, Rahim explained that his group worked more as a team during the engineering tasks than the inquiry ones. Gavin expressed that it was better to have more people during the engineering tasks because of the multiple roles and ideas required to pursue them. As such, while the attitude about the tasks was distinct between boys and girls, the recognition that the engineering ones benefitted from a more collaborative effort was not.

Along with the need for greater input and ideas during the engineering tasks, however, was also the subsequent increase in conflict and arguing in some groups because of this. Parker describes how her group faced more disagreements during the engineering tasks because so many ideas were being presented and that she felt it was easier to incorporate multiple ideas into the inquiry labs. Diana also described that during the Heart Valve task, the group's communication just seemed to be "off". While multiple groups expressed this same perception, many also asserted that the conflict or frustration was not with each other but with the parameters of the task itself. Interestingly, both boys and girls clearly delineated the distinction between disagreements and frustrations about procedures and results rather than with other group members.

The only gender distinction that emerged within the relatedness category in terms of how the group members perceive this condition is a subtle trend among some of the boys expressing perhaps less comfort or familiarity with working together. While the girls consistently and unhesitatingly expressed a desire to work in a group, some of the boys alluded to this as an emerging feeling rather than one they felt inherently from the start. Timothy from Mountain 2FFFM states that he and his group members “figured out how to work together”. Andrew in Cascade FFFM, while positive about his preference towards being in a group, admitted that if his particular job was done, he would “check out” or go be by himself. Robert and Daniel in Cascade MMFF also explained that they “had to get the hang of being in a group”. While each of these males still reported a strong preference to work collaboratively, they each also indicated the slight hint that this may not be wholly inherent to them.

Relatedness, therefore, emerged differently from the other two motivational conditions in terms of student perceptions described in the focus group interviews. While strong gender differences could be distinguished with regard to perceptions of autonomy and competence, this was far less apparent in terms of relatedness. Interestingly, this is the category in which the most striking differences emerged from the videotaped observations, but almost non-existent were distinctions among student perceptions. Only a subtle hint towards collaboration being a perhaps less inherently comfortable condition for boys could be discerned, but a strong preference for group work in such STEM tasks, with all of its complexities and distinguishing features between inquiry and engineering, remained constant between both boys and girls in all groups.

Perceptions of Gender with Regard to Group Composition

In contrast to the findings from the focus group interviews in terms of gender dynamics, fewer patterns within the motivational conditions emerged in relation to group composition. In other words, students' perceptions of their motivated behaviors varied more along gender lines than across varying group configuration. In each category, however, although to a lesser extent than gender, differences did become apparent. While not every behavioral indicator shows a significant comparison and, therefore, not each is described, those perceptions that do differ between groups are outlined with respect to the appropriate motivational condition.

Autonomy

Between groups of varying gender configuration, perceptions of leadership and student involvement differed. While these two themes were distinguished and separated while examining them in terms of gender, they became more muddled together while comparing between groups. In the gender dyad groups, there was a consistent pattern across all six tasks of same-sex pairs maintaining different roles from each other. While the gender distinction was different between the two gender dyad groups, the trend was similar. In Cascade MMFF, Tricia and Abigail maintained the most active involvement in terms of task completion, while the boys, Robert and Daniel assumed support roles, becoming involved when they were asked. Both gender pairs in this group described and confirmed this dynamic. Tricia explained, "And they [Robert and Daniel] did like the stuff we needed, and um, like setting it up and stuff." Robert later confirmed about Tricia, "Yeah, she's the smart one."

In an additional example, Tricia said, "So Amanda and I kind of came up with the hypothesis, and they would either agree or disagree, and then we would explain why." Throughout the six tasks, Tricia was perceived to maintain her leadership status, working actively with Abigail, while the boys supported or followed their directions as needed. While in other instances they portrayed a sense of overall collaboration, their responses clearly presented a gender divide in terms of roles and manner of participation.

The same phenomenon, but with a different gendered orientation, occurred in the other gender dyad group, Mountain 2MMFF. In this case, however, the girls perceived their role to be less active and more supportive to the boys, with Gavin also consistently maintaining his leadership status throughout the six tasks. Both Catherine and Elizabeth, as mentioned previously, describe instances and labs in which they felt they had less to do. Catherine explained experiencing with the hands-on aspect that "like, people could put their ideas in, but hands-on, like actually doing it, not everyone could." Elizabeth corroborates that she did more in some labs and less in others, and Adam concedes in response to Catherine's statement that, while he felt everyone was involved and focused, "there were a couple of experiments where sometimes, like just for little periods of time, not everybody, just like one or two people didn't do anything for a little while."

While the gender roles differed from the other gender dyad group, the partitioning and perception of differing roles remained constant between these two groups. In both cases, one gender pair is perceived to have less to do or to act in a more supportive role than the other gender pair. Also similarly, the group leaders maintained this status throughout the semester, according to the responses given in the interviews.

This is not the case, however, among the female majority groups. In each of these cases, while a leader was still identified, all groups described a phenomenon of the leadership dispersing among the group members and equalizing more over the course of the semester. Further, reports of feeling less involved or more supportive did not emerge among these three groups as they did with the gender dyad groups. Interestingly, in Mountain 2FFFM, a less engaged gender pair, Natalie and Bryn, was identified by Timothy in the first interview. He emphatically accused them of lacking work ethic and effort, while their perception was that he did not in fact allow them to help. While this perception of a gendered pair assuming a less active, more supportive role is similar to that seen with Catherine and Elizabeth, this trend did not continue in the same manner. Both Timothy and girls in this group described in their second interview that the tasks and roles were more evenly divided during the last three tasks. Natalie reports about Timothy's leadership that he "chilled eventually".

