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The Relationship Between Self-Efficacy and Advanced STEM Coursework in Female Secondary Students

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MAT, Boston University, 2004

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Proposal Submitted in Partial Fulfillment

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Abstract

Despite years of attention, gender inequity persists in science, technology, engineering, and mathematics (STEM). Female STEM faculty, positive social interactions, and enrollment in advanced STEM secondary coursework are supportive factors in promoting female students' persistence in STEM fields. To address the gap in understanding these factors, this study employed a sequential mixed method design using a framework of social cognitive theory. Research questions focused on how levels of self-efficacy and perception of personal and social factors among female secondary students related to their enrollment in advanced STEM coursework and extracurricular activities in a rural New England school where gender parity exists. All 18-year-old female students ($N = 82$) were invited to complete the self-efficacy subsection of the Science Motivation Questionnaire II (SMQII). Self-efficacy and enrollment in advanced STEM courses and extracurricular activities were analyzed using a Pearson correlation (N=35). Self-efficacy levels did not correlate with the participants' enrollment in advanced STEM courses and extracurricular activities. In addition, a purposeful sample of participants ($N = 7$) who completed the SMQII was used to conduct individual interviews investigating how the community of practice contributed to female students' decisions to pursue advanced STEM coursework. Two themes emerged: the roles of the personal landscape (e.g., resilient mindset) and the social landscape (e.g., peer interactions). Professional development materials to support staff in implementing a cognitive apprenticeship were created in response to the emergent themes. In addressing the lack of understanding of female secondary students' engagement in advanced STEM coursework, positive social change may be achieved by supporting a greater percentage of women who can pursue STEM career opportunities.

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Section 1: The Problem

According to the U.S. Department of Commerce (Langdon, McKittrick, Beede, Khan, & Doms, 2011), jobs in science, technology, engineering, and mathematics (STEM) fields were expected to grow 18% from 2008 to 2018 as compared to the 9.8% growth in non-STEM occupations. In addition, skills and cognitive knowledge, characteristic of STEM education, will be required in jobs found in nearly all sectors of the economy (Rothwell, 2013). However, today fewer than 25% of jobs in the STEM fields are held by women (Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011; National Science Board, 2015). The gender gap in STEM careers offers a significant opportunity for female high school students to pursue an in-demand career.

In 2014, 47.1% of the Advanced Placement (AP) science exams in biology, chemistry and physics, were taken by female students. The number dropped to 38.9% when the historically female-dominated AP Biology exam is removed from the data (College Board, 2014). At the national level, the disproportionate representation of females in advanced science coursework, specifically chemistry and physics, negatively impacts the prospects of young women to enter a higher education program leading to a career in a STEM-related field (Long, Conger, & Iatarola, 2012). High levels of self-efficacy in secondary students have been positively correlated to students' pursuit of post-secondary education (Chachashvili-Bolotin, Milner-Bolotin, & Lissitsa, 2016). Female secondary students' levels of self-efficacy may also contribute to their decision to enroll in STEM courses. However, young women's self-efficacy has not been studied extensively at the secondary level. In a study of postsecondary students, Simon, Aulls, Dedic, Hubbard, and Hall (2015) found that female students had lower levels of self-efficacy regarding science than their male counterparts. High levels of self-efficacy are characteristic of high levels of persistence and higher levels of achievement which may be necessary to persevere in advanced science coursework. Levels of self-efficacy are also related to the concepts of science anxiety and academic motivation (Bryant et al., 2013).

A rural New England high school is addressing the gender gap in advanced STEM course enrollment; female students represent greater than 50% of the population in the high school's AP science courses, physics, anatomy, and physiology (advanced, science electives), as well as a FIRST Robotics team, National Ocean Science Bowl team, JAGsat (engineering club), and a Science Olympiad team (Lichtmann, personal communication, May 2015). However, research on how self-efficacy and the local community of practice (CoP) contribute to female students' enrollment is limited. By addressing the gap in understanding and the gap in practice of other secondary schools nationally, possible remedies to the gender gap in enrollment may be identified to encourage girls to enroll in advanced STEM courses in other high schools. A greater degree of science anxiety and lower academic motivation may cause low enrollment. Young women, when compared to their male counterparts, have low self-efficacy in regard to science subject matter (Bryant et al., 2013; Cotner, Ballen, Brooks, & Moore, 2011; Simon et al., 2015). Understanding how the local CoP influences secondary female students' enrollment in advanced STEM courses at the study site may contribute to closing the gap in practice at other schools and create positive social change.

Rationale

A gap exists in the understanding of the role of female students' self-efficacy and the CoP on their enrollment in advanced STEM courses and participation in STEM related extracurricular activities. Participation in advanced STEM courses increases the likelihood that female students will pursue STEM careers in postsecondary education (Bottia, Stearns, Mickelson, Moller, & Valentino, 2015; Moakler & Kim, 2014; Perez-Felkner, McDonald, Schneider, & Grogan, 2012). STEM related careers are expected to grow exponentially over the next decade and offer young women a career path leading to equity in pay and advancement. Furthermore, a diverse work force has the potential for increased innovation and resiliency, which is increasingly important in solving the problems of the coming century.

Evidence of the Problem at the Local Level

The high enrollment of female students in advanced STEM courses at the study site contrasts with national and regional data. A gap in practice exists in secondary schools beyond the study site; schools need to create enrollment equity in advanced STEM courses. Data from the College Board's AP Program Summary Report for 2014 indicates that female participation in the AP science exams (biology, chemistry, physics B, and both physics C exams) was 47.1%, 38.9% without the historically female dominated AP biology (College Board, 2014). Female participation at the proposed study site in these courses was 52.6% and 49.2% without AP Biology (Lichtmann, personal communication, May 2015). The question, therefore, is how the local CoP in this rural New England school contributed to the high enrollment of female students in advanced STEM courses and STEM extracurricular activities" In answering the question, this study will include a professional development program to support educators in better understanding the characteristics of female students who enroll in advanced STEM coursework. The professional development program will address the gap in practice in other secondary schools and provide an opportunity for positive social change.

The purpose of this study was to understand the role of female students' levels of self-efficacy and CoP in their enrollment in advanced STEM courses and participation in science related extracurricular activities. Self-efficacy and motivation, while different phenomena, are closely linked. According to Bandura's social cognitive theory (1989), the level of self-efficacy a person possesses determines the level of motivation. Motivation in turn requires the individual to set goals and then rely on a feedback system to evaluate and manipulate strategies to achieve the goal. Achieving the goal then increases the level of self-efficacy, which allows for greater resiliency when faced with impediments and initial failures in achieving goals (Bandura, 1989). As failure is an essential aspect of the scientific process and as advanced STEM coursework challenges students, understanding levels of self-efficacy in young women is important to understanding how the characteristics of motivation, resiliency, and therefore self-efficacy persist. In this study, I sought to understand how female students' levels of self-efficacy correlated with their decision to enroll or not enroll in both advanced STEM course work and extracurricular STEM-related activities. Furthermore, I explored how the CoP may have contributed to the increase in female student enrollment at the study site when compared to regional and national data.

Evidence of the Problem from the Professional Literature

The gender inequity in STEM academics and careers has been documented over the past several decades (Cunningham, Mulvaney Hoyer, & Sparks, 2015; Glass, Sassler, Levitte, & Michelmore 2013; Perez-Felkner et al., 2012; Ramsey, Betz, & Sekaquaptewa, 2014; Langdon et al., 2011; U.S. Department of Education, 2016; Yonghong, 2015). Gender inequity does not begin in postsecondary study; evidence of it exists much earlier in K-12 education. Data from the 2009 National Assessment of Educational Progress (NAEP) survey and NAEP Transcript study administered to secondary school students indicated that 59% of female students responded that they liked science compared to 70% of male students. The same study found that while 41.5% of male students earned high school credit in physics, only 35.9% of females earned equivalent credit (Cunningham et al., 2015). According to Cunningham et al. (2015), 5.6% of male students earned high school credit in engineering coursework compared with only 1.1% of female students.

Life and health sciences coursework, as well as careers, have more equitable gender distributions. Engineering and physics have remained dominated by men (Cunningham et al., 2015; Perez-Felkner et al., 2012). Enrollment in advanced secondary STEM coursework positively impacts the likelihood of students pursuing STEM careers; yet nationwide, secondary schools still demonstrate gender inequity in advanced STEM coursework, especially in the fields of physics, chemistry, and engineering (DeWitt, Archer, & Osborne, 2014; Chachashvili-Bolotin et al., 2016; Long et al., 2012; Sadler, Sonnert, Hazari, & Thi, 2014; College Board, 2014).

Definitions

Community of practice (CoP): A group of people committed to learning collectively around a specific domain of human importance or practice. It has three essential aspects: (a) the community, (b) domain of interest, and (c) the practice (Wenger, 2006).

Failing forward: The positive and proactive response taken when a failure or setback is experienced in pursuit of a goal (Maxwell, 2007).

Motivation: In this study, the amount of effort an individual is willing to put forth in the pursuit of an intended outcome as well as how long the individual will persevere in the face of obstacles in pursuit of the intended outcome (Bandura, 1989).

Science, Technology, Engineering, Mathematics (STEM): The integrated nature of study represented by the fields of science, technology, engineering, mathematics.

Self-efficacy: Peoples' beliefs about their capacity and capability to exercise control over the events that affect their lives (Bandura, 1989). In the context of this study self-efficacy refers to female students' beliefs that they are capable of success in advanced STEM coursework.

Significance

Women employed in STEM fields earn more than women in non-STEM fields (Oh & Lewis, 2011; Langdon et al., 2011; Yonghong, 2015). Jobs in the STEM field are expected to grow at nearly double the rate of all non-STEM jobs by the year 2018. Therefore, increasing the number of women who pursue STEM degrees is an opportunity to increase women's earning potential and promote positive social change (Langdon et al., 2011). Increasing the number of women pursuing STEM coursework and careers is one approach to closing the disparity in income between genders. Female students have been shown to gain greater science confidence, relative to their male counterparts, when coursework is taught by female professors and teaching assistants (Cotner et al., 2011). Therefore, increased female presence in STEM careers may have a positive cyclical effect on gender diversification in the workforce. Diversifying the STEM workforce through increased female representation will further support closing the income gap between women and men. A diverse workforce strengthens any organization (Saxena, 2014). The underrepresentation of women in STEM fields may contribute to an environment where the full potential of the society for creative problem solving and workplace productivity is not realized (Bayer Corporation, 2012; Howe, Juhas, & Herbers, 2014).

To increase work-force diversity in STEM fields, increasing female students' pursuit of post-secondary STEM degrees is essential (Schiebinger, 2008). Taking rigorous courses in high school has been shown to correlate with high levels of achievement in high school students' math scores, increased graduation rates, and increased attendance at 4-year colleges (Chachashvili-Bolotin et al., 2016; Fletcher, 2012; Long et al., 2012). Therefore, understanding the factors that contribute to female enrollment in advanced STEM coursework at the secondary level can support positive social change.

This study focused on a local problem, as there was a gap in understanding why female students at the study site enrolled in advanced STEM courses at a higher rate than the national rate. The project was unique because studies regarding the factors affecting female student enrollment at the secondary level and their perceptions have not been well studied. Most studies focus on the post-secondary level (Bryant et al., 2013; Simon et al., 2015).

The American education system offers equitable access to learning for all students regardless of age, race, gender, and socioeconomic status. However, female students are underrepresented in advanced STEM coursework as evidenced by the numbers of female students completing an AP science exam in all but the historically female dominated AP biology exam (College Board, 2014). Results of this study were expected to provide insight into the factors contributing to the high female enrollment in advanced STEM courses. Understanding the data from young women at the study site on what shaped their decisions to enroll in advanced STEM coursework has the potential to contribute to increasing women's enrollment at other local schools.

Research Question

Understanding how female secondary school students' levels of self-efficacy correlate to their decision to enroll in advanced STEM coursework and participate in STEM related extra-curricular activities will help fill a gap in understanding why some students pursue this coursework and others do not. Information from the study could be used to address the national trend of gender inequity in fields such as physics, chemistry, and engineering. Research question 1 for the quantitative portion of the study was:

RQ1: How do female students' levels of self-efficacy correlate with their decision to enroll in advanced STEM coursework and STEM extracurricular activities?

$H_0$1: There is no correlation between levels of self-efficacy and secondary female students' enrollment in advanced STEM courses.

H_a1: The greater the number of advanced STEM courses a female secondary student enrolls in, the higher their level of self-efficacy.

While the quantitative portion of the study will begin to characterize female secondary students in a rural New England town who pursue advanced STEM coursework, in this study I sought to understand the factors that have supported the development of the characteristic of self-efficacy in these young women. The qualitative research question explored in this study asked:

RQ2: How does the CoP in and surrounding a small rural high school contribute to female secondary students' enrollment in advanced STEM coursework?

Review of the Literature

The basis of this literature review is to provide justification that gender inequity in STEM studies and careers exists and significantly impacts workforce diversity as well as opportunities for women. In addition to exploring the inequity, in this this review I also explore research regarding the differences in male and female students in terms of their academic STEM experiences both in the courses in which they enroll and their self-perceptions. Finally, I examine through this literature review factors that may affect the variable interest of female students in STEM and possible roots of the gender inequity. The theoretical framework of this study grounds the literature review in the concepts of self-efficacy and the influence of a CoP on learners (Bandura, 1989; Lave & Wenger, 1991), specifically, how these theories provide both a possible understanding of why the gender inequity exists and how it might be overcome.

To conduct this review, I used the search engines available through the Walden Library including ERIC, Science Direct, and Education Research Complete. I entered search terms including *female secondary science, STEM and gender, STEM careers, value of a diverse workforce, self-efficacy and STEM, communities of practice, influence of community on learning, self-efficacy* and *female,* among others. I used current articles and internet research to trace the concepts of self-efficacy and CoP back to their origins to better understand the evolution of these concepts and their applicability to this study. Self-efficacy and CoP were frequent themes to the articles related to female students and STEM which led me to focus my theoretical literature review on these theories. Also, I used the literature reviews of peer-reviewed journal articles to lead me to additional scholarly sources.

Theoretical Framework

There were two key learning theories explored in this study's theoretical framework, social cognitive theory (Bandura, 1989) and communities of practice learning theory (Lave & Wenger, 1991). Social cognitive theory explores the decision-making capabilities of the individual and proposes that individuals can shape their lives through their perceptions of self, most clearly correlated with the concept of self-efficacy. However, decision making may be influenced by more than self-efficacy and therefore the role of a CoP on the decisions of female students to pursue advanced STEM coursework is also relevant to this study. Together, these two theories provide the theoretical basis for this study.

Social cognitive theory. Bandura's (1989) social cognitive theory proposes that individuals' beliefs about their capabilities allow them control over events that affect their lives. People's self-perceptions influence the environments they select and the activities in which they participate. Self-perception and motivation can be described as self-efficacy. Higher levels of self-efficacy lead individuals to set higher goals for themselves and to persist when failure is experienced. Low levels of self-efficacy can influence the selection of the environment by increasing risk aversion, where high levels of self-efficacy are correlated with persistence, motivation, recovery from challenges, and commitment in the face of failure. As level of self-efficacy is a major factor in persistence, commitment, high goal setting, and motivation, it offers a framework to explore female students' perceptions of self as it correlates to their decision to enroll in advanced STEM coursework (Weber, 2012). Performance accomplishments, such as academic success in coursework, are strong influencers of self-efficacy as it is based on the mastery of the individual. Therefore, increased self-efficacy resulting from academic success will also have a strong influence on academic motivation and interest (Bandura, 1989; Weber, 2012). Chachashvili-Bolotin et al. (2016) demonstrated a positive correlation between positive experiences in advanced STEM coursework and extracurricular activities and students' pursuit of advanced postsecondary studies. Therefore, the influence of self-efficacy on academic motivation is particularly relevant to this study as early success in STEM courses may be a factor leading to increased self-efficacy and academic motivation. which contribute to the high number of female secondary students participating in advanced STEM coursework at the study site.

Communities of practice. The human mind develops in social situations that frame the process of learning and meaning making. Therefore, the social interactions of the community in which a person participates have important effects on learning, decision making, and the individual's future place in the CoP (Lave & Wenger, 1991). These communities are composed of both old-comers, who have been indoctrinated into the community and are charged with passing on its values, and the new-comers, who are those becoming indoctrinated. Furthermore, the situational learning theory behind CoPs places a value on the decentralization of learning. Decentralization means the responsibility for disseminating learning is not solely the responsibility of a master to an apprentice, but rather a function of the organization of the CoP. In such a community the resources in the community are as essential for the learning of new-comers as is the master who is a part of the community (Lave & Wenger, 1991).

As new-comers to a CoP, students' experiences and knowledge will be shaped by the old-timers. Student achievement is a complex and multifaceted concept. It is a product of not only the formal experiences guided by educators but also the interactions with the larger community. Adults in the community beyond traditional educators have been shown to reinforce and support the message of schools and positively contribute to the college readiness of students and student ambitions, as well as increase overall academic motivation (Alleman & Holly, 2013; Cho & Campbell, 2011; Clark, Tytler, & Symington 2015; Wearmouth & Berryman, 2012; Willems & Gonzalez-DeHass, 2012). In this way, the surrounding community of a school becomes part of the CoP contributing to the development of students as new-comers.

The theoretical concept of a CoP has been explored in fields such as teacher preparation, school improvement, and teacher communities in general (Admiraal, Lockhorst, & van der Pol, 2013; Woodgate-Jones, 2012; Mackey & Evans, 2011). Although the impact of community relationships on student achievement has been documented, inclusion of the surrounding community as part of the overall CoP has been less well established. According to Wenger (2006), to be a true CoP, three characteristics must be satisfied: the *domain*, the *community*, and the *practice*. The domain is the shared area of interest to which the community is committed, while the community is defined as the group of individuals that interact with one another, building relationships as well as sharing information. Finally, the practice is the focus of the community of practitioners. It is the common theme around which their dialogues, shared resources, and experiences are based (Wegner, 2006). In applying this lens to the study of the school setting, I would be remiss to not include the surrounding community as part of the CoP. Both educators, parents, businesses, and community members share in the commitment to preparing students to be successful whether through altruistic or self-serving motives such as decreased crime rates or increased property values. Therefore, the student can be defined as the domain and the educators and surrounding parents, businesses, and other community members can be defined as the community. The community engages in conversations and support of students through a variety of formal and informal interactions which have been shown to contribute to student success (Alleman & Holly, 2013; Cho & Campbell, 2011; Clark et al., 2015; Willems & Gonzalez-DeHass, 2012). The practice then is the set of skills and strategies employed, shared, and built by the CoP to support student achievement. Through this lens, it becomes apparent that to understand the factors contributing to female students' decisions to pursue advanced STEM coursework and their levels of self-efficacy, a researcher must study the potential impacts of the CoP on the student.

Review of the Broader Problem

The gender inequity in STEM career fields has long been studied; however, gender parity in most STEM postsecondary majors and careers still exists. Research has proposed contributing factors ranging from gender stereotyping to lack of female role models. Female interest varies as students move through middle school to post-secondary education and despite comparable ability levels with their male counterparts, female students' negative self-perceptions in science tend to increase as well. However, perhaps more significant to the questions examined in this study are the factors that have the potential to support female students at the secondary level in encouraging their pursuit and persistence in STEM as well as overcoming the negative science self-perceptions. To work towards closing the gender gap in STEM, understanding the scope and factors contributing to the inequity as well as the gender equity is essential.

Inequity in STEM careers. In the United States, women hold nearly half of all jobs in the workforce but less than 25% of STEM jobs. While there are many potential causes of this trend including "lack of female role models, gender stereotyping, and less family friendly flexibility" (Beede et al., 2011, p. 1; U.S. Department of Education, 2016), the STEM career field offers the opportunity for increased employment and earning equity for women (Langdon et al., 2011). The National Science Board (2015) found women account for just below 60% of all degree levels in biosciences. However, female graduates account for less than 20% of all degree levels in engineering, computer science, and physics (National Science Board, 2015). While it seems that gender equity has nearly been reached in life sciences and healthcare related STEM fields, a noticeable and significant inequity still exists in the fields of physics, chemistry, and engineering (Beede et al., 2011; Cunningham et al., 2015; National Science Foundation, 2015; Oh & Lewis, 2011; Smith, 2011). When considering data from NAEP, male and female students (K-12) have comparable achievement levels in all science fields, and so this disparity in career pursuit seems not to be based on ability (Cunningham et al., 2015). Rather, it seems to result from other contributing factors including gender stereotyping, lack of role models, discouragement from instructors, and social pressures (Bayer Corporation, 2012; Mallow et al. 2010; Reilly, Neumann, & Andrews, 2015; Sinnes & Loken, 2014). Overall, as a group, females are less likely to enroll in the collectively diverse fields identified as STEM than their male counterparts. Interestingly, there is some evidence that this inequity does not exist in online degree programs even though it does in traditional 4-year institutions (Wladis, Hachey, & Conway, 2015).

STEM careers are predicted to grow exponentially faster than non-STEM job opportunities by 2018 (18% and 9.8% respectively); this offers an opportunity for women to increase earning potential (Langdon et al., 2011). Even when human capital measured by postsecondary GPA is comparable, income inequity exists for women in the workplace. However, significantly decreasing inequity in STEM careers offers an opportunity for women to increase their earning potential (Langdon et al., 2011; Yonghong, 2015). In considering why female students do not pursue or persist in STEM fields, the income inequality needs to be considered. Yonghong's (2015) longitudinal study concluded that number of dependents and marital status has a negative impact on the income of women in STEM fields but a slightly positive effect on that of their male counterparts. The lack of women persisting in STEM fields is a cyclical problem; a lack of role models and mentors contributes to problems in recruiting. If recruitment is unsuccessful, no additional mentors are added. When examining the phenomena in STEM faculty at 2 and 4 year postsecondary institutions, the low representation of female role models is clear (Bayer, 2012; Rankins, Rankins & Inniss, 2014). To quantify the gender gap in STEM faculty, Rankins, Rankins, and Inniss (2014) calculated a representation index where *RI* = (% representation in a category)/(% representation in the U.S. population). The *RI* for a woman holding a full professor faculty position is 0.8 overall; however, it is below 0.2 for computer science and engineering. The presence of female mentors has been shown to have a positive impact on female students pursuing STEM as a career and so this inequity in the workforce poses an issue of social injustice not only in terms of salary but also in terms of the recruitment and support of female students considering this career option (Cotner et al., 2012).

