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Successful with STEM? A Qualitative Case Study of Pre-Service Teacher Perceptions

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Abstract

This research is a qualitative case study of pre-service teachers' experiences with a Science, Technology, Engineering, and Mathematics (STEM) module during a middle level interdisciplinary course in the teaching of mathematics and science. Data were collected through document analysis of participant reflection journals (during six distinct stem tasks) and college curriculum as well as an analysis of researcher observations of the STEM activities. While the first and last tasks were reflective and designed to identify pre-existing STEM experiences and post-module knowledge, respectively, the other four STEM tasks simulated student-centered STEM activities common to the middle level classroom. The data were analyzed for patterns and significant experiences among participants. Findings indicated that participants perceived little to no experiences with STEM in K-12 education and other college courses despite contradicting data from required college coursework. As the module progressed, participants developed improved self-efficacy and expanded definitions for the teaching of STEM at the middle level. Future recommendations include more purposeful connection of teaching methodology and STEM content courses taught in isolation. Additional research is needed in more consistent and authentic STEM field placements for the continued growth and support of STEM in middle level teacher preparation.

Keywords

STEM, Middle Level Education, Teacher Preparation, Case Study

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This research is a qualitative case study of pre-service teachers' experiences with a Science, Technology, Engineering, and Mathematics (STEM) module during a middle level interdisciplinary course in the teaching of mathematics and science. Data were collected through document analysis of participant reflection journals (during six distinct stem tasks) and college curriculum as well as an analysis of researcher observations of the STEM activities. While the first and last tasks were reflective and designed to identify pre-existing STEM experiences and post-module knowledge, respectively, the other four STEM tasks simulated student-centered STEM activities common to the middle level classroom. The data were analyzed for patterns and significant experiences among participants. Findings indicated that participants perceived little to no experiences with STEM in K-12 education and other college courses despite contradicting data from required college coursework. As the module progressed, participants developed improved self-efficacy and expanded definitions for the teaching of STEM at the middle level. Future recommendations include more purposeful connection of teaching methodology and STEM content courses taught in isolation. Additional research is needed in more consistent and authentic STEM field placements for the continued growth and support of STEM in middle level teacher preparation. *Keywords: STEM, Middle Level Education, Teacher Preparation, Case Study*

Science, Technology, Engineering, and Mathematics (STEM) Education is at the forefront of educational reform initiatives at both national and state levels in the United States. With strong job growth projected in STEM-related fields over the next 10 years and a lack of students choosing pathways to these careers, continued reform in STEM-based learning is crucial to meeting economic demands (United States Department of Education, 2015). The United States is falling behind internationally in STEM areas. Currently, the United States is ranked 29th in mathematics and 22nd in science among other industrialized nations (United States Department of Education, 2015). The disparity between the projected numbers of STEM careers and the numbers of STEM proficient students entering associated college majors and pursuing STEM-related fields is unacceptable. The need for enhancing and growing STEM principles can be seen globally as well. In the United Nations Education, Scientific, and Cultural Organization (UNESCO)'s most recent science report, themes concerned with the growth of "science, technology, and innovation" demonstrate parallels to STEM trends found in the United States. These global initiatives of many member countries note the increased pressure on science to grow and develop to meet challenges that humanity faces from environmental crises, both human and man-made (Soete, Schneegans, Eröcal, Angathevar, & Rasiah, 2015). The solutions for how to improve the number of students choosing STEM careers is multifaceted and likely does not include a global solution that works for all contexts. Studies with specific contexts and influence on policy and program improvement may allow for incremental innovation and contribution to the complex global need for STEM professionals.

Despite the projection of a need for additional STEM professionals, much of educational research reports teachers are unqualified or insufficiently trained to teach the STEM subjects. Teacher misconceptions and a lack of training for teaching STEM subjects is creating students with inadequate STEM experiences and little preparation to enter STEM college majors and careers (Benken & Stevenson, 2014; Colbert, 2014; Garrett, 2008; O'Neill, Yamagata, Yamagata, & Togioka, 2012).

Quality professional development programs and partnerships are demonstrating progress in addressing improvement for current in-service teachers, yet they do not fully address additional layers of the problem (Avery & Reeve, 2013; Gillespie, 2015; Han, Yalvac, Capraro, & Capraro, 2015; Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester, 2013; Schuster, Buckwalter, Marrs, Pritchett, Sebens, & Hiatt, 2012), namely, that the need for such professional development programs indicates that pre-service teachers are graduating unprepared to teach in the STEM-rich environment of today's schools. The necessary competencies for graduates seeking to teach in STEM environments will continue to increase. The release of both the *Common Core State Standards for Mathematics* (CCSS) (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) and the *Next Generation Science Standards* (NGSS) (NGSS Lead States, 2013) have begun a shift in the level of preparation required for teacher candidates. Amid the CCSS's focus on rigor, conceptual understandings, and practical applications and NGSS's focus on processes, core ideas, and cross-cutting concepts between technical areas, the basic STEM prerequisite knowledge needed to teach is unprecedented to date.

With the variety of choices available to young professionals selecting post-baccalaureate professional development opportunities, it is not certain that new teachers will seek out quality STEM professional development programs to develop crucial STEM skills. Therefore, providing foundational preparation in STEM content and pedagogies during teacher preparation programs could be vital to improving the qualifications of future STEM teachers. Leaving improved STEM education to the uncertainty of independent professional development choices creates room for error and a possibility for lack of growth.

Theoretical Framework

A review of social learning theory and Bandura's papers on self-efficacy maintains that self-efficacy is vital to sustained perseverance when challenged with a cognitive task (Bandura, 1977, 1982). Bandura (1982) describes that "judgments of self-efficacy also determine how much effort people will expend and how long they will persist in the face of obstacles or adverse experiences" (p. 123). These theories of self-efficacy support that learners who perceive that they can succeed at a task are more likely to do so than those who doubt their own abilities in that cognitive area (Bandura, 1982). Salomon's work (1984) also supports the theory that if learners have high self-efficacy for a mental task or challenge that they are more likely to invest mental effort into that preferred task because it is perceived as "easy." These theories apply both to this study and to teacher preparation in general because they support the idea that positive experiences with a given new mental task, in this case, STEM-based content and pedagogies, could support teacher self-efficacy. Pre-service teachers' self-efficacy in STEM education supports the idea that a pre-service teacher with improved self-efficacy toward STEM content and pedagogy would apply sustained mental effort and perseverance to future STEM tasks.

