2016

Montana K-8 Teacher Preparation in STEM

Jeanette Murnane
jeanette.murnane@umontana.edu

<u>Montana K-8 Teacher Preparation in STEM</u>

Jeanette Murnane

Davidson Honors College Thesis,
The University of Montana
December 2016

Abstract:

The goal of this thesis is to find out how K-8 teacher education programs in Montana can be improved to better prepare teachers to teach science, technology, engineering, and math (STEM) concepts. While research has been done on what types of courses best prepare teachers for the classroom, my study focuses on how well Montana colleges and universities prepare K-8 certified teachers to teach STEM concepts. A survey was sent out to K-8 certified teachers across Montana to determine how well new teachers can utilize the technology available in their classrooms and what concepts within Common Core Math and Next Generation Science Standards (NGSS) teachers are adequately prepared to teach in their first few years. Results were inconclusive, as the response rate of the survey was too low to be statistically significant. However, the data collected has implications for future research as the Montana Office of Public Instruction and Montana colleges and universities must decide if it possible to provide teacher candidates with enough depth in STEM content areas in a broad K-8 certification program.

Acknowledgements:

Many thanks to Dr. Lisa Blank of the University of Montana Department of Teaching and Learning for her advisement on this thesis. Additionally, thanks to Laure Pengelley-Drake and Emma Prichard for continued inspiration and support throughout the research process.

Introduction:

Nationally, studies have shown that elementary level teachers feel less prepared to teach certain science and math concepts, especially physical sciences (Davis, 2006). As compared to states like Colorado where an elementary certification covers grades K through 5, Montana teachers are expected to be proficient in the content for social studies, language arts, reading, math, science, music, art, dance, and health and human performance through 8th grade. This breadth of content for the Montana elementary license forces colleges and universities with teacher licensure programs to make tough choices about what types of courses are included in the curriculum.

Research shows that elementary teachers who are not comfortable with science, technology, engineering, and math (STEM) do not teach these subjects in as much depth as teachers who are comfortable. In their 2006 study, Bursal and Paznokas found that “low math anxious preservice teachers are more confident to teach elementary mathematics and science than are their peers having higher levels of math anxiety.” Additionally, math anxiety in elementary teachers can affect students performance in math and science. For example, Sian, et. al (2009) found that despite having no correlation to their teacher in terms of math anxiety at the beginning of the year, “the more anxious teachers were about math, the more likely girls (but not boys) were to endorse the commonly held stereotype that “boys are good at math, and girls are good at reading” and the lower these girls’ math achievement.” In a world where the number of STEM-related jobs are projected to grow to 9 million by 2022, a foundation and interest in

STEM must be developed early in a child's education to encourage the child to pursue a STEM-related career (Vilorio, 2014). This primary foundation is developed by elementary and middle school teachers, who must be proficient in STEM in order to prepare our future leaders in science, technology, engineering, and math occupations.

The goal of this thesis is to find out how K-8 teacher education programs in Montana can be improved to better prepare teachers to foster learning in STEM concepts. While research has been done on what types of courses best prepare teachers for the classroom, my study focuses on how well Montana colleges and universities prepare K-8 certified teachers to teach STEM concepts. A survey was sent out to K-8 certified teachers across Montana to determine how well new teachers can utilize the technology available in their classrooms and what concepts within Common Core Math and Next Generation Science Standards (NGSS) teachers are adequately prepared to teach in their first few years.