Variable interest of young women in STEM. In a nationwide longitudinal study of 4,691, STEM career interest was found to be significantly lower in female than male students, 17.5% and 37.9% respectively. The trend persisted in secondary school students with only 16.8% of female students interested in pursuing STEM careers compared to 41% of male students (Sadler et al., 2012). Important in deciphering this changing interest in STEM is the question of how and why female students' perceptions change throughout their academic careers. While achievement levels for male and female students are comparable in secondary school, their self-perceptions reveal a different picture. Female students' attitudes towards science as well as their self-concept in science is significantly lower than their male counterparts. Furthermore, the differences become statistically significant in high school as compared to middle and elementary school (Brotman & Moore, 2008; Deemer, Smith, Carroll, & Carpenter, 2014; Desy, Peterson, & Brockman, 2011; Reilly et al., 2015). The lack of self-concept associated with science can limit a student's self-efficacy in science and therefore negatively contribute to their choices to persist through challenging coursework (Bandura, 1989; Simon et al., 2015). By the time students reach postsecondary education in countries such as the United States, the United Kindom, and Norway, which is one of the most gender equal societies in the world, women compose the majority of enrolled students and yet remain in the minority in majors in the physical sciences and engineering (Sinnes & Loken, 2014). These choices further reinforce the inequity of women in STEM careers.

Course selection and STEM career choices. A significant relationship exists between the number and types of courses high school students complete and their pursuit of a STEM career. Sadler et al.'s (2014) work found that a significant difference in pursuing a STEM career existed for students who took a second year of chemistry compared to a single year. A similarly significant difference was found between no physics and a year of physics as well as between one and two years of physics. Of note is that this study sought to reduce the influence on confounding variables in their model such as predispositions to STEM due to familial influence and experiences. In supporting students to pursue STEM careers and coursework at the postsecondary level, the years of advanced coursework are more important than a specific type such as AP or International Baccalaureate. Rigorous locally designed non-AP coursework is as indicative of fostering STEM interest as these more well-known programs (Sadler et al., 2014).

Other studies have supported similar positive relationships between coursework and pursuit of a STEM major at the postsecondary level, specifically in physics and calculus. Success in advanced math and science coursework leads to increased math confidence and self-efficacy, which increases the likelihood of female students' pursuit of STEM careers (Bottia et al., 2015; Chachashvili-Bolotin et al., 2016; Moakler & Kim, 2014; Perez-Felkner et al., 2012). The positive relationship between advanced STEM coursework and pursuit of STEM careers is noteworthy, particularly in the light of transcript reviews of secondary students where female students completed fewer advanced math and science courses than their male peers (Cunningham et al., 2015; Perez-Felkner et al., 2012). By increasing female enrollment in these advanced courses, increased female pursuit of STEM careers could perhaps be similarly realized. As advanced coursework in secondary school settings is an important precursor to pursuit of a STEM career, understanding the contributing factors to female students' decisions to enroll in advanced STEM courses is important to addressing the issue of social justice.

While participation in advanced STEM coursework has a positive effect on female persistence in STEM fields, less well understood are the factors that contribute to the decision to enroll in these courses overall. In secondary schools with strong math and science curricula, there exists a positive effect on female students' intentions to major in STEM fields and enroll in advanced STEM courses. The positive effect on intentions has been found to persist when confounding variables are controlled and persists into female students' post-secondary experience. Interestingly, a similar positive effect is not observed in male students, thereby offering an opportunity to close the inequity in course enrollment and post-secondary aspirations (Legewie & DiPrete, 2014).

Another possible influence on career choice is the community itself. For example, the percentage of women in the community employed in STEM fields has been found in some cases to have a positive effect on female secondary students' decisions to enroll in historically male-dominated courses such as physics (Riegle-Crumb & Moore, 2014). Furthermore, middle school is a critical time for students to develop an interest in STEM, and during this age, community, family, and socioeconomic status play a major role in the development of identities and self-concepts. While some evidence suggests that the role of these factors diminishes in secondary settings, other factors within a CoP can support or hinder persistence in STEM coursework throughout a students' academic career (Moakler & Kim, 2014; Sadler et al., 2011).

Factors impacting STEM choice and persistence. In answer to the growing demand and career potential in STEM related fields, many STEM high schools have opened their doors. Methodologies or approaches to STEM schools vary from university affiliated, charter, and school within a school model; however, these schools are all characterized by a culture of intellectualism and inclusion. They also value the role of research and inquiry in the learning process and offer opportunities for independence to learners (Tofel-Grehl & Callahan, 2014). An inquiry focus and learner independence in conjunction with a strong community and the pursuit of a positive culture for learning support an atmosphere where rigorous learning can take place (National Association for Gifted Children, 2010; Riegle-Crumb, Moore, & Ramos-Wada, 2011).

Persisting with a positive growth mindset in the face of failure is an essential component of failing forward in academics (Maxwell, 2007). As the inherent nature of STEM subject areas is a culture of failing forward, and where a student's response to challenges encountered is an important indicator of a student's academic perseverance in the subject area, it follows that a positive climate for learning that supports students emerging self-efficacy is an essential component (Maxwell, 2007; Tofel-Grehl & Callahan, 2014; Weber, 2012). When such opportunities to engage in challenging inquiry learning are a valued part of the culture of learning in a community, then the community itself supports the increasing self-efficacy of students in their efforts. High quality and rigorous science experience over simply "fun science" is important in translating student interest into meaningful academic and career pursuits (DeWitt et al., 2014; Weber, 2012). The combination of this rigorous mindset, fostered through the process of scientific inquiry and research and coupled with effective instruction in content areas can help to retain students in STEM fields by supporting their self-efficacy.

The characteristics of an intellectual and inclusive environment present in a CoP may be particularly important to recruiting and retaining young women in STEM fields. Social messaging and self-reported perceptions are strong influencers on female students' choices regarding coursework and career aspirations. The literature illustrates numerous examples of female students possessing lower self-perceptions of their performance in science coursework as well as a more negative view of science when compared to their male peers even though both groups demonstrate similar ability levels (Rudasill & Callahan, 2010; Shumow & Schmidt, 2013; Simon et al., 2015). Adults, including teachers and parents, along with peer networks and same gender friends can positively or negatively reinforce female students' perceptions of themselves (Mallow et al., 2010; Moakler & Kim, 2014; Perez-Felkner et al., 2012; Rudasill & Callahan, 2010; Shumow & Schmidt, 2013).

Receiving positive messages about women in STEM as well as having peer-role models have been found to positively correlate with female students' intrinsic motivation in STEM as well as their perceived competence in STEM (Legewie & DiPrete, 2014; Ramsey et al., 2013). Positive messages, in turn, increase self-efficacy, which is necessary for persistance through challenging tasks or learning. An inclusive and positive messaging environment can be fostered by the proportion of female faculty from whom students learn. The positive impact of female educators has been mostly explored at the postsecondary level where female students studying with a female instructor (professor or teaching assistant) demonstrate an increase in science confidence when compared with those studying with a male instructor. The same effect has not been demonstrated in male students (Cotner et al., 2012).

Furthermore, teachers may possess unintended gender biases in the STEM classroom. In a case study conducted by Shumow and Schmidt (2013), even though teachers did not identify themselves as displaying gender bias in the science classroom, it was evident in their interviews as well as in the classroom where male students were called on 39% more often than female students. Such biases can reinforce female students' negative perceptions of themselves in science and their capacity to pursue STEM careers. Where confidence is a characteristic that leads to persistence and increased self-efficacy, the role of female instructors and overall unbiased educators has the potential to positively impact the decision of female students to enroll in advanced STEM coursework and persist when challenges are encountered (Mallow et al., 2010).

Although most of the body of research regarding gender and STEM has focused on post-secondary studies, similar studies at the secondary level are beginning to build support for similar phenomena. When searching to identify the root of the gender gap of women in STEM majors and careers, the factors that lead to the decision to pursue this must be identified prior to postsecondary experiences. Students' interest upon entering high school is a strong indicator of their future STEM plans and most students pursuing a STEM career have already made this decision prior to enrolling in a postsecondary program (Bottia et al., 2015; Sadler et al., 2011). One factor potentially contributing to female students' pursuit of STEM, specifically in the areas of physical sciences and engineering, is the proportion of female STEM faculty members at the secondary level. When comparing across multiple secondary schools and controlling for confounding variables, female students attending schools with higher proportions of female STEM faculty members demonstrate a significant increase in declaring a postsecondary major in physical sciences and engineering. The relationship between the proportion of female faculty and attainment of the postsecondary degree in biological and physical sciences, as well as engineering, is even more significant (Bottia et al., 2015).

The factors influencing students' decisions are multifaceted and complex, extending beyond the self and into interactions within the CoP. As succinctly stated by Legewie and DiPrete (2014), "the local environment in which adolescents spend their high school years plays an important role in the strengthening or weakening of gender stereotypes" (p. 126). Therefore, to understand female enrollment in advanced science courses and their pursuit of STEM as a career choice, the local context of the secondary school must be examined.

Implications

The study site for this research has a higher percentage of female secondary students enrolling in advanced science coursework than other local schools and the national trend. Enrollment in advanced courses such as AP science coursework, physics, and anatomy and physiology has been shown to increase the likelihood of students pursuing a degree and career in STEM fields. This study seeks to understand how levels of self-efficacy in young women in the local context correlates with their decision to pursue advanced STEM coursework. Additionally, the study seeks to close the gap in understanding the factors that have contributed to these students' enrollments in advanced STEM coursework.

The study site has taken efforts to recruit and sustain the enrollment of female students in advanced coursework and these efforts may represent a contributing factor to the high STEM enrollment. Other factors that may contribute are the presence of female mentors, positive peer groups, presence of adults in the community employed in STEM fields, and the conscious positive social messaging from educators at the school. The results of this study could lead to professional development for teachers and administrators in other districts who want to increase female enrollment and persistence in advanced courses in other secondary schools.

Participation in professional development, which informs educators regarding the characteristics of female students who enroll in advanced STEM coursework, may increase the enrollment of females in advanced STEM coursework in more secondary schools. Effective professional development to support educators' abilities to foster increased self-efficacy in female students may lead to increased opportunities for female students to pursue STEM fields in their postsecondary education. Increased pursuit of STEM fields may in turn create an opportunity for positive social change due to more equitable salaries and increased job opportunities for women.

Summary

The gender inequity in STEM careers offers an opportunity for positive social change for women. In closing the gender gap, the inequity in income and opportunity for women can be addressed as well as the creation of a more diverse and therefore resilient workforce. While gender parity has been achieved for biological sciences, the percentage of women pursuing college majors and careers in fields such as physics, chemistry, and engineering are significantly lower than their male counterparts. Pursuit of advanced

STEM coursework at the secondary level has been shown to be a positive indicator of pursuit of and retention in a STEM major and career.

To better understand why the gap exists at the postsecondary level, this study seeks to explore the role of self-efficacy and the CoP in female students' enrollment in advanced STEM coursework at the secondary level. Advanced STEM courses at the study site have a significantly higher female enrollment than nationwide trends. Through a mixed-methods approach, I sought in this study to address the gap in understanding regarding this populations' decision to enroll in advanced science coursework. Based on the findings of this study, I designed a project as a possible method to close the gap in practice that exists in other secondary schools and which reinforces gender inequity in the pursuit of STEM careers.

Section 2: The Methodology

I chose a sequential explanatory mixed method design to examine levels of self-efficacy in female secondary students as they relate to enrollment in advanced STEM coursework and then provide possible explanations for the self-efficacy levels themselves. A mixed method design offered the opportunity for rich detailed narratives to explore the phenomenon (Creswell, 2008). A purely qualitative case study design was considered for this study; however, it was not chosen as decisions to enroll in advanced challenging coursework are often linked to levels of self-efficacy, which can be measured quantitatively. In measuring levels of self-efficacy quantitatively, I examined the potential correlation with advanced coursework in the population of interest.

Mixed Methods Design and Approach

A mixed method, primarily qualitative, approach was used in this study. An explanatory design was used to provide a more complete analysis of the quantitative data obtained through a survey. A purely quantitative study would have only addressed the correlation between self-efficacy levels and female secondary students' enrollment in advanced science courses. The purpose of the study was to provide possible solutions to address the inequity in STEM majors and careers. Therefore, while the quantitative portion may have revealed characteristics of female students who enroll in advanced STEM courses, it would have failed on its own to produce a rich narrative that could have led to understanding why these characteristics exist. A mixed-method approach provided not only insight into the characteristic of self-efficacy as it related to the decision to enroll in particular courses but also added information about the factors in the CoP that may have contributed to the decision of female students to pursue advanced STEM coursework. The purpose of the study was to understand the role of female students' levels of self-efficacy and CoP in their enrollment in advanced STEM courses and participation in science related extracurricular activities.

A quantitative approach was first implemented to address RQ1: How do 18-year-old female students' levels of self-efficacy correlate with their decision to enroll in advanced STEM coursework and STEM extracurricular activities? Self-efficacy was measured using the Science Motivation Questionnaire II (SMQII) which measures motivation using a 5-point Likert scale (Deemer et al. 2014; Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011). The second variable, enrollment in advanced STEM coursework and extracurricular activities, was operationalized using a count of the number of courses a student was enrolled in; additional information can be found in the data analysis section. As these data are numerical and the hypothesis is specific and measureable, a quantitative design was appropriate to address this initial question (Creswell, 2012). The quantitative portion of the study sought to explore self-efficacy levels of female secondary students who participate in advanced STEM coursework. Participants who enrolled in advanced STEM coursework then became the focus for the qualitative case study.

The central qualitative research question (RQ2) sought to explore and provide a deep understanding of the perceptions of a single group: 18-year-old female students at the study site. Participants were asked to share ideas through open-ended interview questions that I used to explore themes related to the central research question. Open-ended questions and a thematic analysis support a qualitative approach. In addition, the central research question was descriptive in nature, which lends itself to a case study design, as a rich narrative would be produced (Bogdan & Biklen, 2007). To qualify as a case study, the phenomenon of interest must be a bounded system, which has a limit to the number of people who could be interviewed (Merriam, 2009). The data collected in this study was obtained in the natural setting of a rural New England high school where the case was defined as the group of 18-year-old female students enrolled in advanced science coursework. The 18-year-old females were a bounded group, as there were a finite number of individuals who could be interviewed. The proposed instrumental case study explored the perceptions around the central research question. Analysis of these data in turn provided specific recommendations that influenced the development of a project to address the gap in practice in other secondary schools.

Setting and Sample

The setting for the study was a rural New England high school established in 2009. Prior to this time, students attended a large regional high school in a neighboring town. In 2012, the high school graduated its first class and in 2013 it graduated its first group of students who were educated in the town's public schools grades 1-12. During the study, the school enrolled approximately 750 students. The study site was built as a technology integrated school featuring a fully wireless campus and a 1:1 laptop environment for students and faculty. The target high school's profile stated, "[The]high school was built upon a vision of shared community experiences and interconnectivity with post-secondary institutions and businesses. Our students embrace our commitment to service and must perform 40 hours to complete their matriculation."

The quantitative sample population were all female students, 18 years of age, at the study site. There were 194 students in the 12th grade class, approximately 93 total female students and 82 who were 18 at the time of the study. A sample size of "approximately 30 participants for a correlational study that relates variables" (Creswell, 2012, p. 146) was needed to establish statistical significance. As 35 participants completed the survey, the sample was sufficient to accept or reject the null hypothesis (Creswell, 2012). Most students within this rural New England school district self-identified as white (88.3%), followed by Asian/Pacific Islander (4.3%), Hispanic (3.1%), Black (0.5%), and Multiracial (3.8%). The percentage of free and reduced lunch through the National School Lunch Program for the district was 3.4%, an indicator of socioeconomic status (New Hampshire Department of Education, 2015).

Qualitative case studies use purposeful homogenous sampling, as individuals will be selected because they can contribute to the understanding of the central research question (Merriam, 2009). As one purpose of the study was to explore the contributing factors to students' decisions to enroll in advanced STEM coursework, female students having enrolled in 3 or more advanced STEM courses over the course of grades 9-12, were purposefully sampled, giving a sample size of 14. An initial random sample of 5 from within the purposeful sample was selected. The sample of 5 was chosen randomly from the purposeful sample to increase validity of the study (Merriam, 2009). Microsoft Excel was used to assign each participant who enrolled in 3 or more advanced STEM courses a unique random number. Initially the first 5 (chronologically) of the numbers were invited to the interview. As data saturation was not yet reached, the next 2 (chronological) numbers were then selected and these additional participants were interviewed. In qualitative studies, the appropriate sample size is reached when either the case is fully explored or saturation occurs in the data (Bogdan & Biklen, 2007). To provide rich complete narratives, the final sample size ($N = 7$) was determined when saturation of the data was reached. Saturation was determined when interviews failed to produce novel codes or themes (Merriam, 2009).

All participants were 18 years of age, so the study population was not protected. Even so, all parents or guardians received a form by e-mail from the target site detailing the study. An invitation to participate was then sent to all female students who were 18 years of age. All potential participants had the option to opt out of the study. Participants were informed of the purpose and nature of the study to protect their rights (Creswell, 2012). Informed consent was obtained from participants through the quantitative survey. Participants may have shared personal information that would have the potential to negatively impact them; therefore, all personal identifying information was struck from the data after the interviews were completed and data saturation was proven. Participants were identified as participant A, participant B, and so forth. The study site was referred to as the target school and the specific location of the school was not disclosed. The precautions ensure the confidentiality of the participants in order to protect their rights. I was not in a position of authority over these participants, which limited the possibility of coercion. In this study, participation was voluntary and no incentive was provided.

Data Collection Strategies

Data were collected sequentially, beginning with the SMQII and continuing for individual interviews. The self-efficacy subscale (questions 9, 14, 15, 18, 21) from the SMQII was administered as the survey instrument via a GoogleForm. In cooperation with the target school, I had access to participants' e-mail addresses. Access to participants' e-mail addresses made electronic data collection accurate and efficient. All eligible potential participants received an e-mail from me explaining the study and inviting them to participate. A report from this survey that has had all identifying participant information struck is available from me upon request.

The SMQ II was used by Deemer et al. (2014) to examine the motivation of students, which correlates to the construct of self-efficacy. The SMQII has 5 subscales, each containing 5 items: intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation (Glynn et al., 2011). In this study, only the self-efficacy subscale was utilized. The sum of the self-efficacy subscale, which ranged from 0-20, for each participant, was calculated. The Cronbach's alphas for the SMQII self-efficacy subscale has been previously established as .83 (Glynn et al., 2011). Similar Cronbach's alphas were obtained by Bryan, Glynn, & Kittleson (2011). Questions were answered on a 5-level Likert scale of temporal frequency: never (0), rarely (1), sometimes (2), often (3), or always (4). In addition, a question was included that asked students to indicate which STEM extracurricular activities they actively participated in and which courses they have enrolled in at the target school. Active participation in a STEM extracurricular was defined by attending meetings and activities for the entire duration of the extracurricular for the school year. Additional details will be discussed in Data Analysis.

The qualitative question in this study was the primary focus. The qualitative methodology was used to explore how this CoP may have contributed to levels of self-efficacy. One-to-one interviews were conducted with participants using a purposeful homogenous sample of participants who enrolled in three or more of the advanced STEM course/extra-curricular options. As the participant sample is composed of female students living in the same town, attending the same school, and of approximately the same age who have enrolled in 3 or more advanced STEM courses or extracurricular activities, the sample was considered homogenous. Interviews were conducted at the target site or the local library, each lasting approximately 15-20 minutes. Interviews occurred outside of school hours; therefore, the participants did not experience any disruption to learning and instruction. The researcher-produced interview question guide (Appendix D) ensured that all interviewees were asked the same set of questions (Bryan et al., 2011). Audio from interviews was recorded and transcribed for coding and analysis following the three Cs discussed by Lichtman (2012). Data from the interviews were organized in spreadsheets by code, category, and concept. A preliminary exploratory analysis of the raw data allowed me to immerse myself in the data and write memos concerning repeated words or ideas. Exploratory analysis yielded preliminary codes that were then used to analyze the data. A list of these initial codes was then complied to look for redundancies. Related codes were then examined and combined into categories (Creswell, 2012; Lichtman, 2012). Categories were then combined to develop concepts that represented big ideas within the data (Lichtman, 2012). The coding methodology described above was used on the interviews from the first 5 participants. As novel codes emerged throughout this process, an additional two participants were interviewed and the coding methodology was applied to the transcripts. The additional interviews failed to produce novel codes, which indicated that data saturation had been reached with a final sample size of 7.

Member checks were used to increase internal validity and reliability. At the end of each interview, participants were asked to complete a brief open response reflection asking them to describe which factors were the greatest influencers on their decision to enroll in courses. The reflection by interviewees provided another means to triangulate the data throughout the study (Bryan et al., 2011). By examining this group of participants in detail, the qualitative portion of the study helped to close the gap in understanding the characteristics of female secondary students and their participation in advanced STEM courses and STEM extracurricular opportunities.

Once approval was granted from Walden University's IRB (IRB approval #05-23-16-0419105), formal approval for the study was requested according to policies of the target school's school board. Data collection for this study spanned approximately 2 months and was sequential in design. The survey I initially gave had a participation rate of 42.7% and provided the necessary information to then sample the population for the qualitative interviews.

I was a teacher and administrator at the target school from 2009 to July 2015, and as such was a teacher to some of the student participants. While I no longer had authority over the participants or educators in the target school, this may have been an influencing factor on students' responses. My previous connections to the school also represented a potential bias and I used an external reviewer to preview research questions and review the coded analysis to increase validity.

Data Analysis

RQ1: How do female students' levels of self-efficacy correlate with their enrollment in advanced science coursework and STEM extracurricular activities?

Data obtained from the 5-item self-efficacy subscale of the survey were summed to quantify the degree to which students' levels of self-efficacy correlated with their enrollment in advanced science coursework and STEM extracurricular activities as measured by the number of classes and activities in which the survey respondents participated. The statistical software SPSS was used to support the quantitative analysis. Self-efficacy scores were first calculated by summing the responses from the SMQII, where questions 9, 14, 15, 18, and 21 specifically relate to self-efficacy (Appendix B); scores vary from 0 to 20 on that set of items in the subscale.

