The Importance of STEM Education in the Elementary Grades: Learning from Pre-service and Novice Teachers' Perspectives

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Abstract

We seek to understand how pre-service and novice teachers view the importance of STEM education in the elementary grades. A sample of prospective and early career elementary teachers was surveyed using an anonymous online questionnaire. The questionnaire asked for demographic information and this prompt: "Is STEM education important at the elementary level? Why or why not?" A constant comparative approach was used to analyze responses to provide insights about respondents' beliefs. We found that all participants responded that yes, STEM education was important at the elementary years, but that several themes emerged when considering reasons given, and that the types of responses given varied in terms of subject and complexity when comparing responses by respondents' second major. These findings paint an initial picture of what future elementary STEM instruction might look like, insofar as teachers' beliefs can influence instructional choices. Additionally, these findings may have implications for teacher educators and for pre- and in-service teacher education.

Key words: pre-service elementary teachers, STEM, Teacher preparation

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Introduction

When searching Google using the keywords "STEM Education," over 129,000,000 results came up within 0.16 seconds. The first page of results included webpages for non-profit organizations, news stories, academic institutions, governmental agencies, and research journals. Although considerable attention and funding is afforded to STEM Education, STEM degree programs and other STEM related initiatives (e.g., the National Science Foundation's Improving Undergraduate STEM Education program and the Woodrow Wilson Foundation's STEM teaching fellowships). Yet, it is often difficult to ascertain the potential of these initiatives. As stated in the recent NRC report, *Monitoring Progress Toward Successful K-12 STEM Education: A Nation Advancing?*

> The success of these efforts depends on many factors, including students' equitable access to challenging learning opportunities and instructional materials, teachers' capacity to use those opportunities and materials well, and policies and structures that support effective educational practices. In turn, making informed decisions about improvements to education in STEM requires research and data about the content and quality of the curriculum, teachers' content knowledge, and the use of instructional practices that have been shown to improve outcomes. However, large-scale data are not available in a readily accessible form, mostly because state and federal data systems provide information about schools (personnel, organization, and enrollment) rather than schooling (key elements of the learning process). (NRC, 2013a, p. 4)

Popular media and educational research literature both proclaim that children need to be better prepared in the STEM areas starting in the elementary years, in order to prepare them for careers in the future: both STEM and non-STEM related (Murphy, 2011; NRC, 2011, 2013a). At the same time, large scale national reports indicate that students in the elementary grades in the U.S. fall behind students outside of the U.S. on measures of achievement in mathematics and science, time dedicated for elementary science instruction falls behind that of language arts and mathematics, and elementary teachers feel unprepared to teach science and mathematics (NRC, 2011, 2013a). Less information is known about time dedicated toward STEM as an integrated subject at the elementary level; elementary teachers' preparedness in STEM as an integrated subject; or pre-service teachers' beliefs about the significance of STEM education in elementary classrooms. In this preliminary exploratory study, we examine pre-service and novice elementary teachers' beliefs about the importance of STEM instruction at the elementary level. Our study (N = 73) provides an initial picture of future elementary teachers' perspectives on STEM education.

Review of the Literature

The acronym STEM, first coined by the National Science Foundation (NSF) nearly two decades ago, has itself been an ill-defined term (Saunders, 2009). Sometimes the term can refer to any-or-all of the fields of Science, Mathematics, Engineering and Technology both individually or integrated. For example, a chemistry teacher may say she teaches STEM, which is true in that she teaches one of the four STEM disciplines, science. In many ways the term STEM has historically been less exact, and sometimes misleading, since the four elements of STEM have their own distinctive attributes; e.g., science is science and is not engineering, mathematics or technology. More recently, however, the term STEM has been used to connote a more integrative context, promoting important pedagogical relationships among the four STEM elements. The term *integrative-STEM* has been used to describe this change (Sanders, 2009). Sanders' work describes integrative-STEM as a cross-curricular concept in which two or more of the four STEM content areas are combined. This new integrative-STEM context sometimes includes non-STEM content areas (e.g. Language Arts or Social Studies) alongside STEM disciplines. Sanders' work explains that the technology and engineering dimensions of STEM require teachers and students to ground their pedagogy in the engineering design process, which can be unfamiliar to many teachers, who likely have little or no preparation to teach technology or engineering (Malzahn, 2013; NAE & NRC, 2014; Trygstad, 2013). Despite the 'buzzword status' achieved by the acronym STEM, there is much ambiguity in the definition of the term itself and a level of discomfort and unfamiliarity with STEM content and pedagogy among teachers (Malzahn, 2013; NAE & NRC, 2014; Trygstad, 2013).

