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Resilience in STEM Students: An Analysis of the Demographic, Intrapersonal, and Interpersonal Predictors of Resilience

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by

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Abstract

This study is interested in the relationship between students of science, technology, engineering, and mathematics (STEM) and resilience. Specifically, this study aims to identify demographic, interpersonal, and intrapersonal predictors of resilience in STEM students. It was hypothesized that coping would mediate the relationship between anxiety and STEM students' resilience. Data was collected to determine the predictors of resilience. There was no difference in STEM and non-STEM students' resilience. With males demonstrating slightly higher resilience than females, however there were no racial group differences in resilience. Hierarchical linear regression analysis revealed that locus of causality significantly predicted resilience, specifically, that STEM students with higher resilience assigned less blame to themselves for STEM failures. Future research should use personality assessments, measures of grit, focus on attribution, and cognitive functioning to better understand the relationship between STEM students and resilience.

Introduction

If you were to go to Google and search "STEM in 2017," more than 350 million articles and websites would cloud your screen in less than one second. STEM, or science, technology, engineering, and mathematics, is a buzzword, igniting both interest and anxiety about a supposed growing need for STEM professionals in the global work force (Billimoria, 2017). Even Bill Nye of the 90's television show *Bill Nye the Science Guy* claims that science will "change the world" (Pasquantonio, 2017). According to some, STEM is the future. But what's the big deal? One teacher claims that teaching technology in the classroom helps students to engage more with the course material (Schwartz, 2017). Others claim that increasing interest in STEM fields would allow for solutions to troubling global trends and patterns, like climate change (Pasquantonio, 2017).

In theory, pursuing STEM fields sounds great—more engineers, mathematicians, scientists, and technology experts would mean that the global community would see unprecedented strides in research and development. In practice, though, pursuit of STEM careers is not as simple as some of those Google search results would indicate. Historically, women and racial minorities have been shunned from STEM fields, told that they were not smart, capable, or equipped enough to pursue STEM careers. There is now, however, an ongoing focus on promoting STEM higher education in women and racial and ethnic minorities, though (Byrd, Dika, & Ramlal, 2013). While this trend continues, troubles remain. For example, one cannot simply just choose to go into a STEM field and expect success. The right skills and tools must be available to promote such rigorous learning. Environments, family characteristics, and personal traits affect the pursuit and success of STEM students. A gap in the factors that promote the success of STEM students remains. This study aims to identify the factors that promote the development of resilience, a proposed reason why students may choose to pursue difficult and demanding career paths, like STEM majors.

Resilience

Resilience refers to one's ability to overcome difficult or trying situations (Eshel & Kimhi, 2016; Galligan, Barnett, Brennan, & Israel, 2010). Resilience acts as a protective mechanism in which people learn how to adapt to challenging events and situations (Howard, Dryden, & Johnson, 1999). In response to disruptive events, an individual can react in one of two ways: crumble under pressure, essentially being unable to handle the disruption, or be resilient, able to adapt to the challenges presented and effectively cope with the struggles presented (Fletcher & Sarkar, 2013). It reflects an individual's ability to persevere. This adaptation to threatening stimuli is essential; humans can accumulate through disruptive events, or challenging stimuli, qualities that make similar future events less disruptive to their lives (Richardson, 2002). Thus, by learning how to become more resilient during these challenging events, life is less likely to be interrupted by future challenging events. To further support this point, research has shown that resilience reduces the risk of psychological distress, helps with the management of daily demands, and also assists with the development of coping strategies (Pidgeon, Rowe, Stapleton, Magyar, & Lo, 2014).

A learned behavior. In the existing literature, there is some debate about the nature of resilience. Some definitions claim resilience is an internal factor— a personality trait—that helps an individual successfully adapt to situations deemed challenging or threatening (Luthar & Cicchetti, 2000). Resilience has been labeled as an internal force within everyone that drives them to gain knowledge and wisdom about themselves (Galligan et al., 2010). A theory of resilience as a personality trait exists. Known as ego-resilience, this theory was developed to describe a set of personality traits that encompasses sturdiness of character and general resourcefulness. “Resilience” inherently denotes encounters with adverse events, but experiences of adversity are not necessary for one to be labeled as “ego-resilient.” The difference between ego-resilience as a personality trait and resilience as a dynamic process lies in the encounters with and experiences of adversity (Luthar & Cicchetti, 2000). Thus, while there is a construct that explains a resilient personality, this theory does not adequately describe the truest experience of resilience in regard to experiences of adversity, opening a gap in the theory of resilience for future research to fill.

Many researchers have found other ways to describe resilience to counter the theory of resilience as a personality trait. Opponents of this theory hold that other factors, notably one’s environment and family, are critical to the development of resilient behaviors, insinuating that resilience cannot possibly be a static or inherent personality trait (Masten, Best, & Garmezy, 1990; Masten & Garmezy, 1985). Their research has instead pointed towards resilience being a learned behavior (Keye & Pidgeon, 2013; Masten et al., 1990; Masten & Garmezy, 1985). Literature supports resilience as being the outcome of a dynamic process through which individuals learn how to cope with stress and adversity (Pidgeon et al., 2014). In an attempt to conceptualize and better understand this development, research has been conducted on changes in resilience over time. For example, one study demonstrates the development of resilience in athletes through thought-shifts over time (Liu, Reed, & Girard, 2017). Longitudinal research of resilience trajectories demonstrates that resilience changes over time. Trajectory-based research has shown that resilience is either wholly absent, remains constant, increases, or decreases over time. This change in resilience levels at different points following trauma demonstrates that resilience undoubtedly changes over time. More importantly, though, by virtue of resilience levels increasing over time, research has demonstrated that resilience can be learned (Bonanno, Wortman, & Nesse, 2004).

Garmezy's Theory of Resilience. Research on resilience by Norman Garmezy and Anne Masten has led to the development of a three- pronged theory of resilience. According to this theory, resilience is influenced by (1) a child's personality factors, (2) characteristics of the child's family, and (3) factors of an individual's wider social environment (Garmezy, Masten, & Tellegen, 1984; Masten & Garmezy, 1985).

Personality. In accordance with Garmezy and Masten's theory, an individual's personality influences the development of resilience (Garmezy et al., 1984; Masten & Garmezy, 1985). That is, while resilience itself may not be a personality trait, its development through various events and interactions with others is mediated by personality factors. Personality refers to individual differences in patterns of thinking, feeling, and behaving. There are many different theories of personality, but currently, most personality assessments are based on the Big Five Theory of Personality (Israel et al., 2014; "Personality May be Key Risk Factor in Preventive Health Care," 2014). This theory holds that there are five main personality traits of which people have either high or low amounts: openness to experience, extraversion, agreeableness, neuroticism, and conscientiousness. Personality is linked to a wide variety of major life outcomes and general well-being (Hengartner, van der Linden, Bohleber, & von Wyl, 2017). In fact, recent research has shown that high levels of certain Big Five traits indicate better outcomes; for example, high levels of conscientiousness showed better health outcomes ten years later (Israel et al., 2014). Neuroticism is significantly related to acute fear and traumatic distress as well as to more enduring maladaptive coping. Similarly, agreeableness and conscientiousness are positively related to social activity following trauma. In short, research has demonstrated a strong association between personality and behavioral reactions to trauma (Hengartner et al., 2017; Israel et al., 2014).