The main institutions that prepare teachers in Montana are Montana State University and its affiliates, The University of Montana and its affiliates, Carroll College, The University of Great Falls, and Salish Kootenai College. These institutions differ slightly in their preparation requirements in STEM subjects. Montana State University requires 9 credits in Math for K-8 Teachers, 3 credits in a Life Science, 3 credits in an Earth Science, and 3 credits in a Physical Science, 2 credits of Integrating Tech in Education, 3 credits of Math Methods and 3 credits of Science Methods. The University of Montana requires 9 credits in Math for K-8 Teachers, 3 credits of Teaching with Technology, 5 credits of Physical and Chemical Science, 5 credits of Earth and Life Science, 3 credits of Conservation Education, 6 credits of Math Methods and 3 credits of Science Methods. Carroll College requires 2 semesters of Math for Elementary Teachers, one semester of Instructional media and technology, one semester of a Life Science with Lab, one semester of an Earth Science, one semester of a Physical Science, 1 semester of Teaching Mathematics, and one semester of combined Teaching Science and Social Studies. The University of Great Falls requires 9 credits of Math for Elementary Teachers, 2 credits in Instructional Technology, 4 credits of Earth and Space Science, 4 credits of Physical Sciences, 2 credits of Math Methods, and 2 credits of Science methods. Salish Kootenai College requires 15 credits in Math for K-8 Teachers, 7 credits of Computers in Education, 12 credits in Science for Educators, 7 credits of Math Methods and Practicum, and 5 credits of Science Methods and Practicum.

These requirements are summarized in the following table:

Institution	Math for K-8 Teachers	Life Science	Earth Science	Physical Science	Tech in Education	Math Methods	Science Methods
MSU	9 credits	3 credits	3 credits	3 credits	2 credits	3 credits	3 credits
UM	9 credits	5 credits + 3 credits conservation education		5 credits	3 credits	6 credits	3 credits
Carroll College	2 semesters	1 semester	1 semester	1 semester	1 semester	1 semester	1 semester (combined with social studies)
Univ. of GF	9 credits	4 credits		4 credits	2 credits	2 credits	2 credits
SKC	15 credits	12 credits			7 credits	6 credits + 1 credit practicum	5 credits + 1 credit practicum

The ultimate goal of teacher preparation programs should be that of developing Pedagogical Content Knowledge (PCK). PCK, a breadth of knowledge unique to teachers, describes how teachers relate what they know about teaching (pedagogy) to what they know about the subjects they teach (content) (Cochran, 1997).In other words, PCK is “the ways of representing and formulating the subject that make it comprehendible to others” (Shulman, 1986). Additionally, PCK can include an understanding of prior student knowledge, the developmental levels of students, and the learning environment. In terms of science teachers, Hauslein, Good, and Cummins (1992) found that over time, science teachers developed an in depth but fixed structure for thinking about content, which differed both from the loosely organized understanding of content displayed by preservice teachers, and the broad way of thinking about content displayed by science researchers. For math, preservice teachers often fail to develop their PCK by reconceptualizing their roles as future elementary teachers, which means that “preservice teachers emerge as poor duplicators of mathematics methods instead of initiators of learning.” (Foss, 1996). This study aims to collect data on not only how prepared teachers feel about how prepared they are to teach content as well as what courses in teacher preparation benefited teachers the most in fostering learning in these content areas.

Research Questions

Math

I hypothesize that Montana teachers will exhibit similar weaknesses in teacher preparation as teachers nationally. I hypothesize that Montana K-8 teachers feel prepared to teach topics related to Counting and Cardinality, Number and Operations in Base Ten, Geometry, and Measurement and Data. I hypothesize that teachers do not feel adequately prepared to teach concepts related to Ratios and Proportional Relationship, The Number System, Expressions and Equations, Functions, and Statistics and Probability. Additionally, I suspect that teachers do not feel adequately prepared to integrate Common Core "Mathematical Practices" into their everyday lessons, and that they would therefore like more math methods courses in their teacher preparation programs.

Science

In terms of science, I hypothesize that teachers feel prepared to teach concepts related to life sciences and Earth sciences, but do not feel adequately prepared to teach concepts related to physical sciences or engineering, and that teachers would like more courses in elementary education science content and field experience to make up for these inadequacies. I further hypothesize that Montana teacher education programs do not adequately support teachers' understanding of the NGSS science and engineering practices. This is supported by the Idsardi 2016 study of preservice teachers, which found that prospective teachers "were unable to consistently recognize science practices," and were unable to assess the depth of understanding of the practices in their students.

Technology

Finally, I hypothesize that teachers will feel prepared to use tablets and blogs in their classroom but will have limited preparation in the use of Smartboards, and would like more exposure to the types of technology available to them in the classroom.