To explore possible correlations between self-efficacy and enrollment in advanced science coursework, a Pearson correlation coefficient was calculated as the variables are continuous in nature. The variables for consideration were the self-efficacy sub-score as previously described and a numeric value representing the number of advanced STEM courses and extracurricular activities which varied from 0-19 (AP Biology, AP Chemistry, AP Physics I, AP Physics II, Honors Physics, Physics, Anatomy and Physiology, AP Calculus, AP Calculus II, AP Statistics, Calculus, Intro to Engineering, Object Orientated Programming (OOP), SMART Chicks, National Ocean Science Bowl team, FIRST Robotics, Science Olympiad, Mathletes, and JagSat). All courses were 1 credit year-long courses, excepting OOP which is a ½ credit semester course. Due to the difference in credit enrollment, OOP was counted as ½ a course count; all other science courses and extracurricular activities were given a value of 1. The alternative hypothesis (H_A) was that there exists a statistically significant correlation between the sum of advanced STEM courses and extracurricular activities a female secondary student enrolls in and her level of self-efficacy. The hypotheses were:

> $H_0 1$: There is no correlation between levels of self-efficacy and secondary female students' enrollment in advanced STEM courses.
>
> $H_a 1$: The greater the number of advanced STEM courses a female secondary student enrolls in, the higher their level of self-efficacy.

The null hypothesis was rejected if $p < .05$ (Creswell, 2012). Additional correlations were run where advanced STEM coursework and extracurricular activities were not combined.

RQ2: How does the CoP in and surrounding a small rural high school contribute to female secondary students' decisions to enroll in advanced STEM coursework?

All audio recordings of the interviews were transcribed and member checks were used to increase internal validity and reliability. Data saturation was determined when additional interviews failed to produce novel codes. In this study data saturation occurred when 20% of the survey respondents had been interviewed ($N = 7$). The interview transcripts and participant responses were then coded. A preliminary exploratory analysis was used to allow me to immerse myself in the data and write memos concerning repeated words or ideas. The preliminary analysis yielded preliminary codes that were then used to analyze the data. A list of these initial codes was then complied to look for redundancies. Related codes were then examined and combined into themes or categories, which represented big ideas within the data (Creswell, 2012).

Results

Overall, the results of the study provide insights into the characteristics of female secondary students regarding their decisions to enroll in advanced STEM coursework. The quantitative analysis of the correlation between the 35 participants' self-efficacy levels and the number of advanced STEM courses and extracurricular activities they enrolled was not statistically significant (r=.298, N=35, p=.082). Similarly, the correlation between self-efficacy and the number of advanced science courses (r=.261, N=35, p=.130) and between self-efficacy and the number of advanced STEM courses

(r=.273, N=35, p=.113) were not statistically significant. However, the results from student interviews provide support for actionable steps to close the gap in practice in other secondary schools. Two consistent themes emerged from RQ2, which highlight the roles of the personal and social landscape in female students' decisions to enroll in advanced STEM coursework.

Quantitative analysis of findings. To address the quantitative research question (RQ1), how do female students' levels of self-efficacy correlate with their decision to enroll in advanced science coursework and STEM extracurricular activities, the self-efficacy subscale of the Science Motivation Questionnaire II (SMQII) was administered to 18-year-old 12th grade female students at the study site through an electronic survey. Information regarding the participation of specific advanced STEM courses and extracurricular activities were gathered through the same survey (Appendix C). I assigned each participant an overall self-efficacy score by totaling their responses to the 5 SMQII items. In addition, three academic coursework totals were obtained; the number of 1) advanced STEM courses, 2) advanced STEM courses and extracurricular activities, and 3) just advanced science courses (excluding other mathematics and engineering courses) were totaled for each participant (Table 1). The second and third academic coursework totals were obtained as a way to further explore the data. Thirty-five participants (42.7%) completed the survey.

Table 1

Descriptive Statistics for Values Obtained From the Quantitative Survey

Variable	*N*	Range	Min.	Max.	Mean	Std. dev.
Self-efficacy score	35	15	4	19	14.89	3.027
Number of advanced STEM Courses/extracurricular activities	35	8	0	8	2.46	1.884
Number of advanced STEM Courses	35	6	0	6	2.06	1.434
Number of advanced Science Courses	35	4	0	4	1.60	.946

A Pearson correlation coefficient was calculated using SPSS to explore the relationship between participants' self-efficacy scores and each of the three academic coursework totals. The null hypothesis ($H_0 1$) was that there is no statistically significant correlation between the self-efficacy score and any of the three academic coursework totals enrolled in by a female secondary student. There was a weak positive correlation between self-efficacy and the number of advanced science course ($r = .261$, $N = 35$, $p = .130$), self-efficacy and advanced STEM courses with extracurricular activities ($r = .298$, $N = 35$, $p = .082$), and between self-efficacy and the number of advanced STEM courses ($r = .273$, $N = 35$, $p = .113$) (Table 2). However, none of these relationships was significant at the $p < .05$ therefore the null hypothesis fails to be rejected. The correlation between self-efficacy and advanced STEM courses with extracurricular activities was nearly significant at the $p < .05$. A statistically significant correlation would indicate that a positive relationship exists. A statistically significant correlation would not indicate whether the self-efficacy levels caused participants to enroll in advanced STEM courses and extracurricular activities, if the enrollment in these increased self-efficacy levels, or if either factor demonstrated any causality. A larger sample size could either support or refute the correlation more fully and additional research questions would be necessary to explore causality.

Table 2

Pearson Correlation of Self-Efficacy and Academic Coursework in 18-Year-Old 12th Grade Female Students

Variable		Advanced science courses	Advanced STEM courses/extracurricular activities	Advanced STEM courses
Self-efficacy Score	Pearson Correlation	.261	.298	.273
	Sig. (2-tailed)	.130	.082	.113

Note. (N = 35).

Qualitative analysis of findings. RQ2 was qualitative and was used to explore how the CoP in and surrounding a small rural high school contribute to female secondary students' enrollment in advanced STEM coursework? Participants from the qualitative survey who indicated that they had participated in three or more advanced STEM courses or extracurricular activities were invited via email to participate in an interview. The mean self-efficacy score of this sample (N = 7) was 16 where the maximum possible score is 20 and is within one standard deviation of the mean of the larger participant sample (N = 35, $\bar{X}$ = 14.89, SD = 3.027) as reported in Table 1. Over the course of three weeks, seven students were interviewed in a one-on-one setting at the high school. These interviews were audio recorded and then transcribed for coded analysis. The transcript produced from an individual interview was sent to the participant for member checking. At the end of each interview, participants were asked to provide a written answer to an open-ended question (Appendix E). To code the transcript data, I began by reading each transcript and identifying themes and evidence of those themes within a single interview. After completing this process for each transcript, I compared and grouped the themes between multiple interviews. The identified themes have then become the basis for analysis and discussion of RQ2. To triangulate, participants also responded to a written prompt. The themes from each participant's written response was then compared with the themes identified in the participant's individual interview to help increase reliability and provide for triangulation. Two main themes emerged from my analysis of the interview transcripts and written responses; the roles of the social landscape and personal landscape.

Social landscape. The theme of social landscape was derived from four repeating codes found throughout each of the interviews. Social landscape links together the related codes of role models, peers, school culture, and larger societal culture. The smallest code to emerge was that of the influence of the larger societal culture on the overall social landscape of the students. The discussion of STEM being pushed as a nation is something that the participants are aware of although this is more of an awareness than a factor motivating participants to pursue STEM. As participant G stated "…STEM is being looked at as the next big thing. I think there has been a lot of encouragement and support for STEM." The same participant also noted while people see STEM as the next big thing, the advice she would give to younger students is to explore all possibilities and pursue their passion. The same idea was repeated in other interviews and seems to suggest that while society is promoting the idea of STEM, for participants in this study, the pursuit of a personal passion may be more important to them than the interests of the larger society. Several participants also indicated that job security was an influencer they had felt from the larger society; however, this idea was mentioned only briefly in the interviews, and participants elected to expand on other aspects of their journey, only mentioning job security in passing. For example, participant A's statement "And engineering degrees are really useful and getting more popular because you can get more money. That's just what kids want, they just want to be saved by the monetary part of it." suggests that while others may feel this societal motivation, it is not a driving factor for the participant.

The local societal landscape seems to be more important to the decision making of the study's participants. Compared to their discussion of national interests in STEM, the participants spent a large portion of their individual interviews discussing the influence of role models, both familial and teachers, the positive effects of their peer groups and the overall school culture in shaping their STEM course choices and postsecondary pursuits. Six of the interview participants we able to trace their interest in STEM as beginning in the middle school or even younger ages and then its solidification as a postsecondary pursuit in high school. These early influences on the development of STEM interests were largely in the form of familial role models including parents and grandparents. When asked about the influence of others' viewpoints concerning STEM, all participants discussed positive influences such as watching their parents enjoy their work as engineers. Several participants, such as participant C, included unprompted statements such as "I haven't felt the gender stereotypes [that are discussed nationally]." The influence of the familial role model seems to be support and passive observation by the participants. When discussing her father's roll as an engineer, participant E stated "… But seeing what he is doing. He just did a small 6-month contract recently and he had so much fun with it . . . Biogen, I think. But he really enjoyed it!" Participants also discussed their secondary school teachers using similar references and terminology. Participants discussed their teachers "passion," "encouragement," and "introduction of STEM majors." Interestingly, only one teacher was mentioned by name and the theme that emerged was more that teachers in general exposed students to a variety of courses and ideas rather than a defining characteristic of a type of teacher, for example gender, background, or postsecondary degree. STEM teachers were discussed by participants in the larger context of how they contribute to the school culture of promoting STEM.

Students discussed several characteristics of the study site's school culture, referring to how the school supports students' pursuit of STEM. All participants discussed the rich variety of course and extracurricular activities in which they participated, ranging from 3-8 in number. All participants strongly reinforced the value of the advanced STEM courses, offering that they would advise middle school students "take STEM classes like biology, chemistry, and even physics." While the majority of participants indicated they were interested in STEM at a young age, they referenced specific STEM courses, including Object Oriented Programming, AP Biology, and Physics, as solidifying their interest and desire to pursue STEM pathways. Participants value the variety of challenging advanced STEM opportunities and that within the school culture there is support for enrollment.

Participants felt free of gender stereotypes regarding STEM within the culture of the study site. Furthermore, the concept of this stereotype seems to be externalized as they would give the same advice to middle school students of either gender about pursuing STEM as a pathway. Two students did remark that they felt that the external stereotypes affected male students more than female students. These participants felt that STEM, specifically engineering, was an expectation of male students who would then have a more challenging time pursuing other non-STEM majors or even STEM majors like nursing that are perceived as “not STEM enough.” Participants felt that being involved with STEM at the study site was viewed in a positive light. Participant B explained it by stating “I think that STEM, and views on STEM here [study site] are very, very positive as a whole. It, at least from what I’ve seen, there is a lot of emphasis placed on STEM at this school. So people who are in the more challenging STEM classes, they are I don’t want to say well respected, but people take notice of that, and that’s like a very positive thing here.” Participant C also commented on gender stereotypes in STEM, “So, I haven’t, I don’t think I felt that at all in [study site]. In my AP Biology class out of 18, around 18 kids, there are only like two boys. So, there’s not that overarching like all boy class thing, I think you see in like shows or TV or whatever.” The perception of the participants is that the study site has a different kind of culture regarding STEM than exists in other environments. All participants felt that the positive supportive culture allowed them to pursue their “passions” and interests free of stereotypes. “Finally, I think that the environment that [study site] fosters, surrounding STEM, motivated me to enroll in these courses [advanced STEM courses].”

Finally, within the overarching theme of social climate, the code of peer group influence became apparent. The peer group code is separate but not isolated from the overall culture of the study site as previously discussed, as it simultaneously may contribute to the culture and be a product of the culture. Participants commented that their friend groups were pursuing STEM areas of study as well. While this may not reflect the external culture of their chosen postsecondary institutions, the participants expressed that the peer base at the study site was both a source of support and normal within the study site. Participants engaged in extracurricular activities including Destination Imagination, JagSat, and Science Olympiad with other female students who the participants described as motivated and “STEM orientated.” Participants viewed this participation as part of the culture of the study site. As this code was reoccurring throughout the interviews, it seems to suggest that whether a product or a contributor, the peer group is an important influencer on the participants. Several participants discussed the common interest of peer groups as also causing an increased competitiveness within classes and in pursuit of internships. In contrast to the competitive aspect of STEM courses, participants also suggested for all students to take a variety of courses to discover their personal passions and remain independent in their choices. Independence is connected to the second major theme found in the transcript data—personal landscape.

Personal landscape. The theme of personal landscape can be broken down into four distinct repeating codes found throughout the participants’ interviews: independence, resilient mindset, transformative experience, and self-awareness. The themes within personal landscape are how the participants describe and think of themselves; it is in a sense their self-described character. For example, several participants discussed their independent nature as being an essential aspect of themselves. Independence was both directly and indirectly described within the participants’ academic life and beyond. One participant (A) is pursuing a postsecondary STEM education in Hawaii because it is a unique and distinguishing opportunity despite being far from home and familial support. The participants reported that outside stereotypes had little influence on them, for example, participant E remarked "I'm a pretty independent person so I don't really let things like that [others view of STEM] influence me." The characteristic of independence may help to explain the prevalence of females in STEM coursework at the study site as they are able to resist negative stereotypes and instead form their own opinions. Independence is also described by participant's as a necessary trait in their STEM coursework, allowing them to persist, manage their time, and learn content effectively.

Independence could be considered a subdivision of the larger code of self-awareness found throughout the participants' interviews. The participants displayed a high understanding of self throughout the interview and follow-up question. They indicate that in pursuing STEM coursework and careers they have found a pathway that as one participant described "works well with my personality," and another described as fulfilling her own "natural curiosities". Participants described their pursuit of STEM as doing what was best for them regardless of outside or societal influences. Upon enrolling in an Object Orientated Programming course, participant D remarked that she simply "knew that this was where I was meant to be." The same participant shared her experience, feeling that she did not identify with students who took engineering courses. Then during her senior year, as she enrolled in an engineering course coming to the self-awareness that in her words "I'm totally a nerd!" and that she was proud of identifying this passion within herself. The prevalence of this code suggests that self-awareness combined with an independent nature, is a key attribute of these young women and central to their decision to enroll in advanced STEM coursework. Self-awareness can be linked to the societal landscape discussed earlier, as the students' interactions are supported by the CoP in and around the school. Beyond the school itself, personal experiences of the participants have had a significant impact on their concept of self and their pursuit of advanced STEM coursework.

Personal experience, beyond the classroom, and the role of personal experience in shaping the participants' pursuit of advanced STEM coursework was referenced directly by 5 of the 7 participants. Personal experience was described by either having family members who were in the STEM career field or by experiencing a personal medical diagnosis in the immediate family such as cancer. The frequency of this code supports the extended view of the CoP beyond the physicality of the school itself. Consistent with the current body of research, this indicates that the presence of STEM professionals in a student's life has a positive effect on their pursuit of advanced STEM coursework and STEM careers. Comments from the participants indicate that these experiences were active not passive in nature. One participant recalls seeing her father enjoy his engineering career and another referenced watching her father work with cameras. In a similar manner, participant B discussed her experiences with medical professionals while her brother underwent treatment for leukemia. When asked about the factors contributing to her desire to pursue STEM and in her case specifically nursing, participant B remarked "being in the hospital with him [her brother], I got a lot of experience in that area." These personal experiences helped to make visible, possible pathways for students and the thought processes of the practitioners in a cognitively tangible way. These personal experiences made a STEM pathway concrete through observation and modeling.

The final code that significantly contributes to the personal landscape theme is that of a resilient mindset. A resilient mindset, as present in the language participants used to describe their experiences as well as the experiences themselves. This mindset is best summarized in the words of participant G. Referencing challenges she faced in her advanced STEM coursework she stated, “It definitely ended up being positive, at times it might have been stressful, but I think everything had to happen the way it did for me to be here.” Participants discussed the challenge they faced in their advanced STEM coursework as being something they had to overcome, and they then went on to recommend to other students that they should take as much challenging coursework as possible in high school. Participants referenced the pressure and challenge of these courses for example participant B stated “I wanted to take classes that would help me out, not take the easy way . . . I felt like if I can’t do well in those, I must be doing something wrong.” Despite sharing these feelings, the participants continued to take challenging coursework and wish they had taken more. Several participants included in their advice to younger students that they should not be afraid to ask questions or what others think of them, emphasizing that it is OK to take chances and be wrong. Responses such as this, suggest with a resilient mindset that even when faced with and adverse or challenging situations, participants responded with a positive adaptive response. A resilient mindset can be best summarized in one participants’ (E) words, “Definitely challenge yourself in high school cause your gonna feel…even if you don’t do as well as you’d like to in the classes, well especially in high school, you’re gonna feel better that you did take them…just work really hard, challenge yourself… I’m glad I did.”

In summary, the personal and societal landscapes of participants had strong connections to their persistence in advanced STEM coursework and their plans to pursue postsecondary studies in STEM fields. The participants' landscapes changed and developed over time, as evidenced through their responses, suggesting that the landscapes are malleable and can be influenced by thoughtful practices in schools. To cultivate practices that support the strong development of landscape features including independence, resilient mind-set, role models, and school culture, educator professional development is essential. The outcome of this study is the creation of a professional development plan and materials to support the implementation of a cognitive apprenticeship model (CAM) which will support educators in growing the landscape, evidenced at the study site, supporting female enrollment in advanced STEM coursework.

Limitations

The most pronounced limitation of this study is that it was conducted at a single study site with a single researcher. As such, the generalizability of its findings may be limited to other sites similar in demographics and school size. Also, students at the study site are involved in many extracurricular activities, athletics, and diverse course offerings. As such, some female students interested in pursuing STEM as a career may not have been identifiable by participating in a 3 or more advanced STEM courses and STEM extracurricular activities if there is competition for students' time from other non-STEM activities. Additionally, the statistical analysis assumes a normal distribution of participants. If participation level for either gender is extremely different from the other, then the analysis may not reveal a relationship. One final limitation is that as the high school is relatively new, it has attracted many new families to the town who may have chosen the school for its STEM reputation. Therefore, participants may have been part of the CoP for varying amounts of time which could potentially impact the results.

Summary

While the quantitative findings in this study revealed weak or no correlation between female secondary students' levels of self-efficacy and enrollment in advanced STEM coursework, the qualitative interviews uncovered strong themes categorized into the personal and social landscape of participants. Resiliency and independence, as well as the presence of mentors and positive social supports for STEM, were a few of the characteristics of female secondary students' personalities and environments, who enrolled in high numbers of advanced STEM courses. To increase the enrollment of female secondary students in advanced STEM coursework, the findings suggest that schools should seek to increase students' opportunities to work with mentors, engage with curriculum which supports a resilient mindset and offers students the capacity to become more independent in their learning.

Section 3: The Project

The goal of this mixed-methods project was to address the gap in understanding of the factors that support female secondary students' enrollment in advanced STEM coursework. Participants indicated high science self-efficacy independent of the number of advanced STEM courses in which they enrolled. Interviews with participants who enrolled in 3 or more advanced STEM courses indicated that personal and societal landscapes including independence, the presence or role models, resiliency, and school culture all played a key role in their enrollment decisions. Building a cognitive apprenticeship model (CAM) in a secondary school offers an opportunity to support the development of the personal and societal landscape discussed by participants to support increased female enrollment in advanced STEM coursework. For my project, I created the professional development materials necessary to develop and sustain a CAM.

Description and Goals

Increasing female secondary students' enrollment in advanced STEM courses and extracurricular activities has a positive effect on their continued pursuit of STEM majors in postsecondary education and as a career (Chachashvili-Bolotin et al., 2016; Fletcher, 2012; Long et al., 2012). According to national statistics, such as those published by the College Board, female students are in the minority when it comes to participating in advanced STEM courses including AP chemistry, AP physics, and AP computer science (College Board, 2014). One rural New England school that had achieved gender equity in advanced STEM courses was the focus of this study. To address the gap in practice in other secondary schools professional development materials were designed with the goal of creating and increasing the capacity of a CoP to establish a cognitive apprenticeship model to increase female secondary student enrollment in advanced STEM courses and extracurricular activities.

Rationale

In a CoP, both mentors or old-comers and the new-comers or apprentices work in a collaborative environment to build a common practice. While in the traditional setting of a school, mentors may be thought of as the teachers, this study and others suggest that the definition should be expanded to include all practitioners, including family, older students, and community members committed to the domain of interest, which in this case is the student. In the CoP at the study site, a form of cognitive apprenticeship emerged from the terms and ideas coded in the participants' interviews. The participants referred to discussions of careers and coursework, as well as opportunities to observe others engaged in making their thought process visible, which are all activities indicative of an environment supporting the intentional and sometimes unintentional presence of cognitive mentorships in the CoP. A CAM of learning shifts the focus from a teacher-centered model to a collaborative, goal-orientated, problem solving model where teacher and students are equally invested (Cheng, 2016). The collaborative model is present in the CoP of the study site, where learning is a function of the old-timers in the community, including teachers and family, sharing experiences and meaning-making with the students. The shared practice is cognitive in nature in that it provides for a method to make thought processes visible through experience and dialogue.

One aspect of the CoP present at the study site was supporting and cultivating a resilient mind set in students. Resiliency has been described in many ways and can be best summarized in this study as the "positive adaptive response in the face of significant adversity" (Center on the Developing Child at Harvard University, 2015; p. 1). As previously described, persistence in STEM coursework requires that students fail forward as part of the engineering design process. STEM coursework often requires modelling, prototyping, or hypothesizing followed by testing and experimentation, leading to redesign or conclusion. Failure is an instructive aspect of the learning process. A resilient mind-set that allows for a positive response to the adversity of failure supports high levels of self-efficacy (Bandura, 2005; Bandura, 2001). The high self-efficacy levels of participants in this study supported the presence of a resilient mindset.