It is reasonable to conclude, then, that personality factors may influence the development of resilient behavior over time. In fact, leadership styles, a proactive personality, and optimism, were found to be significantly related to resilience (Nguyen, Kuntz, Näswall, & Malinen, 2016). Study of specific personality traits (hope, grit, meaning of life, curiosity, gratitude, control beliefs, and use of strength) showed that all seven of these personality traits significantly moderated the effect of negative life events on subjective well-being, indicating that they, too, are significantly related to resilience (Goodman, Disabato, Kashdan, & Machell, 2017). Self-awareness, especially the personality trait of self-insight, was found to be a significant predictor of both resilience and stress, supporting the notion that personality mitigates stress and promotes resilience (Cowden & Meyer-Weitz, 2016). The Big Five trait of agreeableness was negatively associated with the coping strategy of medication use, indicating that agreeableness may contribute to the development of successful resilient behavior (Hengartner et al., 2017). Taken together, these studies demonstrate that various individual personality factors are related to resilience and indicate that personality plays a significant role in the formation and development of resilience through life events and social interactions.

Family factors. The characteristics of one's family are also key to the development of resilience (Garmezy et al., 1984; Garmezy & Rutter, 1983; Ungar, 2011). The effects of the family, particularly parents, on children are well studied. Children with absent parents, for example, show more ambivalent relationships with teachers and peers compared to peers with non-absent parents. Similarly, the effect of this ambivalence leads to greater levels of anxiety and depression in children (Luo, Gao, & Zhang, 2011). A father's unemployment is negatively related to children's health (Bacikova-Sleskova, Benka, & Orosova, 2015). Conversely, a father's warmth predicts adolescents' positive beliefs. In male adolescents, a father's warmth and English language arts grades are mediated by academic self-efficacy and persistence on challenging work. For female adolescents, relations between a father's warmth and math grades are mediated by optimism and determination. Taken together, these trends indicate that a father's warmth has positive effects on his adolescent children (Suizzo et al., 2016). Parents demonstrating positive support behavior leads to improvements in children's inhibitory control and language development, effectively improving school readiness in children (Lunkenheimer et al., 2008). These studies demonstrate a clear link between family characteristics and child well-being.

Because parents play such an influential role in a developing child's life, it makes sense that a parent's interaction with his or her children affects the development of resilience. In fact, studies have shown that the nature of the parent-child relationship does indeed predict resilient behavior in both parents and children (Garmezy et al., 1984, 1984; Howard, Dryden, & Johnson, 1999). Parental empowerment signifies a parent's confidence in managing their children and is highly related to parents' resilience to demands. Thus, promoting parental self-confidence and providing support to parents reinforces empowerment and promotes the well-being and coping of the entire family unit (Vuorenmaa, Perälä, Halme, Kaunonen, & Åstedt-Kurki, 2016). Effects of the family dynamic can be seen in children, too. Children demonstrate many characteristics of resilience when they have a warm and personal relationship with an adult, like a parent (Richardson, 2002). One study found that war-exposed children still showed resilience when their parents spent time with them and supported them in their school work (Fayyad et al., 2017).

Thus, the importance of parents and the family unit to the development of resilience cannot go unrecognized.

Environmental factors. In accordance with Garmezy's theory, social environments, and the added component of physical environments, are essential to the development of resilience (Garmezy et al., 1984; Masten & Garmezy, 1985). Social environments, especially in the form of friends, peers, teachers, and role models, help mitigate stress and reduce negative affect in the face of adversity (Hershberger, Zapolski, & Aalsma, 2016; Perrier, Boucher, Etchegary, Sadava, & Molnar, 2010; Williamson & O'Hara, 2017). Physical environments significantly contribute to the cognitive and physical development of children. However, early life environments can vary drastically, with some demonstrating higher risks than others. Early socioeconomic risks affect children's reading both directly and indirectly via effects upon home environments. That is, factors like low socioeconomic status may make it more difficult to provide enriching home environments for developing children (Crampton & Hall, 2017). Disorganized and chaotic environments, for example, have been found to increase cheating behavior in children (Jansen, Giebels, van Rompay, Austrup, & Junger, 2017). Current literature suggests that externalizing factors within risky environments, like exposure to illicit drug use, delinquent behavior, and neighborhood crime, contribute to later delinquent behavior in people (Brook, Brook, Rubenstone, Zhang, & Saar, 2011). Community- and school-based programs can challenge these high-risk environments, though. For example, school based programs, specifically teacher-led out-of-school-time programs, can compensate for social disadvantage by promoting better academic performance in children (Pensiero & Green, 2017).

Environment influences the development of resilience, as well. Children living in high risk environments can still achieve positive outcomes, despite the previously-held notion that high risk environments promote psychopathology, poor achievement, and violence (Buckner, Mezzacappa, & Beardslee, 2003; Liu et al., 2017). High risk environments, such as perinatal stress, poverty, and daily instability within the home, introduce children to stressors. With the idea that adaptation to challenging stimuli helps reduce future life distress, these repeated or chronic stressors, in conjunction with other protective factors, taught children how to adapt and function despite the threatening stimuli (Richardson, 2002). In other words, the high-risk environment to which some children are born provides chronic stressors that teach children how to adapt. A study of socioeconomically disadvantaged students in rural India found that students could achieve good outcomes, despite a high-risk environment, and showed that both individual and school factors are protectors factors in the development of resilience (Narayanan, 2015). Another study found that individuals with poorer resilience were more likely to engage in bullying behaviors and more likely to be victims of bullies whereas high resilience factors acted as protective factors against anxiety and depression. As such, research has hypothesized that home environments that foster elements of trust, tolerance, and sensitivity contribute to the development of resilience in adolescents (Moore & Woodcock, 2017). Collectively, these studies indicate that resilience can be directly influenced by the environment in which the individual is born and raised.

In summation, Garmezy's theory proposes three main predictors of resilience: an individual's personality, family, and environment. Together, these factors provide a framework for which resilience in college students, particularly students of STEM, can be studied.

Predictors of Resilience in College Students

Becoming a legal adult and celebrating the 18th birthday is a momentous time in any person's life. However, the cognitive and social changes associated with becoming an adult are just starting. That is, the time following one's high school years, a time known as emerging adulthood, presents its own set of new challenges and experiences (Poole, Van Lieshout, & Schmidt, 2017). During this time, people are between the tail-end of adolescent development and the beginning stages of adulthood. Emerging adulthood is usually characterized as an age of identity exploration, instability, and focus, with particular emphasis on feelings of being "in between," and being optimistic about new possibilities (Munsey, 2006; Poole et al., 2017). This is a time when many young adults travel to new places, enroll in colleges and universities far from home, meet new people, and are exposed to new experiences. However, this is a time of personal change and self-reflection that can be difficult. As such, emerging adulthood is a time in an individual's life where resilience is important. This is a significant time for many people; leaving home, reaching a new level of cognitive understanding, and transforming the meaning of a negative past into a positive identity allows for the development of resilience during emerging adulthood (Jensen Arnett, 2015).

Within American society it is widely accepted that pursuing higher education, like college and university, is necessary for more, and better, job opportunities (Jensen Arnett, 2015). Colleges and universities provide new environments with new experiences for emerging adults (Reckdenwald, Ford, & Murray, 2016). In fact, just choosing a college to attend is a great responsibility for many students, who, at this time, begin to seriously think about higher education as the launchpad for a future career. Attending college not only exposes students to new opportunities, ideas, and people, but it also provides students with the ability to make decisions without parental approval (Jensen Arnett, 2015). As such, some students engage in new and sometimes maladaptive behaviors. For example, studies show that college students are at an increased risk for alcohol use and binge drinking compared to their same age peers who are not in college (Reckdenwald et al., 2016).