Math Content and Course Type

Data suggests that pre-service elementary teachers are lacking in basic math knowledge, and that "preservice elementary teachers may well need further background in mathematics and science presented at a level that connects with their current conceptual level" (Stevens, 1996). Similarly, in their 2014 "Handbook on Teacher Preparation," Griffin et. al found that "many preservice and inservice teachers do not have an adequate understanding of essential mathematics content, and what is learned in teacher preparation courses often is not applied in classroom practice." However, methods courses in math have been shown to decrease math-related anxiety in pre-service teachers (Tooke and Lindstrom, 1998) and to increase performance when compared to increasing the amount of content-focused math courses in teacher preparation programs(Stevens, 1996). Despite over three decades of recommendations from the National Council of Teachers of Mathematics (NCTM) that math teaching should shift from a procedural focus to a conceptual focus, teaching math in a procedural way is still pervasive in the public school system. In their 2014 study, Jacobbe et. al found that combining math coursework with fieldwork for preservice teachers' facilitated "the simultaneous development of conceptual and practical tools." This thesis aims to report on self-identified strengths and weaknesses in math content and to identify which types of courses should be more prevalent in the mathematics curriculum for preservice teachers.

Science Content, Course Type, and Confidence

In the Next Generation Science Standards "knowledge of the life, Earth, and physical sciences continues to be a requirement of effective science teaching."(Bybee, 2014) Overall, elementary teachers have been shown to have weaknesses in physical sciences (such as astronomy), and in connecting concepts between disciplines. (Davis, 2006) Challenges in teaching science extend beyond content, as preservice teachers have been shown to "have little content and pedagogical knowledge, low science teaching self-efficacy, a lack of a positive attitude towards science and experience difficulties with classroom management during science lessons" (Davis, 2006). However, research shows that self-efficacy in science, interest in science, and experience in science field courses can improve elementary teacher performance in science (Olga, 1999). Teachers who experienced hands on field courses that included methods for how to continue to build content knowledge exhibited more confidence in using an inquiry-based approach to science teaching. (Olga, 1999). In terms of the NGSS science practices that have redefined inquiry, Idsardi et. al (2016) found that preservice teachers need "additional support in not only understanding what science practices are, but what science practices look like in classrooms and how to enact science practices at various levels of depth." With this in mind, the most effective course for teachers in terms of improving student performance on standardized tests has been found to be one "that integrates content learning with analysis of student learning and teaching rather than advanced content or teacher metacognition alone" (Heller, 2012). Elements of this study can be applied to teacher preparation programs, where the most effective course for preservice teachers combines content with reflection. This thesis aims to see which types of courses new Montana teachers would benefit from, and to highlight self-identified weaknesses in science content.

Technology Confidence and Use

In their 2004 study of how teachers use technology, Russel et. al found that effective use of technology in the classroom depends on teachers' beliefs about technology in the classroom, categorized technology instruction in teacher education programs, and exposure to applications of technology. First, teachers increased their beliefs in the effectiveness of using technology in the classroom when they were comfortable working with technology. Additionally, though new teachers are comfortable working with technology, "they have not been exposed to applications of technology in the classroom"(Russel, et. al, 2004). I predict that Montana teachers will express that they need more access to application of technology in their teacher preparation programs. Finally, technology use was broken down by researchers into several categories: "uses of technology to deliver instruction, to prepare for instruction, to accommodate instruction, to communicate with others in and out of the school, and to direct students to use technology for specific instructional purposes." This study aims to identify what types of technology teachers feel comfortable using in their classrooms. Short answer suggestions from teachers will help to identify how teachers use their technology.

Methods:

A list of emails for Superintendents and district clerks from all public schools in Montana was obtained from the Montana Office of Public Instruction. Surveys were emailed to all Superintendents and district clerks in charge of elementary districts in the state to be passed on to teachers in their respective districts. The total number of surveys emailed was 290. The survey was created using Qualtrics survey software, and all survey questions were aligned to the domains and practices of Common Core Math Standards and NGSS. All results were collected anonymously, and the institutions the respondents attended were not tracked. Respondents were asked if they had completed a bachelor-level teacher education program at a Montana college or University in the last 5 years. Those that selected yes proceeded to the survey questions, those who selected "no" were sent to a screen ending the survey. Survey questions regarding concepts, practices and types of technology were formatted into a matrix table using a likert scale. Questions regarding suggestions for improvements were in a short response text entry format. Questions regarding course types were in a multiple choice format where respondents could choose more than one answer.