However, having such initiatives, does not always lead to more equitable attention to STEM related instruction or integrative-STEM instruction. National surveys of elementary school teachers reveal beliefs among teachers that individual subjects of mathematics and language arts are given more instructional time than other subject areas in the K-5 teaching and learning environment (Malzahn, 2013; NRC, 2013a; Trygstad, 2013). Malzahn (2013) and Trygstad (2013) recently reported on a large-scale national U.S. study examining elementary teaching. The results indicated that elementary teachers reported they had much less time for science than math and language arts. For example, 99% of teachers reported that mathematics was done "all/most days." By comparison, only 24% of teachers reported that science was done "all/most days." This is also reflected in the approximate minutes per day spent on subjects, where substantially more time was spent on language arts and mathematics than science: Language Arts (88), Mathematics (55), Science (20). Given the disparate attention to STEM and non-STEM content areas, one is left to wonder what factors may contribute to these conditions. Although district testing and other school-related factors may contribute to curricular decisions about content inclusion or exclusions, or time given to particular subjects, factors such as teachers' attitudes and beliefs may also impact in-class instructional decisions. Consider a teacher, for example, who believes that mathematics is composed primarily of rules and procedures that should be memorized and executed. His instructional decisions might reflect that belief insofar as he may choose to emphasize procedural fluency and deemphasize conceptual understandings (NRC, 2011). Or, perhaps a teacher does not value the usefulness of mathematics outside of school (Beyers, 2005), and consequently, she does not teach topics that demonstrate how useful mathematics can be outside of the classroom for elementary-aged students.

Several studies have demonstrated that a multitude of affective factors such as, beliefs about content (Thompson, 1984), dispositions (Beyers, 2011, or self-efficacy (Klassen & Chiu, 2010) can shape the way a teacher chooses to teach. For example, Wilkins (2009) investigated the attitudes of elementary school teachers toward various subjects. Reading and language arts were consistently the favorite subjects while science and writing were the least favorite. Wilkins (2008) found there was a positive relationship between teachers' attitudes and inquiry-based teaching methods. Additionally, Teague and Austin-Martin (1981) reported that a teachers' attitude toward mathematics might impact the effectiveness of teachers' instructional practices in mathematics. Beyers (2005) found in interviewing prospective teachers that their dispositions with respect to mathematics, which include beliefs about the nature of mathematics, were sometimes related to their beliefs about their self-efficacy toward teaching mathematics and their desires to teach particular content. In other words, pre-service teachers who had negative dispositions toward mathematics tended to suggest that they had particular aversions to teaching mathematics even though they would be expected to teach mathematics. Similarly, Madden, Wiebe, Bedward, and Minogue (2011) suggested that elementary teachers who reported having a personal interest in and identifying with science engaged in more reform-based science teaching practices than teachers who did not report an interest or inclination toward science. Taken together, these findings suggest that beliefs about the content and other affective factors may be connected to instructional decisions made when teaching said content. Less is known about the technology and engineering dimensions of STEM in terms of the way affective factors might relate to STEM confidence, however, recent national reports (Trygstad, 2013) revealed that just four percent of elementary teachers felt prepared to teach engineering. It is imperative, then, to understand what pre-service teachers believe to be the significance of STEM education as these beliefs may be shaping how they think about teaching STEM content in the elementary classroom. Therefore, our study seeks to explicate the nature of pre-service and novice teachers' views on the importance of STEM education in the elementary classroom.

STEM as a discipline is constantly evolving. Much of the recent attention on STEM education has focused on integrating technology and engineering into other STEM areas. For example, the Next Generation Science Standards (NGSS) incorporate engineering practices and content ideas throughout their K-12 science standards (NRC, 2013b). Likewise, the National Academies have completed several extensive reports on engineering in K-12 education (NAE & NRC, 2009; NAE & NRC, 2014), while STEM education programs departments and programs are gaining momentum at colleges and universities across the nation O'Brien, Karsnitz, VanderSandt, Parry, & Bottomley (2014).

Preliminary research on integrative-STEM instruction has progressed with this increased attention, (Brophy, Klein, Portsmore, & Rogers, 2008; LaChapelle, Cunningham, Jocz, Kay, Phadnis, & Sullivan, 2011; Parry, Hardee, & Day, 2012; Zubrowski, 2002). Parry et al. reported that there were substantial improvements in K-5 student outcomes on state reading, math, and science test scores when teachers participated in extensive professional development in engineering education and Problem-Based Learning (PBL)—specifically around the use of the integrative-STEM *Engineering is Elementary* (EiE) curriculum (Boston Museum of Science, n.d.). LaChapelle and colleagues (2011) showed that students experiencing the EiE curriculum had increased science test scores compared to a control group experiencing a more traditional science curriculum. These benefits were observed in groups of students from varying backgrounds, abilities, and grade levels. Other research (e.g., Zubrowski, 2002) presents models for incorporating technology and engineering teaching strategies, such as design, into science or mathematics instruction. Still others, (e.g. Ravitz, 2008) report on use of PBL teaching practices in reform-focused new schools. Though these recent studies and reports suggest that the field of K-5 STEM education has emerged and is growing, and that there are benefits of using integrative-STEM instruction in the elementary years, we still know very little about the field. In acknowledging that attitudes and beliefs affect teaching practices, and different practices impact student learning, our current study aims better clarify pre-service and novice teachers' perspectives on the importance of STEM education at the elementary level.