Emerging adults at undergraduate institutions quickly realize that they must decide on a career path. Thus, the decision to pursue STEM fields becomes an important choice made by many students. Many factors may influence emerging adults' decision to pursue STEM for their undergraduate studies. Drawing on historical biases, female and minority undergraduate students may not feel accepted in STEM programs (Simon, Wagner, & Killion, 2017). Anxiety about the course material, readiness, and acceptance can also affects emerging adults' decision to pursue STEM fields (Bryant et al., 2013; Greenburg & Mallow, 1982). Acceptable collegiate STEM programs may not be readily available to all students, especially those facing financial troubles (Hansen, 2014). A lack of representative role models may prevent students from feeling comfortable and may inhibit emerging adults attempting to pursue STEM fields from learning from the experiences of relatable mentors (Borum & Walker, 2012; Carpi, Ronan, Falconer, & Lents, 2017; Hansen, 2014). Because of these roadblocks, college and university students who pursue STEM disciplines must be aware of the challenges they will face as STEM majors and professionals. It is likely, then, that the students who do choose to pursue STEM fields are characteristically different than their non-STEM counterparts. Perhaps resilience explains this difference. Thus, like Garmezy's proposed theory of resilience, this study is interested in predictors of resilience. Specifically, individual, interpersonal, and environmental predictors are considered as possible predictors of the development of resilience in STEM students.

Individual predictors. Proposed individual predictors of resilience include race and nationality, socioeconomic status, causality of performance, and gender.

Race and nationality. Underrepresentation of racial groups in various fields is common. This underrepresentation can be detrimental for racial and ethnic minorities. Underrepresentation accounts for many achievement gaps and inequalities in school settings. It has been hypothesized to be a function of beliefs and stereotypes held by those with power or social capital (Ford, 2014). One study found that underrepresentation of Blacks, Hispanics, and American Indians/ Alaskan Natives was due to low matriculation from high school to undergraduate institutions. This represents a significant contribution to the gap between race-ethnic groups (Garrison, 2013).

Underrepresentation of racial and ethnic minorities in education is telling. In 2011, across all two- and four-year public and private higher educational institutions in the United States, ethnic minorities composed only 18.7% of the total population, whereas 73.8% of the population was White. Minority enrollment is highest in private two-year colleges (30.6%) and lowest in two-year public colleges (17.9%). However, neither public nor private four-year colleges perform much better than two-year public colleges when it comes to minority enrollment (19.2% and 18.0%, respectively). We see this trend continue in graduate programs. In 2012, of the individuals pursuing doctorates in the United States, 73.5% identified as White, 9.1% Asian, 6.5% Hispanic, 6.3% Black, 2.5% identified as two or more races, and 0.3% American Indian (Schmaling & Jones, 2017).

Race-based discrimination, unfortunately, happens quite often and its effects have been well-researched. Some racial and ethnic minorities experience racial discrimination as psychological trauma, with responses similar to posttraumatic stress (Polanco- Roman, Danies, & Anglin, 2016). Similarly, being Black compared to White predicted more perceived discrimination (Vassillière, Holahan, & Holahan, 2016). There are also significant links between race discrimination and substance abuse as a coping mechanism (Thompson, Goodman, &

Kwate, 2016). However, there are ways to mitigate the relationship between race discrimination and poor outcomes. For example, parents can help children process their understanding of discrimination, lessoning the negative effects of race discrimination (Ayón, 2016).

Within the context of school, students who experience direct racial discrimination demonstrate higher depressive symptoms and greater levels of loneliness (Priest, Perry, Ferdinand, Kelaher, & Paradies, 2017). Ethnic and racial discrimination also mediates the relationship between adequate sleep quality and school engagement and performance (Dunbar, Mirpuri, & Yip, 2017). In college students, discrimination is negatively associated with math and science self-efficacy. Having more diverse friends is positively associated with academic self-efficacy and intention to major in STEM. Diversity of friends acts as a buffer between the relationship between discrimination and intention to major in STEM; as such, having more diverse friends decreases the negative effect of discrimination on intention to major in STEM (Hall, Nishina, & Lewis, 2017). One study found that African American women hold weaker implicit gender-STEM stereotypes compared to European women. This relationship contributes to ethnic differences in female STEM participation, as well. African American men, too, hold weaker implicit gender-STEM stereotypes compared to European men, but this does not affect the ethnic participation within STEM fields (O'Brien, Blodorn, Adams, Garcia, & Hammer, 2015). Similarly, research has shown that a being Black or Latinx STEM degree holder has a significantly lower probability of finding STEM job opportunities (Wright & Simms, 2016).

Students of color arguably face the most discrimination in STEM fields. Underrepresentation and discrimination work in tandem to prevent racial and ethnic minorities from feeling comfortable in STEM programs. Similarly, the already established underrepresentation of STEM professors and professionals of color make it difficult for students to access relatable mentors (Byrd et al., 2013). It would be these mentors that would help guide students through both the challenges and rewards of STEM careers , as well as the discrimination they may face in the field (Borum & Walker, 2012; Carpi et al., 2017; Hansen, 2014). If the current trend of underrepresentation and discrimination in STEM fields continues, fewer students of color will enter STEM fields and careers, effectively reinforcing historically-influenced and socially-held stereotypes about people of color and academic and professional ability (Byrd et al., 2013).

Students' nationality may affect their interpretation of STEM majors and courses. American students who studied abroad, for example, believe their time abroad was most valuable because of the social and cultural experiences gained. Foreign students studying in the US instead interpreted their time abroad as an enhancement of academic and professional skills. Similarly, information and communication technologies, a STEM major, were valued more by international students as potential career paths and valued by Americans as a platform for social interaction (Komura, 2014).

Socioeconomic status. Socioeconomic Status (SES) is an individual's or group's social standing of class, and tends to be measured using income, education, and occupation SES also encompasses quality of life as well as the opportunities and privileges afforded to members of society. It is a consistent and reliable predictor of life outcomes, including physical and psychological health and wellbeing ("Education and Socioeconomic Status Factsheet," 2012).

There is a strong relationship between low SES communities and inadequate local schools in the United States (Lewis, Snow, Farris, Smerdon, & Kaplan, 1999). That is, in low SES communities, local schools receive less funding, making it extremely difficult to get updated technology, textbooks, and other school materials that might improve the educational experience of students. Students ultimately suffer the consequences. The education that poor students receive is insufficient compared to the education received by advantaged, middle and upper-class peers (Hudley, 2013). Because they're in a school system where there is no adequate funding to get updated source material, these students face a greater liklihood of not being prepared for college or university (Wirt et al., 2004). For example, in low income communities, mathematics is two times as likely to be taught by a teacher with a degree in something other than mathematics compared to high-income schools (Hudley, 2013). Similarly, due to their low SES, these families cannot move from their community to seek better educational opportunities, making it extremely difficult for low SES students to succeed in these environments and/or pursue and achieve success in higher education (Wirt et al., 2004).

The effects of SES do not only apply only to young children and adolescents; they are far reaching, influencing young adults. Students from low SES see lower levels of self-focus (Jensen Arnett, 2015). SES has an important effect on the general self-efficacy and on subjective well-being of college students. In particular, students from low SES homes score significantly lower on measures of self-efficacy and well-being compared to their high SES counterparts (Tong & Song, 2004). However, emerging adults who are also low SES see this time in their life as a time of great possibility (Jensen Arnett, 2015).

SES also has strong links to academic performance in college. Students from low SES households engaged in fewer extracurricular activities, worked more, studied less, and, overall, had lower GPAs compared to their high SES counterparts (Walpole, 2003). Low SES predicts lower academic performance (Pienaar, Barhorst, & Twisk, 2014). Similarly, SES predicts significant changes in reading and math achievement (Lawson & Farah, 2017). Research has consistently shown that low SES students have fewer opportunities to in succeed university contexts compared to high SES students (Jury et al., 2017). Research has even linked SES with pursuit of STEM majors. Results from one longitudinal study demonstrates that SES plays a significant role in the pursuit of STEM majors; high SES families compensate for negative predictors of STEM enrollment, particularly gender and race. Similarly, high SES strengthens positive predictors of STEM, like math preparation (Niu, 2017). However, even if economic barriers are overcome, low SES students may still experience more threat, health problems, negative emotions, and lower levels of motivation than their peers (Jury et al., 2017). The effect of this disparity can be long lasting. Data from a longitudinal dataset showed that nine years after college, low SES students reported lower incomes, educational attainments, and graduate school attendance (Walpole, 2003). Some individual factors can improve the relationship between SES and academic performance, though. Low negative affect and high effortful control mitigate the negative associations between SES risks in both reading and math development (Wang et al., 2017).