Institutions have found success in developing graduate programs and professional development partnerships to facilitate continuing education in STEM. These post baccalaureate types of programs allow in-service teachers to expand on mathematics and science concepts to grow professionally in STEM-based content and pedagogy. In-service teachers who participate in STEM professional development programs report better confidence and self-efficacy in teaching STEM concepts (Avery & Reeve, 2013; Gillespie, 2015; Han et al., 2015; Nadelson et al., 2013; Schuster, Buckwalter, Marrs, Pritchett, Sebens, & Hiatt, 2012). I have created a table summarizing the main themes of the articles in which pre-service teachers or in-service teachers were involved with STEM professional development (see Table 1, Summarization of Article Themes for STEM Teacher Preparation and Professional Development). The majority of the present research focuses on implementation of professional development programs with in-service teachers. With support from a professional development program or partnership, the teachers were more likely to implement STEM strategies into their classrooms. Often, the transition to STEM pedagogies is difficult for in-service teachers. In-service teachers may routinely provide more traditional instructional methods instead of transforming to the student-centered learning strategies of STEM (O'Neill et al., 2012).

Table 1. Summarization of Article Themes for STEM Teacher Preparation and Professional Development

Author Information	Summary of Themes
Avery & Reeve (2013)	This article offers recommendation for successful professional development in STEM. This qualitative case study followed up with teachers 2 years after professional development from the National Center for Engineering & Technology Education (NCETE).
DiFrancesca, Lee, & McIntyre (2014)	Qualitative case study of how a STEM-focused elementary teacher preparation program (K-5) incorporates STEM principles (specifically engineering) into its program. Model provides themes of increasing teachers' self-confidence with STEM.
Gillespie (2015)	The article discussed the possible need for a national network of expert STEM teachers. Compared the *Knowles Science Teaching Foundation Fellowship* with international programs such as China's *National Teacher Training Program.*
Han, Yalvac, Capraro, & Capraro (2015)	A collective case study of 5 STEM teachers following the implementation of a STEM problem-based learning professional development. Descriptions of teachers' experiences and challenges provided.
Murphy & Mancini-Samuelson, 2012	This article describes the efforts of an interdisciplinary team of college teachers to develop a STEM certificate aimed at elementary teacher candidates. Post assessment data indicate statistically

	significant improvement with candidates' confidence on the basis of knowledge test items.
Nadelson, Callahan, Pyke, Hay, Dance, & Pfiester (2013)	A quantitative study examining two distinct cohorts of teacher preparation candidates of a STEM professional development program. Specific focus on self-efficacy and confidence in the research questions.
Ortiz, Bos, & Smith (2015)	This case study follows the implementation of a robotics-based STEM module for pre-service teachers with varying levels of experience. Implications for increased confidence and motivation are discussed.
Schuster, Buckwalter, Marrs, Prittchet, Sebens, & Hiatt (2012)	An article based in the authors' experiences and grounded theory of professional development. New visions of hybridized teacher education models for new STEM teachers are explored.

Middle level teacher preparation provides an excellent context to scrutinize and improve teacher self-efficacy in the area of STEM teacher preparation. According to the *National Science Foundation's Fifth National Survey of Science and Mathematics Education* (as cited in Colbert, 2014, p. 50) middle level science teachers often teach in courses for which they do not possess a degree. Reports from the survey indicate that teachers often do not have correlating collegiate-level coursework at an acceptable level of difficulty for the courses that they teach. Similarly, Colbert (2014) noted that inconsistent qualifications were also present in middle level mathematics education with teachers more likely to choose traditional methods of instruction over more student-centered best practices found in quality STEM classrooms.

Middle level education possesses an ideal structure for improved self-efficacy in STEM teacher preparation and pedagogy. Middle level programs, by foundation, are designed to be challenging, collaborative, and interdisciplinary. These traits connect directly to strong STEM-based content and pedagogy in which connections between multiple subject areas and collaboration to solve ill-defined problems are recommended practices (Association for Middle Level Education [AMLE], 2010). Middle level teacher preparation programs are rooted in AMLE's teacher preparation standards that specifically address the need for programs that provide candidates with a depth of content knowledge and an ability to traverse the interdisciplinary nature of subjects (Association for Middle Level Education [AMLE], 2012).

Many programs show initial success with integrating STEM into teacher preparation. These initiatives (not all at the middle level) do not always indicate complete proficiency with all of the complex characteristics of STEM content and pedagogy, but a few pioneering studies are finding that introducing concepts of STEM earlier is allowing candidates to experience improved self-efficacy, confidence, and motivation to implement and pursue STEM-based content and pedagogy upon entering future career placements (DiFrancesca, Lee, & McIntyre, 2014; Gillespie, 2015; Murphy & Mancini-Samuelson, 2012; Ortiz, Bos, & Smith, 2015).

This research contributes to the body of research implicating that STEM education competencies and experiences could be instituted into a regular portion of teacher preparation.

Understanding candidates' thought processes in various contexts helps to grow STEM initiatives in the context of teacher preparation.

Purpose

Additional research is necessary to determine how integration of STEM into middle level teacher preparation can improve candidates' confidence and competence with STEM content and pedagogy. The purpose of this study was to examine how candidates with little to no experience in STEM pedagogies perceive and interact with common types of STEM activities often utilized with middle level students. Understanding patterns that exist among pre-service teachers' interactions with STEM concepts may help contribute to the body of research dedicated to creating and improving programs for training future middle level teachers. Of additional concern was the collection of evidence to support or refute the idea that simulated experiences in a teacher preparation environment are sufficient experience to prepare candidates for careers in contemporary STEM classroom environments. This qualitative case study focused on the following research questions:

1. How do middle level pre-service teachers' definitions of STEM change after exposure to simulations of STEM learning activities?
2. What (if any) changes occur to middle level pre-service teachers' self-efficacy after exposure to simulations of STEM learning activities?
3. What are middle level pre-service teachers' attitudes toward future STEM experiences after exposure to simulations of STEM learning activities?

The purpose of the study most logically led to the use of a qualitative case study design. The natural education setting and interactive nature of the module was compatible with the qualitative methods of data collection, specifically, observation and personal reflection (Creswell, 2014). These methods allowed me to interact familiarly with participants to understand their thoughts and experiences with the STEM content.

Research Setting

The case study research took place at Saint Vincent College, a small liberal arts college in Pennsylvania. The college's education department offers middle level (4-8) certification with mathematics, social studies, language arts, or science as possible concentrations. The department also offers additional certifications in other areas (early childhood and various secondary and K-12 certifications), but the course in which the research took place is designed specifically as a requirement of any middle level candidate.

The introduction to the STEM module was planned as a part of an interdisciplinary teaching of math and science course designed for middle level candidates. The course is offered once per calendar year, and due to a smaller-sized middle level certification program, often only has enrollment of between 4 and 12 individuals per course offering. The main goal of the course is to teach candidates best practice instructional strategies for middle level mathematics and science environments. It is a required middle level methods course needed for state certification. The module was added as a method to study for improvement of candidates' prerequisite knowledge for STEM-based field placements during more advanced field experiences in mathematics and science.