This progression was also perceived in Cascade FFFM. While Taylor was the group and self-identified leader, all of the group members in the second interview described that the group got more collaborative over the last three tasks. Taylor herself explained, "I definitely feel like [I was the leader] the first three labs instead of the other, 'cause we started to get more. Yeah, the first three, but I think we all contributed to all of the second." This description was corroborated by the other group members. Thus, while they recognized and appreciated Taylor's leadership, there was also a distinct sense that this became more distributed among the group members in the later part of the semester.

The third female majority group, Mountain 1FFFM, exhibited less progression in this manner but a more consistent sense of shared roles throughout. While once again, Parker was both the group and self-identified leader, all members portrayed a sense of involvement in the group's work; no perception of lack of involvement was on anyone's part was presented. Parker explained about her sense of leadership, "I don't think it really mattered. We all just kind of chipped in on everything." While a sense of evolution in this group is not as apparent as with the other two female majorities, the sense more equally distributed involvement and a lack of gender parity as compared with the gender dyad groups is consistent.

The final all-male group presented another distinct version of hierarchy and participation as compared with the other groups of varying configurations. There was little sense presented that any one student acted as a leader or maintained a leadership status. While Zeke mentioned that Rahim "did the most", this did not necessarily suggest that the group members felt he was guiding or directing them. Referring once again to Steven's comment about whoever in the group had the best idea took over, there appeared to be a perception that no one person dominated the group nor was less involved than the others. As compared with the other five groups, this all-male group did not present autonomy in terms of recognized leadership or participation in any way. Rather, there was an almost competitive nature in the sense of "best ideas" and "shooting down crazy ideas". They did not present or describe specific roles in terms of the type of participation but rather the level of knowledge they brought to the group: Rahim described Zeke as being the "math person" and Steven as "writing the most down", and they all described being equally involved in sharing ideas and working with materials.

This is the only group in which participation was not based on level of activity or hierarchical status in the group but more a sense of the individual student's strength at the time in terms of what he could bring to the task. The group's leader was whoever had the best idea at the time.

Leadership and manner of participation were perceived and presented differently across groups of varying gender composition. While the gender dyad groups reported a more static hierarchy and unequal involvement along gender divisions, the female majority groups assumed an initial hierarchy that became more collaborative over the course of the six tasks with a sense of more equal participation among all group members. Finally, the all-male group described an experience that was focused more on participation in which individual strengths and best approaches were more significant than leadership or any hierarchical organization.

Competence

One area emerged in the category of competence as being distinct across groups of varying gender composition: perceptions of support and methods of resolving questions and confusions. Further, this is an area that differed dramatically between students' perceptions and the behaviors observed from the videotapes.

When students in the six groups were asked what they did when they were stuck during a task, students in the gender dyad groups immediately responded that they got a teacher for help. Further, of the group members, only girls responded to this question at all: Catherine, Tricia, and Abigail. Tricia reports, "Well, if we did get stuck, we would just ask the teacher what we were doing right, or what we were doing wrong." Abigail then added, "Yeah, she directs us in the right direction." In neither of these gender dyad groups is there mention of turning to each other for help or talking through conflicts. Only when pressed to answer if anyone in the group was able to help during “sticky” times, did Elizabeth suggest that Gavin helped in this manner, but this was after Catherine had already responded that they first sought their teacher’s help.

There are several interesting aspects of these groups’ assertions. First, the students in Mountain 2MMFF, while indicating that they relied on their teacher for help, also described how the interventions of both their teacher and the classroom’s student teacher also could confuse them further. Catherine and Gavin described how during the pill bug lab in particular, both teachers “kept coming over to help us, and it got really confusing”. While they indicate seeking out their teachers’ help, therefore, they also acknowledge that it was not always the support they needed: yet, they did not connect these ideas to relying on each for support.

Also interesting with this group in particular is that, despite claiming they looked to the teacher to help clear up confusions, in reality, this group actually exhibited fewer instances of seeking out teacher support than asking each other questions. Further, they did not seek out teacher support to a greater degree than the other groups. As such, their perception of requiring teacher support did not necessarily match the reality of what they did.

This is true of the other gender dyad group, Cascade MMFF, as well. Despite the girls’ immediate assertion that they relied on the teacher to help them move in the right direction, this group is actually observed to seek teacher support far less than they did of each other and less than many of the other groups. Inconsistent with the observed behaviors but consistent with each other, the gender dyad groups (and more specifically, the girls in these groups) assert seeking teacher support before that of their peers and to a greater extent than is observed to be true.

In contrast, all three female majority groups and the all-male group described not needing the teacher's help for anything further than permissions or approvals on their designs. They all described seeking clarification from each other, talking out issues, and backing up their ideas with evidence as methods of resolving conflicts, confusions, or disagreements. When the question was posed to Mountain 1FFFM, all group members responded that they could not remember ever needing the teacher's support; Parker only suggested that maybe they needed him to give approval at some point. Andrew in Cascade FFFM explained the same scenario, describing getting clarification from his peers first and only asking the teacher if the group needed permission for some aspect of their task. Tina, in this same group, only mentions the possibility of getting help from the teacher after describing how the group members built off of each other's ideas and how greater learning came from these times. She was not saying that she had gotten a teacher's help, however, only that this would be a next step if talking in the group had not worked. Diana and Natalie from Mountain 2FFFM, despite their descriptions of some tumultuous times in the group, are clear that they never asked their teacher for support, although he would have given it if they had asked. Finally, all three boys in the male group assert that they never got stuck during a task and could not remember a time when they needed the teacher's help.