Causality of performance. Attribution theory is one explanation of the cause of events and behavior, generally organized as internal or external attribution. Internal attribution refers to the process of assigning causality of performance to oneself and to personal factors. External attribution refers to assigning cause of behavior to external and situational factors (Weiner, 2012). Attribution is particularly important when analyzing school and academic achievement. That is, an individual can either blame himself—internal attribution— or other factors—external attribution—for failures (Schacter & Juvonen, 2015).

A longitudinal study revealed that effort and ability were the most important factors when considering cause of school performance. However, in the face of failure, ability beliefs may undermine a student’s motivation and can have negative effects (Roque, Serra de Lemos, &

Concalves, 2014). Self-blame affects academic performance in students. A greater use of self-blame as a coping strategy is linked to higher burnout rates in internal medicine students. Similarly, greater use of self-blame is associated with greater emotional exhaustion (Spataro, Tilstra, Rubio, & McNeil, 2016). The effects of self- blame can be decreased by interventions that specifically target cross-aged teaching of social issues. Not only do such interventions decrease levels of self- blame, but they also improve self-esteem and help-seeking (Boulton & Boulton, 2017). Similarly, studies have demonstrated that decreasing bullying behaviors, like discrimination in schools, decreases the occurrence of self-blame in students (Schacter & Juvonen, 2015).

Gender. STEM fields have historically been dominated by men. Recently, however, an increasingly large number of women are earning STEM degrees and entering the workforce. Despite record high numbers of women earning degrees in STEM, there remains a significant gender gap in the field. Living in denser STEM labor markets elevates the probability of matching between STEM degree holders and STEM jobs and opportunities. However, women remain far less likely than men to be placed (Wright & Simms, 2016). Similarly, despite more women earning STEM degrees, there remains a gender gap within the field of mathematics (Borum & Walker, 2012). The gap could also be explained by implicit gender biases. Female engineering students, for example, hold weaker implicit gender-math and -reasoning stereotypes compared to female humanities students. This indicates that women in STEM courses tend to not hold the historically-informed implicit biases that women cannot or are not able to do math and science. Similarly, female engineering students were less likely to hold implicit gender- math and -reasoning biases compared to male-engineering students and male-humanities students, indicating that men, overall, tend to hold these historically informed biases about women's ability to perform in STEM fields (Smeding, 2012).

STEM women report inadequate access to advanced training in STEM occupations. This unfortunately contributes to a lack of commitment and results in women leaving STEM occupations (Glass, Sassler, Levitte, & Michelmore, 2013). Survey respondents identified blatant gender discrimination (i.e. "What if she has to leave to take care of her children?") during STEM job hiring processes as a reason for the underrepresentation of women in STEM field. Women in STEM leadership positions have also claimed that their accomplishments are relatively uncelebrated compared to their male counterparts (Howe-Walsh & Turnbull, 2016). Taken together, the gender-gap within STEM fields is very apparent. What's more troubling, though, is that this gap remains due to blatant discrimination of women during the hiring process of STEM occupations.

Social Support

Social support is the present study's proposed interpersonal predictor of resilience. It has been defined as the "emotionally sustaining qualities of a relationship" like feeling loved, cared for (Glozah & Pevalin, 2017, pg. 88). In fact, current literature holds that in time of distress, people look for attachment figures and social support in the form of family, friends, and peers (Hershberger et al., 2016). The link between social support and outcomes is well known. For example, social support is related to beneficial psychological health outcomes in response to adversity (Perrier et al., 2010). It mitigates stress and promotes emotional health during times of transition, as well (Leinonen, Solantaus, & Punamäki, 2003). Social support is associated with positive affect and decreased negative affect (Williamson & O'Hara, 2017). One study found that individuals' experience of hopelessness because of race-related stress is reduced by social support (Odafe, Salami, & Walker, 2017).

The effects of social support can be seen in college students and career choices, as well. Social support systems provide graduating college seniors with opportunities for more concrete career decisions and exploration of occupational identities (Ghosh & Fouad, 2017). Similarly, higher levels of social support were found to be significantly related to greater competence in students (Krabbenborg, Boersma, van der Veld, Vollebergh, & Wolf, 2017). Students with greater social support in mathematics and science from family, friends, and teachers reported better attitudes and higher perception of competence in math and science courses (Rice, Barth, Guadagno, Smith, & McCallum, 2013). One study found a potential link between STEM and relationships, with female STEM majors indicating that a supportive romantic partner is a positive determining factor for their success in STEM (Barth, Dunlap, & Chappetta, 2016). For women, increased social support resulted in a greater sense of belonging, motivation, and less insecurities related to STEM disciplines and competence. Social support also predicted lower STEM dropout rates for women (London, Rosenthal, Levy, & Lobel, 2011).

Institutional Support

Institutional support is this study's environmental predictor of resilience. School environment, such as, size, type (public or private), location, and racial and SES composition, are factors that either contribute to or undermine the academic achievements and engagement of students (Wang & Degol, 2016). Classrooms and teachers are essential to the success of students in academic settings. For example, one study found that class structure, as created by a teacher, was extremely important in determining student engagement within class. That is, teachers with authoritarian discourse tended to lecture more, used close-ended questions to test knowledge, and spent less time answering students' questions. Conversely, teachers employing dialogic teaching methods in their classrooms varied instruction and used open- ended questions to test knowledge. These students, in turn, answered questions more frequently and thoroughly, and also felt compelled to share their own ideas more (Tofel-Grehl, Callahan, & Nadelson, 2017).

Teacher support has been shown to be very important for students. That is, students who start the year as high-risk but receive high teacher support, end year on par with low-risk students (Pitzer & Skinner, 2017). High turnover of STEM faculty negatively impacts mathematics retention in students. Unfortunately, high STEM faculty turnover occurs more in low-performing schools, which only further hurts the potential of students (Hansen, 2014). Research has indicated that when schools restructure their classrooms and programs to increase the availability of resources, like updated textbooks, students experience more positive academic outcomes (Wang & Degol, 2016).

High schools and the academic support they do or do not provide are also important to the development of resilience and the pursuit of STEM fields. Many high schools provide honors or advanced education tracts for students with the aim of promoting STEM careers. These include Advanced Placement (AP) and International Baccalaureate (IB) courses and provide an avenue through which students can excel and be introduced to more STEM courses (like advanced mathematics and life sciences) ("Work Toward College Success," 2017). For example, AP math courses prepare students more, encouraging a greater understanding and mastery of the course material (Judson, 2017a). Contrary to popular belief, enrollment in AP classes in high school does not predict pursuit of STEM careers later, even though such courses are often advertised to do so. Minority students are not benefiting much from STEM AP courses, either. In fact, they tend to be among the lowest of AP exam performers (Judson, 2017b). In urban schools, more AP courses are now available but students do not feel any more prepared for college compared to non-AP course takers (Hallett & Venegas, 2011). Thus, tract programs do not automatically predict better academic outcomes, like better test scores and greater pursuit of STEM careers, and, instead make it even more difficult for an institution to provide support for its students.