Course Limitations

The course used for research had several characteristics that could be viewed as limitations or challenges for the placement of a STEM-based module. Identifying these challenges helped me to consider factors that could intervene with candidates' experiences with module activities. These limitations also influenced how the module was designed for the program already in place at the research site. First, the course is not offered during regular middle level school hours when during-course fieldwork placements or partnerships might be possible. The middle level program is relatively new to the college and was formed after other certification programs. To accommodate room availability, the course is held as a night course, eliminating the possibility of visiting a school or related site during class times. The second factor that could limit the placement of the STEM-based module is candidate availability for quality field placements. A required component of the course is the completion of 10 mathematics and science field hours at the middle level. The college employs a fieldwork supervisor who meets with candidates and schedules appropriate partnerships that meet the fieldwork parameters and competencies set by the course professor. Although these parameters are expected to be met by assigned field experiences, variance in the types of available school sites often lead to inconsistent quality of fieldwork experiences in STEM for each candidate. Finally, the physical location of the classroom where the course is held contains limited technology. The room is equipped with a teacher workstation, projection system, and other presentation equipment (DVD, audio, etc.). With no specific technology for candidates' personal use, a Bring Your Own Technology (BYOT) policy is in place to compensate. The majority of candidates elect to bring personal technology devices and utilize them, but technology use is still not consistent due to candidate access. Candidates without personal technology are encouraged to share with a peer to fully participate in all course experiences.

Despite course limitations, the increasing prevalence of STEM initiatives indicates a need for STEM content and pedagogy to be included at the level of teacher preparation. This study proposes that introducing STEM pedagogical experiences into teaching methodology courses may allow candidates to effectively engage with STEM pedagogies sooner. The earlier integration could allow candidates to feel more confident with STEM-based lessons and content, increasing the likelihood of candidates to use and seek additional professional development opportunities in STEM following certification.

Author's Context

As a teacher educator for middle level candidates, I am perpetually concerned with providing experiences that make candidates competitive in an ever-changing educational climate. As economic trends fuel educational change, colleges and education institutions must renew themselves, preparing their candidates to acclimate to the variable pace and sometime volatile nature of educational reform. Of even more significance though, is the need to create confident candidates competent in best-practice pedagogies that will lead to high-quality middle level education experiences for the students they serve.

STEM and middle level education have always melded well together for me personally as an educator and a researcher because of the interdisciplinary nature of both educational trends. Both research areas consistently focus on the fibers of connection between fundamental subjects. The connections of these subjects are believed to be a path leading to more integrated solutions for state, national, and international issues. Climate change, hunger, clean water access, global health initiatives—they all link to the interconnectedness and problem-based instructional strategies of STEM subjects.

As a former middle level teacher, I recognize the potential of young adolescents and hope to harness that potential, thus building toward college and career readiness, including those STEM subjects that are underrepresented as career choices. Teachers may seem to need better STEM preparation, but the how of program change is often yet to be determined. Though the context of this study is small, I believe it is small initiatives like this one that make the incremental changes toward better teacher preparation programs. Careful qualitative case study research in specific context to guide policy and programming decisions can help small institutions such as the research site to continue to have a positive effect on middle level learning through strong career preparedness with the support of quality teachers through research.

Methodology

Before the research was conducted**,** the procedures for the qualitative case study were approved by the Institutional Review Board of Saint Vincent College. Qualitative research matched well for the methodological design. Qualitative design "seeks to understand the world from the perspectives of those living in it" (Hatch, 2002, p. 7). These participant voices provide understandings of participant experiences and how they are developed within contextualized settings. The qualitative case study was the most appropriate design because it is characterized by the attempt to describe a bounded experience or activity within a finite amount of time (Creswell, 2014). The course and group of students chosen were in a particular course in a specific program and therefore qualitative case research describing the "how" or "why" of their experiences was most conducive to the research context (Merriam & Tisdell, 2016; Yin, 2014).

Course Procedures

The introductory undergraduate STEM module was planned as part of an interdisciplinary teaching of mathematics and science course for middle level teacher candidates. The collaboration of mathematics and science in one course offering seemed an ideal place for an interdisciplinary STEM module such as the one utilized. The course is a middle level candidate's first or second teaching methods course. The teacher education programs are not cohort driven, and a candidate is able to take the course during the spring of his or her sophomore, junior, or senior year prior to applying for the final student teaching experiences during the first and second semesters of the senior year. Therefore, the level of teaching experience can vary for each candidate depending on the talent of the candidate and the timing of when he or she has decided to take the course during his or her program.

I was also the professor of record for the course during the semester the research was completed. This arrangement required actions to protect both candidates and data. Because of this unique position, I had to be consistently concerned with sources of bias. Consideration of potential bias was the reason that the STEM tasks were generic and from third parties, and not of my own design. A program created by me could have possibly led to a desire for showing success of a certain program or designer set of teaching experiences, so a more generic set of experiences were chosen to lessen the opportunity for bias. Instead, the research served to confirm or refute STEM activities as valuable or misplaced in middle level teacher preparation.

The STEM module was completed as an ungraded, regular portion of class. Course structure, observations, and the STEM module would have been the same in the absence of a research study. Retaining the module as a non-graded course component encouraged participants to respond freely without fear of judgment in course assessment. Participants were recruited through an informed consent process during regular class hours. Participants were asked to email a consent statement to the professor of record after the close of regular semester grading. They were guaranteed through this agreement that no individual's journal or observation data would be used for the study without the candidate's permission. Since final grades were already submitted when permissions were collected there was no implication of participation (or non-participation) affecting a candidate's grade.

Participants

There were 7 participants enrolled in the teaching of mathematics/science course at the time of the research. All candidates elected to participate in the research project. There were more females than males in the class and the entire class was composed of candidates seeking first time certification. There was a small number of students who were post-baccalaureate candidates seeking first time certification. The post-baccalaureate candidates possessed degrees from a college or university that was not the research site. Their prior degrees were from fields of study unrelated to education. Participants had varying levels of experience with teaching. Some of the participants had already experienced several teaching method courses, while others had only completed the one course required for formal acceptance to the teacher education program.

In-Class Procedures

The module was broken up into six distinct experiences. The experiences took place during regularly scheduled course times, with no more than one experience occurring per week during the 6 weeks when the research was completed. During the first experience, participants were asked to reflect on their current knowledge of STEM in middle level schools. These reflections were completed without influence from outside resources. The experience set a baseline to establish prior knowledge and experiences with STEM. Then, the participants engaged weekly in four different types of STEM experiences including (a) a problem based learning task, (b) a creative thinking task, (c) an engineering design challenge, and (d) a STEM problem identification and lesson construction experience.