As with the gender dyad groups, some of these students' perceptions, while consistent with their similarly configured groups, do not match the observations gathered from the videotapes. Both Mountain 1MMM and Mountain 2FFFM, gender majorities who claim they needed sought support from the teacher, in fact requested teacher clarification far more times than any other group in the study. Of these gender majority groups, the perceptions of groups Mountain 1FFFM and Cascade FFFM seem more aligned with the data observed.

Perceptions of how support was gained during the tasks varied across groups of varying gender configuration, with the gender dyad groups claiming they turned to their teacher for support, while the gender majority groups (both male and female) asserted they did not. While these perceptions differ from the behaviors observed, it is beyond the scope of this study to speculate reasons for this discrepancy at this time.

Relatedness

Similar to an examination of relatedness perceptions through the lens of gender, little discernible pattern is noted with regard to group gender composition. In the same way that both boys and girls across groups described their experiences working together as positive, as developing productively over time, and as fostering a higher level of learning than could be achieved individually, these same messages emerged in a consistent manner across the various groups as well. Regardless of gender composition, both boys and girls in these groups repeated many of these same thoughts.

A subtle difference, if any, can be discerned with regard to the singular boys in the female majority groups. While a trend was noted between genders in the boys' perhaps slightly more burgeoning openness to group work, this may be taken one step further when examining the boys' attitudes in the female majority groups. While the overall presentation was still positive and preferable to working alone, only the boys in the female majority groups expressed any hint of negativity towards their experiences.

While the boys in the gender dyads and the all-male group had only positive feedback about their work in the group and about the other group members, subtle comments from the boys in the female majority groups raised the question if their experience was as wholly positive as those in the other differently-configured groups.

Andrew in Cascade FFFM, while saying the he felt the group “clicked” and was not stressful, also made an allusion to some aspect being uncomfortable for him. In addition to stating that he would go off by himself if his work was done, he also refused to answer a direct question about the group work. When asked if there was any part of working in the group that he did not like, he pointedly replied, “No comment.” While it is impossible to determine to what he was referring or why he felt he could not respond, this leaves some question about whether there was any element that was less than fully positive for him in his group’s dynamic.

There is little question that Timothy in Mountain 2FFFM expressed negativity about his group’s work at first. He was clearly upset by what he called a lack of work ethic and by some group members not doing what he seemed to consider their fair share. This dynamic did seem to evolve more positively over the course of the semester, with him admitting by the end that there was more collaboration and equal work being done throughout the later three tasks. Timothy, however, held nothing back in terms of expressing his frustration with his group and was perhaps the only student in the study to express such a dramatic emotional response.

Brian in Mountain 1FFFM was generally positive about the collaboration and work of his female majority group. He spoke highly of the benefit of having multiple perspectives and of the collective thinking of his group. However, in one instance, which was shared by both him and by his female groupmates, he expressed frustration with an idea that he had which he felt was not considered appropriately by his peers. The girls in the group adamantly maintained that they did use his idea in the end, but the presentation of this occurrence by the students suggested that Brian felt he was not being valued in this moment, even though his ultimate perception by the end of the semester was that his ideas were heard and their group was a functional one.

While these are minor instances, some of which changed by the end of the semester, they were not observed among the males in the other three groups, only by those in the female majorities. The male students in either of the gender dyad groups or in the all-male group related no instances of feeling similarly or experiencing any such conflicts within their groups – their reflections are completely positive and supportive of their group dynamics. These examples simply suggest that the boys in these female majority groups may have experienced moments of discomfort that were not shared by the other male students in differently configured groups. This trend is subtle enough as to be difficult to define in a more complete manner, yet raises the possibility that the singular males in a female majority group may face unique challenges that are not equally shared or perceived by males in groups that have more males in the gender composition.

Again, as with a gender comparison, relatedness presents differently in students' perceptions in that there is less discrepancy among the varying groups. While the singular males in female majority groups may experience a different dynamic than their peers in other groups, the distinguishing patterns and trends that are present within the conditions of autonomy and competence are murkier within the construct of relatedness. Overall, as students present their experiences working within these STEM groups, greater differences are noted both between genders and across groups in terms of autonomy and competence. Perceptions of relatedness, at least as relayed by the students, show far less variation and tend to present an overly positive experience of the group's work, one that is not always consistent with the behaviors observed but that indicates an over-arching desire to work collaboratively.

The focus group interviews provide an additional layer to making meaning of the classroom observations and the enactments of motivation observed. In some ways, they confirm and supplement the students' behaviors by explaining or providing additional information, as is seen in how students responded positively to the girls' leadership both visibly and verbally or in the consistency presented between boys' more on-task behaviors during and their preference for engineering tasks. Data from these two sources also raise further questions and discrepancies, however, such as in students' conflicting perceptions of how often they needed teacher support or the emphatic success of their group work many described, despite observations to the contrary. Worthy of further examination, but beyond the scope of this study, is a closer look at these both consistent and discrepant reports and the reasons why students may describe their science group work in specific ways for certain aspects of their experience.

CHAPTER V

DISCUSSION

Introduction

Despite research and initiatives intended to increase the representation of girls and women in domains of science, the "leaky pipeline" effect of females exiting a science trajectory still remains (Harding, 1998; Hill, Corbett, & St. Rose, 2010; Jones, Howe, & Rua, 2000; NRC, 2007; NSF, 2011, NSF 2017; Osborne, Simon, & Collins, 2003). As long as this is the case, research is necessary that furthers the collective understanding of gender equity issues in the realm of science and suggests approaches for increasing females' access, particularly in the science classroom. In light of this, this study aimed to add to the body of research exploring this phenomenon by examining specifically the role of group gender composition as well as a comparison of inquiry and engineering curriculum on girl's science motivation.