Results:

The survey was sent to 290 administrators and district clerks servicing all elementary districts in the state. Though the total number of Montana teachers who received a K-8 teaching degree in the last 5 years could not be ascertained, the total number of public school teachers in Montana is 10,200. Of the 57 survey respondents, 11 teachers had completed their undergraduate level teacher licensure program at a Montana college or university in the last 5 years, and therefore completed the full survey. As the number of new elementary teachers in Montana can be assumed to be between 50 and 2000, the low response rate of the survey renders results not statistically significant within a +/-10 percent error. Though significant results cannot be drawn from the data, the results for the 11 new teachers are reported. Future research should utilize a different method for distributing surveys, as well as develop a mechanism for tracking the institution teachers attended in the state.

Math: Content

Respondents were asked to respond to the statement: "My teacher education program adequately prepared me to support student learning in the following concepts: Counting /Cardinality, Number and Operations in Base Ten, The Number System, Operations and Algebraic Thinking, Expressions and Equations, Functions, Geometry, and Measurement and Data." **(Table 1)** In the Content areas of Counting/Cardinality, Operations and Algebraic Thinking, Number and Operations in Base Ten, and Geometry, 58% to 67% of respondents selected Strongly Agree or Agree, while less than 17% of respondents selected somewhat disagree, disagree, or strongly disagree. On the other hand, in the content areas of Expressions and Equations and Measurement and Data, only 33% of respondents selected “strongly agree” or “agree,” whereas 45% of respondents selected “Somewhat agree” or “neither agree nor disagree.” The weakest content area was Functions, where only 16.67% of respondents selected that they strongly agreed or agreed that their programs had adequately prepared them to support students in learning the concept. Half of respondents selected “somewhat agree” for Functions, and one third of respondents selected “Disagree” or “Strongly Disagree.” The strongest content area was the Number System, where 75% of respondents selected “Strongly Agree” or “Agree.”

Table 1: Mathematical Concepts

Question	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
Counting/Cardinality (counting, addition, place value, ect.)	25.00%	33.33%	33.33%	0.00%	8.33%	0.00%	0.00%
Number and Operations in Base Ten	33.33%	33.33%	16.67%	16.67%	0.00%	0.00%	0.00%
The Number System	25.00%	50.00%	16.67%	0.00%	8.33%	0.00%	0.00%
Operations and Algebraic Thinking	25.00%	33.33%	25.00%	0.00%	8.33%	8.33%	0.00%
Expressions and Equations	16.67%	16.67%	41.67%	0.00%	16.67%	8.33%	0.00%
Functions	8.33%	8.33%	50.00%	0.00%	16.67%	16.67%	0.00%
Geometry	25.00%	41.67%	25.00%	0.00%	8.33%	0.00%	0.00%
Measurement and Data	16.67%	16.67%	33.33%	16.67%	8.33%	8.33%	0.00%

Math: Practices

Respondents were asked to respond to the statement: “My teacher education program adequately prepared me to support students in learning the following mathematical practices: “Make sense of problems and persevere in solving them, reason abstractly and quantitatively, construct viable arguments and critique the reasoning of others, model with mathematics, use appropriate tools strategically, attend to precision, look for and make use of structure, and look for and express regularity in repeated reasoning.” **(Table 2)** The strongest mathematical practices were “make sense of problems and persevere in solving them,” and attend to precision, where 50% of respondents either agreed or strongly agreed that they were adequately prepared, and less than 10% of respondents selected "somewhat disagree," "disagree," or "strongly disagree." The weakest practice was "construct viable arguments and critique the reasoning of others," where 60% of respondents selected "somewhat disagree," "disagree," or "strongly disagree." For the remaining practices, results were mixed, with approximately 50% of respondents selecting "somewhat agree."