At the end of the module, participants were asked to complete a final reflection to revisit knowledge gained from the STEM experiences. Participants were encouraged to discuss attitudes and beliefs about STEM as well as perceptions of any abilities to implement STEM in future placements and/or classrooms. Instructions for each experience were given in the format of a simulation to allow each candidate to experience STEM instruction from the perspective of a middle level student. During tasks, the candidates were asked to keep a detailed journal that required reflection at each stage of the module, especially when using a problem solving routine or engineering design process. The journals allowed the candidates to revisit experiences through reflection and helped them to connect in-class experiences to plans for future teaching practices. More specific descriptions of each experience from the STEM module are described next.

Task 1: Establishing a baseline of prior knowledge

In Task 1, each participant was asked to reflect on his or her prior knowledge and understandings about STEM education at the middle level. The task took place during a regular class time. Participants were given survey-type questions to encourage the narrative reflection process, but they were not required to answer all questions and were encouraged to explore any topic or area believed to be pertinent to the module. The first question prompted participants to reflect on their definition of STEM. They were not permitted to seek Internet or other text resources during reflection to prevent outside influence. It was reinforced that the reflection participation and module responses were not for grades, nor were participants' answers going to be publicly shared with peers. I constructed these procedures in an attempt to increase validity and encourage participants to answer honestly about any prior knowledge and experiences in STEM education despite any worry of deficit or misconception of STEM practices.

If a participant possessed a personal definition for STEM education, he or she was then prompted through the reflection questions to discuss further any past experiences with STEM and any personal ideas or strategies for implementing STEM in the classroom. Additional questions asked participants to discuss beliefs about possible benefits of STEM in the classroom and to also identify any additional questions or ideas that they possessed about STEM education that they were hoping to explore as part of the STEM module.

Task 2: Introduction to authentic problem-based learning and reflection through an engineering design process

Task 2 was defined as a semi-structured problem because it was a finite task accessed from the public materials available from the Mathematics Assessment Project (Mathematics Assessment Resource Service, 2015). As one of the many tasks available on the website for students of varying mathematics abilities and experiences, the task was an authentic context that required participants to use mathematical rationalization and judgment and a knowledge of recording devices to evaluate the placement of a camera in a store's security system. The participants were asked to look at the current camera placement and decide if the location of the camera was in the most effective position for an oddly shaped room. The participants were able to arrive at a solution through any preferred strand of mathematics that was applicable to the context of the problem. Although correctness of calculation and use of mathematics were considered important, the problem was ideal for the first task of the module because it allowed candidates to experience one of the foundational principles of STEM, the use of flexible thinking and multiple solutions to approach the solving of a problem.

Participants interacted with this problem using an engineering design process and were required to follow five distinct checkpoints where they had to stop and record in their journals. These checkpoints were required for tasks 2, 3, and 4 because of the simulation of actual middle level Problem-Based Learning and STEM Design Challenges. Many variations of engineering design processes exist in both private organizations and commercialized materials. Instead of choosing a specific model for implementation, the participants were instead encouraged to examine the themes of a general engineering design processes. The focus was placed on how they as groups or individuals conceptualized and worked through each task as it was completed. The distinct checkpoints for journal reflection were provided with accompanying questions to assist candidates with the exploration of each level of a design process. Questions and thoughts for reflection were organized by each distinct checkpoint:

1. *Reaction to the problem:* What is your reaction to the task? What past experience(s) do you have with this type of task? How will you use prior knowledge to help you in this task?
2. *Problem research and conceptualization*: How will you/your group use what you already know to begin the task? What might the design/solution look like? What research or strategies will you use to influence your design?
3. *Discovery and discussion*: Discuss anything you/your group discovered through your exploration time with the problem. How did peer feedback affect your final solution/design?

4. *Applying a solution:* After sharing your/your group's solution with others, what input did you receive from others that will influence your solution or designs? What did others do that you may choose to emulate or use as part of future solutions?
5. *Application to teaching practice:* How effective was your/your group's design/solution? Identify any new knowledge you will take from this task. What influence do you perceive it having in your future classroom?

Task 3: Creative thinking task

For Task 3, participants were asked to engage in a building challenge using common household materials. The participants were given a rationed number of materials with limited types of connecting materials (e.g., tape, string) and asked to build the tallest tower possible. The activity was chosen because of its motivating nature and easy implementation for candidates just beginning in STEM. This task was purposefully paired with more complex STEM tasks to help participants compare flexible and creative thinking tasks to more complex STEM curriculum. Despite the restricted nature of the task, participants were still required to stop and reflect at the key checkpoints described during Task 2.

Task 4: An improved bicycle helmet design

During the fourth task, participants were introduced to more complex design challenges with authentic contexts applicable to world issue problem solving or product design and development. Participants were given 2 hours to research, design, test, and market an improved design for a bicycle helmet. Participants were again asked to reflect at each step of the design process using the engineering design checkpoints and the reflection journal. Participants were notified of the context of the problem during the previous session to allow them to begin to think about additional materials for the challenge. Some materials were provided for the activity (e.g., containers, foam, pipe cleaners, adhesives, cotton, and various other types of household building materials) to use freely when constructing a group design for an improved bicycle helmet. Participants were also encouraged to innovate and bring additional materials to the session. They were introduced to the concept of prototypes and encouraged to test multiple helmet designs and revisions using hardboiled eggs as test subjects. Participants evaluated damage to the hardboiled eggs during an impact test and inferred what changes needed to be made to the helmet prototype based on the results. Participants were instructed on evaluating their designs for practicality, safety, and marketability.

Task 5: STEM problem identification and lesson construction

In the fifth task, participants were asked to treat the college campus environment as a possible common context for STEM problem identification. During the task, individuals were invited to identify problems or needs in the campus or surrounding community that could be studied or improved upon using STEM processes or activities. Participants were encouraged to identify ways to collect data and make multiple connections through various subtopics of the STEM subjects. Although participants created lessons as individuals, participants were encouraged to work in collaborative partnerships and groups to gain peer feedback. Participants did not use the official reflection process described in Task 2. They were instead asked to reflect on and discuss the instruction, learning goals, and activities students would be engaged with during each step of their lesson's designs.

Task 6: Final reflection

The participants revisited their original reflections that were completed in Task 1. They were asked to revise or change their answers as appropriate to reflect any new knowledge, definitions, or skills gained for implementing best practices of STEM education. Participants were also encouraged to discuss any thoughts and beliefs or ideas for implementing STEM into their future classroom environments. If there was something from the module that the participants still had questions about, they were encouraged to express any needs in this reflection as well.