Most CAM research has focused on graduate level education and more recently to online learning environments, where it was shown to increase the skills, reflective practice, development, and persistence in students (Boling, Hough, Krinsky, Saleem & Stevens, 2012; Kopcha & Alger, 2014; Maher, Gilmore, Feldon, & Davis, 2013; Saadati, Tarmizi, Ayub, & Bakar, 2015) In a study exploring the effects of a cognitive apprenticeship on skill development in doctoral students, Maher et al. (2013) found that the CAM increased the skill development of students, but only when it included deliberate and intentional activities on both the part of the mentor and the apprentice. Therefore, to address the gap in practice in other secondary schools, a professional development curriculum to help support educators in the CoP to develop their skills as cognitive mentors, to develop the structures in the CoP to support cognitive apprenticeships, and to support a culture of resiliency was chosen for its potential to create positive social change.

Review of the Literature

Prior to developing professional development materials to address the study's emergent themes of the personal and social landscape, I needed to better understand andragogy as well as how a cognitive apprenticeship supported the development of the emergent themes. To conduct this review, I used the search engines available through the Walden Library including ERIC, Science Direct, and Education Research Complete. I entered search terms including *andragogy, adult learning, effective professional development, performance assessment, STEM dispositions, self-efficacy, mentors,* and *resiliency,* among others. The term *cognitive apprenticeship* emerged several times through my related searches, which led me to use this term further in the project's development. The concept of a cognitive apprenticeship connected the emergent themes of social and personal landscape from the study. The search terms used allowed me to justify and decide on the genre of the project as well as the content. I used current publications from the U.S. Department of Education to trace the latest findings on increasing the number of students pursuing STEM postsecondary education and degrees. Combining rigorous authentic coursework, mentorships, and the value of the CoP were frequent themes that led me to a focus on CAM as it combined these elements in addition to the study's emergent themes. Also, I used the literature reviews of peer-reviewed journal articles and articles that themselves were literature reviews in order to lead me to additional scholarly sources.

Effective Professional Development

The learning needs of educators are distinct from those of the students they instruct; therefore, adult learning theory must be considered in the design of professional development if it is to be meaningful and achieve its desired goals (Knowles, Holton, & Swanson, 2014). In this instance, the purpose of the professional learning is to create and strengthen a CAM with a focus on resiliency in secondary schools to support a greater percentage of female students enrolling in advanced STEM coursework. According to Knowles et al. (2014), five aspects of the adult learner must be considered in order to provide meaningful professional learning to support institutional growth or change: (a) adult learning is motivated by the needs and interests of the adult; (b) the learning must be life-centered, because this is what is important to the adult learner; (c) the learner's experiences must be valued and central to the methodology; (d) the learning must be driven by opportunities for mutual inquiry and collaboration; and (e) the learning must be differentiated, because the learner's needs evolve through age and experience. To support the tenets of adult learning theory, a cognitive approach to professional learning is particularly appropriate. A cognitive approach to adult learning has been utilized in a variety of professional development settings and has demonstrated increased proficiency by the educators as well as gains by their students in the targeted areas (Cheng, 2014; Fogleman, Fishman, & Krajcik, 2006; Greer, Cathcart, & Neale, 2016; Madden, Grayson, Madden, Milewski, & Snyder, 2012; Maher et al., 2013; Nyaumwe & Mtetwa, 2011). A cognitive approach supports a learner in finding meaning in what is being taught and applying this knowledge to new situations. As the result of the proposed professional learning, secondary school CoPs will form cognitive apprenticeships that foster resiliency in students; therefore, a cognitive model of professional learning will allow the facilitators to model for educators in an authentic approach.

Cognitive Apprenticeships

The process of bringing about change in an educational system can be a time and resource intensive process. Schools experiencing success in creating long term meaningful change have discovered the value of creating internal capacity to support change over an extended time. Internal capacity must be cultivated and nurtured through professional development in the same way that achieving increased student success must be supported (Cheng, 2014; Fogleman et al., 2006). By supporting a CoP through professional learning in order to foster cognitive apprenticeships with students, learning can be focused on student achievement and closing the gap of the ratio of female to male students enrolled in advanced STEM coursework. A CAM of education is anchored in learning through authentic tasks by utilizing the social and physical environment. Through a CAM, the internal thought process of mentors is made visible and acts as a catalyst for student learning (Collins, 2006). Mentors need to pay deliberate attention to making their thought process available as well as scaffolding for mentees, which requires an understanding of a cognitive framework for learning (Boling et al., 2012; Stalmeijer, 2015).

In recent years, the increase in enrollments and options for students to learn in blended or online settings has brought the importance of the CAM of learning into focus. Studies of online CAMs indicate that thoughtful design using CAM principals positively impacts student achievement (Boling et al., 2012; Bouta & Paraskeva, 2015; Kopcha & Alger, 2014; Saadati et al., 2015). The benefits of a CAM have also been explored in teacher preparation programs, doctoral programs, as well as engineering and science postsecondary programs of study (Greer et al., 2016; Nyaumwe & Mtetwa, 2011;

Wedelin, Adawi, Jahan, & Andersson, 2015). The successful use of CAM in research is accompanied by the cautionary tale that use of this practice must be intentional and grounded in an understanding of cognitive theory and practice.

According to Collins (2006), a cognitive apprenticeship model has four main dimensions: (a) content or type of knowledge, (b) methodology or instructional pedagogy, (c) sequencing of learning activities, and (d) sociology or the social context of the learning environment. A cognitive approach to learning shifts the learning from a teacher-centered environment to a student-centered environment. Shifting to a student-centered environment necessitates a reexamination of the content students are expected to master. In a student-centered environment, higher order thinking skills and a higher depth of knowledge (DoK) are expected and become a natural consequence of a cognitive curriculum (Webb, 2002). Cognitive learning is centered in authentic problem solving and practices, which forces the move to higher DoKs and assessment of learning through more performance based assessments. Authentic assessments that also measure skills like modelling and problem solving are a critical recommendation in developing STEM thinking and more relevant coursework (Duckworth & Yeager, 2015; Reeve, 2015). The CAM is effective at changing the knowledge landscape to more authentic and meaningful learning in diverse populations and age groups as evidenced in teacher preparation programs, development of postsecondary research assistants, and enhanced middle school science curricula (Kraft, Schmiesing, & Phillips, 2016; Madden et al. 2012; Maher et al., 2013; Nyaumwe & Mtetwa, 2011).

A shift in pedagogy and instructional strategy is a necessary complement to the deeper shifts in content as part of a CAM. A CAM presumes that students are active participants in their learning and that their learning experiences evolve as their proficiency increases. Through a CAM, students not only learn content but metacognitive skills such as reflection, as well as how to think and problem solve. Due to the nature of STEM, metacognitive skills are essential for students persisting in advanced STEM coursework and postsecondary study (Butler, Marsh, Slavinsky, & Baraniuk, 2014; Fouad and Santana, 2017; Simon et al., 2015; U.S. Department of Education, 2016). Student learning shifts from modeling and coaching to articulation, self-reflection, and independent exploration (Boling et al., 2012; Madden et al., 2012; Stalmeijer, 2015; Thompson, Pastorino, Lee, & Lipton, 2016; Yilmaz, 2011). To achieve the positive effects of a CAM, teachers need to shift their instruction, which requires professional development. When students are provided with the opportunity to scaffold the learning process from modeling to self-exploration and are supported in a self-reflective process along the learning continuum, student achievement increases. As students take more responsibility for learning it also increases their capacity to transfer learning to novel situations and for deeper learning to take root (Butler et al., 2014; Kraft et al., 2016; Saadati et al., 2015; Thompson et al., 2016; Wedelin et al., 2015).

In a CAM, the student moves from modeling to self-guided exploration which is an example of the gradual releases of responsibility from teacher to student. Sequencing, the third dimension of a CAM, provides logical steps in the progression of student learning. The purpose of a CAM is for experts to support novices until they become full members of the CoP. A gradual release of responsibility must occur as the novice gains proficiency and is able to complete tasks of increasing complexity and diversity (Boling et al., 2012).

Sequencing shifts the ownership of learning, representing a crucial aspect of CAM curriculum design. Research using a CAM framework suggests that the teachers, or experts, most effective at increasing student competency and achievement, provide personalized authentic feedback and understand student needs for flexibility (Butler et al., 2014). Experts now, more than ever, guide students through the learning process rather than act as the sole vehicles of knowledge transmission (Boling et al., 2012; McPherson, 2014; Thompson et al., 2016; Tompkins, 2016). As DoK increases, and pedagogy keeps pace, the mentors must create learning experiences which increase in complexity and allow students to transition from the coaching phase into self-exploration. Students who can attend to a small diverse set of complex problems are able to achieve at higher levels than those who attend to a larger number of low complexity problems. Low complexity problems do not encourage authentic application of skill, transfer of knowledge, and the metacognitive processes of problem solving and perseverance (Wedelin et al., 2015; Wells, 2016). CAMs foster the resiliency and cognitive processes necessary for success with complex, authentic problems encountered in advanced STEM coursework, postsecondary study, and in STEM career fields.

Cognitive theorists suggest that learning is a social process and that to separate the physical acquisition of knowledge from the social, leads to an incomplete picture of how students learn (Bandura, 1989; Brown, Collins, & Newman, 1989; Yilmaz, 2011). Findings from the study site suggested the importance of the social landscape in female students' pursuit of advanced STEM coursework. Many participants discussed the culture of the school and the role their supportive peers played in choosing and succeeding in the advanced STEM courses.

Researchers exploring the social aspects of CAMs also found peer support to be an important aspect of success (Boling et al., 2012; Greer et al., 2016; Hardin & Longhurst, 2016; Kopcha & Alger, 2014; Nyaumwe & Mtetwa, 2011; Saadati et al., 2015). In a study by Hardin and Longhurst (2016), female students' science self-efficacy, in an introductory postsecondary STEM course, was found to decrease as they progressed through the course and were not exposed to overt encouragement and social support. Conversely, social supports including collaborative cognitive-activation strategies increase female students' enjoyment and therefore potential persistence in STEM coursework (Cantley, Pendergast, & Schlindwein, 2017). Successful online programs, demonstrating high levels of student achievement and student engagement, take the social nature of learning into account and look for ways to support this in a virtual environment (Boling et al., 2012; Saadati et al., 2015). Furthermore, in studies examining use of a CAM in teacher preparation programs, professional development, and transitioning doctoral students into teaching roles, the social use of peer groups and cohorts is a significant contributing factor to the success of the student (Greer et al., 2016; Kopcha & Alger, 2014; Nyaumwe & Mtetwa, 2011). The high self-efficacy levels I observed at the study site corroborate research findings showing a strong CoP can support the social aspects of learning, not only in mastering content, but also in cultivating the resiliency needed to persevere in challenging coursework.

Project Description

I will develop a professional learning plan to build cognitive apprenticeships which addresses the inequity in the male to female ratio of secondary students participating in advanced STEM coursework. The project is intended to support the community's learning and will be implemented over the course of a year. The results of the project will be measured using enrollment numbers, SMQII, and the interview guide (Appendix D), the same data as the present study. A collective commitment to carry the learning forward is important on the part of the administration and teaching professionals in the CoP to offer opportunities for increased social justice for women.

Potential Resources and Existing Supports

The growth of a CoP into successful cognitive apprenticeships, which cultivate a resilient mindset in students, requires the commitment of the entire community of school A. Students in the CAM will require intensive support from structured human resources. Many supportive adult human resources already exist in school A including teacher leaders, administrative teams, mentoring programs, and school-community partnerships including internships, career days, guest speakers, and STEM professionals who offer free tutoring. Identifying and promoting teacher leadership from within the district is one goal of the professional development curriculum, as teacher leaders support sustainability in the CAM (Fogelman et al., 2006).

Administrators, curriculum experts, mentors, and community liaisons are essential to developing, implementing, and maintaining the capacity of a successful CAM. For a school to achieve a functional CAM, professional learning must be ongoing. As such, school A must dedicate 8 full days of PD over the course of year 1 in addition to supporting teachers during weekly meetings during their planning time or after school and may need to postpone other school or district level initiatives. Administrators must understand the value of the CAM for students as well as how CAM structure is critical to learning. The support of school A's principal and assistant principals is necessary to ensure focus on the initiative in terms of the time and expertise of the faculty. As the public face of the school, administrators' leadership is needed to build community understanding, support, and involvement in the CAM. Administration must also lead by example. Through active participation in the all phases of the CAM, administrative leaders are instructional leaders and provide support for the project as well as to emerging teacher leaders.

Curriculum expert teacher leaders in school A are the heart of the ongoing learning, development, and implementation of the CAM. Throughout the development of the CAM, several shifts in curriculum and pedagogy must occur. Curriculum experts, who are already recognized by both their peers and the administration as leaders are necessary supports to ensuring the curriculum and instructional shifts are deep and transformative rather than superficial. In school A, the curriculum experts are teachers from within the school who will lead the work from their classrooms and include department heads, instructional coaches, and teachers who have achieved a proficient with distinction rating on school A's teacher effectiveness evaluation framework. Leadership from within each department at school A creates a greater sense of authenticity among their peers as all are invested in the work together. Curriculum experts will facilitate groups during the formal professional development sessions as teachers need to experience participating in a CAM so that they can better support the goal of developing a CAM with their students. Curriculum experts will also be available for consultation, peer observation, and support to other teachers in the daily implementation of the new learning and therefore will require the support of administration. School A's curriculum teacher leaders for the CAM project have already demonstrated their expertise in knowledge and practice to lead the work through recognition as department heads, in their assignment as an instructional coach, or by having achieved a proficient with distinction rating on school A's teacher effectiveness evaluation framework. Curriculum expert teacher leaders may also act as mentors for teachers within the school. As new teachers are hired by school A in subsequent years, sustaining the CAM becomes a priority of the teacher mentors within each department as newcomers are initiated by old comers. The teacher mentors help support the training of new members of the CoP to understand, contribute, and sustain the CAM to which school A has made a commitment.

The final phase of professional learning in establishing the CAM is building an understanding of the supports within the larger context of school A and the surrounding community. In addition to the work lead by teacher leaders, school A's extended learning opportunity (ELO) coordinator will be necessary to maximize internal and external systems of support. In school A, the ELO coordinator is an individual who researches and creates partnerships within the community. The ELO coordinator develops community-based internships for students, shadowing experiences, and organizes tutoring programs with community experts from STEM fields. The formation of community- school partnerships extend the opportunities for students to work with multiple cognitive mentors. The ELO coordinator, already employed by school A, has the capacity to make community connections and in partnership with the school's administration create safe spaces for groups to meet and to take advantage of the expertise beyond the school walls.

Potential Barriers

Once school A decides to pursue a Cognitive Apprenticeship Model to increase the number of female students enrolling in advanced STEM coursework, the main barrier to successful implementation will be time. As community partnerships are essential the success of a CAM, if school A cannot continue to support its existing ELO coordinator, it will be more challenging to develop the community school partnerships including mentors, internships, and job shadowing opportunities. Ongoing support and time will be needed to transform and support teachers practice and forge community supports. There also exists a potential danger of school A embarking on other curricular initiatives such as adopting new academic standards or implementing a new student behavioral response program, before truly devoting the time to ongoing professional learning necessary to embed the CAM as the way of fulfilling the mission of the school. Furthermore, the proposed professional learning depends largely on the presence and willingness of teacher leaders within school A, working to strengthen their personal learning and facilitating that of others. Administrative leaders must assess the skill set of their teachers using school A's teacher effectiveness evaluation framework and supplement additional professional learning where necessary. To support teacher professional development, school A will consider release time or stipends for this continued work. Finally, technology and technology infrastructure will be evaluated. While the PD in establishing and implementing the CAM can take place without major investments in technology, having updated equipment and the infrastructure to support it will greatly enhance personalization of student learning.

Proposal for Implementation and Timetable

Ongoing sustained professional learning in school A, which leverages the expertise and experiences of the adult learners, is the most effective method of creating the deep changes needed in content, methodology, instruction, and sociology necessary to support a successful cognitive apprenticeship (Knowles et al., 2005). The proposed professional learning plan for school A will build expertise and capacity within the school to create, implement, and support a CAM. The PD activities model the same gradual release of responsibility necessary for teachers instructing students, as the teachers establish the cognitive apprenticeship in their classrooms and beyond. I will lead the early learning in the professional development, whereas the ongoing learning will rely on school A's teacher leaders, other building administrators, and the teachers themselves who are mentoring students in the CAM.

The initial meeting with teachers and administrators will take place in June of the school year prior to when school A plans to implement the CAM. Administration will contact STEM teachers prior to this event for planning purposes. The purpose of the first half day meeting is to establish a unifying call to action and build a common understanding of the CAM and its potential to close the gap in practice. Establishing a CAM leads to greater gender equity in advanced STEM coursework. The focus in the initial meeting will be on the importance of resiliency and a growth mindset. During the June early release day, small groups (6-10 participants each) will read Dr. Robert Brook's article, "The Common Underlying Factor" and discuss it using a text rendering protocol (Appendix A) (http://www.drrobertbrooks.com/resilience-common-underlying-factor/). Teacher's discussion of Brook's article is a critical juncture in building a shared vision of why resiliency is a key characteristic of participants in a CAM and how teachers need to be the “charismatic adult” in Brook’s article. The second activity for this opening session will be a presentation to build a common vocabulary and background knowledge of the 4 dimensions found in a cognitive apprenticeship; (a) content, (b) method, (c) sequencing, and (d) sociology. The 4 dimensions of a CAM will be the framework for the ongoing professional learning throughout the next year.

In late June, after the final day with students, a 1-week summer institute will be held for school A’s STEM teachers to examine and revise their curriculum. Teachers will focus on creating more higher order thinking by designing assignments with higher levels of Webb’s DoK, as well as creating opportunities which allow students to build resiliency necessary to persevere through advanced STEM coursework (U.S. Department of Education, 2016).

Three sets of activities will take place during the summer institute. First, teachers will build foundational knowledge of the cognitive demands that each of the 4 levels of DoK places on the learner. Participants will then examine summative tasks from their current curriculum and evaluate the DoK levels of each question or prompt depending on the type of assessment. Teachers will then work in collaborative groups with their subject matter peers to increase the cognitive demand of the assessments or decide to discard the assessment and create a new one better aligned to the curriculum and a higher cognitive load.

The second set of activities during the summer institute week will build an understanding of performance assessments (PA) and how they assess students’ ability to use knowledge in meaningful ways at high DoK levels. Through a presentation, teachers will gain background knowledge regarding the characteristics of a quality performance assessment as well as how they are developed and validated. Using a carousel style activity, teachers will then complete a close read of existing quality performance assessments and discuss specific characteristics and the instructional shifts necessary for students to successful complete the assessment.

During the third set of activities, teams of teachers will work to begin designing quality performance assessments and the necessary instructional shifts for each content area with the assistance of tools produced from the Center for Collaborative Education (Brown & Mednick, 2012). As performance assessments increase the cognitive demands on student, they necessitate instructional shifts to prepare students to meet these demands. The instructional shifts associated with performance assessments are student centered, focus on a growth mindset, and the process of learning. Performance assessments support an iterative process of instruction that is necessary for students to be successful in the final assessments. The instructional shifts and their corresponding assessments build resiliency in that learning in an ongoing process of continuous improvement.

During the next school year, teachers' PD will continue in collaborative groups led by curriculum expert teacher leaders within school A. The most meaningful professional learning, leading to long term systemic changes in practice, is sustained over extended periods of time (Knowles et al., 2005). To support the instructional shifts in school A necessary to build a CAM, the team of curriculum leaders, administration, and STEM teachers will devote two PD days in October to refining performance assessments and analyzing instructional shifts through examining exemplar unit and daily lesson plans. The second and third characteristics of a CAM are teaching methods, which include coaching, modeling, and sequencing. Sequencing is gradually increasing complexity of the required tasks and a gradual release of responsibility for learning (Boling et al., 2012; Saadati et al., 2015). Teachers will participate in learning new methods and refining their performance tasks in an environment that resembles a CAM. The design of the professional development will reflect the style of learning teachers are working to create for their students. Teachers will receive coaching on their developing performance tasks. In addition, exemplary lesson plans will be used as models and to discuss the sequencing of learning students engage in before completing a performance task.

To achieve meaningful PD for individuals, a needs assessment will be completed by each teacher, reflecting on their how they implement performance assessments in a student-centered classroom. The needs assessment will then be used to inform the resources and structure of the two days. Tailoring the PD reflects the theory of andragogy, which states that adults value learning that incorporates their experiences and allows them to be a participant in the learning rather than just a receiver (Knowles et al., 2005). Using the needs assessment curriculum leaders from school A can tailor the days to teachers' specific needs. A needs assessment will also help identify those teachers already demonstrating proficiency to help facilitate and take on a coaching role with their colleagues to help build capacity throughout the school.

During the October PD days, earlier topics may need to be revisited and additional topics for discussion and analysis include sharing of victories and challenges with the implementation of performance assessments and student learning. Teachers will also spend time analyzing exemplar lesson or unit plans, that engage students in the coursework in a way that will support the gradual release of responsibility of learning necessary for DoK level 3 and 4 assessment of learning. During the second day of PD, teachers will collaboratively refine upcoming units and lessons using the exemplars. The collaborative nature of the October PD will build a community for collaboration which will anchor the group for continued informal discussion and analysis in the coming months.

Primary to the successful development and long term success of the CAM will be the collaborative learning and discussion that school A's teachers engage in with one another, coaches, curriculum experts, and administrators. These discussions continue to build a shared purpose and proficiency in the work and model for students the process of collaboration. Over the remaining school year, teachers will establish weekly collaborative sessions with their colleagues to continue to refine their practice. The schedule will be shared with school A's curriculum leaders, coaches, and administrators so that they can be participants and support the continuing work in a non-evaluative way. All participants will work together to establish times to observe lessons in progress to provide non-evaluative coaching and reflection on refined units and instructional practices. Collaboration between teachers, coaches and administrators also begins to lay the ground work for the fourth characteristic of a CAM, the sociology of learning.

Near the end of the school year in May, one additional day of PD will be planned to discuss the importance of the sociology of a CAM. I will lead participants in building a shared understanding of the social structures that support self-efficacy and resiliency in students. The participants will include teachers, curriculum leaders, administration, guidance counselors, and the ELO coordinator. The task of the group is developing actionable items that support the sociology of learning which may include the creation of internship opportunities, formation of PLCs to support teachers' efforts, creation of STEM extracurricular activities, creation of peer tutoring, advisory programs, or even restructuring the space of learning to support study spaces available to students outside the school day for collaboration. As a group, participants will come to consensus on 1-2 action items that they can develop immediately and finish in the next 6 months, as well as 1-2 other tasks that the group feels essential but will require a year or more to fully realize. The group will also identify other stakeholders in the school and community which will be essential to the success of developing the social learning aspect of the CAM.