Table 2: Mathematical Practices

Question	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
Make sense of problems and persevere in solving them	20.0 0%	10.00%	20.00%	10.00%	10.00%	10.00%	20.00%
Reason abstractly and quantitatively	20.0 0%	0.00%	10.00%	0.00%	30.00%	40.00%	0.00%
Construct viable arguments and critique the reasoning of others	0.00 %	20.00%	10.00%	10.00%	20.00%	10.00%	30.00%
Model with mathematics	10.0 0%	10.00%	50.00%	10.00%	10.00%	10.00%	0.00%
Use appropriate tools strategically	20.0 0%	30.00%	40.00%	10.00%	0.00%	0.00%	0.00%
Attend to precision	20.0 0%	30.00%	30.00%	10.00%	0.00%	10.00%	0.00%

Look for and make use of structure	20.0 0%	10.00%	20.00%	0.00%	40.00%	10.00%	0.00%
Look for and express regularity in repeated reasoning.	20.0 0%	0.00%	50.00%	0.00%	10.00%	10.00%	10.00%

Math: Class preparation

Respondents were asked: "Which of the following math courses effectively prepared you for the mathematics concepts that you use in teaching?" Two thirds of respondents selected elementary education math content courses, 42% of respondents selected math methods courses, other math courses, and field experience courses in math classes, and 25% selected none of the above.

When asked where more preparation would have been helpful, 54.5% of respondents selected field experience courses in math classes, 36% selected elementary education math content courses and math methods courses, and 9% selected other math courses or none of the above.

Math: Satisfaction and suggestions

When asked how satisfied they were with how their teacher education program prepared them to teach math concepts, 40% selected moderately satisfied, 20% selected slightly satisfied and extremely dissatisfied, and 10% selected extremely satisfied or moderately dissatisfied.

When asked what suggestions they had for improving how teacher candidates are prepared to teach mathematics, responses included suggestions an increase in placements in the upper grades and more experience in not only content but also concept development using the Common Core standards.

Science: Concepts

Respondents were asked to respond to the following statement: "My teacher education program adequately prepared me to support the students in learning the following science concepts: life science, physical science, engineering, and earth science." **(Table 4)**The weakest content area was Engineering, with 33% of respondents selecting "strongly disagree, 22% selecting "disagree" or "somewhat disagree," and 22% selecting "somewhat agree" or "agree." No respondents selected "strongly agree" for engineering. Similarly, 55% of respondents selected "disagree" or "somewhat disagree" for earth science, 33% selected somewhat agree or agree, and no respondents selected “strongly agree.” The physical science and life science results were spread across the categories, with 44% of respondents selecting somewhat agree for physical science, and 33% selecting somewhat agree for life science.

Table 4: Science Concepts

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
Life science	11.11%	11.11%	33.33%	11.11%	22.22%	11.11%	0.00%
Physical science	11.11%	0.00%	44.44%	22.22%	22.22%	0.00%	0.00%
Engineering	0.00%	11.11%	11.11%	22.22%	11.11%	11.11%	33.33%
Earth Science	0.00%	22.22%	11.11%	11.11%	44.44%	11.11%	0.00%

Science: Practices

Respondents were asked to respond to the following statement: “My teacher education program adequately prepared me to support students in using the following science practices: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating and communicating information.” **(Table 5)**The strongest practice was “asking questions and defining problems,” with 75% of respondents selecting agree or somewhat agree, and 25% selecting strongly disagree. For the following practices, 62.5% of respondents selected strongly agree, agree or somewhat agree, and 25% selected disagree, somewhat disagree, or strongly disagree: “developing and using models,” “planning and carrying out investigations,” and “analyzing and interpreting data.” For the following practices, data was split 50/50 between the strongly agree, agree, and the somewhat agree categories, and the disagree, somewhat disagree, and strongly disagree categories: “using mathematics and computational thinking,” “constructing explanations and designing solutions,” and “obtaining, evaluating and communicating information.” The weakest practice was “engaging in argument from evidence, with 62.5% of respondents selecting disagree, somewhat disagree, or strongly disagree, and 42.5% selecting agree or somewhat agree.