Professors often act as very important sources for their students, holding within them expert knowledge of a given field and knowing what it takes to succeed in that field. Thus, college and university faculty often become role models and mentors to their students. Mentorship is particularly important for students pursuing STEM career paths. Undergraduate students are more likely to pursue professional and academic STEM career tracts involving post-graduate study, and effectively increasing pursuit of STEM careers, when engaged in undergraduate mentored research (Carpi et al., 2017). Women report that having mentors, a supportive program, and study groups were vital and important factors that significantly contributed to their success in STEM fields (Borum & Walker, 2012). In fact, quantitative data collected from women in STEM showed that a lack of female professors was particularly detrimental to the development of female students. Similarly, STEM women felt little or no support in the development of their STEM careers when there were few or no females holding leadership positions (Howe-Walsh & Turnbull, 2016). Past research has indicated that male students who report stronger ability for self-regulated learning have greater chances for success in classes taught by female instructors (Johnson, 2017). Similar trends can be seen in minority students, as well. Having ethnically diverse faculty increases preparedness and comfort on campus for ethnic minority students (Parasnis & Fischer, 2005). Diverse faculty members act as role models for students to learn from and relate so as to have a relatable mentor to demonstrate the challenges and rewards of particular career paths. Thus, promising students in academic settings without relatable faculty role models can be negatively impacted (Mendoza, 1986).

Anxiety and Resilience: The Effect of Coping

Students often experience anxiety in response to schoolwork, but this anxiety can have adverse effects on performance. Specifically, anxiety about school in kindergarten through high school will persist into college and university unless there is some intervention to reduce this anxiety (Auger, 2013). The school environment itself, regardless of subject, can be anxiety-provoking. Test anxiety is a good example of the anxiety produced by the demands of school. Students with high test anxiety demonstrate reduced working memory capacity during high pressure tasks, like a test (Zhang, 2017). High anxiety makes it difficult for students to plan, organize, and set deadlines (Auger, 2013).

Anxiety can also be associated with specific subjects, too. For example, mathematics anxiety is significantly negatively correlated to mathematics performance. What's more is that math anxiety is also significantly correlated to poorer overall academic performance (Venkatesh Kumar & Karimi, 2010). Math anxiety is a global phenomenon, seen in students all over the world, and can be partially contributed to the worldwide growing need for STEM professionals (Foley et al., 2017). Analysis of Scholastic Aptitude Test (SAT) scores indicate that at every math skill level, math anxiety correlated negatively with interest in scientific careers (Chipman, Krantz, & Silver, 1992). Math anxiety and general anxiety can be reduced in high school students, however, using expressive writing interventions that promote thought organization and pattern recognition (Hines, Brown, & Myran, 2016).

Similar patterns of anxiety can be seen in science and technology fields. Women tend to be more science-anxious than men, likely drawing upon years of historically-informed biases about women's STEM abilities. This gender difference in science anxiety is particularly high in female American students and minorities (Bryant et al., 2013; Greenburg & Mallow, 1982). Women also tend to have higher levels of computer anxiety compared to men (Williams & Johnson, 1990). Research indicates that more positive attitudes about science correlates to lower statistics anxiety in college students (Bui & Alearo, 2011). One study found that students majoring in education tend to have high computer anxiety, which could have direct effects on the development of technology anxiety in their future students (Williams & Johnson, 1990).

STEM courses can be quite stressful and anxiety-producing, as they tend to take a lot of time and effort to comprehend. Coping is important, then, for students who face anxiety and adversity within these contexts. For example, literature supports the claim that positive coping strategies protect students from lower academic achievement linked to social mobility (Boon, 2011). The type of coping strategy used, like avoidant or active/engaged, contributes significantly to the variance in psychological distress, positive affect, negative affect, and satisfaction in life (Roxas & Glenwick, 2014).

Research has shown coping strategies to be important to students' ability to handle stress, but coping strategies also have significant relations with cognitive motivation and achievement variables (Hsieh, Sullivan, Sass, & Guerra, 2012). Regarding STEM, literature supports the notion that coping strategies that are natural and direct, like recognizing math difficulty and asking for assistance when necessary, will significantly reduce math anxiety in undergraduate students (Perry, 2004). Coping strategy has been shown to mediate self- regulation and mastery goal setting. In fact, mastery goal is related to self- initiation, persistence, deep learning, and self-monitoring behavior, all of which are essential to success in STEM fields (Hsieh et al., 2012). It is likely, then, that students who face adversity or anxiety within the context of STEM courses develop these effective coping strategies that promote qualities important for success in STEM careers. Because of this relationship between anxiety, coping, and behaviors that promote success in STEM fields, coping strategies likely mediate the relationship between resilience and anxiety, so that students who are high in resilience are better at coping and thus, see a reduction in anxiety related to STEM courses.

Current Study

Much remains unknown about the predictors of resilience. Garmezy's theory of resilience pinpoints three general predictors of resilience: an individual's personality factors, characteristics of the family, and factors of an individual's wider social environment (Garmezy et al., 1984; Masten & Garmezy, 1985). While his study looked specifically at children and their families, this theoretical framework readily applies to emerging adults. The specific factors that contribute to resilience in STEM students remains largely unknown. This specific group of individuals is required to undergo years of strenuous study, indicating that resilience might affect who does and does not choose to pursue STEM majors. The present study aims to identify the predictors of resilience as a learned behavior within the context of college STEM students. The relationship between interpersonal, intrapersonal, and environmental factors will be examined to determine which factors predict greater resilience in college STEM students. Based on previous research, this study predicts that STEM majors will demonstrate higher levels of resilience compared to non-STEM majors (Hypothesis 1); gender and race differences in resilience for STEM students will emerge, such that minority female STEM students are more resilient than male STEM students (Hypothesis 2); anxiety will indirectly relate to resilience in STEM students, and use of coping strategy will mediate this relationship (Hypothesis 3).The individual and institutional predictors of resilience will also be analyzed in this study.

Method

Participants

Participants completed the survey on Qualtrics, an online service that hosts and administers surveys. Thirty males, 123 females, and two unidentified individuals, for a total of 155 participants, completed the survey. Participants were between the ages of 18 and 45 (*M* = 21.03, *SD* = 3.33). Thirteen participants did not report their age. Participants were diverse in racial-ethnic identity, but the majority of participants identified as White/ European Origin, Non-Hispanic (*n* = 108). Participants also identified as Black/ African Origin (*n* = 13), of Asian Origin (*n* = 15), and as Biracial/ or Multiracial (*n* = 4). Nine participants preferred not to provide their racial-ethnic identity (*n* = 9). Three participants self-identified as Pacific Islander (*n* = 1), Chinese American (*n* = 1), and Middle Eastern (*n* = 1). Most of the participants attended a liberal arts college (n = 76). Fifty-three participants attended a four-year public university, and 26 participants attended a four-year private university.

One hundred and eleven participants were STEM majors. Of these STEM major participants, 20 identified as male and 89 identified as female and were between the ages of 18 and 32 (*M* = 20.86, *SD* = 2.33). Seven participants did not report their age. The majority of the STEM participants attended a liberal arts college (n= 45) or a four-year public university (n = 44), while 22 participants attended a four-year private university. The majority of STEM majors identified as White (n = 78) and 31 participants identified as a Person of Color. Two participants chose not to reveal their race.

Materials and Procedure

Participants were recruited online, via email. Participants were found by emailing the Student Government Associations, Black Student Associations, International Student

Associations, and other college and university groups whose memberships are composed of both STEM and non-STEM students. The college and university groups' email addresses were accessed via the educational institution's student organizations website. Recruitment was also completed through The College of Wooster's internal social science research site, SONA Systems. Wooster students were eligible to participate in the survey and receive credit for class. After receiving the survey link via the recruitment email or signing up via SONA systems, participants completed the survey on Qualtrics. After viewing and electronically signing consent forms, participants were asked if they had taken, or are currently taking, a STEM course at their college or university. Those who answered "no" were taken to the end of the survey and thanked for their participation. Those who answered "yes" were taken to the first set of survey questions.