The social nature of the work will be a critical component to support teachers in their continued reflection and refinement of their craft as well as to the success of fully realizing the power of a CAM to support greater enrollment of female students in advanced STEM coursework. The last day of PD during the initial year of implementing a CAM at school A may conclude the proposed PD; however, the work will continue in subsequent years as a reflective process of continuous improvement. Layers of student, parent, and local community voice and feedback will be important to consider carrying the work forward. In addition, while the PD outlined discusses STEM teachers in school A specifically, the work and development of a CAM is not germane to STEM teachers. Therefore, including more teachers and departments in this work can magnify the efforts and benefit even greater numbers of students.

Roles and Responsibilities

Developing a common understanding, commitment, and the capacity to maintain a CAM within the community of school A will need to be a combined effort of all stakeholders. Strong leadership is critical in organizing the PD, identifying curriculum leaders, and supporting the ongoing sustained effort. While the CAM at school A will function best with teacher ownership and leadership, administrative leadership will be necessary to begin the process and consistently support the efforts over the year and years to come. Building and district administrators in school A will establish and communicate with teachers about the reasons for the work. Administrators will also identify who, whether administrator or teacher, has the instructional expertise in performance assessments and DoK to lead teachers in the summer work.

School A teachers will be the primary participants and developers of the CAM. STEM teachers will work to refine their instruction and curriculum to be more performance based and integrated with STEM practices. Teachers will redesign assessments, aligned with the standards, to reflect DoK 3 or 4 level work. Redesigning assessments will also necessitate a close examination of instructional practices to ensure students can be successful on more cognitively challenging assessments. Teachers will partner with curriculum experts and the administration to develop collaborative groups. The collaborative groups will be responsible for creating a schedule of weekly meetings over the course of the year to support the CAM. Teachers will also work with the curriculum experts to schedule observations and non- evaluative discussions of practice. In addition to implementing the curriculum, teachers will serve as mentors to students who are seeking internship opportunities identified by the Extended Learning

Opportunity (ELO) Coordinator. The ELO Coordinator for school A will have primary responsibility in helping to support the sociology of learning in the CAM. The ELO coordinator will serve as the bridge between the community and the school. They will identify and monitor internship opportunities. The ELO Coordinator will be invaluable in identifying, developing, and supporting community school partnerships for students.

Project Evaluation

The overall purpose for the PD associated with the development of a CAM is to close the gap in practice present in secondary schools where female students do not enroll in advanced STEM coursework at the same frequency as male students. Both quantitative and qualitative evaluation methods will be used to assess the increase in female secondary student enrollment in advanced STEM coursework and the effectiveness of the PD in developing the CAM. The quantitative evaluation is summative in nature and will evaluate the outcomes of the PD plan. An outcomes-based evaluation will assess the successes, challenges, and future needs of the school community in the process of continuous development of the CAM. The number of students enrolling in advanced STEM coursework as well as the percent change in the number of female secondary students enrolling in advanced STEM coursework are the quantitative outcomes that will be measured.

A secondary outcome of the PD to develop a CAM is the shift in instructional practices to create a more student-centered curriculum and performance based assessments. A qualitative approach will be used to evaluate the effectiveness of the PD in supporting the changes necessary in a successful CAM. The qualitative portion of the evaluation is formative in nature. Formative evaluation provides real-time feedback to strengthen the CAM and instructional shifts. Formative evaluation throughout the year of PD will support and inform changes in the professional learning to better meet the needs of the participants. Observations by administration or preferably an outside evaluator, to identify evidence of student-centered learning and an audit of performance based assessments in advanced STEM courses provide the evaluative data. School A's teacher evaluation framework incorporates 3, 15-minute observations over the course of the school year for every teacher. Using the existing framework, observers will use the "STEM Classroom Observation Protocol," created by SERVECenter at the University of North Carolina, Greensboro to provide specific feedback to teachers and to inform future PD (Arshavsky, N., Edmunds, J., Charles, K., Rice, O., Argueta, R., Faber, M., and Parker, B, 2012) Appendix A). Feedback will be provided to teachers as it offers an opportunity for the curriculum leaders to coach and support teachers in their new learning. Feedback will also be analyzed to evaluate the effectiveness of the PD in affecting teaching and the instructional shifts to support a CAM. The "STEM Classroom Observation Protocol" was chosen for STEM observations as it specifically targets the elements of instruction and learning present in a strong STEM classroom and reflects the CAM PD.

The goal of the project is to increase the enrollment of female students in advanced STEM coursework. The dual approach of quantitative and qualitative evaluation, achieves the purpose of assessing if the goal of increasing female secondary school enrollment in advanced STEM coursework is achieved and the effectiveness of the PD in implementing the CAM. Key stakeholders, including administration and expert teacher leaders play a critical role in interpreting the evaluative data. Curriculum expert teacher leaders and administration will review the data to determine current and future PD needs.

Project Implications

The purpose of this study was to examine the factors contributing to high female secondary students’ enrollment in advanced STEM courses at the study site. I investigated, through a mixed methods approach, female students’ levels of self-efficacy and the role of a CoP to better understand how they contribute to female students’ enrollment in advanced STEM courses and female participation in science related extracurricular activities. Social (including positive role models, peer support, and inclusive school culture) and personal landscape (including independence, resilient mindset, transformative experiences, and self-awareness) emerged as two important themes in contributing to increased female enrollment. The inclusive factors of positive role models, peer support, resiliency, independence, and transformative experiences can be addressed and supported in communities of learners through the implementation of a cognitive apprenticeship model.

To close the gap in practice in the secondary school A where female students enroll in advanced STEM courses in lower numbers than their male counterparts, it was necessary to develop a series of professional learning activities to develop and implement a CAM. The project in school A will lead to a CAM which supports female secondary students’ science self-efficacy and enrollment in advanced STEM coursework therefore providing them a greater opportunity for success in pursuing STEM in their postsecondary education. All students in school A will benefit from the professional learning and the shifts in instruction which take place in the implementation of the CAM.

A more student-centered classroom, focused on resiliency and community partnerships will enhance the learning of all students and anchor their educational experiences in real world learning and application. Students engaged in real-world STEM learning have the potential to positively impact their local communities by having greater involvement in contributing to the solutions of local issues. In turn, community partners surrounding school A will benefit from an influx of fresh ideas as well as the opportunity to contribute to their future workforce by increasing interest and in creating cognitive transparency with students.

The school administration at school A gains a team of STEM educators who are well versed in student centered instructional practices and authentic assessments. Teachers participating in the professional learning will develop and refine strategies which promote resiliency and real-world application of knowledge. In addition, teachers will build their assessment literacy, enabling them to be leaders in using student feedback and performance to shape curriculum and instruction. The opportunities for students pursuing a career in STEM are significantly greater than other careers (U.S. Department of Education, 2016). Thus, in building a school culture at school A that increases STEM enrollment of a traditional underrepresented demographic, the school and its administration may garner a reputation which draws families to the district and in doing so increase enrollment.

The project may provide long ranging benefits to individuals and communities outside school A, as well as the nation. As the number of STEM jobs and income potential continue to increase (U.S. Department of Education, 2016), an opportunity exists for social justice for women. As female students participate in advanced STEM coursework in greater numbers, they increase their likelihood at successfully pursuing a career in STEM and achieving income parity with their male counterparts. Furthermore, women with postsecondary STEM degrees will be able to take advantage of the increasing number of job opportunities (National Science Board, 2015). By investing in the professional learning outlined in this project to build cognitive apprenticeships, communities of practice will support female students in acquiring the skills and habits of mind to persist and diversify the STEM workforce potentially leading to greater innovation for industry and the country.

Section 4: Reflections and Conclusions

Building, understanding, and implementing a successful CAM in secondary schools has the potential for positive social justice by closing the gender gap in STEM studies. This section of the project study discusses the relative strengths and weaknesses of the professional learning plan to implement the CAM. I also discuss implications for future research and expanding the CAM to benefit a greater number of students. Finally, I reflect on my journey through the doctoral program and what I have learned about scholarship, research, and the potential for a scholar-practitioner to enact positive social change.

Project Strengths

The development, implementation, and continued support of a CAM for learning in secondary schools will support female students in developing science self-efficacy and lead to their enrollment in advanced STEM coursework in greater numbers. Participation in advanced STEM coursework at the secondary level increases female students' likelihood of pursuing a STEM pathway in postsecondary education. In turn, a STEM degree offers an opportunity for social justice for women as STEM careers offer greater pay equity between genders and represent an exponentially growing career field (U.S. Department of Education, 2016).

The project leverages internal personnel supports, values the expertise of stakeholders, creates opportunities for teacher leadership, and offers an opportunity to strengthen school-community partnerships. For public schools, which must balance the educational needs of students with being fiscally responsible, one of the project's greatest strengths is that it leverages personnel already employed by the school to lead and learn.

By focusing on instructional design to lay the groundwork of a CAM, teachers delivering instruction to students are those leading the work and learning along with their colleagues. Opportunities and avenues for teacher leadership is an area of focus in many local districts as well as nationally. The project offers pathways for teachers who want to lead from within the classroom to find that professional fulfillment. Internal teacher leadership supports a more positive work force, increases teacher moral, and builds capacity in schools (Berry, 2015). Lastly, by increasing the opportunities for community-school partnerships, the work of the school becomes more transparent to the community. Partnerships have the potential to increase knowledge and the investment of the community in supporting the local educational system.

A final strength of the project is its potential to benefit all students, not just female secondary students. By focusing the PD of building a CAM in improving opportunities for resiliency and STEM skills through student-centered curriculum refinement, all students can benefit from the expectations of increased cognitive demand. While the goal of the project is to increase female enrollment in advanced STEM coursework, through the implementation of the CAM, STEM enrollment for all students may increase.

Recommendations for Remediation of Limitations

While there are many merits to the project, there also are limitations that should be considered by any school seeking to implement the project. While not insurmountable, many of these limitations may occur due to one of the project's strengths of utilizing extensive existing resources such as curriculum experts and teachers proficient in STEM content as outlined in the Next Generation Science Standards (https://www.nextgenscience.org/). First, the project does presume a level of STEM literacy on the part of the teachers. The NGSS has raised the level of expectation for students by creating a set of performance expectations embedded with science and engineering practices and concepts. NGSS raises engineering and design practices to the same level as the scientific method and is an area where proficiency in teachers should not simply be presumed. In conjunction with the CAM work, schools may need to invest in additional professional development for teachers related to the new science standards, science content, and engineering practices. The additional professional development may take time and potential resources away from the CAM development; however, content is an essential prerequisite to proceeding with the project. The project presumes that there are teachers qualified to teach the advanced STEM courses already present within the school.

Similarly, there are many benefits to the grassroots nature of the project and its support of teachers as leaders and curriculum experts. However, in some schools, these may be challenging positions to fill based on either the expertise present or the lack of additional stipends to support the work of teacher leaders. Teachers who are already proficient in the development of student-centered instruction and performance-based assessments are critical to lead this work as mentors. A school may choose to bring in outside consultants or hire curriculum coaches to fill this role if strong leadership is not already present within the school. The challenge with these alternatives is building trust between the leaders and teachers, as well as the financial implications of creating a contract or new position.

Recommendations for Alternative Approaches

Full development and implementation of a CAM may not be logistically or fiscally possible for a secondary school. While more limited in scope, investing in STEM afterschool activities or developing a STEM mentoring program may be viable alternatives. STEM-focused after-school activities can supplement the learning happening in a traditional classroom setting. For some students, extracurricular activities provide the gateway to grow their interest in STEM (VanMeter-Adams, Frankenfeld, Bases, Espina, & Liotta, 2014). Several museums and nonprofits are working to create these programs in conjunction with local districts to support their efforts. These may provide a low cost or grant funded alternative for schools unable to engage in the proposed professional development activities (Christensen, Knezek, & Tyler-Wood; 2015). These same institutions may also be able to provide experts to mentor teachers in the curriculum and assessment revisions outlined in the project. The Boston Museum of Science, for example, offers a number of resources and professional development opportunities to support teachers (https://www.mos.org/educator-resource-center). Another alternative to the professional development plan is to pursue school and community-based mentors without reexamining the curriculum and instruction. The importance of the societal landscape, including mentors, emerged from the present study. Mentor programs are a research-based practice that increases students' likelihood to pursue STEM (Clark et al., 2015; U.S. Department of Education, 2016). While after-school activities, leveraging community partners such as museums, and mentor programs are alternative approaches to the project, each is incomplete alone. The professional learning plan to develop and implement a CAM is a holistic approach and provides a complete multidimensional strategy to support female secondary students' enrollment in advanced STEM coursework.

Scholarship

Throughout my doctoral journey at Walden University I have been challenged to translate my biological scientific background to that of educational researcher. I have learned how to conduct scholarly research as it relates to human subjects, immersed myself in understanding the ethical implications of research when it involves students or other protected groups, and discovered how to develop a project for social justice grounded in a rich body of literature and theory. My professors have guided my learning, and my coursework built a strong foundation upon which my project was constructed. In my methodology courses, I learned the importance of crafting strong research questions that then drive the choice of qualitative, quantitative, or a mixed-methods study.

My committee has been invaluable in helping to shape my scholarly work and hone in on the research questions. The iterative process of scholarly work challenged me to constantly refine my thought process and analysis to remove bias, increase clarity, and provide a strong body of evidence to support my findings. In addition, the IRB process helped me to better understand the protections and ethics of research with human subjects. Justifying my experimental design and study population while demonstrating the protections of privacy that are afforded to participants was a new learning experience. The IRB process made me more cognizant of the protections researchers must apply as practitioners when trying to understand an issue or conduct action research in schools.

Project Development and Evaluation

The development of the project resulting from my research was particularly rewarding. To be able to develop a project that created an actionable series of professional learning opportunities that addressed an issue for social justice brought my research full circle. The cornerstone of my research was students and the opportunities teachers provide for them to achieve their aspirations. The project allowed me to share my research with others to magnify the impact of the research in other schools. However, there were challenges to developing this project and evaluation. Designing a project without a full knowledge of the internal resources and supports a school has in place was difficult. Also difficult was the understanding that inequity in personnel and training between different schools could cause the achievement gap to persist if the project could not be implemented successfully. I learned that one strategy to overcome a lack of knowledge about a possible implementing district was to consider the limitations of the project and what types of alternatives could be explored to remediate the limitations. I also learned that project development cannot occur in isolation. Projects are strengthened through collaboration and discussions with those who understand the literature and research. In this way, the project development had a similar iterative process to the overall research, which served to strengthen the final project and evaluation.

Leadership and Change

Throughout my doctoral program, my ideas concerning the importance of leadership and change have been tested and refined. Effective leadership requires the ability to examine system change at the big picture level and break it into meaningful strategic actions at specific implementation levels such as school, classroom, or teacher.

Understanding how decisions affect various groups is critical in successfully leading through change. Listening to and working with stakeholders as well as observing without bias are essential practices to build understanding and support for the change process. For change to be successful, those participating in the change must understand the *why*. A leader's purpose is to help explain this why so that all stakeholders have a clear vision of the value of the change and work ahead. The why is the connection a leader must demonstrate to the work so that the change aligns with the values of the educational institution and those it serves, its students. I have also learned that leading through change is most effective when the leader is willing to work with stakeholders and be an active participant in the work. Change can be difficult, and when a leader is willing to participate, even fail forward, then the collective commitment of stakeholders increases and leads to the opportunity for successful change.

Analysis of Self as Scholar

My confidence in myself as a scholar increased throughout the development of this project. Becoming well versed in both learning theory and the body of research surrounding the project was a challenge that I found enjoyable, and it increased by ability to objectively view the problem. Reaching saturation in the literature as well as finding relevant studies required creativity in searching and identifying key words that would help me to become well read. As the problem was not well studied, I had to determine what other related research could better help me develop the project in a scholarly manner. Overall, I found that my research skills increased throughout the project as well as my ability to draw connections between the project and other related research to build a well-supported potential solution to close a gap in practice and social equity.

Analysis of Self as Practitioner

As a practitioner, the project allowed me the opportunity to take a personal passion and create actionable research-based steps to address the problem. Working in classrooms with teachers and students and becoming more proficient as a scholar-practitioner allowed me to support meaningful change. My double role as a scholar and practitioner provided me with an added layer of credibility and trust that supported teachers' willingness to be vulnerable in working collaboratively to better meet the needs of all students. Developing as a scholar enhanced my role as practitioner through reflecting on my actions to ensure that they were supported through data and researched best practices. Self-reflection impacted not only myself but also the larger school community in which I am growing and learning.

Analysis of Self as Project Developer

As a project developer, I gained a better understanding of the challenges a school or district must contend with when developing and implementing a new project, including capacity, other initiatives, and financial and material resources. I learned that even a well-designed researched-based project may fail if it is not strategically anchored in the system. Considering the challenges and resources within an institution is an essential aspect of developing a project that has the potential to promote positive social change. Translating scholarly research into a project was perhaps the most rewarding aspect of my doctoral journey. As a project developer, I had the power to address the gap in practice which began my journey. The project offered me an opportunity to bring my learning full circle by applying my coursework and my scholarly research to building an authentic project to increase social equity in an area of personal passion and interest.

Reflection on the Importance of the Work

Closing the gender gap in STEM careers has long been discussed and minimally closed. The project offers an opportunity to support students early on in their academic careers to develop the personal characteristics, in a supportive environment, necessary to pursue a STEM postsecondary major and career. STEM careers offer greater pay equity and a diverse work force has greater potential for innovation. For these reasons and those outlined throughout this study, this project has been developed to provide a meaningful actionable research-based plan to support female students in pursuing advanced STEM coursework. Closing the gender gap is not simply a matter of introducing female students to STEM, but in creating an environment that fosters the skills and characteristics that are necessary to persist in STEM. Outlined in this project is a strategy to implement a CAM in secondary schools that builds the capacity of the CoP to strategically support all students in the pursuit of STEM careers.

Over the course of this study, I have transitioned from researcher to project developer to implementing aspects of the project in my own learning community. Applying the principals of a CAM has impacted not only what we teach but how it is taught. The CAM has created a learner centered environment which fosters resiliency, independence, and supports the learner with a community of learners and mentors. Empowering students with these characteristics has the potential to support their pursuit of advanced STEM coursework and postsecondary STEM careers. While these changes are taking place at the local level, they have the potential for a much larger impact as students pursue STEM careers. When greater numbers of female secondary students pursue STEM careers, the workforce becomes more diverse and innovative. Women will have access to a growing number of career options and job openings where pay equity is more likely to be achieved. Implementing a successful CAM has the potential for positive social change. My doctoral journey has instilled in me the belief that practitioners can research a problem and apply the findings to make small changes in school which translate into positive social change on a larger scale.

Implications, Applications, and Directions for Future Research

The data gathered in this study has the potential to close the gap in practice in secondary schools leading to unequal enrollment of female students in advanced STEM coursework. The study describes a CoP in which a CAM supports female students' high levels of science self-efficacy. Replicating the CAM in other schools has the potential to similarly benefit students and support their self-efficacy in science and other areas. According to Rothwell (2013), at a minimum 20% of U.S. jobs require a high degree of proficiency in at least one STEM field and nearly all job sectors require proficiency in the skills and cognitive knowledge characteristic of STEM training. Increasing the enrollment of underrepresented populations and truly all students in advanced STEM coursework creates an opportunity for students to take advantage of the ever-increasing demand for STEM knowledge and skills. The CAM has the potential to benefit all students in increasing their capacity to compete and be successful in pursuing STEM post-secondary majors allowing them to take advantage of increasing job opportunities.

The current study is limited in scope as it focused on a single study site. Expanding the study to multiple sites in the future will provide a more complete picture of female students who enroll in advanced STEM coursework. The insight gained from a greater number of participants will increase the generalizability of the findings and will be used to further refine the professional development materials and the implementation of a CAM. CAM implementation in this study focused on STEM teachers and their curriculums. Broadening the professional development to include other academic areas may increase all students' levels of self-efficacy in not only science but other areas as well. Researching the development of a CAM in other areas and the impact on students is a natural extension of this research and has the potential to benefit a greater number of students. Additionally, implementing a CAM at the middle school level in conjunction with a secondary school may have even greater impacts on the number of female students enrolling in advanced STEM coursework. Examining if the expansion of the CAM has a positive impact on students is an avenue of future research which has the potential for even greater social justice as students' gain the skills and increased self-efficacy to take advantage of increasing opportunities offered by STEM careers.

Conclusion

While many schools across the U.S. are experiencing inequity in the number of female secondary students enrolling in advanced STEM coursework, this study sought to understand how the community of practice at one school has supported equity in enrollment trends. Replicating the high enrollment numbers through the creation of cognitive apprenticeships in other secondary schools is the overall goal of this project as it offers an opportunity for increased social justice for women. Increasing the number of female students enrolled in advanced secondary STEM coursework, increases their likelihood of pursuing STEM careers, accessing an expanding job sector, achieving pay equity with male counterparts, and contributing to a more diverse and therefore potentially innovative workforce. The study provides research- based actionable steps that schools can implement to ensure they are fulfilling their mandate; providing every student with an equitable opportunity to an education which allows them access to any future path they endeavor towards.

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Appendix A: The Project

Professional Development Project to Implement a Cognitive Apprenticeship Model (CAM)

The project's overall goal is to increase female secondary students' enrollment in advanced STEM coursework and extracurricular activities, through the implementation of a CAM. The project, a yearlong professional development plan to implement a cognitive apprenticeship model (CAM) in a secondary school, is outlined in the following paragraphs. The purpose of the professional development plan is for secondary school science teachers to build an understanding of a CAM to support its development and successful implementation in the target school. Secondary science teachers will gain the skills, tools, and knowledge necessary to support the CAM through their curriculum and the social structures present in the local community of practice. Secondary science teachers will be supported in their professional development by school administration, instructional coaches, and curriculum leaders who are all present within the school or district. Funding for teacher participation stipends, if appropriate and as outlined in the teacher's Collective Bargaining Agreement (CBA), may be secured from Title II funding. The project utilizes local resources and should not represent a significant additional financial investment, other than what may be outlined in the local CBA.