It stands to reason then, that pre-service and novice teachers' beliefs about STEM education might influence whether they employ instructional methods that are consistent with the notion of an integrative-STEM experience, (e.g., integrating core content areas within STEM or integrating with content outside of core STEM areas) in the elementary grades. Furthermore, if disconcerting beliefs about STEM education at the elementary level can be identified early on, perhaps teacher educators can be more prepared to address such matters before classroom instruction is impacted. Although many factors can influence how a teacher teaches content, we have elected to focus solely on their beliefs about the importance of STEM in the elementary grades.

Conceptual Framework

We conducted this preliminary exploratory study from the perspective that education in general, and STEM education in particular, should be viewed from an integrative perspective. We used frameworks of the NGSS and Common Core State Standards (CCSS) to define our description of integrative STEM instruction.

The recently-developed NGSS include several key shifts away from prior standards for science instruction (e.g. the National Science Education Standards). One such shift is that the NGSS incorporate ideas about engineering for the first time. The engineering ideas appear throughout the K-12 spectrum. At the elementary level, they offer a developmentally appropriate operationalization of the discipline of engineering—to apply science and mathematics to design solutions to problems. Another shift is the incorporation of crosscutting concepts. These crosscutting concepts are the ideas that connect across the various scientific domains (e.g. life science, earth science, physical science) demonstrating that science should not be viewed as a collection of separate ideas. A third shift is the inclusion of science and engineering practices (the key skills that scientists and engineers use when “doing” science and engineering) within each performance expectation. Finally, each performance expectation in the NGSS is linked explicitly to CCSS in Mathematics and Language Arts (NGA, 2010; NRC, 2013b). It should be noted that the CCSS also include a strong focus on practices, many of which overlap with the NGSS’ science and engineering practices, representing a practice-focus view of integrative STEM instruction (see Appendix F of the NGSS, p. 21 for a representation of these overlapping practices).

None of the four STEM disciplines (science, technology, engineering, or mathematics) exists in a vacuum—each discipline relies on the others to explain and grow. The NGSS and CCSS provide a framework for discussing the connectedness between these integrated disciplines as well as for emphasizing this connectedness as early as the elementary years (NGA, 2010; NRC, 2013b). We will present our findings and interpretations in light of such frameworks.

Methodology

Study Context & Participants

This was an exploratory study intended to provide a snapshot of the structure of beliefs among prospective and novice teachers regarding the importance of STEM education at the elementary level. The aim was to establish an initial baseline set of themes outlining their beliefs about the importance of STEM education at the elementary level. The current study involved an online survey given to pre-service teachers and recent graduates at a small public liberal arts college in the northeastern United States. The institution is characterized by high-achieving students (average combined verbal and quantitative SAT scores for incoming freshman are consistently > 1300)[i]. The student body is made up of predominantly in-state students (94%). Two thirds of students identify as Caucasian 57% are female. Within the institution’s School of Education, proportionally, the population of Caucasian and female students is greater than the college at large, so the population of participants is predominantly female and Caucasian. This study’s participants were current (and recently graduated[ii]) undergraduate students from the School of Education being prepared to teach children at the elementary school level. Participants were contacted by the research team via email and asked to participate in the survey. The email was sent to a sample of 170 students who completed a block of elementary mathematics and science methods courses with a field placement component within the last four semesters.

Undergraduates normally take this block of science and mathematics methods courses during the sophomore or junior year. The State requires that pre-service teachers have two majors—one in an education discipline and one in a disciplinary content area. Education majors include: Elementary Education, Early Childhood Education, Urban Education, Special Education, and Deaf and Hard of Hearing Education. Content area second majors include: English, History, Women and Gender Studies, Psychology, Sociology, Integrative-STEM, Mathematics, Chemistry, Biology, Foreign Language, and the Arts (music or art).

Seventy-three of the students completed the survey, representing a response rate of 43%. According to the demographic data collected via our survey, 93% of respondents in the study were female, and seven percent were male (68 and 5, respectively). Eighty-five percent of respondents identified as white or Caucasian. The next largest group was Hispanic or Latino students, representing five percent of the pool; Asian students represented three percent of the respondents, and the remainder of respondents either chose not to indicate, identified with more than one ethnicity, or self-identified as Middle Eastern or African American[iii].

Each of the five education majors was represented in the pool of participants. As can be seen in Figure 1, Elementary Education majors made up the largest group, representing just over half the participants. Special Education majors represented just under a third of the participants. The proportion of Urban Education, Early Childhood Education, and Deaf and Hard of Hearing Education majors (7 %, 5%, and 4% respectively) was smaller the other groups.