The purpose of this study was to analyze, through the lens of gender, manifestations and reflections of motivation in high school science students working in small groups in their biology class. Using Ryan and Deci's self-determination theory (2000a, 2000b) and Dasgupta's *stereotype inoculation model* (2011a, 2011b) as the over-arching frameworks, this study examined the motivated behaviors exhibited by boys and girls working in groups of varying gender composition, specifically in relation to the motivational conditions of autonomy, competence, and relatedness. Further, a comparison of student behaviors between science inquiry and engineering design tasks was conducted. This qualitative study was a secondary analysis of an NSF-funded project on small group dynamics in science and utilized an a priori set of behavioral codes derived from Jovanovic and King's 1998 study on student performance in the science classroom. Using thematic analysis, patterns and trends in students' behaviors and reflections with regard to motivation were examined between genders, across groups of varying gender composition, and between the type of task, science inquiry or engineering design.

Summary of Findings

Jovanovic and King's (1998) study on performance in the science classroom examined the quantity of specific behaviors that boys and girls exhibited during science tasks, after professional development on exemplary science instruction occurred, and representing the level of equality in the classroom between the genders. In their quantitative study, Jovanovic and King found that boys still out performed girls in terms of frequency of many active behaviors, such as handling equipment and making task-related suggestions. This study further refines and updates those findings by looking qualitatively at the behavioral indicators described by Jovanovic and King and their relationship to *self-determination theory* (Ryan & Deci, 2000b). In light of the vast body of literature examining girls' participation in STEM and initiatives to better include them, it is necessary to consider more than counts of behaviors because students' experiences and attitudes are far more nuanced and complex, with many factors that cannot be excluded from the analysis. Rather, an examination of how these behaviors are manifested, how they present differently, and the specific characteristics they represent more meaningfully tells a girls' story in her science classroom and within her small science group. The results of this study are inconsistent with the findings of Jovanovic and King showing that boys outperformed the girls: in many cases, boys and girls did not differ in their simple frequency of active performance behaviors within these science tasks. Rather, it was the intent and the quality of these behaviors that better reflected girls' motivation in this domain and will more accurately inform future implications for truly engaging them in STEM.

With respect to the research questions, findings from the study indicate that the behaviors associated with autonomy, competence, and relatedness are manifested differently between boys and girls in many cases and also between groups of varying gender configuration, although some exceptions do exist. Overall, autonomy presents differently than competence and relatedness, with distinctions falling along gender lines rather than with regard to group gender composition. In most cases, a hierarchical structure emerged in each group, with one of the group's females often taking on a leadership role. While this role was shared between Timothy and Diana in Mountain 2FFFM and between Catherine and Gavin in Mountain 2MMFF, in all cases in which a group contained girls, one particular female was more likely to be dominant than the others in terms of guiding and directing. In the case of the all-male group, this leadership role still emerged.

Also distinct between genders, however, was the manner of directing, with girls offering more facilitation and guidance intended to keep the group focused on the task's parameters rather than offering simple commands and directives, as was more frequently seen among the boys. While both boys and girls were equally likely to handle materials and equipment productively towards task completion, regardless of the group, when not actively engaged with this behavior, boys were far more likely to play with materials in a manner unrelated to the task, while girls would more often pursue written aspects of the task. Little pattern was observed between the genders or among groups in terms of on or off-task behaviors. Autonomy, in sum, manifested in more facilitative and task-oriented ways for girls, with off-task behaviors often occurring concurrently with boys' hands-on explorations of materials. These findings are consistent with prior literature which highlights girls' science identities as being on task and responsible students rather than risk-takers (Brickhouse, Lowery, & Schultz, 2000; Brickhouse & Potter, 2001, Campbell & Clewell, 1999; Jones, et al., 2000; Robinson, 2012; Shakeshaft, 1995). In many instances in this study, girls' behaviors were aligned to the specific parameters of the task, with their directing and hands-on actions being task-driven and within the boundaries of the expectations set forth by the teacher and the activity rather than exhibiting a more exploratory or tinkering nature.

Competence and relatedness, however, showed more distinction between groups of varying gender composition rather than between boys and girls. Within the female majority groups, girls who exhibited leadership tendencies also showed more explaining and suggesting behaviors than the girls in the gender dyads. Suggesting also appeared more evenly distributed across all members of the female majority groups in contrast to the gender dyad groups, indicating more cognitive participation in the female majority groups with regard to task execution. Little pattern is noted in terms of how the groups sought support and clarification among the groups with females; however, the all-male group requested help from the teacher more frequently than any other group. While relatedness showed some important distinctions between genders, with girls exhibiting more behaviors that attempted to foster whole group collaboration than boys, this trend is further confirmed by increased whole group cohesion and fluid partnerships seen in these female majority groups as well. In contrast, the gender dyad groups showed frequent partitioning into same-sex pairs, with more unequal work distribution and quality of participation between these gendered pairs.

These findings regarding relatedness support a wealth of literature that describes girls' preference towards learning in social and collaborative environments (Bourette, 2005; Brickhouse & Potter, 2001; Brotman & Moore, 2008; Burkham & Smerdom, 1997; Dasgupta & Stout, 2014; Robinson, 2012; Shakeshaft, 1995; Shanahan & Nieswandt, 2009; Shapiro, 1994; Tucker, Hanuscin, & Bearnes, 2008). As shown in this study, not only was the frequency of overt relatedness behaviors far greater among girls than boys, many of their other behaviors (directing, for example) held an underlying quality of group facilitation and organization, indicating this intent towards collaborative learning contexts. New, however, is the distinction shown between groups of varying gender composition with regard to their whole group functioning. The phenomenon of self-segregating into gendered pairs versus the more cohesive dynamic observed in the gender majority groups has not yet been explored and would greatly benefit from additional research.