Table 5: Science Practices

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree

Asking questions (for science) and defining problems (for engineering)	0.00%	50.00%	25.00%	0.00%	0.00%	0.00%	25.00%
Developing and using models	12.50%	25.00%	25.00%	12.50%	0.00%	0.00%	25.00%
Planning and carrying out investigations	12.50%	25.00%	25.00%	12.50%	12.50%	12.50%	0.00%
Analyzing and interpreting data	12.50%	0.00%	50.00%	12.50%	12.50%	12.50%	0.00%
Using mathematics and computational thinking	0.00%	12.50%	37.50%	0.00%	25.00%	0.00%	25.00%
Constructing explanations (for science) and designing solutions (for engineering)	0.00%	25.00%	25.00%	0.00%	37.50%	12.50%	0.00%
Engaging in argument from evidence	0.00%	25.00%	12.50%	0.00%	25.00%	12.50%	25.00%
Obtaining, evaluating, and communicating information	0.00%	37.50%	12.50%	0.00%	25.00%	12.50%	12.50%

Science: Courses

When asked which of the following science courses effectively prepared you for the science concepts that they use in teaching, 44% selected other science courses (chemistry, physics, geology, etc.), 22% selected elementary education science content courses, and 11% selected science methods courses, field experience courses or none of the above.

When asked where more preparation would have been helpful, 56% selected field experience courses, 44% selected elementary education science content courses and science methods courses, and 22% selected other science courses. It is important to note that content courses are prerequisite courses for methods courses, and that methods courses focus on how to teach the content rather than on the content itself.

Science: Satisfaction and suggestions
When asked how satisfied they were with how your teacher education program prepared you to teach science concepts, responses were evenly distributed from “extremely satisfied” all the way down to “moderately dissatisfied.”

Suggestions centered around more content development and more experience in developing science lessons. Respondents said they would have benefited from more content in physics and chemistry and more practice teaching science concepts before entering the classroom.

Technology: Types
Respondents were asked to respond to the statement, “My teacher education program adequately prepared me to use the following types of technology: iPads or other tablets, Smartboards, google applications, and blogs or websites.” **(Table 3)** In the iPads and tablets category, 70% of respondents selected “somewhat disagree,” “disagree,” or “strongly disagree,” while 30% selected “strongly agree” or “agree.” In the Smartboards category, respondents selected all of the options in equal percentages. For Google applications, 40% of respondents selected “somewhat agree.” Similarly, in the blogs and class website category, 50% of respondents selected “somewhat agree.”

Table 3: Types of Technology

	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree	Total
iPads or other tablets	20.00%	10.00%	0.00%	0.00%	20.00%	20.00%	30.00%	10
Smartboards	10.00%	20.00%	20.00%	0.00%	20.00%	30.00%	0.00%	10
Google applications (such as Google Classroom, Google Docs, ect.)	10.00%	10.00%	40.00%	10.00%	20.00%	10.00%	0.00%	10

Blogs or my own class website	10.00%	20.00%	50.00%	10.00%	10.00%	0.00%	0.00%	10

Technology: Courses

When asked in which types of classes more preparation would be helpful, 78% of respondents selected teaching with technology courses, 22% selected other subject specific methods courses, and 33% selected computer science courses.

Technology: Satisfaction and suggestions

When asked to respond to the following statement, “I feel confident in my ability to adapt to new technology available to me in my classroom,” 60% of respondents selected “strongly agree,” “agree,” or “somewhat agree,” 10% selected “neither agree nor disagree,” and 30% selected “disagree.”

When asked how satisfied respondents were with how their teacher education programs prepared them to use technology in the classroom, no respondents selected “extremely satisfied,” 50% selected “moderately satisfied,” or “ slightly satisfied,” and 40% selected “slightly, moderately or extremely dissatisfied.”

Suggestions for improving how teacher candidates are prepared to use technology in their classroom centered around more practice with technology before candidates enter the classroom. Responses included “exposure to more types of technology,” “more practice with smartboard,” “more time on relevant tech,” “practice in lesson development,” and “using technology found in most classrooms, elmo, smart or promethean board, and projector.”

Discussion:

Limited conclusions can be drawn from this data because of the low response rate, but suggestions can be made for future research.