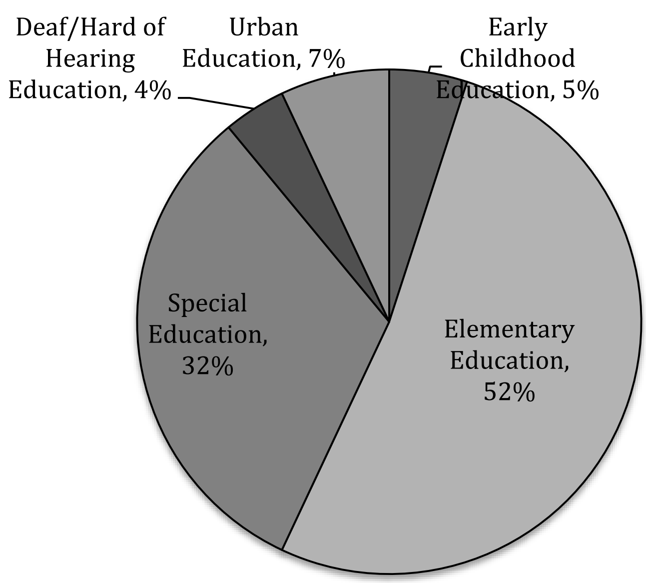

Figure 1: Percentage of participants in each of the five possible education majors.

Most of the possible second majors were also represented in our pool of participants, as can be seen in Figure 2.[iv] Integrative-STEM (I-STEM) majors made up the largest group of respondents, representing just over a third of the pool. Psychology majors made up the next largest group, representing one fifth of the respondents. English and History majors each represented 11 percent of the pool of respondents. Each of the other groups represented 10 percent or less of the pool of respondents.

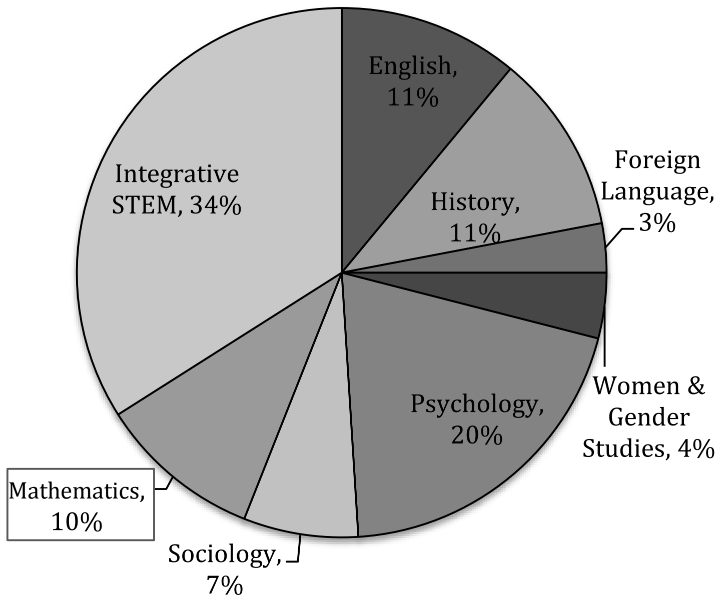

Figure 2: Percentage of participants in each of the education majors offered at our institution.

Data Collection & Analyses

Data were collected using an anonymous online survey via Qualtrics®. The survey included items about descriptive demographic information (year, ethnicity, gender, GPA, education major and second major) as well as one open-ended question:
Is STEM education important at the elementary level? Why or why not?

Participants were contacted via email once (no follow-up emails were used because of the high response rate of 43 %) and provided with a link to the survey. All respondents reported that yes, STEM education is important at the elementary level, and most provided a reason for their agreement. A grounded thematic qualitative approach was used to analyze data (O'Connor, Netting, & Thomas, 2008). Three coders read all responses to identify initial trends and define preliminary themes, each using constant comparison between responses to narrow and refine codes (Corbin & Strauss, 2008). The coders then met and compared their lists of themes. After discussion, they came to consensus on an initial coding scheme. After coding three responses collaboratively, the coders coded 17 responses independently and reported back to the group. On this initial pass, inter-rater reliability was 86 %. Discrepancies among individuals' coding were discussed, and once again, a constant comparison between and within codes was employed, and the coding scheme was refined and finalized. Table 1 displays the final list of 10 codes as well as examples of responses that were coded in each category. The coders independently coded the remaining 51 responses using the revised scheme, with an 87 % inter-rater agreement. In all cases of disagreement, two of the three coders were in agreement. The code given by the two in agreement was used for all further analyses in all cases. All responses were coded, using a 0 or 1, to indicate whether any of the 10 codes outlined in Table 1 were present. Participants' responses were coded 1 if the coded theme was present in their response, and 0, if not. Therefore, it was possible for any single response to have as many as 10 or as few as zero reasons coded.

Table 1

Qualitative Coding Scheme for Open-ended Responses to:
Is STEM education important at the elementary level? Why or why not?