Data Collection and Analysis

There were two main sources of data for this study. The first type of data source came from separate sources of document analysis. The first source for document analysis was the participant reflection journals. These reflection journals were also the main source of candidate data for this research. Journals were chosen as the main form of data because of the manner in which they, and other strategic personal documents from participants, can provide a snapshot of what the individual perceives as important (Hatch, 2002; Merriam & Tisdell, 2016). The journals were completed during the course following each of the assigned tasks. The entries were completed in class as part of a structured reflection format. These structured reflections (as described in each task) ensured a protocol for reflection allowing for consistency among each journal. Adequate time for reflection was also considered so candidates could thoroughly communicate their thoughts. Journals were collected initially after the first task to help ascertain background knowledge and then were collected again in their entirety prior to the end of the course. An informed consent form asking for permission to keep and use the journal as a data source were sent out following the completion of final grades.

The second source of data collected were obtained from the college course catalog and handbook developed by the research site's education department. These documents were used to determine further context for the research site. In qualitative case studies, it is often impossible to separate the variables of the phenomena being described from their context, so clarifying the context of the course and understanding the number and types of courses that candidates are required to take helped the researcher to further conceptualize candidates' past experiences with STEM (Yin, 2014). This outline of program elements contributing to the candidates' STEM experiences and knowledge connects to the greater purpose of the study: teacher preparation program improvement at the research site.

Finally, my observed experiences and reflections on class activities were used as a source of data. One of the benefits for implementing the module for research in a simulated format was the opportunity to instruct and observe as the participants worked independently or in small groups during the assigned experiences. As the professor of record, I interacted constantly with the participant group. This participation yielded its own information believed to be pertinent to the overall research questions. Creswell (2014) discusses that collecting reflective data as an active participant can yield important information as it is being revealed. This method can also have limitations in that, as the researcher, I cannot divulge private data. It also could provide a source of confirmation bias if I had a specific preconception of study outcomes. Because of these limiting factors, this data collection method was used sparingly and only added to data analysis when there was an extreme need for further clarification of a gap in the data. Specifically, I recorded reflection data as a question arose in the initial baseline data and there was a need for additional clarification (i.e., source of the perception of little to no previous STEM experience). To ensure accuracy, the data were collected immediately following each task at the end of the course meetings only when I perceived that events aligned with the initial research questions.

It is pertinent to note that ideally, each session would have been video or audio recorded and transcribed for more specific interpretation of the classroom participation events. This was impossible for this particular study due to the participants as members of a required course. Had video or audio recording been used as part of the study, permission would have had to be obtained ahead of time for all participants. Had a participant elected not to participate, there was no alternate section of the course for a non-participant to take instead and no way to exempt them from the course since it is required for certification.

Data Analysis

As a qualitative case study, the data analysis procedures were driven by Merriam and Tisdell's (2016) general procedures for qualitative data analysis. Procedures were developed to achieve consolidation, reduction, and interpretation of the data. The first step in data analysis occurred concurrently with the study. Beginning data analysis during research is recommended by Yin (2014) as a method to begin to make sense of the data's trajectory. An initial review of the first reflection was completed during the module for tentative themes to help drive instruction. These potential themes were revisited and revised again during post-study analysis for clarification of accuracy.

Once the semester had concluded and permission was obtained, the researcher first did a general read of each participant's journal to get an overall sense of the data. Notes were made indicating possible themes or patterns in the data (Merriam & Tinsdell, 2016). For the purpose of the better conceptualization of the data for each task, participant journals were disassembled and reorganized so that all Task 1 reflections were analyzed concurrently. Other tasks followed in a similar fashion.

At this point in the analysis, I decided to focus on patterns of data for the research questions by organizing and reviewing journals by each task for findings instead of using each journal in its entirety as a separate artifact. I did not believe there were enough consistent learning trends with each journal as a separate, standalone artifact to show a progression of the candidates' learning. Instead, I focused on the overall change of the group and their inherent patterns in each task to seek evidence for the research questions. The group experience was paramount to the context of the case study, and therefore, data analysis was shaped for that focus.

Task 1 and Task 6

The first and last tasks of the module were the most similar to each other and were treated identically in procedures of the data analysis. After multiple readings of the data in the reorganized form, the researcher began to assign color codes to patterns as they were revealed. These patterns were kept consistent throughout the rest of the journal data analysis. These color-coded data were then examined together and compared to the literature for possible research implication (Creswell, 2014). Coded patterns such as "acronym," "authentic context," "interdisciplinary," and "uncertainty" were revealed from the patterns in the initial task evaluation. Table 2 gives a sample of how similar terms were reduced to the coded pattern. Multiple readings occurred as each task's data were re-read after each new coded pattern was discovered. I decided to use the domains of the research questions (definitions, efficacy, attitudes) to visualize and identify findings among the participant responses. Classifying comments and events according to the research questions' domains furthered the analysis process by allowing me to reduce the data to those most closely related to the main questions of the study (Hatch, 2002; Merriam & Tinsdell, 2016). For the interpretation of data in Task 1 and Task 6, I found it helpful to reorganize the color-coded data into graphic organizers based on the domains of the research questions. Making a distinct illustration of the accurate, partially accurate, and misconceptions of coded data for each research question in Tasks 1 and 6 helped me to compare the data for changes from the beginning to the end of the study. Samples of the organizers of the codes for the "definition" domain of Tasks 1 and 6 are provided in Table 3 and Table 4. It should be noted that some categories (i.e., "uncertainty") did not fit the visualization of the data but still were influential in the study findings.

Table 2. Sample of Evidence for Similar Concepts Complied to Create a Single Coded Pattern

Participants' Descriptions Accepted for "Interdisciplinary"
1) "Use of knowledge from each of these four subjects;"
2) "Interdisciplinary opportunities':
3) "Integrate technology and language into science";
4) "Subjects should not be learned in isolation";
5) "Subjects are intertwined;"
6) "All subjects are connected";
7) "An interdisciplinary approach that focuses on applied knowledge."

Table 3. Visualization of Coded Data for Definition Domain of Task 1

Definitions of STEM		
Accurate	Partially Accurate	Misconceptions
Acronym (7)	Interdisciplinary (Secondary only)	No Language Application (1)
Authentic Context (2)	Hands-on discovery with (no expanded rationale) (3)	
Interdisciplinary (1)		

Note. Numbers in parentheses indicate the number of participants who displayed the coded pattern.

Table 4. Visualization of Coded Data for Definition Domain of Task 6

Definitions of STEM		
Accurate	Partially Accurate	Misconceptions
-Acronym (7)	-Interdisciplinary	
-Interdisciplinary (6)	(Still Secondary Only) (1)	
-Hands-on (6)	STEM projects can be Language	

-Problem-Based Learning (6)	Based (provided a divergent thinking literature task only) (1)
-Authentic (6)	
-Critical Thinking (5)	
-Creative Thinking (4)	
-Collaboration (3)	

Note. Numbers in parentheses indicate the number of participants who displayed the coded pattern.