Patterns between the science inquiry and engineering design tasks are subtler in terms of observed behaviors, but some distinctions did emerge. These differences were not, however, necessarily significant in combination with gender dynamics but often showed consistency across groups and genders. With regard to autonomy, for example, the engineering tasks showed more on-task and hands-on behaviors across all groups, but in terms of competence, the inquiry tasks appeared to involved more suggesting and explaining, relating perhaps to the more content-driven nature of these tasks. In other words, there was a greater indication of thinking and planning first during the inquiry tasks, but more problem-solving through doing during the engineering tasks. Finally, more independent behaviors and less collaboration was observed during the engineering tasks than inquiry, suggesting overall a greater need for a unified approach with the inquiry tasks. This finding is notable in terms of girls' participation in both science inquiry and engineering tasks, suggesting that there are either differences in the nature of the tasks, their presentation, or students' approach to them that may lead to distinct manners of student engagement between inquiry and engineering design. With the engineering tasks showing less whole group collaboration, which is fundamental to girls' increased motivation, far more research must be done in order to better understand the source of this difference and ways to make engineering design better aligned to girls' learning preferences and styles.

Perceptions of motivation as reflected in the focus groups interviews also portrayed gender dynamics, both between genders and across groups. While a hierarchical nature was recognized and identified by the students, they also described a gender difference in how these leaders guided their groups, with girls described more as organizers and facilitators, and boys reflecting a more authoritarian nature. In terms of groups' gender composition, female majority groups reflected a phenomenon in which the leadership dispersed among group members over the course of the semester, while the perception of an unequal gender parity remained constant in the dyad groups.

Hands-on behaviors also reflected a gender distinction in that girls described the hands-on nature of the tasks by its connection to learning and success in the class and on tests, while boys expressed more of an intrinsic interest in building and manipulating materials. This distinction directly supports prior literature that describes girls' motivation in science as being typically linked not to the content but rather to its contribution to their academic success and future educational plans (Campbell & Clewell, 1999; Miller et al., 2006). According to Ryan and Deci's previously-described spectrum (2000a, 2000b), girls' motivation with these hands-on tasks appeared to remain at the introjected level in that they valued their benefit towards their education rather than enjoyed them at an intrinsic level, as was described by the boys in the study.

A striking gender divide occurred in the realm of competence, both in terms of gender and gender composition. Boys and girls, regardless of the gender composition of their group, described their feelings of competence with the tasks completely differently, with boys showing much more confidence with the engineering tasks and girls consistently preferring the inquiry tasks. This finding has multiple implications when situated in current literature. At the gender level, it supports the research that describes girls' preference for and greater self-efficacy in the life sciences rather than engineering (Bennet & Hogarth, 2009; Britner, 2008; Burkham & Smerdon, 1997; Dasgupta & Stout, 2014; Murphy & Whitelegg, 2006). Notable, however, is that two additional factors which had the potential to modify girls' response to these engineering tasks appeared to have little positive impact: the connection to the biology content and the female majority group composition for some girls. Despite the fact the engineering tasks incorporated real world scenarios with a clear focus on societal benefit in life sciences (removing oil from an ecosystem, creating a heart valve for a cardiac patient, and improving a pill coating for a girl with stomach issues), this did not serve to greatly increase girls' perceptions of the tasks' value. Further, even for girls in female majority groups, their overall reflections of competence were not significantly higher than those in the gender dyad groups, which, at first glance, appears in contrast to Dasgupta and her colleagues' findings that a female majority helped reduce women's anxiety in engineering (Dasgupta, Scircle, & Hunsinger, 2015). Enacted behaviors as observed, however, did not reflect this gender distinction between task type, and that may indicate an important first step for increasing girls' participation in engineering, despite their reflections. Another necessary consideration, drawing on prior literature regarding teacher self-efficacy in engineering education (Hammack & Ivey, 2017) is the role of the teacher in presenting these tasks and highlighting their relevance to students. While beyond the scope of this study, a deeper examination into these specific teachers' attitudes and confidence towards engineering design would be necessary before drawing definite conclusions between this study's findings and that of Dasgupta and her colleagues in terms of females and engineering. Other possible factors, such as teacher training in engineering education, the novelty of the engineering tasks for both the teacher and students, and prior engineering experiences for the girls, may have had confounding impact on their perceptions of the tasks.

Further in terms of competence and group gender composition, distinctions emerged in terms of seeking support with these tasks, with gender dyad groups expressing the need for teacher support and gender majority groups insisting they resolved conflicts and confusions internally, despite inconsistencies with the actual observations in this area. This difference in perception versus reality in terms of seeking support may reflect an increased sense of collaboration, or relatedness, as seen in the gender majority groups. While no significant distinction emerged with regard to students' perceptions of their relatedness, either between genders or across groups, actual observations indicated a much stronger visible whole group cohesion in the gender majority groups, and this may have impacted their sense of how much teacher support they required versus how much internal group support they perceived.