Included in Appendix A are the full agendas, presenter notes, PowerPoint presentations, associated materials or links necessary for the embedded activities, and the evaluation materials. The professional development activities will take place over the course of a calendar year. Table A1 includes a detailed agenda of the activities as well as the participants for each activity. Generally, participants are the secondary science teachers, building administrators, and instructional coaches. Throughout the professional development, teachers demonstrating masterful knowledge and skill in implementing the curriculum shifts resulting from the CAM will be identified by administration and coaches using the school's existing teacher observation protocols and the STEM Observation Protocol (Arshavsky et al., 2012). The identified curriculum leaders will become facilitators and sustainers of the work.

The kick-off to the project takes place at the end of the school year, in June. The half-day session is designed to introduce participants to the essential role they play in establishing a resilient mind-set, necessary for STEM perseverance, and to build understanding of the CAM. The project continues during a week-long summer institute that will take place after school is out of session, in the end of June. The goals of the summer institute are to: 1) build a common understanding of depth of knowledge (DoK) and cognitive rigor, 2) build a common understanding of performance assessments, and 3) refine and redesign units, lessons, and assessments with this new understanding. At the conclusion of the summer institute, participants will fill out the Professional Development Exit Questionnaire included in Appendix A.

Beginning in October and continuing throughout the school year, administration and instructional coaches will conduct observations using the schools' existing teacher evaluation model and the STEM Observation Protocol (Arshavsky et al., 2012). The observations will identify curriculum leaders from among the science teachers and exemplary lessons or assessments that will be used in the October professional learning days. During the two professional learning days in October participants, as outlined in Table A1, will: 1) work collaboratively to analyze exemplary lessons and assessments, 2) continue to refine, revise, and redesign lessons and assessments in line with the characteristics of quality performance assessment. Participants will again fill out the Professional Development Exit Questionnaire included in Appendix A at the conclusion of the October session.

During the remaining school year, the cycle of design, implement, evaluate, and revision, will continue in weekly content area collaborative sessions facilitated by the curriculum leaders. The agenda for the sessions will be collaboratively built by the group, to be shared with administration and instructional coaches so that they can support the work. The final scheduled professional development activity will take place in May, almost a full year after the initial introductory activities. During the final session, the facilitator will help participants to better understand the social component of a CAM. The social component session will also include guidance counselors and the Extended Learning Opportunity (ELO) coordinator as these roles are essential links across the school and between the school and the extended community. The goal of the social component session is to identify and implement short and long-term actions to support the social component of the CAM within the school. The protocols to facilitate the work are included later in Appendix A.

The purpose of the project is to increase the number of female secondary students enrolled in advanced STEM coursework and extracurricular activities. To quantitatively evaluate the success of the project in achieving this purpose, the enrollment numbers of females in advanced STEM coursework and extracurricular activities will be monitored over subsequent years. The qualitative analysis tool used throughout the year, the STEM Observation Protocol, will continue to be used and evaluated by the administration and instructional coaches to determine the effectiveness of the professional learning in creating the changes in curriculum and instruction necessary to support the CAM.

Table A1

Detailed Agenda, Including Necessary Resources and Participants, of the Professional Development Activities to Implement a CAM to Increase Female Secondary Student Enrollment in Advanced STEM Coursework and Extracurricular Activities.

	Agenda	*Resources*	*Participants*
		June	
12:00-1:00pm	Resiliency and the role of the charismatic adult	http://www.drrobertbrooks.com/resilience-common-underlying-factor/ http://schoolreforminitiative.org/doc/text_rendering.pdf	Bethany Bernasconi (facilitator), grades 9-12 science teachers, principal, assistant principal, instructional coaches
1:00-3:00pm	Characteristics of a cognitive apprenticeship	Appendix A slides (Part 1)	Bethany Bernasconi (facilitator), grades 9-12 science teachers, principal, assistant principal, instructional coaches
		June Summer Institute	
Day1	Building an understanding of depth of knowledge & cognitive rigor	Appendix A slides (Part 2) Cognitive rigor matrix tool (http://www.karin-hess.com/cognitive-rigor-and-dok)	Bethany Bernasconi (facilitator), grades 9-12 science teachers, principal, assistant principal, instructional coaches
Day 2	Understanding performance assessments	Appendix A slides (Part 3) Teacher’s will bring current local science assessments	Bethany Bernasconi (facilitator), grades 9-12 science teachers, principal, assistant principal, instructional coaches

(table continues)

	Agenda	Resources	Participants
Day 3	Deeper dive into performance assessments (Task Carousel)	Appendix A Slides (Part 4) Sample tasks pulled from: https://www.performanceassessmentresourcebank.org/	Bethany Bernasconi (facilitator), grades 9-12 science teachers, principal, assistant principal, instructional coaches
Day 4/5	Examination of local summative assessments and (re)design of local performance assessments	Teachers will bring local summative tasks to evaluate; assigning DoK levels to each question. Teacher will bring and validate local performance assessments using validation protocols (www.cce.org). Performance assessments will be modified or new tasks created as a result of the work.	Bethany Bernasconi (facilitator), grades 9-12 science teachers, principal, assistant principal, instructional coaches
October			
Prior to PD days	Needs assessment	Each teacher will answers submit via Excel Form: 1) In what area (ex. DoK, PA, rubrics) do they need additional assistance. 2) Wonders they have about implementing performance assessments. 3)Instructional practices they have found successful in creating deeper learning via performance assessment.	Grades 9-12 science teachers

(table continues)

	Agenda	*Resources*	*Participants*
Prior to PD days	Identification of exemplar lessons and assessments	Through observation, exemplar lesson plans and assessments will be identified for use during the PD days.	instructional coaches, principal, assistant principal, 9-12 science teachers that administration has named curriculum leaders
Day 1	Analysis of exemplar lessons and assessments	Previously identified exemplars	Bethany Bernasconi (facilitator), grades 9-12 science teachers, principal, assistant principal, instructional coaches
Day 2	Refinement of unit and lessons using exemplars	Teachers will bring lesson plans, units, and activities to work in content area (common course) teams.	instructional coaches and curriculum leaders (facilitators), grades 9-12 science teachers working in content area teams
October- June			
Weekly	Content area collaborative sessions	Agenda and needs determined by the group to continue instructional shifts, refinement of assessments and units. These will be shared with coaches, principal, and assistant principal.	curriculum leaders (facilitators), grades 9-12 science teachers working in content area teams, instructional coaches, principal, and assistant principal support as needed

(table continues)

	Agenda	Resources	Participants
3 times, 15-minutes each	Classroom observations	STEM Observation Protocol (http://www.serve.org/STEM.aspx)	outside evaluator, principal, assistant principal, instructional coaches
		May	
	Social supports for learning in a cAM	Appendix A Slides (Part 5) School ReTool handouts Professional Development Exit Questionnaire (SERVEcenter)	9-12 science teachers, curriculum leaders, guidance counselors, principal, assistant principal, and the ELO coordinator

Presenter Notes

Slide 3 Our students are part of a k-12 learning community or continuum. Students arrive at their graduation day by walking day in and out on a journey through our schools. We are lucky enough to share in just a small part of each child's journey, and yet neither they or we are ever the same as a result. Our thoughtful design of curriculum and assessments in 1st grade matters for a student 6 years later in the middle school and 3 years beyond that in the high school.

Slide 4
- Divide participants into groups of 6
- Each group appoints a facilitator to lead the SRI Text Rendering Protocol

Slide 5 Flash Chat Protocol: 1 minute to reflect individually, 5 minutes to discuss, 1 minute to share out per group to the larger group
Objective: Discuss the role of charismatic positive adult mentors in student learning. These are key to successfully establishing a CAM which will place high cognitive demands on students. Students must feel safe and supported as well as challenged for a CAM to be successful.

Slide 6 There are so many things we do as educators each day... (insert PD activities school has been involved with).... but all of this is about making assessment meaningful to drive student instruction. Practice today what we aspire for tomorrow.

Slide 8 Outline our collaborative role together and expectations going forward

Slide 9 **Equity**: Learning goals, Enduring Understandings, complex texts, and assessment tasks ensure equity for all students.
Access: Essential Questions, Enduring Understandings, Assessments and Texts, as well as interdisciplinary connections, in particular, encourage access to the learning standards by engaging students and providing clarity; they connect the learning to the student's world.
Quality: As a school/district, we value the expertise we bring in the use of protocols and collaborative process to assure quality curriculum for our students.

Slide 10 Note to participants that the PD over the next year follows a CAM so that they themselves are participating in a CAM as they work to build one with students.

Slide 13 After a discussion of each of the steps, have participants watch the video and then debrief.

Slide 15 We want to move students from DoK 1 (low Blooms) to DoK 4 (High Blooms) through sequencing

Slide 20 How is this different from what is on the screen?
A lot easier to fix this problem if you have your destination in mind
- instruction, assessment, and learning goals all have to be aligned
It is important to align all levels of the system. For example, it is also important to align instruction and assessment and sometimes there is a mismatch here too.
different levels of alignment:

- Learning Goals (really where the train is going – we start with the end in mind)
- Instruction
- Assessment
- Over time Assessment Tasks need to align with the overall Assessment System

Slide 21 Participants will set this aside, revisit, and perhaps revise their personal definitions later in the workshop – this is a formative assessment probe used to promote self-assessment

Slide 22 See if volunteer is possible and ask them to tell the story of the Three Little Pigs in two minutes.

Slide 23 Introduce activity- write independently 2 minutes, let them know they will be doing a pair share.

Slide 24 Introduce pair share and give them 3 -5 minutes to share and review matrix while discussing question. after they share a couple of questions- let them know that you'll be giving them a bit of background about cognitive rigor and then they will be using the matrix to place their questions in the boxes

Slide 25 After they share a couple of questions- let them know that you'll be giving them a bit of background about cognitive rigor and then they will be using the matrix more after the overview

Slide 27 You will have to remind people about this MANY times! Answers – DOK 1 (recall a definition, 2 (comparing 2 ideas – conceptual), 3 (requires supporting evidence, and 4 (requires both supporting evidence AND multiple sources)--- I ask participants to tell me WHY it is DOK 1, 2, 3, or 4
They will have to justify where they place their task on the cog. Rigor matrix and prove it to each other and to us. Just using the verbs is not enough, sometimes the verbs trick us.

Slide 29 DOK 1: Spanish vocabulary or definition example. Interact w/ content on basic level haven't gone deeply yet- memorization and recall. Higher levels require: are they using that vocabulary in their speaking, writing, etc.

Slide 31 Interact with the knowledge- Math word problems

Slide 33 -Social Studies (Document Based Questions/primary source analysis and essay)
-requires evidence

Slide 35 Capstones and independent research
-multiple sources and evidence

Slide 37 Introduce we are going to do some together.

Slide 38 Checklist is a mix of Dok, 1, 2, can get to 3 if multiple drafts that really address- beginning, middle, and end and thinking about audience so makes sense to reader. A story about having fun outside can be dok 2 or 3 depending on complexity of student work, but this prompt is probably only going to elicit dok 2 work based on time students will have to write and lack of real connection to the texts that students read.

Slide 39 DOK 2
Slide 39 DOK 2
Slide 41 DOK 2- could be DOK 3 if writing full article, but revising paragraph
- have them identify on cognitive rigor matrix

Writing - School Day

Grade: 4

Claim 2: Students can produce effective and well-grounded writing for a range of purposes and audiences.

Target 6. WRITE/REVISE BRIEF TEXTS: Write or revise one or more paragraphs demonstrating ability to state opinions about topics or sources: set a context, organize ideas, develop supporting evidence/reasons and elaboration, or develop a conclusion appropriate to purpose and audience.

CCSS: W-1a, W-1b, W-1c, W-1d, W-8, and/or W-9

This item asks students to provide relevant elaboration in order to revise a text.
From Rubric: The response: • provides appropriate and predominately specific details or evidence • uses appropriate word choices for the intended audience and purpose

Slide 42 DOK 2
Grade: 6
Claim 2: Problem Solving
Target: 2A
CCSS: 6.SP.3
This item connects students work with operations of earlier grades to their work with measures of central tendency in grade 6.

Slide 43 We can't get to our destination of cognitive rigor using dok 1 or 2 road and then expecting students to get to a dok 3 or 4 destination

Slide 44 To help students engage in the cognitively complex tasks within a CAM, all levels of assessment are needed to support students in a gradual release of responsibility.

Slide 47 Explain task to group using cognitive rigor matrix (Slide 13)

Slide 50 First bullet is critical! Teacher questioning daily should be at DOK 3 – why do you say this? Can you prove this solution will work? What evidence supports this?

Slide 57 Explain how this supports to 4 principals of the CAM

Slide 58 Cognitive Rigor can be described in different ways using different models that address something different.

Bloom- What type of thinking (verbs) is needed to complete a task
Webb- How deeply do you have to understand the content to successfully interact with it? How complex or abstract is the content?

Slide 59 Explain process. They should have CRM out when you are reviewing the process. Review all questions on steps slides and take questions. Let them know we will be circulating.

Slide 60 Continue to explain process.
Remind them to keep cognitive rigor matrix out.

Slide 61 Continue to explain process.

Slide 62 Continue to explain process.

Slide 64 Leads discussion focusing on prompts and circulating to different groups. Try to hear from a range.

Slide 65 Remind them tools on website, guides available, support during afternoon, work will continue over time.

Slide 67 Participants will choose a performance task to review. They will carousel between 3 stations (Alignment, Student engagement, and DoK). At each station, they will discuss their performance task in regards to that station's theme. They will chart out their discussion on large paper to be shared with other groups.

Slide 68 Performance assessment resource bank (https://www.performanceassessmentresourcebank.org/) has a variety of vetted tasks the facilitator can choose from to meet the needs of the group

Slide 70 Start with the end in mind….
What do you want kids to know?
How are you going to get them there?
How do you know they know?

Slide 72 Choice and Ownership
2+ modalities (Written, Oral, Visual)
Relevance
Real World Authenticity

OVERVIEW OF PROFESSIONAL DEVELOPMENT PLAN

- Kick-off (end of the school year)
  - Understanding the Role of Mentors
  - Introduction of CAM
- Summer Institute (1 week)
  - Day 1: Building an Understanding of Depth of Knowledge & Cognitive Rigor
  - Day 2: Performance Assessment
  - Day 3: Task Carousel & Development of Assessments
  - Day 4-5: Assessment Development and Validation
- Supporting & Deepening the Work (ongoing throughout school year)
  - Revisiting summer institute work, analysis of exemplar assessment tasks, unit development and refinement, mentoring sessions (continued on PD days and ongoing in PLCs)
- Social Supports of Learning in a CAM (May/June)

PART 1

Timeline: End of School Year

IT TAKES A VILLAGE….

THE CHARISMATIC ADULT

- Use the SRI Text-Rendering Protocol to read and discuss the Dr. Robert Brooks article: "Resilience: The Common Underlying Factor"
  - http://www.drrobertbrooks.com/resilience-common-underlying-factor/
  - SRI: http://schoolreforminitiative.org/doc/text_rendering.pdf

FLASH CHAT:
THE CHARISMATIC ADULT

- Focus Question:
  - Who was the charismatic adult in your life?
  - What is the role of the charismatic adult in student learning?

RESILIENCY AND PERSISTENCE IN STEM

Practice today what you aspire to be tomorrow!

GOALS:

- Build our knowledge and understanding the Cognitive Apprenticeship Model (CAM).
- Develop a deeper understanding of depth of knowledge and performance assessment in order to apply that understanding in unit development to support a CAM.
- To work together as a community of practice to refine and critique our work in service of deeper student learning and achievement.

SUPPORTING ALL LEARNERS THROUGH A CAM

In order to achieve this...

Then we must function as this...

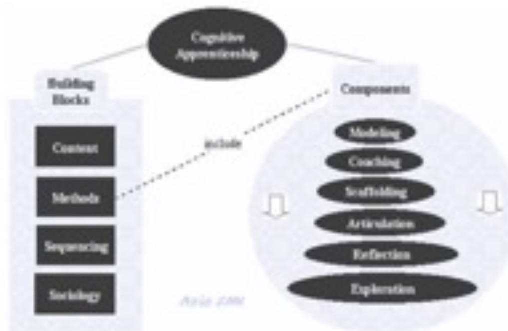
KEY VALUES GUIDING OUR WORK:

- **Student Equity**
- **Student Access**
- **Quality through Collaboration**

COGNITIVE APPRENTICESHIP MODEL (CAM) OF LEARNING

- Makes internal thought processes externally visible
- Uses coaching and modelling in a social setting to support the next knowledge

- Content- type of knowledge
- Method of instruction
  - modeling, coaching, scaffolding, articulation, reflection, exploration
- Sequencing
  - ordering of learning activities to increase in complexity and diversity
  - movement from global to local skills
- Sociology
  - Social context of learning environments



http://kb.edu.hku.hk/cognitive_apprenticeship.html

4 DIMENSIONS OF CAM

CONTENT

- What is the domain knowledge students need to master in this field?
- What are the skills students will need in this content domain in order to solve problems?
- Deep knowledge is needed so that it can later be applied.

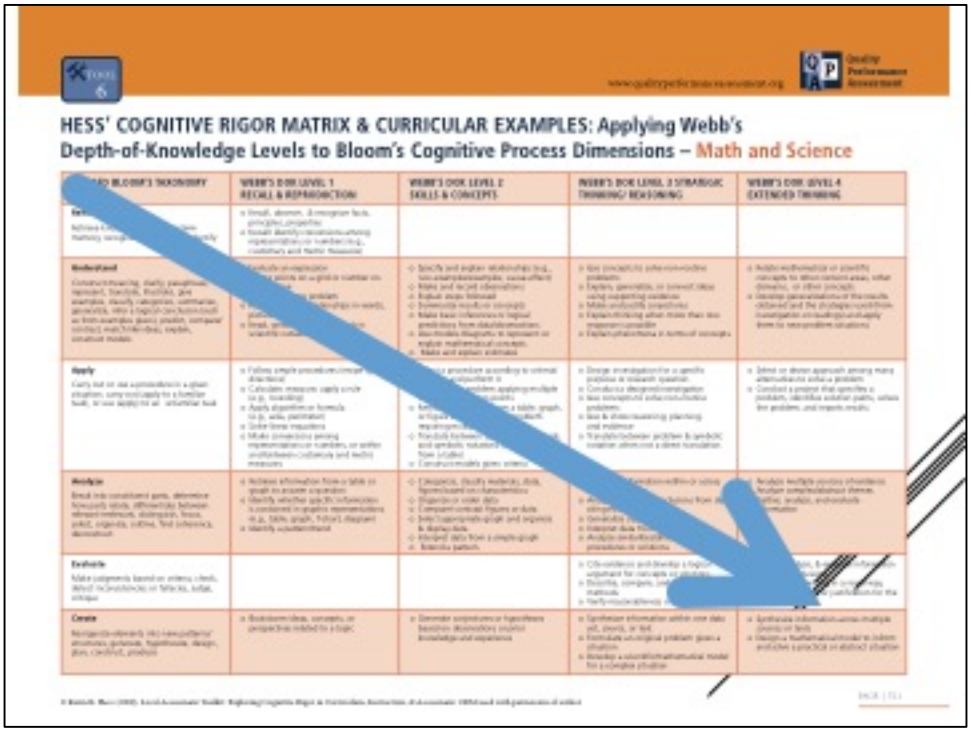
Ex. Learning designed with the Next Generation Science Standards

METHOD OF INSTRUCTION

- A Real Life Example
  - (https://youtu.be/GAQ5wq6cWOk)
- Table Talk:
  - How does this apply to instruction?
  - Choose a topic and with your table discuss how you could proceed through each phase of instruction described in the graphic.

SEQUENCING

- Tasks increase in cognitive rigor through a lesson, through a unit, through the course of study.
- Culminate in performance assessment at a Depth of Knowledge 3+



SOCIOLOGY

- As a Community of Practice, how do we support learners?
  - Mentoring
  - Positive peer groups
  - Peer tutoring
  - Community partnerships
  - Celebrations of learning
  - School/Classroom culture of support and excellence
  - Student collaboration

OBJECTIVES… THE ROAD AHEAD

- Model a CAM as we work together to implement a CAM to support our STEM Curriculum
  - Content- Next Generation Science Standards
  - Methods & Sequencing- Use DoK 3+ Performance Tasks to backwards design units and assessments to support students' abilities to become experts and experience more autonomy in learning
  - Sociology- Create structures and supports within the school and surrounding community to create a positive social context for learning, failing forward, and building resiliency

PART 2

Timeline: 1 Week Summer Institute; Day 1

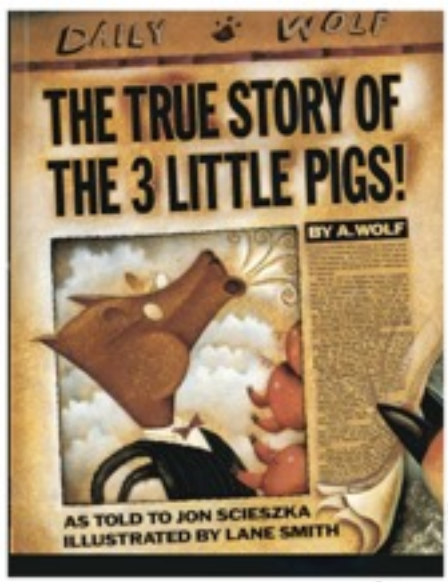
DESIGNING FOR LEARNING:

VALIDITY MEANS….ALIGNMENT

BEFORE WE BEGIN…

- Take two minutes to write your personal definition of "cognitive rigor" as it relates to instruction, learning, and/or assessment.
- Discuss this definition with your group and be prepared to share a definition.

THE THREE LITTLE PIGS: EXPLORING DOK



APPLYING YOUR DEFINITION OF COGNITIVE RIGOR

Imagine you just read The Three Little Pigs

- What is a basic comprehension question you might ask?
- What is a more rigorous question you might ask?

THE THREE LITTLE PIGS

Pair Share:

- Review the DOK Matrix (Tools 5 & 6)
- Place your questions on the matrix

QUESTION SHARE OUT

DEFINITIONS

- **Bloom** – **What type of thinking** (verbs) is needed to complete a task?
- **Webb** – **How deeply** do you have to understand the content to successfully interact with it? How complex is the content?
  - Complexity not Difficulty

DOK IS ABOUT COMPLEXITY—NOT DIFFICULTY!