Tasks 2, 3, 4, and 5

Similar to the processes for tasks 1 and 6, the data were reread following the reorganization of the data by task. Just as in Tasks 1 and 6 a general sense of pattern emerged and codes were assigned. Some codes remained consistent from Task 1 but other new codes emerged as well (i.e., problem-based learning). These codes were not as plentiful in the journals of the tasks connected to simulated experiences. For each code assigned within these parts of the journal, the journals were reread for evidence of that particular pattern. However, there were also “significant events” that connected to the domains of the research questions. The codes found in tasks 2-5 seemed most valid when they were connected to an event of the simulated tasks (i.e., construction of a problem, authentic contexts, finding of multiple solutions). So in the results, the patterns and events of the simulations in Tasks 2-5 are discussed in relation to the specific task introducing both patterns and non-patterns for data interpretation (Hatch, 2002).

College course catalog data

Although not initially intended as data, the course catalog data were perceived as necessary as patterns from the participants were revealed. Surprising misconceptions of a lack of STEM experiences led me to better define the context of the program in which candidates were participating. To analyze this source of data, I obtained a current copy of the course catalog and program requirements for middle level students. . If the course description from required courses contained content that could be connected to the four main STEM areas it was catalogued and included in the document analysis results. This description is included in the results section.

Researcher’s observation notes

Merriam and Tisdell (2016) discuss that observation notes from a researcher as a participant can be a valuable tool for support when used in conjunction with other forms of data such as this study’s journals for document analysis. Because the overuse of this data could lead to a source of bias, the notes were used sparingly as a secondary data source (Creswell, 2014). Following the thematic coding of the student journals, I read my notes, and they were reviewed several times, and hand coded for themes from the initial codes from the student data. My observation data were included with the study only when a theme code or question was perceived to match to the findings from the actual participant data (e.g., the perception of no STEM coursework.). Since my perceptions were not the focus of inquiry, they were only used to support the primary data source, the student journals. My reflections instead helped document task context, lesson occurrences, and questions for clarity of emerging themes that originated from participants.

Creswell (2014) offers several methods for validating data. First, Creswell (2014) recommends multiple sources of data to build corresponding themes. To follow this recommendation, the journals were completed using a standard method allowing students to respond to a structured set of questions for each task. Next, current and up-to-date program requirements were obtained to identify the STEM-related content for students that may have contributed to their baseline knowledge of STEM content and pedagogy. Finally, I used observation data as a secondary source when a lack of clarity occurred during the first reflection, or following course activities. Multiple sources of data from the context of the study helped to build "coherent justification" for research (Creswell, 2014, p. 201). Next, I made an attempt to provide "rich, thick description" to report findings and create transparency to data (Creswell, 2014, p. 201). This strategy conveyed honest and open access to my context and thought processes during interpretation and created credibility between myself and the audience. Third, I provided my personal context to help clarify my connection to the topic. I also provided descriptions of strategies to avoid bias of a designer set of experiences as part of the Methodology. Finally, I provided negative or discrepant information for the simulated tasks to continue building validity. Providing readers with the patterns that both fit and do not fit the themes can help show that I took steps to provide accurate accounts of all data (Creswell, 2014.

Results

The resulting narrative of the data's emerging themes and patterns are organized by each question of inquiry. This organization of the qualitative narrative provided a descriptive chronology of the participant data for each theme of inquiry. For the first question (How do middle level pre-service teachers' definition of STEM change after exposure to simulations of STEM learning activities?), data collected through the researcher's reflections and the analysis of participants' journals indicated that simulating and reflectively experiencing STEM activities at the undergraduate level allowed participants to expand their definitions with the hands-on and problem-based learning activities vital to STEM education.

In the first task in which background knowledge was assessed, all of the participants were able to define the acronym of STEM as representing education based in science, technology, engineering, and/or mathematics. Past this understanding, uncertainty seemed to prevail among the majority of the participants. Participants utilized phrases such as "I think it means. . ." or "I believe I have heard that STEM is," which gave the strong impression that despite having some correct information, participants were not sure of the accuracy of their contexts. Three of the participants were unable to define STEM concepts beyond defining the acronym. Of those who contributed additional thoughts or perceptions, the reflections provided partially accurate information that had foundations in STEM but were missing connected or expanded information. For example, one participant knew that it was important to cross disciplines for STEM but reported that middle schools should "expose the children at that age to see their interests and maybe take (STEM) classes in high school with that focus." Another participant offered, "I believe STEM Education improves middle school education because it introduces a new way of thinking through discovery and tactile manipulatives." Although manipulative use and discovery learning techniques can be valuable strategies of STEM, her definition did not provide clear information about how those strategies fit into STEM theory. Yet another participant shared, "I think STEM improves middle level education in that it shows students' real-world application of the concepts they learn in school and encourages them to achieve beyond the textbook. I might be able to integrate STEM in my classroom by implementing the use of a lot of technology and hands-on based activities (e.g., using iPad apps, Smart Board)." This participant perceived value in STEM, but when implementations were suggested, they were only common technology used in the classroom.

During this task, none of the participants indicated past experiences with STEM in other undergraduate courses or high school level coursework. With the large number of required credits of STEM course content present in the middle level teacher preparation program design, further clarification was obtained during the next class meeting. The participants were polled about their past experiences with STEM. The in-class poll (reported in the researcher's observation notes) verified that participants did not perceive having coursework with STEM. This raised questions about the quality of connections made between subject-specific STEM courses taught in isolation during the preparation program. The missing connections are possibly a vital attribute to a quality STEM preparation plan. Contextual data from the course catalog to clarify that students would have had several STEM content classes prior to the course are included next.

Course Catalog Results

The research site requires 60 credits as the general studies component of each degree. Any course is science, technology, engineering, or mathematics should contribute to participant's STEM experiences. First, the core component includes three required mathematics credits. The requirement is most often filled by a course that is a compilation of college algebra, trigonometry, and analytical geometry skills. If the candidate has shown more advanced mathematics skills through either advanced placement (AP) credit or placement testing, he or she will instead be placed in or given AP credit for a Calculus I course. In the domain of science, the curriculum includes eight required natural science credits. One course with a lab (four credits) is completed at the 100-level, and one course with a lab (four credits) is completed at the 200-level. These two courses are required to have two different categorical disciplines (earth science & life science). If the candidate chooses an earth science course at the 100-level, he or she must take the opposite category (life science) during the 200-level (and vice versa). Middle level certification candidates also must take a three-credit course that is an introduction to web page design that focuses on the design principles of content organization and navigation.