Demographic information was collected first: gender, nationality, and type of institution (e.g. liberal arts college, 4- year private university, 4- year public university). Socioeconomic status (SES) based on household income was also collected. Lastly, participants were asked to identify their race/ ethnicity.

STEM major status was measured by having participants report their specific major (e.g. neuroscience, biology, chemistry, economics, etc). This was later coded as either "STEM" or "non-STEM" majors based on the following categories of majors: Math and natural sciences ("STEM"), history and social sciences ("non-STEM"), and arts and humanities ("non-STEM").

Institutional support was measured using two yes/ no questions and one free response question (see Appendix A). The first question targeted whether the participant was aware of STEM resources on campus. A follow-up question identified the participants who use the STEM resources. A free response answer allowed participants to identify specific resources they use (e.g. a tutor, study groups, etc).

Social support was measured using the Academic Support Scale (Lent et al., 2005) (α = .85). The nine items were rated on a 5- point Likert- type Scale, ranging from 1(*strongly disagree*) to 5 (*strongly agree*), with higher numbers indicating greater amount of support. Items included the following, “I feel support from important people in my life (teachers) for pursuing my intended major” and “I get encouragement from my friends for pursuing my intended major.” Scores were obtained from summing all items within the scale and dividing the sum by 9.

Perceived discrimination in the classroom was measured by the Educational Discrimination Distress Subscale of the Adolescent Discrimination Distress Index (Fisher, Wallace, & Fenton, 2000) (α = .49). Participants were asked to consider their past or current experiences in STEM courses when answering these items. The four items were rated on a 3-point Likert- type Scale, 1 (*disagree*), 2 (*neither disagree nor* agree), and 3 (agree). Items included, “You were discouraged from joining an advanced level class” and “people expected more of you than they expected of others your age.” (There was an error in inputting the survey into Qualtrics which might explain the low inter-item reliability. This will be explained more in the Discussion.)

Resilience was measured using the Brief Resilience Scale (BRS) (Smith et al., 2008) (α = .87). The six items were rated on a 5- point Likert- type Scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), with higher scores indicating a greater level of resilience. Items included “I tend to bounce back quickly after hard times,” and “I usually come through difficult time with little trouble.” Scores were obtained by summing all the items within the scale and dividing by the total number of questions answered.

Anxiety was measured using the Beck Anxiety Inventory (BAI) (Beck & Steer, 1984) (α = .94). Participants were asked to consider their experiences within STEM courses when answering the items. The 19 items were rated on a 4- point Scale, ranging from 1 (*not at all*) to 4 (*severely- it bothered me a lot*), with higher scores indicating greater levels of anxiety. Items included "numbness or tingling" and "fear of losing control." Scores are obtained from summing each item together. Scores between 0 and 21 indicated very low anxiety. Scores between 22 and 35 indicated moderate anxiety. Scores exceeding 36 indicated high anxiety.

Causality of performance was measured using the Revised Causal Dimension Scale (CDSII) (McAuley, Duncan, & Russell, 1992). Participants were asked to imagine they failed an exam or an assignment within their STEM course. Participants then indicated level of agreement on a 9- point scale to one of two scenarios for each item (see Appendix B). For example, when considering the cause of the failed test, participants were asked to identify how much they believe it, a) reflects an aspect of themselves, or b) reflects an aspect of the situation. The total scores for each dimension were obtained by summing the items. Items 1, 6, 9 measured locus of causality (α = .71), items 5, 8, 12 measured external control (α = .51), items 3, 7, 11 measured stability (α = .50), and items 2, 4, 10 measured personal control (α = .73). Because the statistical reliability was strongest for the measures of locus of causality and personal control, these subscales were used in subsequent data analysis. Higher locus of causality scores indicated more self-blame for STEM failures. Higher personal control scores indicated greater perception of control over STEM failures.

Coping style was measured using the COPE scales (Carver, Scheier, & Weintraub, 1989). The eight items were rated on a 4-point scale, ranging from 1 (*I usually don't do this at all*) to 4

(*I usually do this a lot*). Items 1-4 measured active coping (α = .74) and items 5-8 measured suppression of competing activities (α = .74). Items included “I take additional action to try to get rid of the problem” and “I put aside other activities in order to concentrate on this.”

Results

Participants completed a battery of surveys focusing on identifying STEM students' resilience. Demographic information and self-reported information about anxiety, resilience, social support, institutional support, and coping strategies was collected. This study predicted that resilience levels would differ between STEM and non-STEM majors (Hypothesis 1); gender and race would affect resilience in STEM students (Hypothesis 2); and that anxiety would indirectly relate to resilience, with the use of coping strategies mediating this relationship (Hypothesis 3). All correlations, means, and standard deviations for the principle variables of the present study are reported in Table 1.

Resilience and STEM

An independent t test was computed to determine differences between STEM and non-STEM students regarding their resilience (Hypothesis 1). Analysis found that there was not a significant difference in resilience for STEM (n = 111, M = 3.42, SD = .77) and non-STEM students (n = 38, M = 3.20, SD = .84), $t(147)$= 1.49, p = .14.

Resilience, Race, and Gender

A 2x2 ANOVA was used to determine the main effects and interaction between gender and race on resilience in STEM students (Hypothesis 2). There was a main effect of gender on resilience, where males (M = 3.73, SD = .69) were more resilient than females (M = 3.34, SD = .77), $F(1, 107) = 4.66$, $p < .05$. The effect size was medium, d = .54. There was no main effect of race on resilience, $F(1, 107) = .27$, p = .61. There was no interaction between gender and race on resilience, $F(1, 107) = .58$, p = .45.

Table 1

Intercorrelations, Means, and Standard Deviations among Principle Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Gender															
2. Race	-.12														
3. Nationality	.02	.28**													
4. Major	-.01	.01	.07												
5. Aware STEM Resources	-.04	.00	.05	.03											
6. Use of STEM Resources	.25**	-.04	-.03	.13	.44**										
7.Institution Type	.05	.11	-.14	-.43**	.22*	.09									
8. Resilience	.18*	-.09	.07	.12	.02	-.02	-.02								
9. Support	-.04	.09	.05	.12	.08	.20*	.16	.08							
10. Anxiety	-.17*	.10	-.13	.18*	-.13	.04	-.11	-.24**	.03						
11. Locus of Causality	-.01	.07	.11	.15	.18*	.23**	-.02	-.19*	-.01	.18*					
12. Personal Control	.15	.07	.24**	.12	.20*	.12	.05	.16*	-.07	-.13	.34**				
13. Active Coping	-.10	-.12	-.14	.02	.06	.05	.07	.19*	.04	.04	.06	.03			
14. Suppression of Competing Activities	-.08	.04	-.06	.00	-.09	-.05	-.03	.03	-.02	.08	.02	.07	.55**		
15. Discrimination	-.10	-.02	.04	.09	-.06	.02	-.09	-.20*	-.04	-.27**	.09	-.21**	-.03	.09	
M	.20	.71	.82	.74	.89	.61	.50	3.35	4.01	34.01	19.07	18.48	12.31	10.81	6.88
SD	.40	.46	.39	.44	.31	.50	.50	.79	.70	11.67	4.18	4.19	2.39	2.78	1.96

Note. [a]Gender: 0 = *female*, 1 = *male*. [b]Race: 0 = *Person of Color*, 1 = *White*. [d]Major: 0 = *non-STEM* (history and social sciences; arts and humanities), 1= *STEM* (math and natural sciences). [e]Aware of STEM resources: 0 = *no*, 1 = *yes*. [f]Use of STEM resources: 0 = *no*, 1 = *yes*. [g]Institution type: 0 = *4-year private/ public university*, 1 = *4-year liberal arts college*. [h]Locus of Causality: higher score indicates blame placed on self for STEM failures. [i]Personal control: higher score indicates higher perception of control over STEM failures.

* $p < .05$. ** $p < .01$.