Code	Examples
Foundation for Later Academics	• STEM education is absolutely important. An early start and understanding of STEM topics can generate greater interest. • It is important to expose children to multiple fields and ideas at an early age.
Connections to Everyday Life	• [STEM] helps students to understand the world around them and prepares them for real life! • STEM can really help elementary school students to gain knowledge that can benefit them in the real world.
Nurturing Positive STEM Attitudes	• STEM education is important that the elementary levels because it allows for students to become involved and interested in these subjects. • Students can be turned off from science at a very young age and never regain that positive attitude towards it again. In elementary school, we should foster students' interests and abilities in these content areas
Integrating or Balancing Content	• [STEM] not only gives students content area knowledge, but it gives them a better understanding of how everything can be related. It's nearly impossible to have one area of STEM without incorporating the other three areas as well. • It's important for stem education at an elementary level to help kids begin to think strategically how science, math and technology all correlate with one another.
Preparing Students for Jobs or Replenishing the STEM Pipeline	• These subjects need to be taught at [the elementary] level so the children stay in the STEM pipeline. • The future is constantly changing and students need to be able to keep up with the changes.
Promotes Learning/Higher Order Thinking	• STEM education also challenges children's high level thinking abilities and allows them to question everything around them (what? how? why?). • Yes because it will help young students improve their problem solving skills and ability to think critically.
Promote Gender Equity in STEM	• I think STEM is still seen as a strictly "boy" area of learning and we need to broaden that to all learners. • I would like to see more girls in the STEM fields, breaking gender stereotypes!
Maintaining Global Competiveness	• Our [US] education [system] is falling behind and putting more emphasis on math and science is extremely important. • STEM education helps students start early in learning the skills that will help our country as a whole improve in these areas and be able to compete with other countries who are currently more advanced than us.
Promote Hands-on Inquiry/Design	• It is important students learn through inquiry, the design process, and exploration. • [STEM] allows more "hands on" learning to be enforced rather than just memorizing.
Pervasiveness of Technology	• Technology is improving and advancing at a rapid rate and elementary students need to have more…experiences with STEM topics. • It prepares students for a world in which everything is technologically-driven.

Note: some example responses were edited so that they addressed only the specific code identified.

Findings

When all data in this preliminary exploratory study were initially reviewed, we found that 100% of participants agreed that STEM Education was important at the elementary level. The challenge then, was to better understand how students' responses varied in terms of the reasons given for why Elementary STEM Education was important. Given the relative homogeneity of the pool of respondents in terms of race/ethnicity, gender, and G.P.A., we elected to look first at overall trends, and then compare these trends by second major[v]. Our analyses cover three foci:

- Overall trends in reasons given for why Elementary STEM Education is important
- Comparisons of the reasons identified rate[vi] [RIR] for reasons given by respondents
- Comparison of the types of reasons given by second major

The percentages of respondents overall who offered a particular reason are shown below (see Table 2, below). From the data shown here, we can see that the most frequently offered reason, given by 31.51% of the respondents, for the importance for STEM education in elementary school is the foundation it provides for students for later coursework. While the least frequent response given, by 2.74% of respondents, has to do with STEM education helping to maintain global competiveness. A chi-squared analysis was not feasible as there were not the requisite number of respondents in several categories or a sufficient number of responses within codes; for example, there were fewer than five respondents in two of the coding categories. Therefore, only percentages were reported for descriptive purposes.

Table 2

Reasons given by participants for why STEM is important

Reasons (codes)	Percentage of Responses including this Reason
Foundation for Later Academics	32 %
Connections to Everyday Life	26 %
Nurturing Positive STEM Attitudes	25 %
Integrating or Balancing Content	22 %
Preparing Students for Jobs or Replenishing the STEM Pipeline	22%
Promotes Learning/Higher Order Thinking	21%
Pervasiveness of Technology	14%
Promote Hands-on Inquiry/Design	11%
Promote Gender Equity in STEM	4%
Maintaining Global Competiveness	3%

Upon coding the responses, there were found to be a total of 130 reasons identified by the total population of respondents describing the importance of STEM education. Among the 73 respondents, it was calculated that the RIR was 130/73 or approximately 1.78 reasons that STEM education is important per respondent. RIR for each of the second majors has also been determined and can be found in Table 3 below. For example, there were three Women and Gender Studies (WGS) students, and only one respondent offered one reason. The response was coded as an important reason for STEM education. Therefore, the RIR for students whose second major was WGS was 1/3. While, for the Psychology second major, for example, there were 14 respondents identifying 29 reasons STEM education is important in the elementary grades, yielding an RIR of 29/14 or approximately 2.07 reasons per respondent in the Psychology major. The RIR was calculated for all possible categories of second major (See Table 3).

Table 3

Reasons identified rate [RIR]

Second Major	RIR per student by second major
Integrative-STEM (n=24)	2.08
Psychology (n=14)	2.07
Foreign Language (n=2)	2.00
Mathematics (n=7)	1.71
English (n=8)	1.63
History (n=8)	1.43
Sociology (n=5)	1.40
Blank (n=2)	1.00
Women & Gender Studies (n=3)	0.33
Overall (N=73)	**1.78**
Total # of reasons identified	130
Overall RIR	1.78

The results indicate that the second majors of Integrative-STEM, Psychology, and Foreign Languages reported the on RIR per student above the average, at 2.08, 2.07 and 2, respectively, while the remaining second major categories were below the average, and ranged from the lowest RIR of 0.33 in Women and Gender Studies, to Mathematics at approximately 1.71 reasons per student.