While themes noted in the data showed some variance in terms of their presentation with regard to gender and gender composition, a connection back to self-determination theory and the stereotype inoculation model suggests that, in some significant ways, science groups with a female majority may support not only the necessary condition of relatedness but are beneficial in many ways for the female group members. Not only does a female majority support the participation of the girls in the group, but it may positively impact the whole group's functioning in general. Female majority groups overall showed increased opportunity for girls to take on a leadership role, and for this role to be appreciated and perceived by others as positive for the group's success. Their leadership style as a facilitator was recognized as helpful and productive by their peers and increased the overall participation of all. As such, there was greater participation in many ways by all group members, more equal distribution of work, fewer incidences of stereotypically gendered behavior, and less gender partitioning, as found in both the classroom observations and within students' own perceptions. While it is certainly true that gendered behaviors emerged in all groups, with girls consistently showing more task-driven behaviors as opposed to intrinsic interest, over the course of the semester, the female majority groups showed, and were perceived by the students, to equalize in terms of active participation, with all members becoming more invested and positively involved in the group's collaborative efforts towards completing the tasks.

Girls who already had tendencies toward leadership were able to positively enact this role, but girls who were perhaps less inclined to be actively engaged in science tasks were also able to increase their involvement over time. While it is beyond the scope of this study's findings to assert that a female majority group increases girls' motivation in STEM overall, it does support the stereotype inoculation model's claim that girls will be more likely to transcend some of their stereotypically gendered behaviors and be more actively engaged in some STEM situations when they are surrounded by other female peers, which surely has to be a positive first step in this overwhelming systemic issue. As indicated by findings from this study, this can be most immediately achieved when girls can work in female majority groups, as opposed to those in which there is an equal number of both boys and girls.

Limitations of the Study

This study has several limitations which will need to be reexamined in future research. First, not all possible gender configurations were included. To further enrich the data, the inclusion an all-female group as well as a female minority group would have broadened the scope of the study's findings and implications. This was not possible, however, given the population and demographics of the classrooms involved in the study, but replication of the study with greater variance in group configuration would be a possible avenue for future research. In addition, the effect of the biology interest inventory as the initial means of grouping students prior to configuring for gender composition was beyond the scope of this study and not considered in the analysis or findings. Future research could include post-test data on students' biology interest in order to better understand how the groupings may have affected, or were affected by, this additional variable.

Another limitation of the study, while useful in the sense that it increased homogeneity among certain characteristics, is that this study was focused in schools that were both rural and similar in population. Many other co-existing factors were, therefore, not included or recognized in terms of their role in the students' presentation throughout the study, such as cultural, socio-economic, or geographic variables. As such, this study examined all students from a narrow lens which took only gender into consideration. Future research should address issues of intersectionality by replicating this study in a different school environment and community in order to compare findings across populations of students.

A final limitation of this study is simply the small sample size. While these six groups presented many distinctions and commonalities in the findings with regard to both individual gender and group gender composition, a greater number of groups to compare would provide a richer and more consistent analysis of these patterns. Because of this, these findings are bound by the small sample size and must be qualified as such, with a clear acknowledgement that the results are true of these groups only and that further generalizations are speculative at this point.

While these limitations are certainly worthy of future consideration, they do not decrease the relevance of the findings. Each limitation represents not a fault of the experimental design but a narrowing of the study's scope as necessary to make meaning of these students' experience through the lens of gender dynamics. By limiting the groups' configurations, the population, and the sample size, this allowed other factors not to confound the data or findings in this exploratory study and for the focus to remain clearly defined by the research questions. Broadening the scope of the study to include a wider representation of students is the next step and will strengthen and inform these preliminary results.

Implications for Practitioners

As teachers at all grade levels plan for collaborative work in their classrooms and for meaningful STEM instruction, an awareness of girls' experiences and attitudes towards STEM as well as a recognition of best practices in small group facilitation and management are key. As the Next Generation Science Standards (2013) outline the need for such collaboration in their practices, including carrying out investigations, constructing explanations, arguing from evidence, and communicating information, teachers require guidance and support with ensuring that these collaborative experiences are both inclusive and productive for all of their students.

According to the findings of this study, most fundamental is that teachers should intentionally and thoughtfully create frequent opportunities for students to work in small groups on engaging STEM tasks. As all students in the study confirmed their preference for hands-on collaborative activities, this approach is not only simply appreciated by the students, it is also fundamental to an authentic STEM experience and an expectation of NGSS. Further, such opportunities may provide students with greater access to the condition of relatedness, which is fundamental in supporting students' more intrinsic interest and motivation in any domain, which can only add to their potential for achievement.

However, teachers must also think meaningfully about how they configure such collaborative small groups in their classrooms. While the tendency is to divide students evenly along gender lines, with two girls and two boys per group, this is shown to not necessarily enhance the productivity or success of the group. Rather, groups with a gender majority, especially in the case of the female majorities, may provide a more supportive and comfortable scenario that optimizes the participation and engagement of the female group members and allows them to transcend gender stereotypes in the science classroom (Dasgupta, 2011a; Dasgupta, Scircle, & Hunsinger, 2015).

In addition to an awareness of group configuration, this study also suggests that teachers must recognize the distinct ways that boys and girls engage with hands-on tasks. While boys exhibit more inherent enjoyment with equipment and materials, girls tend to view such actions in terms of task-relevance and learning goals. Making consistently explicit the connection to over-arching concepts and learning expectations that the hands-on task provides may motivate girls to stay actively engaged with this aspect of the activity. When active participation dissolves in a group, boys move towards playing with materials while girls are more likely to pursue written aspects of the task. This further suggests that the teacher must have some method for holding all students, both male and female, equally accountable for all aspects of the task, so that the writing and recording do not fall immediately to the girls. Creating rotating roles within groups, requiring the same amount of written output from all students, or simply expanding the parameters of the task to include more creative outlets than simply a lab report may provide greater to students for all roles and entry points into the task (Bourette, 2005; Brickhouse and Potter, 2001; Brotman & Moore, 2008; Dasgupta & Stout, 2014; Robinson, 2012;

Shakeshaft, 1995; Shanahan & Nieswandt, 2009; Shapiro, 1994; Tucker, Hanuscin, & Bearnes, 2008).