In addition to the core requirements and a teaching of math/science pedagogy course used for this research, all middle level candidates also take additional STEM courses. These courses include a four-credit physical science course with lab, three-credit math theory course for prospective teachers, a three-credit geometric theory course, and a three-credit research, probability, and statistics course. If a middle level candidate elects mathematics or science as his or her area of concentration, there are four-five additional courses taken in those specific college departments. These courses are based outside of the education department, and candidates are placed with students classified as mathematics or science majors. If the candidate elects to concentrate in the language arts or social studies, no additional STEM coursework is required. Despite the large number of required credits in STEM-based subjects found in the analysis of the research site's course catalog that would have been part of the teacher preparation program design, participants did not perceive themselves to have prior STEM experience.

As the tasks progressed, other journal evidence emerged showing changing definitions of STEM. During Task 2 (authentic problem-based task) some students began to identify important STEM strategies for future practice. Participants shared various thoughts on the problem solving process. "I was a little confused on the math involved, but then (in groups) used my calculator correctly to find the correct percentage. It was a good example of group problem solving and critical thinking." Another participant noted, "During our process (another participant) and I came to similar solutions. I disagreed on 5% which helped us explain our thinking." Yet another was reminded, "I need to remember that there can be multiple answers. Student groups can't worry about being right." The "real world" context of the problem was also valued. One inventive participant suggested, "I would bring in different security (or at least) web cameras to allow student experimentation with the devices to give a better understanding of how angles of view and sight lines work using the actual technology. It helps with students' reasoning skills, but using a webcam would create a more authentic experience." Another noted cross-curricular connections, "For science, you had to know that a camera sees straight angles. For math, you had to find the obstructed percentage. It teachers the students real world issues, not just theories."

During Task 4 (simulation of improved bicycle helmet design), four of the participants reported in their reflection journals that they associated the assigned simulation with an egg drop that they had done in elementary school or high school. This is of note because the egg drop experiences were not reported earlier in Task 1 when participants were questioned about their past STEM experiences. Not connecting these former activities with STEM principles reinforces that gaps exist in the participants' definitions of STEM and its pedagogies.

In Task 5, participants designed their own STEM problems in the context of the research site location. While some participants created strong STEM experiences, others did not. Participants were encouraged to research additional STEM tasks and discuss in their reflections the processes that they believed to be vital at each stage of the problem. Two participants wanted to have students explore the ecological footprint on campus through the recycling of paper or a paperless initiative. Key processes introduced leading students to research recycling in their communities and collecting data by comparing baseline refuse disposal rates with possible improved rates following the implementation of the project. "For example, students could check the print logs of printers for an estimated pages used per day or log the frequency of paper reams ordered. The students could maybe come up with plans to lessen the use of paper. This may entail some outside research, such as looking into companies that produce paper that is more recyclable, biodegradable, or otherwise more eco-friendly for the school to use. Then we could reflect on the reduction of paper waste and how it compared to before the transition."

One of these 2 participants also suggested that encouraging student activism through activities such as making posters could improve the results of the recycling project and empower student participation in future recycling. She noted the activism as important for student connection to the project. "If I raise awareness with my students, they will hold themselves accountable more to recycle." Another participant constructed a problem proposing that unused green space at the research site could be used to facilitate agriculture. "There is a lot of land that is not currently being used. I would challenge students to grow their own food for the cafeteria. We could explore if the school could save money. The goal will be to lower the current cost of meals. They can include cost, time, and tools for implementing their plans and share where these skills can be applied in their home lives."

Two of the problems turned in by participants were not of a quality that could be considered as STEM explorations. The first inappropriately constructed problem suggested using reusable cups instead of throw away cups on campus. Although ecological in theme, the processes suggested for the problem did not mirror STEM student-centered principles, and the participant did not recommend any exploration strategies for higher leveled thinking skills such as data collection. Another inappropriately constructed problem suggested having students explore the amount of unused cafeteria meals on campus. The participant suggested calculating the total number of meals wasted each semester and creating an invitation for the less fortunate to benefit from those meals. While a valuable service-learning task, the problem structure mirrored more finite tasks from beginning levels of the STEM module and did not mimic more in-depth STEM tasks from later in the module.

The most notable problem submitted was one that was left open-ended for improving water conservation on campus. I considered this task to be the highest implementation of a STEM task, because it kept the format of a loosely defined problem and left much of the research direction to student innovation and creativity. This participant opened with an introduction to students. "With all of the students on campus and the many people that visit our school, we use a very large amount of water. To reduce the school's ecological footprint, we need to find a way to be more efficient with our use of water. Could you create a system or procedure to conserve water?" The participant suggested having student groups formulate their own strategies for water conservation on campus using research, data collection, and technology representation to create the unique plans for improvement. The participant also discussed purposeful checkpoints for sharing, peer review, and discussion so that students participating could benefit from others' ideas and research discoveries. Specifically, "Feedback that is constructive could help all involved." "The students do not necessarily need to take the suggestions of the other groups. However, writing feedback down for review in groups later will help them give more thought to the project solution."

During the final reflections, the definitions of STEM had expanded exponentially from the original data in which participants were only able to represent the acronym. All participants' definitions reflected on the interdisciplinary nature of STEM instruction. A participant reported, "Since STEM is innately interdisciplinary it works perfectly in the middle level setting." Another participant reported, "STEM teaches students that subjects are not to be learned in isolation, but should always be thought of as a part of a whole." Five of the participants discussed how they would use the tasks of STEM to promote critical thinking in the classrooms. "STEM teaches students to think critically and not give up on a problem just because one solution does not work; it encourages them to try again to improve on ideas." Four of the participants reported that they learned how STEM could be used to promote creative thinking in the classroom. For example, "STEM education allows student to use 'out of the box' thinking. They are able to and encouraged to use their knowledge from many different areas to solve a problem. STEM education allows students to apply their learning to a real world task and take themselves through a creative and inventive process."

For the second research question (What [if any] change occurs to middle level pre-service teachers' self-efficacy after exposure to simulations of STEM learning activities?), participants showed insecurities for implementing STEM in their Task 1 reflections. In addition to some of the participant misconceptions discussed in the definitions, other participants also shared evidence of uncertainty. "I am not sure what STEM theory even is, so I am not at all knowledgeable in constructing a (STEM lesson) plan." Another participant expressed fears of the STEM module as a candidate pursuing language arts certification. She was unaware of the possibility of cross-curricular ties of language to STEM principles. "I believe I may not be as effective to implement STEM-based education because I am a future language arts educator and the emphasis of STEM education minimizes focus on the arts and linguistics."

By the third week of the module students began to show some patterns of improved efficacy with STEM tasks during the engineering design task. A majority of participants (6 of 7) reflected on a belief that the practice could be more effective using either multiple attempts with materials or opportunities for improvements to the design with additional building time. "Our solution could have been improved with a wider base. I think we would be better next time." Another noted, "After looking at pictures of other structures ours was too precise. If we were allowed to do this again a simpler structure would be best." Although the responses to the activity were generally positive, 2 participants perceived that better time allocation and organization of the building sessions could allow students to revise and improve designs making the task more academic for future students. One participant said, “I would make everyone stop and think in the middle (of the project). This would allow everyone to take a step back and improve the design process.” An additional participant concurred, “I think our solution worked well but with more time and better planning sessions our tower would have remained standing longer.” The same participant also noted the collaborative nature of the challenge as valuable for future use. She defined the challenge as, “a teacher tool to help the students work together using the STEM concepts.”