In addition to calculating the number of reasons per student (RIR) overall and within second majors, the percentage of students offering each of the coded reasons overall, and within each second major was determined. This was calculated in order to determine the prevalence of reasons offered by students both overall and in each second major. In other words, the percentages of responses offered were calculated to determine what might be deemed more important reasons within (not across) each second major, as determined by the greatest percentages of respondents offering said reasons.

The percentages of reasons offered within second majors for each code is given below (See Table 4). For example, of the eight respondents in the History major, three offered that it was important to lay a foundation for later courses, yielding that 3/8 or approximately 37.5% of the population felt that way about the importance of STEM education. That is the highest percentage among all reasons given by History majors, suggesting that this is potentially an important reason for History majors in this sample, or at least more important than replenishing the STEM pipeline, which according to the data no History major indicated as being important. Whereas, in the I-STEM second major (See Table 4), 50% of the respondents (12 out of 24) identified that integrating STEM across the content areas is important, the greatest percentage determined for any reason among I-STEM majors in this study. These data suggest that the reasons valued for the importance of STEM education vary among the students who responded to this survey, insofar as, some second majors did not identify some reasons while others did, and within second majors, there are clear distinctions among the percentages of students who identified some reasons over other reasons.

Table 4

Percentage of Reasons Given by Respondents for STEM Importance by Second Major

Reasons Given	Second Major History n = 8	English n =8	Foreign Language n = 2	WGS n = 3	Psychology n = 14	Sociology n = 5	Mathematics n = 7	I-STEM n = 24
Foundation for Later Academics	37.50%	32.50%	0.00%	0.00%	42.86%	60.00%	42.86%	20.83%
Connections to Everyday Life	37.50%	12.50%	50.0%	0.00%	42.86%	20.00%	42.86%	12.50%
Nurturing Positive STEM Attitudes	12.50%	25.00%	50.0%	0.00%	42.86%	20.00%	0.00%	29.17%
Integrating or Balancing Content	12.50%	12.50%	50.0%	0.00%	7.14%	0.00%	0.00%	50.00%
Preparing Students for Jobs or Replenishing the STEM Pipeline	0.00%	25.00%	0.00%	0.00%	21.43%	20.00%	42.86%	29.17%
Promotes Learning/Higher Order Thinking	12.50%	0.00%	50.00%	0.00%	7.14%	0.00%	28.57%	37.5%
Promote Gender Equity in STEM	0.00%	12.50%	0.00%	0.00%	14.29%	0.00%	0.00%	0.00%
Maintaining Global Competiveness	0.00%	0.00%	0.00%	0.00%	7.14%	0.00%	0.00%	4.17%
Promote Hands-on Inquiry/Design	0.00%	12.50%	0.00%	0.00%	7.14%	0.00%	14.29%	20.83%
Pervasiveness of Technology	37.50%	25.00%	0.00%	33.33%	14.29%	20.00%	0.00%	4.17%

Note: Percentages in individual second majors might total more than 100% as responses could include more than one reason.

Discussion

Our exploratory study examined the beliefs about the importance of STEM education at the elementary level from a small, voluntary sample of pre-service and novice teachers at the same institution. Nonetheless, clear trends emerged in our pool of pre-service and early career elementary teachers. When asked whether STEM education is important at the elementary level, results suggested that the answer was a resounding yes. When we consider this unanimous "yes" response with respect to the body of literature that connects teachers' beliefs to instructional practices (c.f. Beyers, 2005, 2011, Madden et al, 2011; NRC, 2011), we are encouraged that the participants' beliefs suggest that they value STEM education very much at the elementary level. Given what the literature suggests about the connections between beliefs and instructional practices, it seems reasonable to hold hope that these new and future teachers demonstrate some beliefs that may be considered availing or supportive of promoting STEM oriented instructional practices. Although we cannot assert that these participants' beliefs will translate into additional STEM related instructional practices, we can explore in a future study whether these beliefs are connected to particular STEM related instructional strategies and begin to investigate whether there are relationships between the beliefs structures about the importance of STEM education at the elementary level and related instructional practices. There were clear trends in reasons given, as well as in the complexity of responses as indicated by number of reasons given and types of reasons given when comparing respondents based on their second majors. Explicating these trends can help us to better situate our description of our respondents' views on STEM and how we might better structure future efforts to enhance teacher preparation in the STEM disciplines. In the following sections, we will discuss these trends in detail.

Why is STEM Important at the Elementary Level?