Predictors of Resilience

To test the hypothesis that STEM students' resilience is predicted by demographic, intrapersonal, and interpersonal variables, a three-step hierarchical linear regression was conducted. Demographic variables (race, age, gender identity, SES) were entered at step one of the regression to control for participants' demographic factors. Intrapersonal variables (anxiety, locus of causality, personal control) were entered at step two. At step three, interpersonal variables (discrimination, social support, institutional support) were added (Table 2).

The hierarchical linear regression reveals that at step one, demographic variables did not contribute significantly to the regression model, $F(4, 77) = .99$, $p = .42$, and accounted for 4.9% of the variance. None of the individual demographic variables significantly predicted resilience in STEM students. At step two, intrapersonal variables significantly predicted resilience, $F(7, 74) = 3.92$, $p < .01$, and accounted for 27.1% of the variance. Locus of causality, a measure of attribution, significantly predicted resilience in STEM majors, $p < .01$. At step three, interpersonal variables significantly predicted resilience, $F(10, 71) = 2.82$, $p < .01$, and accounted for 28.4% of the variance. Locus of causality continued to significantly predict resilience in STEM students, $p < .01$. These results indicate that causality of performance, specifically locus of causality, significantly predicted resilience in STEM students.

Results of the hierarchical linear regression revealed that anxiety did not significantly predict resilience. Due to these findings, there was no reason to assume that the hypothesized mediation model of coping mediating the relationship between anxiety and resilience is true for this data set. As such, mediation analysis was not completed.

Table 2

Summary of Hierarchical Regression Analysis for Variables Predicting STEM Students' Resilience (N = 82)

	Model 1			Model 2			Model 3		
Variable	*B*	*SE*	*β*	*B*	*SE*	*β*	*B*	*SE*	*β*
Intercept	3.87	.79		4.77	.83		5.38	1.20	
Step 1: Demographic variables									
Race	.07	.19	.05	.00	.17	.00	.00	.17	.00
Age	-.03	.04	-.08	-.01	.03	-.03	-.02	.03	-.05
Gender	.43	.22	.22	.15	.21	.08	.18	.22	.09
SES	-.01	.05	-.01	-.03	.04	-.07	-.03	.04	-.07
Step 2: Intrapersonal Variables									
Anxiety				-.01	.01	-.21	-.01	.01	-.17
Locus of Causality				-.08**	.02	-.41	-.07**	.02	-.38
Personal Control				.04	.02	.21	.03	.02	.16
Step 3: Interpersonal Variables									
Discrimination							-.05	.04	-.13
Social Support							.01	.11	.01
Institutional Support							.03	.17	.02
R^2		.05			.27			.28	
ΔR^2					.22**			.01	

Note. *$p < .05$. **$p < .01$.

Discussion

The purpose of this study was to determine possible predictors of resilience in college and university science, technology, engineering, and math (STEM) students. This discussion will be organized by presenting the predicted results, the actual findings, and the corresponding literature that either supports or contradicts the current findings, with a rationale for contradictory findings. A brief discussion will follow about limitations of the present study and possible directions for future research.

Resilience in STEM and Non-STEM Students

It was predicted that college and university STEM students would demonstrate higher resilience compared to their non-STEM counterparts. Analysis showed that there was no significant difference in resilience levels between STEM and non-STEM students. It's likely, then, that there is no tangible difference between STEM and non-STEM students, even though it was predicted that the nature of STEM fields inherently draws only some students. For example, STEM fields tend to discriminate against women and minorities (Simon et al., 2017), can be anxiety-provoking (Bryant et al., 2013; Greenburg & Mallow, 1982, 1982), tend to have few representative role models for students (Borum & Walker, 2012; Carpi et al., 2017; Hansen, 2014), and have financial barriers of entry (Hansen, 2014). As these negative experiences may hinder some from entering STEM fields, they may also provide space for students to grow and develop. Thus, it was predicted that the students who choose to pursue STEM fields are characteristically different than their non-STEM counterparts and this predicted difference was resilience.

In reality, however, there are likely a variety of factors that explain why some students choose to pursue STEM while others do not. Personality and personality factors provide one explanation. Another explanation is that there is simply no difference in the resilience levels between STEM and non-STEM students because all college students, by virtue of being in college, are roughly equally resilient. Research by Angela Lee Duckworth indicates that grit might be a deciding factor in STEM field entrance. Duckworth claims grit is “a quality that enables individuals to work hard and stick to their long-term passions and goals,” (Perkins-Gough, 2013, pp.16). The key difference between resilience and grit, Duckworth claims, is a driving passion that keeps one committed to a goal. However, resilience is a contributor to or one aspect of grit (Perkins-Gough, 2013). Further, resilience may not wholly explain why some students choose to pursue STEM because of variability in the operational definitions of “resilience,” making it difficult to pinpoint in research what resilience truly is. Grit, then, provides an alternative answer to explain why some students pursue STEM careers while others do not.

Race and Gender Differences in STEM Students’ Resilience

This study also aimed to determine gender and race differences on resilience. Historically, both women and ethnic minorities have been largely discriminated against (Ford, 2014; Glass et al., 2013; Schmaling & Jones, 2017). This pattern is obvious within the STEM fields, with both groups being extremely underrepresented compared to their white male counterparts (Ford, 2014; Glass et al., 2013; Howe-Walsh & Turnbull, 2016; Schmaling & Jones, 2017). Other research has linked discrimination to psychological trauma similar to that of post-traumatic stress (Polanco- Roman, Danies, & Anglin, 2016). This research, paired with the knowledge that resilience is an adaptation to adversity (Luthar & Cicchetti, 2000), informed this study’s prediction that minority women in STEM would report the highest levels of resilience. The results of this study do show that there is a main effect of gender, but not race, on resilience levels in STEM students. However, the main effect of gender shows that STEM men, not women, demonstrate higher levels of resilience.

These results may reflect the fact that men have historically dominated STEM fields; in fact, men still dominate STEM fields, with women holding less than 25% of STEM jobs (Beede et al., 2011). Perhaps the expectations of men in STEM are higher than those for women, thus encouraging the development of resilience in male STEM professionals. Because of the dominance of men in STEM fields, men have more resources and role models at their disposal. Previous research has shown that mentorship is particularly important for students pursuing STEM career paths, as undergraduate mentorship significantly increases pursuit of academic STEM fields and increases pursuit of STEM careers (Carpi et al., 2017). Because there is no shortage of men entering and practicing in STEM fields, there exists a large population of male mentors to encourage and mentor other young men.

Predictors of Resilience

The current study hypothesized that demographic, intrapersonal, and interpersonal factors would predict resilience in STEM students. Step one of the hierarchical linear regression analysis showed that the demographic variables of age, race, gender identity, and SES did not predict resilience in STEM students. This is somewhat contradictory to previous analysis, which revealed that gender had an effect on resilience, with men showing slighter higher resilience than females. These results indicate that gender identity is not a significant predictor of resilience when taken together with the demographic variables of age, race, and SES. Gender identity may influence the development of resilience, but demographic factors alone do not predict resilience in STEM students. This can be explained by previous research by Garmezy that pinpoints individual factors, family characteristics, and social and physical environmental factors to influence the development of resilience (Garmezy et al., 1984; Masten & Garmezy, 1985). Similarly, a significant body of research suggests that resilience is shaped by much more than just demographic factors. For example, children born in high-risk environments, like impoverished communities or chaotic family dynamics, can still achieve relatively positive life outcomes. Similarly, repeated, or chronic stressors, have been shown to teach children how to adapt and function despite the threatening stimuli (Richardson, 2002). In other words, much more than just demographic factors (like personality and environmental factors) should predict resilience. For this reason, step two and step three of the hierarchical regression included both intrapersonal and interpersonal factors to determine if they were significant predictors of STEM students' resilience.