Math

Though the hypothesis cannot be supported or rejected by the data, teachers expressed more confidence in Counting and Cardinality, Number and Operations in Base Ten, and Geometry and less confidence in Functions as predicted. In terms of mathematical practices, no definitive conclusions can be drawn from the data, though few teachers expressed strong confidence that their teacher education program adequately prepared them to teach any of the mathematical practices. This is reflected by teachers’ responses to preferred course type and their suggestions, where the majority of teachers felt that field experience and methods courses were the most helpful, and over half of respondents wanted more math methods courses focusing on curriculum progression and familiarity with the Common Core. This emphasis on methods and field courses is supported by the research, which suggests that “those who studied children's mathematical thinking while learning mathematics developed more sophisticated beliefs about mathematics, teaching, and learning and improved their mathematical content knowledge more than those” who took only content courses. (Phillip, et. al, 2007).

Though research has centered around overall content proficiency in mathematics, research needs to be tailored more specifically to teachers’ performance and confidence in the Common Core Math domains. It is recommended that research focus on determining the domains in which elementary teachers need the most support, and what types of courses can increase teacher confidence in using the Mathematical practices. Further research in these areas can help Universities to make the difficult choices about what types of courses to add or remove from teacher preparation programs, as well as what content to emphasize in elementary education math content and methods courses.

Science

The hypothesis is neither supported nor refuted by the data. Although engineering was the weakest content area as predicted, results were inconclusive in the content areas of life science, earth science, and physical science. However, very few respondents selected “agree” or “strongly agree” for any of the categories. This suggests that the teachers sampled, though not necessarily representative of the population of new teachers as a whole, do not feel that their teacher education program adequately prepared them to teach any of the content areas.

In terms of the science practices, the teachers sampled showed confidence in the practice “asking questions and defining problems,” as hypothesized, but the results for the remaining science practices were spread across the response options. There is no clear trend in how adequately teacher education programs prepared these teachers to use the NGSS Science practices, but the results do show us that respondents self reported being more prepared to use the NGSS practices than they were in science content.

When asked which courses effectively prepared them for the concepts they use in teaching, more respondents reported that other science courses, such as courses in physics, chemistry and geology, adequately prepared them for the science concepts that they use in teaching when compared to elementary education content courses. Similar to math, respondents wanted the most additional coursework in field experiences in science, followed by elementary education science content and methods courses. Respondents also suggested that they need more experience in concept development and basic science knowledge before entering the classroom. This is supported by findings that suggest, “that when prospective teachers are provided with opportunities to apply and reflect substantively on their developing considerations for supporting children's science learning, they are able to maintain a subject matter emphasis” (Zembal, et. al., 2002). Methods and field courses in science that allow teachers to think about how they will progress through a science unit may help to increase elementary teacher confidence and performance in teaching science.

Similar to the suggestions for math, it is recommended that further research focus on what NGSS content areas and practices need more emphasis in teacher preparation programs, as well as how to improve teacher confidence in using the standards. Additionally, colleges and universities should think seriously about how to better prepare elementary teachers in science content.

Technology

In terms of types of technology, respondents were the least prepared to use iPads/tablets, and were somewhat prepared to use google applications and class websites. These results do not support the hypothesis that teachers would feel more prepared to use tablets and blogs than they would Smartboards. However, respondent suggestions were consistent with the hypothesis that teachers would like more exposure to the types of technology available to them in the classroom. This is consistent with the research, which shows that increased exposure to different types of technology, in the context of categories of classroom use, increases teachers belief in and use of technology. (Russel, et. al., 2004).

Future research should focus on the curriculum common in teaching with technology courses. Do the courses focus on the application of technology in planning, communicating information, presenting information, and student use? Do the courses expose teachers to all of the different types of technology that will be available to them in the modern classroom? Do the courses explicitly teach skills to help teachers to adapt to new technologies that become available in the future? Additionally, colleges and universities should examine these questions to ensure that their teaching with technology courses adequately prepare teacher candidates to use relevant technology.