- The intended student learning outcome determines the DOK level. **What mental processing must occur?**
- While verbs may appear to point to a DOK level, it is what comes after the verb that is the best indicator of the rigor/DOK level.
  - ***Describe*** the process of finding an average
  - ***Describe*** how two characters are alike and different; describe an observation you made about these materials
  - ***Describe*** using words, diagrams and equations the evidence that supports the reasonableness of your solution
  - ***Describe*** the evidence you found in 2 or more texts that shows different perspectives on this topic.

DOK LEVELS

- DOK-1 – Recall & Reproduction
- DOK-2 - Basic Application of Skills/Concepts
- DOK-3 - Strategic Thinking
- DOK-4 - Extended Thinking

DOK 1

- **Recall and Reproduction**
  - Fact
  - Term
  - Vocabulary
  - Principle
  - Concept
  - perform a routine procedure

DOK 1 SAMPLE QUESTIONS

- Simplify the Expression (no negative exponents)
  - $X^4 * X^3 =$
  - $(X^4)^{-3} =$
- Buenos dias = ?

DOK 2

- **Basic Application of Skills/Concepts**
  - Use of information
  - Conceptual knowledge
  - select appropriate procedures for a task
  - two or more steps
  - routine problems
  - organize/display data
  - interpret/use simple graphs

DOK 2 SAMPLE QUESTIONS

- Math Word problem using exponents.
- Summarize the key points from a text.

DOK 3

- **Strategic Thinking**
  - Reasoning
  - developing a plan or sequence of steps to approach problem
  - decision making and justification
  - abstract, complex, or non-routine
  - more than one possible answer

DOK 3 SAMPLE QUESTIONS

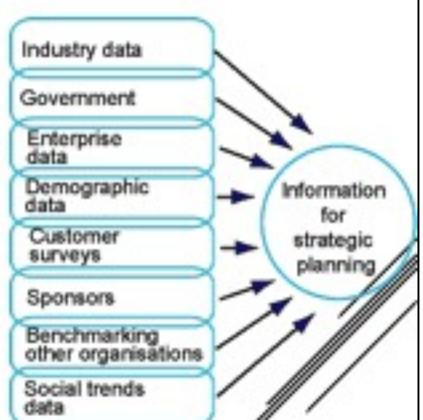
- Students use information from one bank to decide how to invest their money and explain their reasoning.
- Students write an essay exploring literary themes used in a text.

DOK 4

- **Extended Thinking**
  - An investigation or application to real world
  - requires time to research, problem solve, and process multiple conditions of the problem or task
  - non-routine manipulations, across disciplines/content areas/multiple sources

DOK 4 SAMPLE QUESTIONS

- Investigate saving options at various local banks and write a report which explains which bank you will use and why.
- Research multiple sources on a topic of choice. Synthesize your findings and present to the class.



APPLYING DOK LEVELS:

As you read each problem, discuss with your group and then each person holds up the number of fingers that represent DOK level when requested by facilitator:

- DOK-1 – Recall & Reproduction
- DOK-2 - Basic Application of Skills/Concepts
- DOK-3 - Strategic Thinking
- DOK-4 - Extended Thinking

GRADE 2 READING STREET:

PROMPT

The stories told about having fun outside. Think about a time you had fun outside.
Write a story about a time you had fun outside. Tell where you were. Tell who was with you. Tell what you did.

CHECKLIST FOR WRITERS

_______ Did I think about a time I had fun outside before I started writing?
_______ Did I tell where I was, who was with me, and what I did?
_______ Does my story have a beginning, middle, and end?
_______ Did I choose my words carefully?
_______ Do my sentences make sense?
_______ Do my sentences start with capital letters?
_______ Do my sentences end with end marks?
_______ Did I check my spelling?
_______ Did I make sure my paper is the way I want readers to read it?

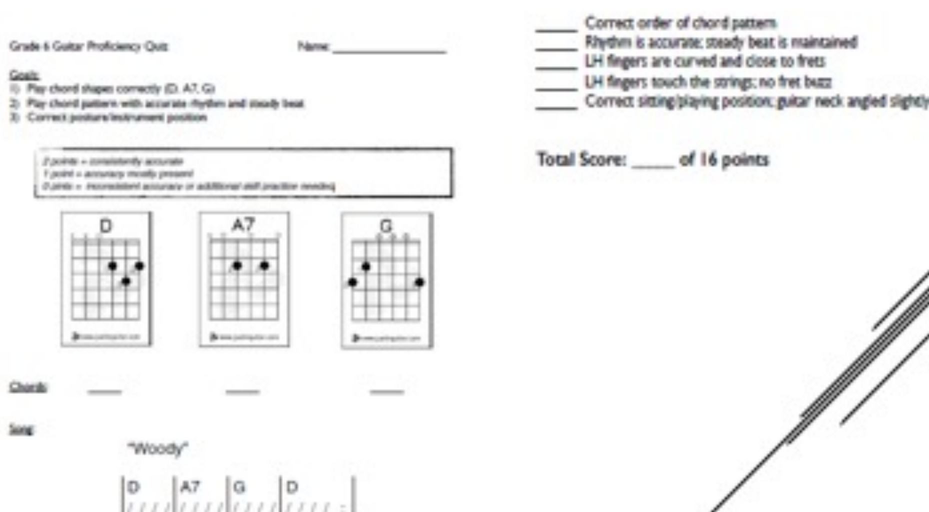
A rope ladder with 8 rungs that 9 inches apart is hanging over the side of a pool. The first rung is 9 inches from the bottom of the empty pool.

If we fill the pool at a rate of 1 foot per hour, how long will it take to reach the top rung of the ladder?

Explain how you got your answer.

EXEMPLARS GRADE 4: FILLING THE POOL:

INTEGRATED ARTS EXAMPLE: GUITAR GRADE 6


Grade 6 Guitar Proficiency Quiz Name: ____________

Goals:
1) Play chord shapes correctly (D, A7, G)
2) Play chord pattern with accurate rhythm and steady beat
3) Correct posture/instrument position

2 points = consistently accurate
1 point = accuracy mostly present
0 points = inconsistent accuracy or additional skill practice needed

D A7 G

Chords: ____ ____ ____

Song:
"Woody"
D A7 G D

____ Correct order of chord pattern
____ Rhythm is accurate; steady beat is maintained
____ LH fingers are curved and close to frets
____ LH fingers touch the strings; no fret buzz
____ Correct sitting/playing position; guitar neck angled slightly

Total Score: ____ of 16 points

GRADE 4 SMARTER BALANCED ELA:

The following is a rough draft of a paragraph that a student is writing for the school newspaper about why there should be a longer school day. The draft needs more details to support the student's reasons for having a longer school day.

Now look at the following daily schedule for a school that has switched to a longer school day.

Revise the paragraph by adding details from the daily schedule that help support the reasons for having a longer school day.

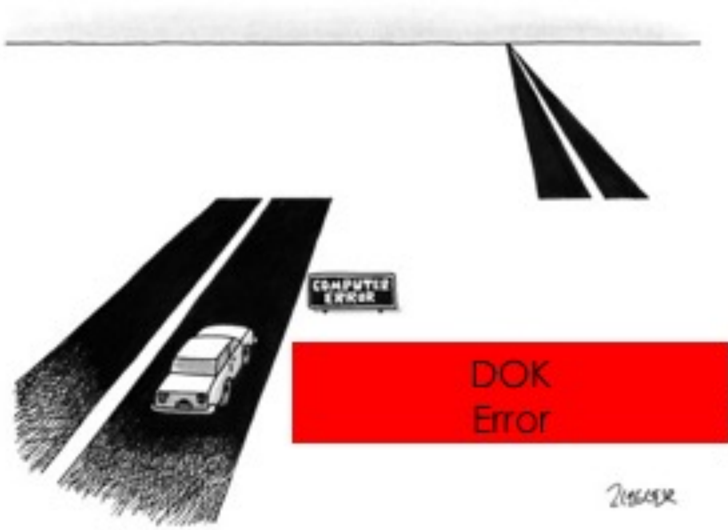
Why There Should Be a Longer School Day

Schools should have a longer school day for students. First, students could learn more about different subjects if the school day were longer. Also, students could get extra help from teachers. More hours in class each day would also mean more vacations scattered throughout the year!

8:00	Morning Announcements
8:20	Reading Language Arts
9:30	Foreign Language
10:30	Morning Recess
10:45	Mathematics
11:45	Lunch
12:45	History
1:45	Art or Music
2:15	Afternoon Recess
2:45	Science
3:30	Homework Preparation
3:45	After-School Tutoring or Sports

Jamal is filling bags with sand. All of the bags are the same size. Each bag must weigh less than 50 pounds. One sand bag weighs 57 pounds and another sand bag weighs 41 pounds. Explain whether Jamal can pour sand from one bag into the other so that the weight of each bag is less than 50 pounds.

GRADE 6 SMARTER BALANCED MATH



WE NEED ALL LEVELS OF ASSESSMENT IN OUR TOOLBOX

LET'S WORK WITH RIGOR:

- Your class is studying one of the following topics/concepts:
  - Science: Weather
  - Social Studies: Revolutionary War
  - World Languages: Cultural traditions
  - English: Hero's Journey
  - Mathematics: Ratio and proportion
  - Integrated Arts: Design
- What is a basic understanding task?
- What is **a more rigorous** task?

EXAMPLE OF BASIC/COMPLEX: SPACE EXPLORATION

- Basic: Read the book Space Exploration, create a timeline of U.S. space exploration that identifies the year of each major U.S. space exploration milestone.
- Rigorous: Compare US space exploration milestones with another country that has achieved major space exploration milestones such as Russia or China. Create a picture book that justifies the benefits of space exploration for each country, a timeline of achievements, and provides evidence for which country has the most significant accomplishments. Model after Jerry Pallota's *Who Would Win* series.

GROUP TASK: 60 MINUTES

Step 1: In your group select a content area and develop the following for the concept/topic your group has chosen:

- Develop a basic understanding task?
- Develop **a more rigorous** task?

Step 2: Use CRM tools to analyze your task:

- CRM template for ELA (reading-social studies)
- CRM template for math-science
- CRM template for writing

Step 3: Be prepared to report to the whole group

REFLECTION QUESTIONS

- What stood out for you about using the cognitive rigor matrix?
- What are the implications of the conversation for our work and how we support rigorous instructional and assessment?

TIPS FOR ANALYZING DOK

- What comes after the verb that is the best indicator of the rigor/DOK level.
- If there is one correct answer, it is probably level DOK 1 or DOK 2
    - DOK 1: you either know it (can recall it, locate it, do it) or you don't know it
    - DOK 2 (conceptual): apply one concept, then make a decision; express relationship (if-then; cause-effect)
- If more than one solution/approach, requiring evidence, it is DOK 3 or 4
    - DOK 3: Must provide supporting evidence and reasoning
    - DOK 4: all of "3" + use of multiple sources/data/ texts

TAKE-AWAY MESSAGE: COGNITIVE RIGOR & SOME IMPLICATIONS FOR ASSESSMENT

- Begin with DOK3 classroom discourse!
- Assessing only at the highest DOK level (the "ceiling") will miss opportunities to know what students do & don't know – go for a range; end "high" with selected/prioritized content
- Performance assessments can offer varying levels of DOK embedded in a larger, more complex task

PART 3

Timeline: 1 Week Summer Institute; Day 2

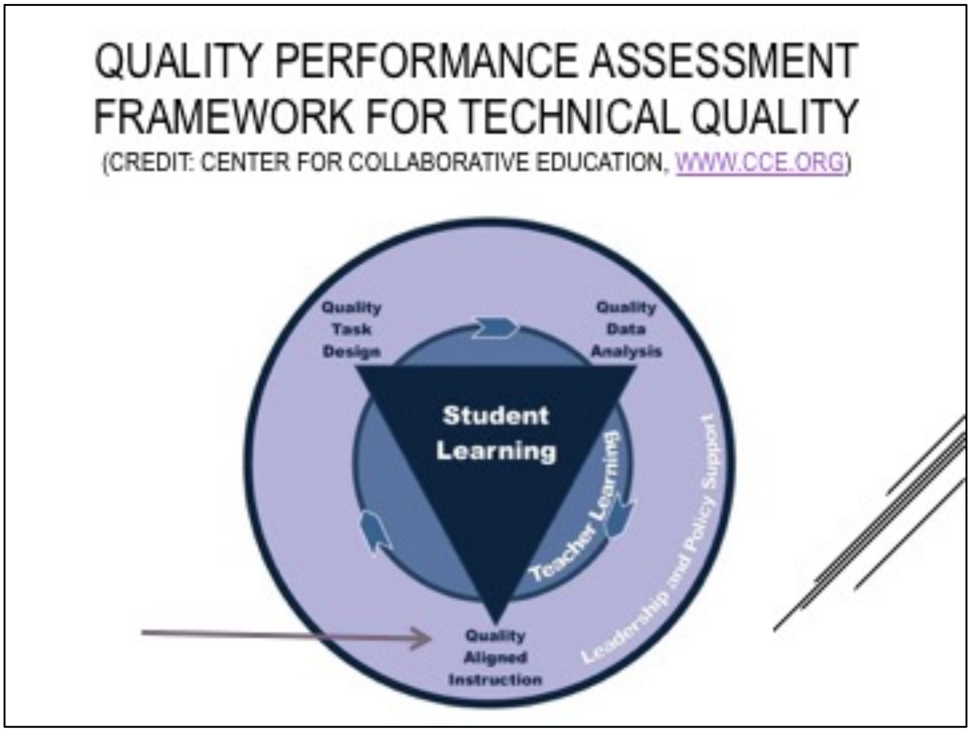
PERFORMANCE ASSESSMENTS FOR LEARNING:

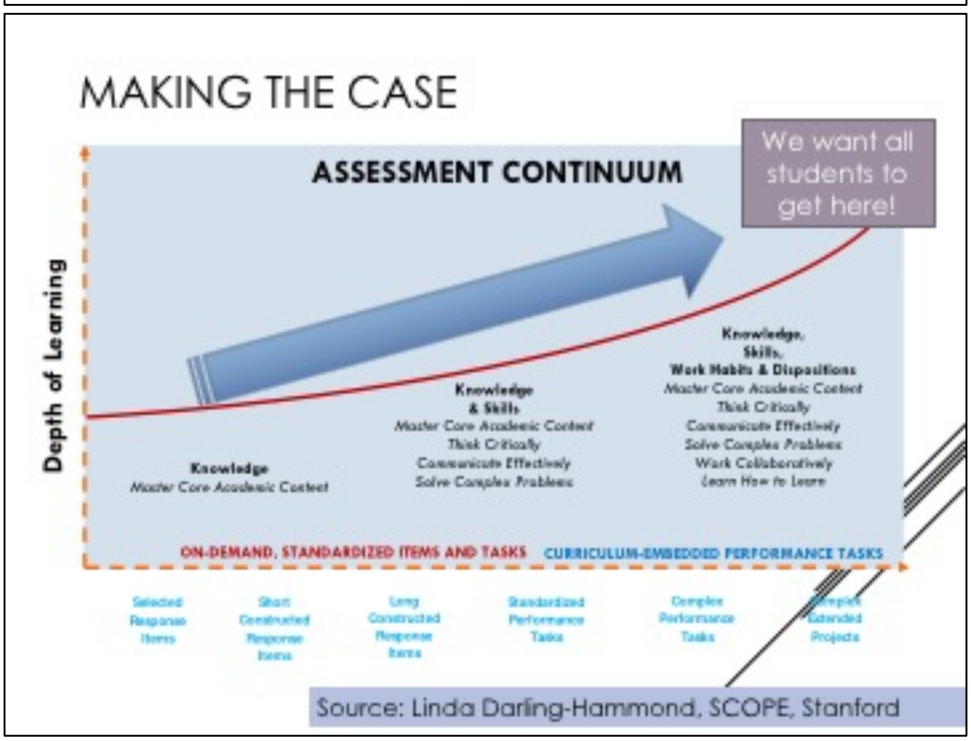
WHAT IS PERFORMANCE ASSESSMENT?

Performance assessments are **multi-step** assignments with clear criteria, expectations, and processes which measure how well a student **transfers** and **applies** knowledge and complex skills to create or refine an original product and/or solution.

WHAT DOES TRANSFER INVOLVE?

Applying prior learning to a novel and increasingly new and unfamiliar-looking task, in increasingly challenging context and situation (in terms of purpose, audience, dilemmas, etc.). This should occur in the learning (practice) context and not just in assessment (game) situations.


QUALITY PERFORMANCE ASSESSMENT FRAMEWORK FOR TECHNICAL QUALITY
(CREDIT: CENTER FOR COLLABORATIVE EDUCATION, WWW.CCE.ORG)
Quality Task Design
Quality Data Analysis
Student Learning
Teacher Learning
Leadership and Policy Support
Quality Aligned Instruction


MAKING THE CASE
ASSESSMENT CONTINUUM
We want all students to get here!
Depth of Learning
Knowledge
Master Core Academic Content
Knowledge & Skills
Master Core Academic Content
Think Critically
Communicate Effectively
Solve Complex Problems
Knowledge, Skills, Work Habits & Dispositions
Master Core Academic Content
Think Critically
Communicate Effectively
Solve Complex Problems
Work Collaboratively
Learn How to Learn
ON-DEMAND, STANDARDIZED ITEMS AND TASKS
CURRICULUM-EMBEDDED PERFORMANCE TASKS
Selected Response Items
Short Constructed Response Items
Long Constructed Response Items
Standardized Performance Tasks
Complex Performance Tasks
Extended Projects
Source: Linda Darling-Hammond, SCOPE, Stanford

POWER OF COMMON PERFORMANCE ASSESSMENTS

1. **Professional Engagement:** Teachers and administrators are engaged in the development and scoring. (Darling-Hammond and Falk, 2013)
2. **Ownership:** Professional learning teams shape the learning, gather data and guide adjustment to practice.
3. **Assessment of Deeper Learning:** Learning linked with curriculum and high quality instruction is likely to promote desirable changes in practice as test content and format mirror high-quality instruction (Rand Report, 2013).
4. **Student Engagement:** Students are active participants in their learning and assessing their effort and outcomes.

THE HESS COGNITIVE RIGOR MATRIX APPLIES WEBB'S DOK TO BLOOM'S COGNITIVE PROCESS DIMENSIONS

Depth + Thinking	Level 1 Recall & Reproduction	Level 2 Skills & Concepts	Level 3 Strategic Thinking/ Reasoning	Level 4 Extended Thinking
Remember	- Recall, locate basic facts, details, events			
Understand	- Select appropriate words to use when intended meaning is clearly evident	- Specify, explain relationships - summarize - identify main ideas	- Explain, generalize, or connect ideas using supporting evidence (quote, example...)	- Explain how concepts or ideas specifically relate to other content domains or concepts
Apply	- Use language structure (pre/suffix) or word relationships (synonym/antonym) to determine meaning	- Use context to identify meaning of word - Obtain and interpret information using text features	- Use concepts to solve non-routine problems	- Devise an approach among many alternatives to research a novel problem
Analyze	- Identify whether information is contained in a graph, table, text feature, etc.	- Compare literary elements, terms, facts, events - analyze format, organization, & text structures	- Analyze or interpret author's craft (literary devices, viewpoint, or potential bias) to critique a text	- Analyze multiple sources - Analyze complex/abstract themes
Evaluate			- Cite evidence and develop a logical argument for conjectures	- Evaluate relevancy, accuracy, & completeness of information
Create	- Brainstorm ideas about a topic	- Generate conjectures based on observations or prior knowledge	- Synthesize information within one source or text	- Synthesize information across multiple sources or texts

ASSESSMENT TASK REVIEW STEPS:

- **Step 1: Pair Share (20 minutes):** Using the assessment tasks that you brought collaboratively examine the task and answer questions on worksheet.
- **Step 2: Table Share (20 minutes):** At your table each pair will share highlights of their discussion for two minutes. Group will select one task to look at as a group that is complex and will allow the group to think about DOK deeply.

PAIR SHARE: EXAMINING AN EXAMPLE ASSESSMENT/TASK AND RUBRIC

- Examining Depth of Knowledge (DoK) and Rigor
  - What level or levels of DoK are represented in the assessment/task?
- Connecting to our work
  - What are the strengths of this assessment?
  - How could you increase the level of cognitive rigor of this assessment?
  - What type of scaffolding is necessary for students leading to this assessment?

ASSESSMENT TASK REVIEW STEPS:

- **Step 3: Whole-team Task Review (40 minutes):** At your table each team will review one complex task/student assessment and answer questions on chart paper. Each group will post task and conversation highlights for a gallery walk after the task

LARGER GROUP: EXAMINING AN EXAMPLE ASSESSMENT/TASK AND RUBRIC

- Examining Depth of Knowledge (DoK) and Rigor
  - Examine the alignment of the assessment or rubric descriptors: Is the task/rubric aligned with the intended DoK levels and intended standards? Use computers to find standards if necessary.
  - How can the alignment to DoK be strengthened?
- Connecting to our work
  - How can the assessment be strengthened to provide multiple entry points for diverse learners at all levels?
  - What are the implications of this assessment/conversation for practice and unit development?