Step two and step three of the hierarchical linear regression showed that together, demographic, intrapersonal, and interpersonal factors did not significantly predict STEM students' resilience. However, locus of causality, a variable of attribution, significantly predicted resilience. The regression showed that locus of causality was inversely related to resilience, such that the more one holds him- or responsible for failing a STEM assignment, the less resilient he or she was. Attribution explains the process of assigning causality or placing blame for an event. Locus of causality specifically speaks to the placement of that blame, either internally (assigning causality to self) or externally (assigning causality to situational factors). The indirect relationship between assigning blame to oneself and lower resilience in STEM students can be explained by internalizing the experience. That is, in the face of failure, one's beliefs about their STEM ability can undermine a student's motivation and can have negative effects (Roque et al., 2014). For example, rates of self-blame can increase, resulting in emotional exhaustion that is linked to higher burnout rates in medical students (Spataro et al., 2016).

This information may prove critical for teaching professionals. For example, teachers and professors can see from these results that attribution, or causality of performance, is an important factor to STEM students' resilience. Specifically, if a student indicates that he or she assigns STEM failures to themselves (which would indicate low resilience), the teacher can help the students process their failure in an effort to avoid the internalization of the failure. For example, teachers can help their students identify external factors contributing to STEM failure, prevent the internalization of STEM failure, and encourage the use of study groups, tutors, and use of other STEM resources.

A mediation analysis was not completed since no relationship was shown between anxiety and resilience in students of STEM. While correlational analysis showed a small but significant negative correlation between resilience and anxiety for all participants, regardless of STEM major status, this was not shown to hold true in the regression analysis for STEM students. These findings suggest that in the presence of other variables, like demographic, intrapersonal, and interpersonal variables, anxiety alone does not predict or significantly relate to resilience in STEM students. Previous research suggests that both schoolwork and school environment can be anxiety provoking (Auger, 2013). Anxiety has also been shown to decrease working memory function (Zhang, 2017) and make it extremely difficult to plan, organize, and set and meet goals (Auger, 2013). Based on these findings, it was predicted that anxiety and resilience were inversely related. Because coping mechanisms help students to manage stress and achieve goals, it was predicted that coping would mediate this relationship (Hsieh et al., 2012). However, this relationship was not shown to be true for this data set. Since anxiety has been shown to affect motivation, it's possible that for this population, anxiety is affecting another factor, like motivation, rather than STEM students' resilience. Similarly, anxiety has been shown to decrease cognitive function and it's possible that this is happening in the present study. Perhaps looking at the relationship between anxiety and cognitive outcomes of STEM students can provide greater insight into STEM students and resilience.

Limitations and Future Directions of Study

The greatest limitation of the present study was its design. Firstly, perceived discrimination in the classroom was measured by the Educational Discrimination Distress Subscale of the Adolescent Discrimination Distress Index. The inter-item reliability in the present study was determined to be rather low. This can be explained by an error made in entering this measure into Qualtrics. Not enough selections were provided in the Likert-type scale, thus limited the reliability of this measure. .

Another limitation of the present study lies in the recruitment method used. That is, participants were primarily students of The College of Wooster recruited through SONA systems, an inter-campus network that allows for the recruitment of the school's students as participants in social science research projects. Secondly, participants were primarily recruited by the primary investigator via email. Email addresses were collected from college and university student organization websites. These schools and their student organizations were found by searching phrases such as "college in [state]" on the Google search engine. This inherently introduced bias since search phrases were filtered through the primary investigator and results were filtered through the search engine. Due to the recruitment method used, the participant population was not very diverse. That is, mostly White women completed this survey in its entirety. This population is not representative of the greater population, making it difficult to make broad conclusions about the effects of race and gender on resilience in STEM students. Future research should aim to work with more diverse populations, particularly comparing difference in STEM field entrance between native-born American students and international students. With this in mind, more specific environmental factors, like culture, and demographic factors, like race and ethnicity, can be researched in regards to resilience in STEM students.

The present study largely was shaped by the idea of adversity promoting the development of resilience. As such, its hypotheses were largely based on the idea that discrimination, adversity, and other hardships have a significant role in the development of resilience. In reality, though, the development of resilience is strongly influenced by personality factors in addition to personal experiences of adversity. That is, while resilience might not be a personality trait, one's personality may affect how one develops resilience (Goodman et al., 2017; Nguyen et al., 2016). Research has demonstrated a strong association between personality and behavioral reactions to trauma (Hengartner et al., 2017). Thus, resilience cannot simply be analyzed by only measured experiences of hardships; personality must be considered. Future research should focus on some potential predictors of resilience. Adding a personality measure, like the Big Five, could provide insight into how resilience forms alongside personality and if resilience is associated with particular personality types and traits.

Grit should also be taken into consideration. That is, future resilience-based research can include measures of grit. This will provide insight in both differences and similarities between resilience and grit. Similarly, future studies should determine if resilience is an aspect of grit, as some research indicates (Perkins-Gough, 2013).

The results of the hierarchical regression suggest that attribution is very important to the resilience of STEM students. Future research should focus on the domain of causality of performance, particularly attribution, in students to provide greater insight into academic and career success. This research would inform teachers, who have immeasurable influence on the learning and success of their students.

Conclusion

Resilience-based research is very important for retention in SEM fields, as well as for understanding the pervasive lack of diversity that plagues STEM fields in the United States as well as abroad. Additionally, gaps in the understanding, measurements, and acquisition of resilience exist, and must be filled. More research about the development and predictors of resilience will not only help develop a concrete definition of resilience, but will also help determine if resilience is, in fact, a learned behavior or a personality trait. Similarly, understanding the predictors of resilience can inform early life and school interventions that promote better outcomes and possibly inform STEM field entrance and success. In particular, this study found that attribution, specifically, locus of causality significantly predicted resilience, more so than any other variable considered. Resilience-based research, particularly focusing on attribution, can inform school interventions and the way in which teaching professionals interact with their students. Importantly, teachers, with the knowledge of how resilience and locus of causality relate, can help students process STEM failures in a healthy and productive manner, promoting the development of resilience while preventing the internalization of failure.

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Appendix A

Institutional Support Questions

1. Are you aware of any resources at your college or university that provide support or aid for STEM classes and majors?

    Yes

    No

2. If yes, do you make use of these resources?

    Yes

    No

3. What STEM resources do you use on campus?

    Free response

Appendix B

Revised Causal Dimension Scale (CDII)

Instructions: Think about the reason or reasons you have written above. The items below concern your impressions or opinions of this cause or causes of your performance. Circle one number for each of the following questions.

Is the cause(s) something:										
1. That reflects an aspect of yourself	9	8	7	6	5	4	3	2	1	reflects an aspect of the situation
2. Manageable by you	9	8	7	6	5	4	3	2	1	not manageable by you
3. Permanent	9	8	7	6	5	4	3	2	1	temporary
4. You can regulate	9	8	7	6	5	4	3	2	1	you cannot regulate
5. Over which others have control	9	8	7	6	5	4	3	2	1	over which others have no control
6. Inside of you	9	8	7	6	5	4	3	2	1	outside of you
7. Stable over time	9	8	7	6	5	4	3	2	1	variable over time
8. Under the power of other people	9	8	7	6	5	4	3	2	1	not under the power of other people
9. Something about you	9	8	7	6	5	4	3	2	1	something about others
10. Over which you have power	9	8	7	6	5	4	3	2	1	over which you have no power
11. Unchangeable	9	8	7	6	5	4	3	2	1	changeable
12. Other people can regulate	9	8	7	6	5	4	3	2	1	other people cannot regulate

NOTE: The total scores for each dimension are obtained by summing the items, as follows:
1, 6, 9 = locus of causality; 5, 8, 12 = external control; 3, 7, 11 = stability; 2, 4, 10 = personal control.