With the gender divide described by boys and girls in terms of their interest and perceptions of competence between science inquiry and engineering tasks, teachers must be exceedingly aware of how they structure and present engineering design tasks in order to make them equally engaging and relevant for their female students, and this may require greater attention to teacher training in this area. Worth further consideration is how prior literature discussing girl's interest in social issues and real-world connections as well as social collaboration may impact how such tasks could be delivered in the classroom (Bennett & Hogarth, 2009; Lee, 1998; Shakeshaft, 1995; Solomon, 1997, Yanowitz & Vanderpool, 2004). Would providing a greater connection between engineering and world issues appeal to girl's social conscience and desire to help those in need? Would a more specific requirement for preplanning, discussion, and designing before building help reduce the boys' tendency to just "jump in and start building" and equalize a systemic inequality between boys' and girls' prior access to and experience with building toys and materials? While these considerations require further research, they pose necessary questions for teachers to ask themselves when they are implementing engineering design activities in their classrooms in order to better motivate all of their students.

As educational reform in STEM seeks to improve all students' achievement in these domains and to include a more socially just approach to engaging all students, teachers must regularly reflect on the stereotypically gendered behaviors they may be seeing in their science classrooms. An honest assessment of such behaviors should thus lead teachers to consider how they structure groups and collaborative tasks within their classrooms in order to meet the needs of the greatest number of their student population.

Future Directions for Research

While future research should include a broader range of students, reflecting more varied cultural, socio-economic, geographic, and gender identities, there are other aspects of this study that warrant additional examination.

First, a closer look at the experience of the boys in this study is warranted. The dynamics seen in the all-male group often presented distinct and unique patterns, which should be examined in their own right. While this study supports the claim that a female majority may provide a more optimal scenario for girls' participation in STEM activities, the same claim cannot at this time be made for male-majority groups. As such, additional research should focus more intentionally on boys' experiences in small groups, particularly when they represent the majority.

Another area of this study that should be extended is the impact on science achievement that students from groups of varying gender configuration exhibit. In other words, does the increased participation of girls in female majority groups translate also to greater academic success? Exploring patterns and trends in outcomes would be a logical and important next step in evaluating the benefit of differently configured small groups.

Finally, replicating aspects of this study at a different age level would be important in terms of giving greater context and meaning to the *stereotype inoculation model* in this scenario. Research has already shown some positive effects of group composition, namely female majority, on university students working on engineering design tasks. While this study asserts positive outcomes for high school girls working in female majority groups, these findings have not yet been observed at any other age level. A critical next step would be to replicate this study at the middle school level, and perhaps at the elementary level as well, in order to determine the impact of developmental stage on motivated behaviors. Exploring the effect of group composition at these various stages would provide a richer and more complete understanding of the trajectory females experience through STEM, the longitudinal picture of their motivation in this domain, and how the stereotype inoculation model best fits into this overall story.

While current data remain unsettling regarding women's representation in many domains and fields of STEM, the collective understanding and approach to ameliorating this phenomenon continues to develop. Although initiatives must address this issue at every systemic level, from societal images and stereotypes, to family messages and background experiences provided to children, to education and community offerings, one promising area is specifically addressing the essential needs of intrinsic motivation for all students within the STEM classroom – those of autonomy, competence, and relatedness. Further, when a more nuanced look at relatedness is incorporated into how students work together in the classroom, greater opportunity can be provided for creating scenarios in which girls may engage and learn most meaningfully. Allowing girls to develop and broaden their STEM confidence and self-images through the opportunity to collaborate specifically with each other may contribute, as the *stereotype inoculation model* (Dasgupta, 2011a) posits, to an increase in the number of girls and women making it all the way to the end of that science pipeline.

APPENDIX A

JOVANOVIC & KING (1998) BEHAVIORAL INDICATORS

Performance Behaviors Observed During Small-Group Science Activities

Performance Behavior	**Description**
Directing	Instructing other group members on the procedure and execution of the activity
Manipulating	Handling the materials/equipment
Explaining	Explaining a science concept to another student
Suggesting	Offering suggestions regarding the execution of the activity or part of the activity
Assisting	Helping a student who is directing the activity
Following	Following another student’s directions
Observing	Passively observing the activity
Record-keeping	Taking notes or writing down results
Reading directions	Reading directions to others in the group
Request explanation from student	Requesting an explanation from another student
Request explanation from teacher	Requesting an explanation from the teacher
On task	Engaged not distracted in the activity
Working interactively	Working cooperatively with others in the group

APPENDIX B

DESCRIPTION OF SIX TASKS

Pill Bug

The pill bug task was a science inquiry activity that required the students to design researchable questions that they could answer regarding the pill bugs' responses to environmental stimuli. The students spent one day observing the pill bugs and conducting internet researching about the creatures' physiology, habitat, behavior, and other pertinent characteristics. As a group, they then developed a research question based on the background knowledge they had gained and designed an experiment that would allow them to collect data to answer their research questions. Examples of students' questions were: Do pill bugs prefer dark or light? Do they prefer hot or cold environments? Do they prefer sweet or salty foods? Through these questions, students also gained a greater awareness of controlling variables and creating experimental designs that would best meet the requirements of their questions.