By the final reflection, theoretical knowledge of STEM concepts seemed expanded, but there was not consistent evidence of all participants’ abilities to implement STEM activities independently. All participants indicated a belief that they could implement activities similar to the ones given in class. One participant noted, “After being exposed to some activities, I could implement them. As for construction of STEM projects, I believe with some critical thinking on my part I would be able to create an engaging activity.” Another noted, “I think I have a basic understanding of constructing STEM problems. For me, the key is to think larger than I usually would for a traditional problem.” Yet another reported, “I think I would be more effective at implementing STEM into a curriculum now than I would have at the beginning of the semester, but I would probably still need help from others with making sure I chose challenges that would be appropriate for my grade level.”

In total, 4 participants indicated a need for additional support and research when creating and implementing problems of their own designs. Specifically, 2 of the participants, as language arts concentration candidates, indicated a need for further information and research on how to fit STEM principles into language arts content. “I am not really sure how I would integrate STEM into my future classroom if I was in a 7th or 8th grade Language Arts classroom. I do not think I would be able to without a lot of help from the Internet and people who have already experimented with STEM. I would love to learn how to do so.”

For the third research question (What are middle level pre-service teachers’ attitudes toward future STEM experiences after exposure to simulations of STEM learning activities?), 4 participant journals indicated that they would need more specific training for STEM. Because there were not explicit enough data patterns indicating specific attitudes toward the future STEM training a conclusion cannot be drawn for this research question at this time.

Discussion

The results of this study suggest several implications for the use of a STEM module in this course. The first significant finding, though not initially intended through the research questions, does partially relate to the research question of participants’ definitions of STEM. Data from the reflection journal entries and my reflection data indicated that candidates did not perceive having experiences with STEM education even when document analysis of college curriculum contradicted these perceptions. This was surprising, with the excessive courses in the program rooted in STEM. It cannot be completely confirmed why participants were not able to identify that any course in science, technology, engineering, or mathematics could help to improve experience with STEM content. Program structure points to a possible lack of connection between the content-based STEM courses taught in isolation. With participants reporting no prior STEM experiences in their first reflections, the connections between STEM subjects were either not introduced or not explicitly expressed so that participants perceived them as experiences with STEM content. Additional planning for connection between content-based and pedagogy-based coursework may be necessary to maximize the college’s middle level teacher candidates’ connection with STEM among STEM courses across domains.

For the results discussed regarding both changing definitions and efficacy with STEM, the implications of the data aligns with initial findings from a few pioneering studies in which researchers experimented with teacher candidates' abilities to prepare for STEM content and pedagogy prior to receiving certification. In these studies, candidates at the undergraduate level were capable of engaging with the student-centered pedagogies of STEM. The engagement with these hands-on strategies in these studies allowed students to engage fully with STEM content, expand current STEM definitions, mimic more student-centered pedagogies, and have improved attitude and confidence to try STEM-based learning again in the future (DiFrancesca, Lee, & McIntyre, 2014; Gillespie, 2015; Murphy & Mancini-Samuelson, 2012; Ortiz, Bos, & Smith, 2015). The increased confidence in the use STEM pedagogies in future career placements could play an integral part in the improvement of STEM competence as candidates continue to develop and grow throughout their professional careers. Participants did report improved confidence and self-efficacy but the conclusion that the confidence and self-efficacy will guarantee a positive attitude and motivation toward future STEM activities cannot be drawn from the data available. Although educational research does support that self-efficacy often leads to a positive attitude toward future activities data patterns were not specific enough to be supported at this time.

It should be noted that similar to many of the studies cited, this study was limited as a small, qualitative case study only transferrable to other programs and courses of similar size, function, and design. The evidence of potential for improvement is promising, but additional research is needed longitudinally and on larger scales to fully understand the possible long-term and widespread effects of implementing STEM education at the level of teacher preparation. Locally, the findings indicate the potential success of the STEM module in this teacher preparation course do have positive benefits for students and will be continued as part of the course. Moving forward, I intend to further explore other strategies for implementing STEM into teacher preparation to gather more information for best-practice implementation. With the potential for improvement in STEM confidence and competence at the level of teacher preparation, more research is needed on the best program structures and practices to meet the growing need for improved STEM teachers. In research on middle level teacher preparation, initial success in training teachers has been found in strong clinical partnerships among institutions of higher learning and local school districts. A recent article by Howell, Carpenter, and Jones (2013) explored different partnerships between institutions of higher learning and local providers of middle level education. These reciprocal partnerships provide more advanced levels of clinical experience for middle level teacher candidates with benefits of professional development for the staff and school site.

There could be potential for bridging the research between studies exploring STEM development in teacher candidates and the studies that explore the benefits of clinical partnerships between institutions of higher learning and local education providers. Exploring the possible benefits for candidates immersed in successful STEM field placement partnerships could provide more authentic STEM experiences to candidates, thus creating an avenue for exploring more advanced implementation of STEM practices at the level of teacher preparation. Although participants in this research received instruction and simulation in the college classroom environment, participant reflection data did not explicitly connect STEM course content to any practices observed while in required field placement hours associated with teacher preparation programs. Explicit connection between quality field placements and college classroom STEM content also has the potential for improving STEM experiences for teacher candidates.

The strong job growth projected in STEM (United States Department of Education, 2015) and a need for improvement of teachers' abilities to prepare students for STEM majors and careers (Benken & Stevenson, 2014; Colbert, 2014; Garrett, 2008; O'Neill et al., 2012) keeps innovation in preparation of STEM teachers at the forefront of teacher preparation and professional development initiatives. Initial success from professional development partnerships (Avery & Reeve, 2013; Gillespie, 2015; Han, et al., 2015; Nadelson, et al., 2013; Schuster et al., 2012) and teacher preparation programs (DiFrancesca et al., 2014; Gillespie, 2015; Murphy & Mancini-Samuelson, 2012; Ortiz et al., 2015) indicates that initiatives to improve teacher candidates' use of STEM pedagogies are key in providing an earlier and more developed experience with STEM for future career placement. Innovation in engaging candidates shows early evidence for improving candidates' efficacy for future STEM experiences and could work to better prepare teachers for quality instruction in STEM education. By explicitly connecting STEM college curriculum, pedagogical experiences, and quality STEM field experiences, middle level teacher preparation possesses the potential to improve new teachers' abilities to engage students with STEM, consequently improving students' experiences with STEM in contemporary middle level schools.

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