Nature of reasons offered. When analyzing all of the responses, we found that 10 clear trends emerged (Table 4), thus becoming our codes. The largest number of responses gave reasons suggesting that STEM instruction in the elementary years helped create a foundation for later academics; just under a third of all responses identified this reason. About a fifth of responses identified the importance of preparing children for jobs of the future, and about a quarter discussed the importance of nurturing positive attitudes about STEM. Taken together, these three categories of reasons focus heavily on preparing future-ready students. It is possible that in the teacher preparation program that these participants were exposed to some of the reasons they in turn offered in their math and science methods courses, which could in turn explain the popularity of the reasons given. Elementary teachers are tasked with preparing children for the future and building academic foundations—these trends in responses could have led to STEM-specific responses to the initial prompt. Given the attention paid to STEM in popular media (e.g. Murphy, 2011) and educational literature (e.g. NRC, 2011, 2013a), it may be reasonable to suggest that our participants may also have learned about STEM via social media and educational literature. As such, it might follow that they would offer reasons supporting the importance of STEM which could be consistent with the reasons offered in popular media or educational literature, such as maintaining global competeviness or gender equity in STEM fields. However, just under three percent of all responses given made mention of reasons that are consistent with some of those offered in social media or education literature, such as being important for helping attain and maintain global competitiveness, while about four percent mentioned issues of gender equity. Given the relatively low frequency of such responses it appears that societal reasons may be less important to these participants than other reasons.

Another large portion of the responses mentioned the importance of connections between STEM and everyday life. About 14 percent discussed the pervasiveness of technology, suggesting that an understanding of STEM in the early years might help prepare children for a technology-centric world and lifestyle. The incorporation of engineering ideas into the NGSS make this connection as well— stressing the importance of understanding ways to use science to solve real-world problems:

> Given the importance of science and engineering in the 21st century, students require a sense of contextual understanding with regard to scientific knowledge, how it is acquired and applied, and how science is connected through a series of concepts that help further our understanding of the world around us. (NRC, 2013b, Appendix A p. 1)

A fifth of responses directly stated the importance of promoting higher order thinking and problem solving skills. Just over a fifth of responses focused on the importance of integrating or balancing content in the elementary years—another goal of the CCSS and NGSS efforts (NGA, 2010; NRC, 2013b). Finally, just over a tenth of the responses discussed specific reform-based instructional practices such as the use of inquiry, design, or hands-on activities, again in line with the goals of the CCSS and NGSS. In sum, these responses suggest that at least some of the respondents might see STEM instruction as a vehicle for enhancing relevance and addressing the goals of the new standards.

Number of reasons offered. As noted in the methods section, individual responses could include as few as zero and as many as 10 reasons for why STEM education is important at the elementary level, according to our coding scheme. On average, each respondent gave 1.78 reasons. Though all respondents aspired to teach elementary school and took a number of the same (or similar) education courses, they represented a large variety of second majors, which led to our investigation of the average number of responses given by second major. The number of respondents from each second major varied considerably (from 2 through 24). Yet, there were some apparent patterns that emerged in the types of responses that were given by the major groups, warranting further discussion.

The following second majors had an average number of responses that was higher than the whole group mean of 1.78: Foreign Language (2), Psychology, (2.07), and I-STEM (2.08). For example, the following response, given by an I-STEM major included two reasons (Prepares students for future, and promotes higher order thinking skills):

> Yes it is extremely important! STEM at the elementary level sets up students for success later on in life. It teaches them to be critical thinkers and to question and better understand the world around them.

Each of these three second majors focuses heavily on considering multiple perspectives and incorporates multiple perspectives on ideas through interdisciplinary coursework. Perhaps it is not surprising that respondents in these groups tended to give more nuanced responses to the prompt. Interestingly, all of the single content area second majors, English, History, and Mathematics had averages of 1.63, 1.43, and 1.71, which were lower than the group average. These degree programs focus on developing deeper and more complex knowledge in specific content areas. However, WGS and Sociology, majors that also include coursework across multiple disciplines each had averages lower than the whole group mean at 0.33 and 1.40 reasons given on average respectively. As discussed in the literature review, the body of research on integrative STEM education is new and growing, and we know of no other studies investigating how elementary teacher content specializations influence opinions on STEM importance. The findings of our preliminary exploratory study should be interpreted with caution, but offer an entry point for discussion about differences in teacher views of STEM education with respect to content area expertise.

Types of reasons. When we consider the entire pool of reasons given for the importance of STEM by participants, it should also be noted that no trends emerged citing individual STEM disciplines, e.g., science, mathematics, technology, or engineering. Rather, integrating across such content areas did come across as a trend, suggesting that for at least some of the respondents in this study, integrative STEM is consistent with their beliefs about the discipline. Another trend that did emerge is the pervasiveness of technology in general, though not as an academic discipline, suggesting that perhaps, our respondents viewed technology as a constant in the world we live in that should be incorporated across the curricula. When we considered the trends that did emerge, we elected to investigate differences in the specific reasons given by respondents in each of the various second majors, and saw some clear differences. For example, integrating or balancing content in the elementary years was the most popular reason given by I-STEM majors, with half of all I-STEM majors citing this reason. With the exception of Foreign Language, none of the other majors had more than 12.50% of their respondents mentioning this reason. Perhaps this finding is unsurprising as recent national reports (e.g. NAE & NRC 2014; NRC, 2013a) advocate for approaching the four STEM disciplines using an integrated approach, including integrating STEM content with non-STEM content. Interestingly, setting up a foundation for later academics was cited in only about a fifth of I-STEM majors' responses. This was the most popular response overall, and the most popular response[vii] among five of the eight possible second majors: History, English, Psychology, Sociology, and Mathematics. Additionally, there were some major differences in the categories of responses among the different majors. For example, if we consider all responses by Psychology majors, each code was mentioned by at least one respondent. I-STEM majors' responses represented 9 of the 10 possible codes (all but "promotes gender equity"). On the other hand, WGS, Foreign Language, Sociology, and Mathematics majors each cited five or fewer of the codes across all their responses.