Naked Egg

The naked egg task was another science inquiry investigation that allowed students to explore the process of diffusion across a cell membrane. Students learned, through research and teacher-directed instruction, about the process of osmosis and diffusion of molecules from areas of higher concentration to lower concentrations. By using raw eggs that had their shells removed to model cells, students predicted whether their eggs would gain or lose volume when placed within a variety of different liquids:

salt water, distilled water, oil, and soda, for example. Students designed experiments to test whether their predictions were correct.

Cellular Respiration

In this final science inquiry lab, students demonstrated their understanding of photosynthesis and cellular respiration and designed an experiment to show that all living things respire. Using test tubes of water with snails and elodea, students created various conditions that would prove that respiration had occurred in each of the test tubes. By using different combinations in each test tube as well as the additional variables of light and dark, students used bromothymol blue (BTB) to determine the pH, and therefore detect the presence of carbon dioxide and oxygen in their results, to show that respiration had indeed occurred.

Oil Spill

This engineering design task introduced students to the real-world problem of marine oil spills and required them to develop a system for cleaning up oil that would both contain and remove it from a shoreline. Using a model of a shore and various materials, students worked with a restricted budget to design, test, and improve their system. Improvement and success were determined by the amount of oil left on the surface of the water (using a piece of graph paper to collect a water sample and count dots of oil) and if any oil had reached the shoreline. Students completed several iterations of their prototype to try to improve their overall design and success rate.

Heart Valve

This second engineering design task presented students with a scenario in which a patient with specific medical needs and considerations requires a heart valve transplant. Based on the scenario, students design a prototype heart valve that will allow blood cells to flow in one direction through the heart and not travel back in the opposite direction. Using cardboard boxes or liter bottles for the hearts and marbles to model the blood cells, students created heart valves using various materials that would meet this criterion. They improved on their design, trying to reduce their percentage of marble that flowed back through the valve.

Pill Coating

In this final engineering task, students were asked to design a coating for pills that would taste good to the patient, stay on the pill, be an appropriate thickness, and would protect the pill from the acidic environment of the stomach. Students learned how simulation can help medical engineers predict a body's reaction to a medication. Using a variety of ingredients for the possible coatings, Skittles candy for the pills, and soda to simulate the stomach acids, students created recipes for their pill coatings and tested their effectiveness by putting them in soda and collecting data on the time taken for the coating to dissolve. Students improved on their recipes in terms of its appearance, presentation, and dissolving time.

APPENDIX C

FULL SET OF NSF FOCUS GROUP INTERVIEW QUESTIONS

General perceptions about the inquiry labs/design activities

- How did you like the different labs/design activities you did during the **last few weeks**?
- **Of the last three lab/design activities** was there one lab/activity that you liked better than others? One that you didn't like at all? Why?
- **Looking back to all the six labs/activities you did throughout the semester, was there one that you liked the most? If so, why? If not, why did you like all of them?**
- **Was there anything about the six labs/activities (three inquiry labs and three engineering design activities) that stood out for you? Why do you say this?**
- What do you think you learned **from the last three and from all six** labs/design activities?

Students' perceptions of how the group worked

- How did you like working in your group with your peers? What did you like/what didn't you like about working with your peers?
- Did you notice anything different when working on the inquiry lab (*name specific inquiry task*) in comparison to the engineering design activity (*name specific task*)?
- Do you think the tasks of the labs/activities were divided evenly among all of you? Why/why not?
    - **[NOTE: open circle indicates *possible* probe or follow-up questions] Did anything change in your tasks responsibilities during the last three labs/activities in comparison to the first three labs/activities?**
- **Do you think the way you worked in your group changed throughout the semester? If so, how and what? If not, how would you describe how your group worked?**
- What would you do differently as a group the next time you work together on a lab/activity?
    - Thinking about future labs/activities, would you want to work as a group again or would you prefer to work alone?

Individual contributions during group work – questions to be answered by each group member

- How did you choose your group or how did you end up with this group? Are you friends? Do you always work together in the science class? How about in other classes?
- **Note: If you remember what the students answered in the first interview, then you can ask them the follow-up question such as:**
    - **Are you still friends? Are you now friends? Do you work together in the science class and/or in other classes?**
- Did you see yourself having a particular task/role throughout the labs/activities (e.g., do experiment, answer questions)?
    - Did this role change during the inquiry lab (*name specific tasks*) vs. engineering design activity (*name specific tasks*)?
    - What did you do that helped your group to conduct the experiment and to find answers to the lab questions?
    - Do you think that your peers took your suggestions and comments seriously? Why/why not?
    - Do you think you knew what you should do for the different labs? Why/why not?
- How did each of you feel working with your peers at the different labs/activities? How did your feelings influence your work with your peers?

Group task management issues

- When you got stuck at a task, what did you do?
    - Was there one person in your group who could help you the most?
    - **Was there one person in your group who could help you the most depending on what lab/activity you were doing?**
    - Did you listen to this person and/or to each other's comments and suggestions? Why/why not?
    - What did you do when you couldn't agree on how to proceed with the experiment or to answer the lab/activity questions? When did you fell it was OK to ask the teacher?
- Where there times that you were frustrated during the lab/activity? If so, what did you do?
    - Was there a specific lab that you felt was frustrating?
    - Were there specific parts of a lab that were frustrating?
    - Were there situations that you were frustrated with your peers' work?

Ask a general questions about the class to finish formal interview:

- Did you enjoy your biology class? Why/why not?

Then give them their code page and ask them to write for a couple of minutes on the back side: If there is anything else that you want to share with me about how your group worked together during the labs/activities, then take a couple of minutes and write it down here on the back site of your code page. Also, please answer the questions about your grade.

Final question *(is on bottom of code page but ask students as well):*
If we have further questions, will it be OK to send them by email? If so, then please list your email on the bottom of the code page

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