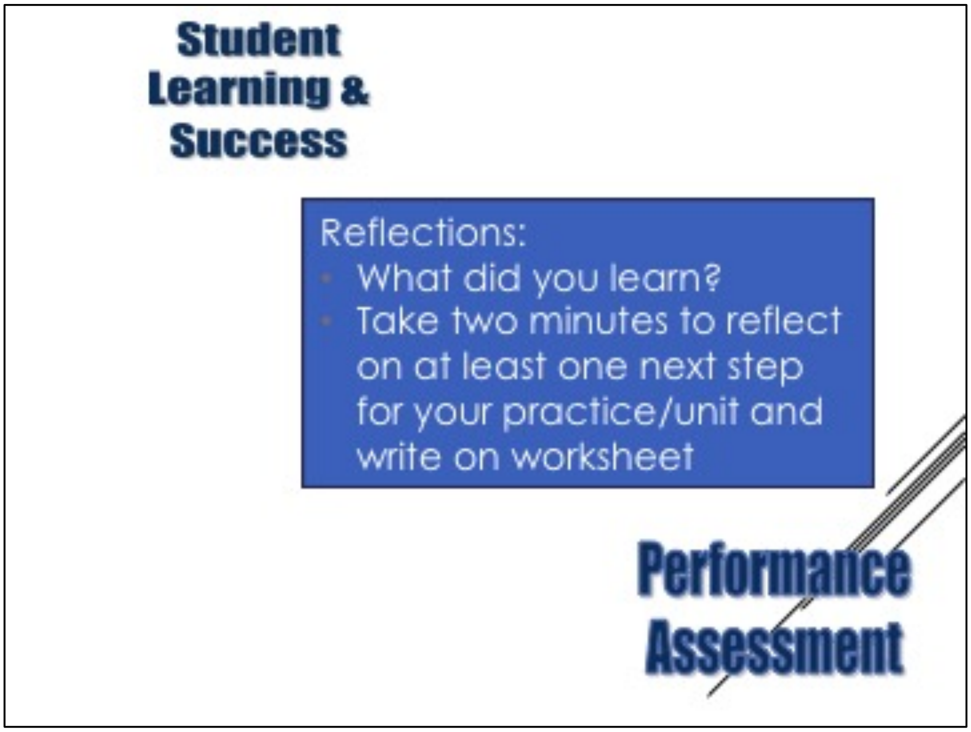
ASSESSMENT TASK REVIEW STEPS:

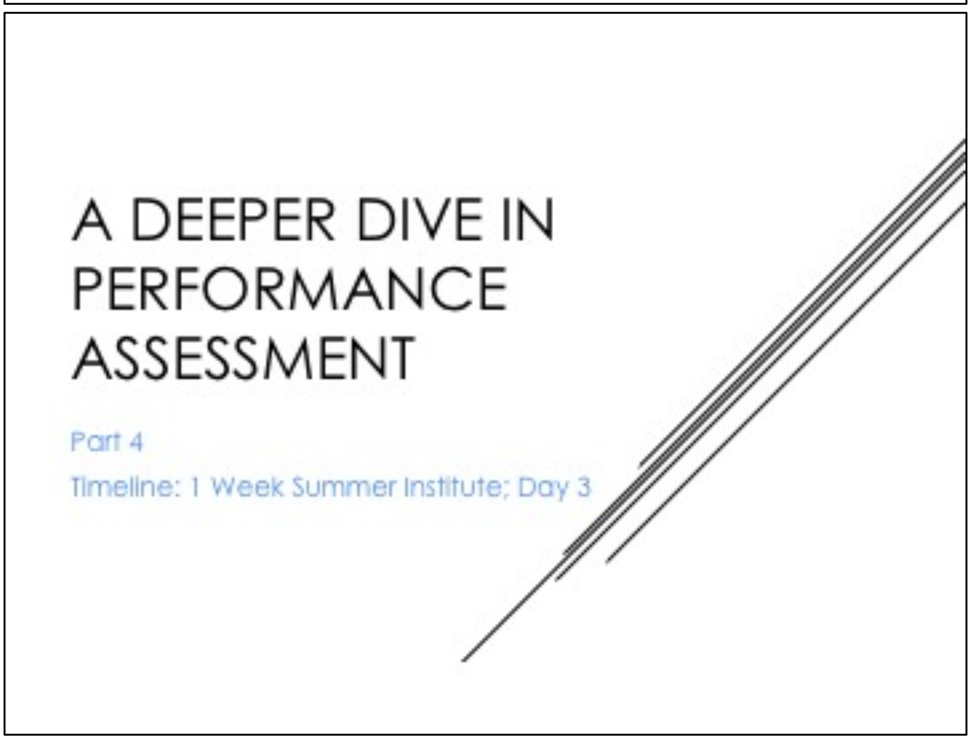
- **Step 4: Gallery Walk (10 minutes) and whole-group discussion (15 minutes):** The group will post the following:
  - Task
  - Results of discussion
  - CRM marked to illustrate the complexity of the task
- Using Post-its during the gallery walk the group will post the following and this will be the focus of the whole-group discussion following the gallery walk:
  - Wonders: Ask questions
  - Learning: Thoughts and comments
  - Implications for practice

WHOLE- GROUP DISCUSSION AFTER GALLERY WALK

Focus on the following prompts during discussion:

- Learning
- Wondering
- Implication for practice
- Questions


Student
Learning &
Success
Reflections:
What did you learn?
Take two minutes to reflect on at least one next step for your practice/unit and write on worksheet
Performance
Assessment


A DEEPER DIVE IN PERFORMANCE ASSESSMENT
Part 4
Timeline: 1 Week Summer Institute; Day 3

PERFORMANCE ASSESSMENT CAROUSEL (30 MIN)

Goals:

- Activate prior knowledge and practice around performance assessment
- Collaboratively analyze example performance assessments

- Designing a Dog Play Yard (geometry, gr 9-12)
- Yearbook Sales (math, grade 8)
- Engineering Design Problem (science, grade 8)
- Create a Creature (ELA/SS, grade 5)
- Start Right! (PE, gr 8)
- Explorers: Heroes or Villains (SS, grade 5)

TASK GROUPS

ALIGNMENT

- Applies content knowledge to the skills (and vice versa)
  –I am a critical thinker using Shakespeare.
  –I use area and perimeter to demonstrate proficiency as a problem solver.
- Same Wording Throughout
  –standards
  –essential questions
  –planning template
  –student directions
  –rubric

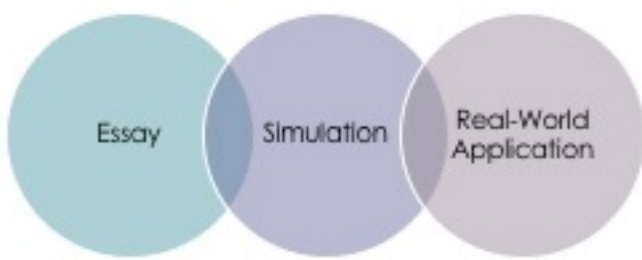
ALIGNMENT

- Start with the end in mind: the standards!
- Connect "what you want them to know" (standards) with "how do you know" (assessment).
  - What evidence will demonstrated proficiency in that standard?

COGNITIVE RIGOR (DOK LEVELS)

DOK 1	DOK 2	DOK 3	DOK 4
Recall and Reproduction	Basic Application	Strategic Thinking	Extended Thinking
1 answer Either you know it or you don't		More than one answer Requires evidence	

STUDENT ENGAGEMENT FOR POWERFUL LEARNING



Does the assessment …

… provide opportunity for ownership and decision making?

… focus on significant content and address authentic issues?

… include multiple ways for students to engage with content?

FOCUS QUESTIONS

- What evidence do you see of ___________?
- What opportunities exist to increase the level of __________?

GALLERY WALK (10 MIN)

What similarities do you observe between tasks in regards to cognitive rigor, alignment, student engagement?

GRADE LEVEL DEBRIEF (10 MIN)

- How has your thinking changed as a result of today's learning?
- What new knowledge have you gained?
- What questions has today's activity raised for you?

- Questions, Comments, Concerns
- Reflections: Share out the highlights of your grade level conversation on polleverywhere.com!

NEXT STEPS FOR THE SUMMER INSTITUTE WEEK

- Examination of Summative Assessments to evaluate DoK and alignment with Next Generation Science Standards
- (Re)Design of performance assessments using the Quality Performance Assessment Framework (Center for Collaborative Education, www.cce.org)

SOCIAL SUPPORTS OF LEARNING IN A CAM

Part 5

Timeline: May/June

ASPIRATION: CREATE A SCHOOL & COMMUNITY CULTURE THAT SUPPORTS SUCCESS IN STEM SO THAT MORE FEMALE STUDENTS ENROLL IN ADVANCED STEM COURSES

- Goal: Use Design-Thinking and tools from School ReTool (http://schoolretool.org/) to:
  - Brainstorm ways to meet out aspiration using levers such as process, place, finances, roles, etc
  - Decide on 4-6 actions or Hacks (using the School ReTool language) to try before the end of the School year
  - Reconvene to share results of Hacks and choose 1-2 to develop to scale in the next 6 months, 1-2 to develop to scale over the next year

WHAT IS A HACK?

- Intro Video: https://vimeo.com/118731499
- Quick
- Small scale action that might lead to larger change
- Immediate

FRAMEWORK

- **Aspiration**: Create a school & community culture that supports success in STEM so that more female students enroll in advanced STEM courses
- **Behaviors:** 1)Students connecting with outside resources; 2) Students celebrating risks and successes; 3) Greater numbers of female students enrolling in advanced STEM courses
- **Big Idea:** Advisory… Academic Internships… Students as Teachers… other possibilities? (http://schoolretool.org/big-ideas)

SCHOOL RETOOL: TOOLS TO USE

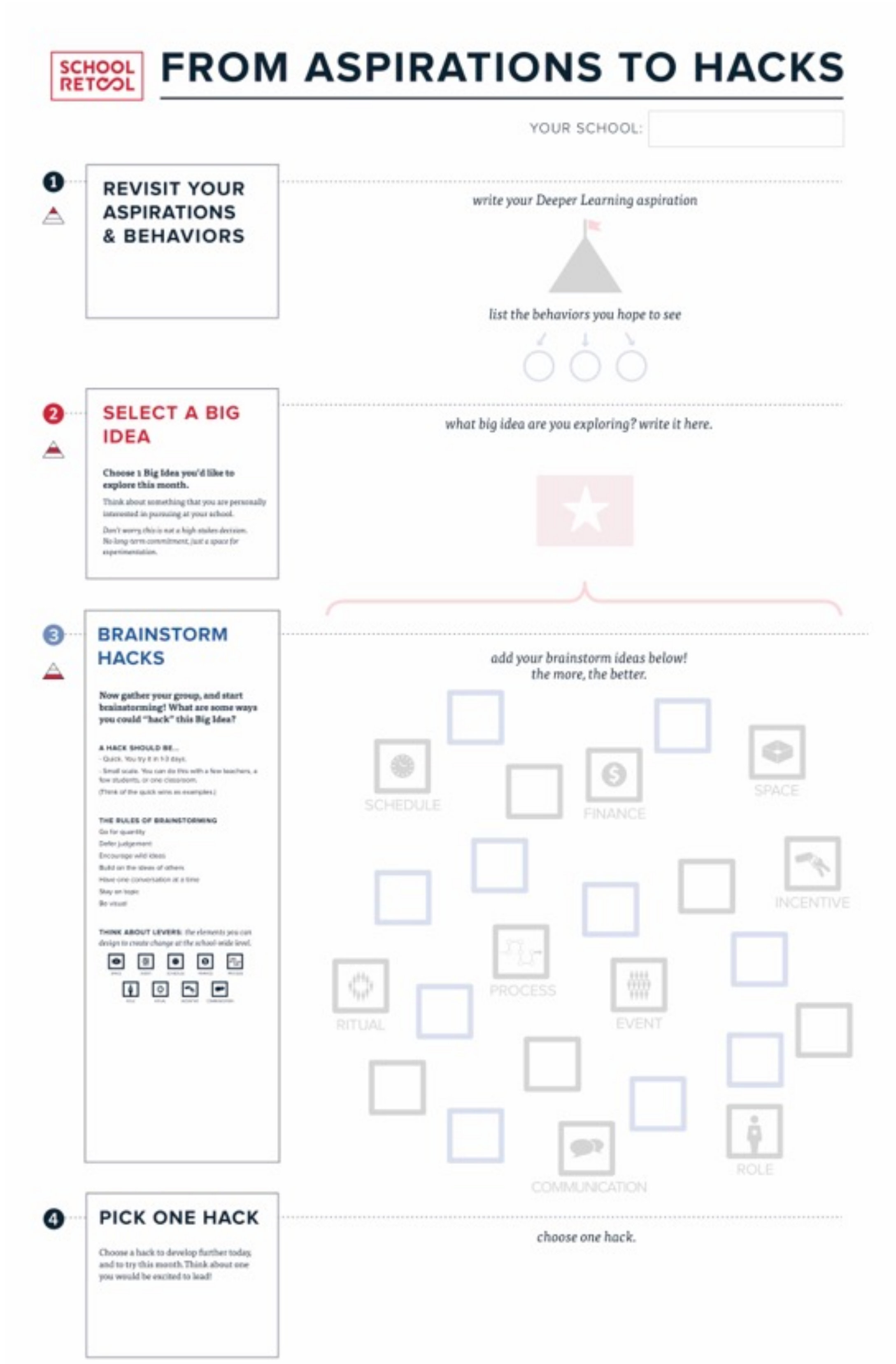
- Brainstorm Rules:
- Hack Brainstorm Poster:
- Hack Design: A Sketch:

THE RULES OF BRAINSTORMING

SCHOOL RETOOL

*The goal of brainstorming is to generate as many ideas as possible—
from low-hanging fruit to combinations of ideas, and crazy new ideas.
These basic ground rules help set the conditions for productive brainstorming.*

- Go for quantity
- Defer judgment
- Encourage wild ideas
- Build on the ideas of others
- Have one conversation at a time
- Stay on topic
- Be visual
- Write headlines



SCHOOL RETOOL

FROM ASPIRATIONS TO HACKS

YOUR SCHOOL:

1 REVISIT YOUR ASPIRATIONS & BEHAVIORS

write your Deeper Learning aspiration

list the behaviors you hope to see

2 SELECT A BIG IDEA

Choose 1 Big Idea you'd like to explore this month.

Think about something that you are personally interested in pursuing at your school.

Don't worry this is not a high stakes decision. No long-term commitment, just a space for experimentation.

what big idea are you exploring? write it here.

3 BRAINSTORM HACKS

Now gather your group, and start brainstorming! What are some ways you could "hack" this Big Idea?

A HACK SHOULD BE...
- Quick. You try it in 1-3 days.
- Small scale. You can do this with a few teachers, a few students, or one classroom.
(Think of the quick wins as examples.)

THE RULES OF BRAINSTORMING
Go for quantity
Defer judgement
Encourage wild ideas
Build on the ideas of others
Have one conversation at a time
Stay on topic
Be visual

THINK ABOUT LEVERS: *the elements you can design to create change at the school-wide level.*

add your brainstorm ideas below! the more, the better.

SCHEDULE
FINANCE
SPACE
INCENTIVE
PROCESS
RITUAL
EVENT
COMMUNICATION
ROLE

4 PICK ONE HACK

Choose a hack to develop further today, and to try this month. Think about one you would be excited to lead!

choose one hack.

SCHOOL RETOOL

HACK DESIGN: A SKETCH

YOUR NAME:

Name your hack.

Something short and playful.

Sketch it.

One scene, or a comic-book-style storyboard.

Describe it.

What do you hope to learn?
What behaviors do you hope to change?

SCHOOL RETOOL

HACK PLANNING: WHO, WHEN, WHERE

YOUR NAME:

Block out time.

At a very high level, what activities might happen when?

WEEK 1

HACKING

Don't get stuck in planning! Bias to action.

WEEK 2

REFLECTING + ITERATING

Things didn't go as expected? Learn from it and try again.

Who

Who will be key in making this hack happen? (A small tight team is best, to start.)

Where

Where could your hack take place? (Specific classrooms, common spaces, outside the school walls...)

Support

What do we need to get hacking?

Tomorrow, I will...

This is your commitment to yourself—to start small and jump right in!

NEXT STEPS

- Carry out your hack
- Bring feedback and observations to our next meeting
- Next meeting: Decide which Hacks can help us move forward over the next 6 months, next year

EVALUATION MATERIALS

- Adapted from SERVECenter, University of North Carolina at Greensboro- www.serve.org)
  - Professional Development Exit Questionnaire (document will be modified to reflect CAM instead of "formative evaluation")
  - STEM Classroom Observation Protocol: Topics 1-6 directly align with the characteristics of quality performance assessments and the corresponding instructional characteristics (http://www.serve.org/STEM.aspx)

NC STATE UNIVERSITY COLLEGE *of* EDUCATION

THE WILLIAM & IDA FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION

Professional Development Exit Questionnaire
[Title of Professional Development]
Date

Name (optional): ____________________ Position Title/Role: ______________________
District/School: ____
Topic: _________________________ Duration (hours/days): ___________________

To what degree do you agree with the following statements regarding the professional development?

The staff development…	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Not Applicable
1. was of high quality	(SA)	(A)	(N)	(D)	(SD)	(NA)
2. was timely.	(SA)	(A)	(N)	(D)	(SD)	(NA)
3. was relevant to my needs.	(SA)	(A)	(N)	(D)	(SD)	(NA)
4. format and structure facilitated my learning	(SA)	(A)	(N)	(D)	(SD)	(NA)
5. enhanced my understanding of how to develop a formative evaluation plan.	(SA)	(A)	(N)	(D)	(SD)	(NA)
6. enhanced my understanding of how to implement a formative evaluation plan.	(SA)	(A)	(N)	(D)	(SD)	(NA)
7. helped me gain new information and skills.	(SA)	(A)	(N)	(D)	(SD)	(NA)
8. will assist me in making better-informed decisions	(SA)	(A)	(N)	(D)	(SD)	(NA)
9. provided important resources for me.	(SA)	(A)	(N)	(D)	(SD)	(NA)
10. will assist my district/school and/or me in developing a formative evaluation plan.	(SA)	(A)	(N)	(D)	(SD)	(NA)
11. will assist my district/school and/or me in implementing formative evaluation.	(SA)	(A)	(N)	(D)	(SD)	(NA)
12. met my expectations	(SA)	(A)	(N)	(D)	(SD)	(NA)

How will you use what you have learned?

What was the most useful part of this staff development? Why?

What was the least useful part of this staff development? Why?

What additional training/support do you need?

Appendix B: Science Motivation Questionnaire II

SCIENCE MOTIVATION QUESTIONNAIRE II (SMQ-II)

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

Statements	Never 0	Rarely 1	Sometimes 2	Often 3	Always 4
01. The science I learn is relevant to my life.					
02. I like to do better than other students on science tests.					
03. Learning science is interesting.					
04. Getting a good science grade is important to me.					
05. I put enough effort into learning science.					
06. I use strategies to learn science well.					
07. Learning science will help me get a good job.					
08. It is important that I get an "A" in science.					
09. I am confident I will do well on science tests.					
10. Knowing science will give me a career advantage.					
11. I spend a lot of time learning science.					
12. Learning science makes my life more meaningful.					
13. Understanding science will benefit me in my career.					
14. I am confident I will do well on science labs and projects.					
15. I believe I can master science knowledge and skills.					
16. I prepare well for science tests and labs.					
17. I am curious about discoveries in science.					
18. I believe I can earn a grade of "A" in science.					
19. I enjoy learning science.					
20. I think about the grade I will get in science.					
21. I am sure I can understand science.					
22. I study hard to learn science.					
23. My career will involve science.					
24. Scoring high on science tests and labs matters to me.					
25. I will use science problem-solving skills in my career.					

Note. The SMQ-II is copyrighted and registered. Go to **http://www.coe.uga.edu/smq/** for permission and directions to use it and its discipline-specific versions such as the Biology Motivation Questionnaire II (BMQ-II), Chemistry Motivation Questionnaire II (CMQ-II), and Physics Motivation Questionnaire II (PMQ-II) in which the words *biology*, *chemistry*, and *physics* are respectively substituted for the word *science*. Versions in other languages are also available.

Science Motivation Questionnaire II (SMQ-II): Components

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

Components (Scales) and Statements (Items)	Never 0	Rarely 1	Sometimes 2	Often 3	Always 4
Intrinsic Motivation					
01. The science I learn is relevant to my life.					
03. Learning science is interesting.					
12. Learning science makes my life more meaningful.					
17. I am curious about discoveries in science.					
19. I enjoy learning science.					
Self-Efficacy					
09. I am confident I will do well on science tests.					
14. I am confident I will do well on science labs and projects.					
15. I believe I can master science knowledge and skills.					
18. I believe I can earn a grade of "A" in science.					
21. I am sure I can understand science.					
Self-Determination					
05. I put enough effort into learning science.					
06. I use strategies to learn science well.					
11. I spend a lot of time learning science.					
16. I prepare well for science tests and labs.					
22. I study hard to learn science.					
Grade Motivation					
02. I like to do better than other students on science tests.					
04. Getting a good science grade is important to me.					
08. It is important that I get an "A" in science.					
20. I think about the grade I will get in science.					
24. Scoring high on science tests and labs matters to me.					
Career Motivation					
07. Learning science will help me get a good job.					
10. Knowing science will give me a career advantage.					
13. Understanding science will benefit me in my career.					
23. My career will involve science.					
25. I will use science problem-solving skills in my career.					

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Appendix C: Survey

Name (last, first):

School E-mail:

Alternate e-mail:

Adapted from: SCIENCE MOTIVATION QUESTIONNAIRE II (SMQ-II)

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

	Never (0)	Rarely (1)	Sometimes (2)	Often (3)	Always (4)
I am confident I will do well on science tests.					
I am confident I will do well on science labs and projects.					
I believe I can master science knowledge and skills.					
I believe I can earn a grade of "A" in science.					
I am sure I can understand science.					

Please select the courses and extracurricular activities you have enrolled or participated in:

- ☐ AP Biology
- ☐ AP Chemistry
- ☐ AP Physics I
- ☐ AP Physics II
- ☐ Physics
- ☐ Honors Physics
- ☐ Anatomy and Physiology
- ☐ AP Statistics
- ☐ Statistics
- ☐ AP Calculus
- ☐ Calculus
- ☐ AP Computer Science
- ☐ Intro to Engineering
- ☐ Object Orientated Programming I
- ☐ Object Orientated Programming II

- Smart Chicks
- Marine Science Team
- Science Olympiad
- Math Team
- JagSat

Appendix D: Interview Question Guide

1. What are your plans for after graduation?
    a. If attending college/university/tech school what do you plan on studying?
2. Why are you interested in studying _________?
3. Please describe the factors or experiences that you think have contributed to your desire to study _________.
4. Can you describe challenges you've faced in pursuing this major?
5. How are you affected by other's view of STEM?
6. What advice would you give to a middle school girl interested in studying ________?
7. Would that advice be the same or different for a middle school boy?
    a. Please explain.
8. If you could give your high school freshman self one piece of advice about the road ahead through high school, what would it be?

Written prompt to be given after the interview is complete:

Please respond to the following prompt:

Please describe which factors have had the greatest influence on your decision to enroll in advanced STEM (Science, Technology, Engineering, Mathematics) coursework.