What do these trends mean? The sample size was modest (N = 73), and for several second majors, there were fewer than five respondents. Yet, there are some clear differences in the way participants in each of these groups responded to the open-ended question about the importance of elementary STEM education. The importance of integrating or balancing content, a goal of both the NGSS and CCSS (NGA, 2010; NRC, 2013b), was not a uniformly popular response among all majors, but was most popular among I-STEM majors. Similarly, the Psychology and I-STEM majors, which include coursework across multiple disciplines and courses that require students to consider multiple perspectives, cited all or nearly all of the codes across the entire pool of responses. These differences suggest that perhaps students in certain second majors (I-STEM and Psychology in particular) are thinking about STEM differently from others majors, and these differences warrant further investigation.

Conclusion & Future Work

The fields of STEM education and STEM education research are relatively new, and constantly evolving, and we believe this study sheds new light on what tomorrow's elementary

STEM education might look like. Our respondents agreed that STEM was important and gave a variety of reasons for its importance, including some that addressed goals of elementary school in general, and some that met the goals of the NGSS and CCSS (NGA, 2010; NRC, 2013b). Knowing that beliefs can influence practice, these findings suggest elementary STEM education practices might look different in the future when the remaining portion of the pool of participants enters the workforce. Or perhaps, that as teacher educators, we do not sufficiently emphasize the integrative nature or significance of STEM education at the elementary grades.

However, at this point, we know only about the respondents' beliefs about the importance of STEM, not what their intentions are for future practice. Thus, a future study is planned to address this shortcoming.

Our findings also hold implications for pre- and in-service teacher education. If pre-service teachers have only a fragmented understanding of the significance of STEM education at the elementary levels, then it is our duty as teacher educators to address these gaps in order to better prepare them to teach STEM in elementary school. It is also important to note that research shows that teachers' low confidence about their discipline-specific content knowledge can be related to decreased confidence in their ability to teach said content, or even reluctance to attend professional development in that area (NAE & NSF, 2014). Thus, it is critical that we as teacher educators ensure a solid foundation of Integrated STEM content and pedagogy. Our study found that teachers recognize the importance of STEM—it is critical that we prepare them to feel knowledgeable and confident in STEM as well.

The NGSS and CCSS focus heavily on the interconnectedness of various content areas, setting the stage for integrative STEM instruction. We suggest that methods courses and teacher preparation programs which may still be offering instructional training in the individual STEM disciplines might consider highlighting the connections between ideas and disciplines and offer pre-service teachers concrete opportunities to see and practice integrative STEM instruction.

Limitations of Current Study

This study is preliminary and exploratory in nature. Although the purpose of the study was to gather initial insights into the beliefs of prospective and novice teachers, the pool of respondents was relatively small. This initial study does, however, provide a series of beliefs that might be able to lead to a framework for beliefs about STEM education in the elementary grades. An additional limitation of the current study is that potential limits in how representative the sample is of the overall population of teacher candidates and novice teachers. The entire sample comes from the same institution. Additionally, the survey data were self-reported. The science and mathematics methods courses at the institution, which all respondents completed prior to the study, are taken in a block with a single field placement. This course design emphasizes the connectedness of science and mathematics at the elementary level. Finally, some of the participants may have had the first or second author of this manuscript as an instructor for one of these methods courses, perhaps influencing their response to the open-ended question; however, this could be understood through the translation of beliefs as the instructors also believe in the importance of STEM education at the elementary level. Despite these potential caveats, this study is valuable and its findings can set the stage for future investigations, as well as, pre- and in-service STEM teacher education, such as focused interviews and additional qualitative research to flesh out some of the belief structures identified here.

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[i] Students in the School of Education are representative of the demographics of the College in terms of student achievement.
[ii] The participants were recruited because they completed their mathematics and science methods course block the four semesters prior. Most students are sophomores or juniors when they take those courses, but a handful are transfer students who take courses in a different sequence. Thus, three participants in this study already graduated, representing a very small portion of the pool (4%).

[iv] Though there were 73 respondents to the study, 2 elected not to report a second major.
[v] Note: comparisons based on education major will be reported in a future manuscript.
[vi] For the purposes of these analyses, the reasons identified rate (RIR) is operationalized as the rate of reasons given for why STEM education is important per respondent overall per respondent within a particular second major designation (e.g., the number of reasons given by history majors divided by the total number history majors). Examples of the calculations are given in the text that follows the initial description.
[vii] Note: in some of these majors, there were two most popular responses.