Impact on Licensure Requirements

Overall, teachers in this study displayed the need for more instruction in science, math and technology. Future research should inform how Montana proceeds as it revises licensure requirements. Questions about the preparation of new K-8 certified teachers to teach STEM concepts at the middle school level has not been addressed in the research. Additionally, middle school teachers in rural areas are expected to teach multiple subject areas, which begs the question do middle school teachers have enough preparation time to invest in middle school level math and science content? Most importantly, researchers should ask if it is possible to provide teacher candidates with enough depth in STEM content areas in a broad K-8 certification program. This question could be pursued through analysis of student achievement, PRAXIS scores, or case studies.

Whether the state moves towards a middle school endorsement or requiring middle school teachers to be 5-12 certified in a specific subject area, Montana needs to think seriously about how to best prepare elementary and middle school teachers in STEM and how Montana colleges and universities should adapt their curriculums to best service this change in licensure. Though science is not tested in the new Smarter Balanced Assessment, we are living in a world where the job market in STEM fields is growing by 17% compared to 10% for other types of occupations. As a result, it is imperative that Montana educational institutions prioritize teacher preparation in STEM.

References:

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics*, *106*(4), 173-180.

Bybee, R. W. (2014). NGSS and the next generation of science teachers. *Journal of science teacher education*, *25*(2), 211-221.

Cochoran, K. F. (n.d.). Pedagogical Content Knowledge: Teachers' Integration of Subject Matter, Pedagogy, Students, and Learning Environments. Retrieved December 15, 2016, from https://www.narst.org/publications/research/pck.cfm

Davis, E., Debra Petish, & Julie Smithey. (2006). Challenges New Science Teachers Face. *Review of Educational Research, 76*(4), 607-651. Retrieved from http://www.jstor.org/stable/4124416

Griffin, C. C., van Garderen, D., & Ulrich, T. G. (2014). Teacher Preparation. *Handbook of Research on Special Education Teacher Preparation*, 271.

Hauslein, P. L., Good, R. G., & Cummins, C. L. (1992). Biology content cognitive structure: From science student to science teacher. *Journal of Research in Science Teaching*, *29*(9), 939-964.

Heller, J. I., Daehler, K. R., Wong, N., Shinohara, M., & Miratrix, L. W. (2012). Differential effects of three professional development models on teacher knowledge and student achievement in elementary science. *Journal of Research in Science Teaching*, *49*(3), 333-362.

Idsardi Jr, R. C., Crawford, B. A., Romero, M., Capps, D., Murray, J. K., & Ammons, J. F. (2016). Prospective Science Teachers' Understanding of Science Practices in Classroom Scenarios.

Jacobbe, T., Ross, D. D., Caron, D. A., Barko, T., & Busi, R. (2014). Connecting Theory and Practice: Preservice Teachers' Construction of Practical Tools for Teaching Mathematics. *Teacher Education and Practice*, *27*, 332-355.

Jarrett, O. S. (1999). Science interest and confidence among preservice elementary teachers. *Journal of Elementary Science Education*, *11*(1), 49-59.

Philipp, R. A., Ambrose, R., Lamb, L. L., Sowder, J. T., Schappelle, B. P., Sowder, L., ... & Chauvot, J. (2007). Effects of early field experiences on the mathematical content knowledge and beliefs of prospective elementary school teachers: An experimental study. *Journal for Research in Mathematics Education*, 438-476.

Russell, M., Bebell, D., O'Dwyer, L., & O'Connor, K. (2003). Examining teacher technology use implications for preservice and inservice teacher preparation. Journal of Teacher Education, 54(4), 297-310.

Stevens, C., & Wenner, G. (1996). Elementary preservice teachers' knowledge and beliefs regarding science and mathematics. *School Science and Mathematics*, *96*(1), 2-9.
Tosun, T. (2000). The beliefs of preservice elementary teachers toward science and science teaching. *School science and mathematics*, *100*(7), 374-379.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15,* 4-14.

Tooke, D. J., & Lindstrom, L. C. (1998). Effectiveness of a mathematics methods course in reducing math anxiety of preservice elementary teachers. *School science and mathematics*, *98*(3), 136-139.

Vilorio, D. (2014). STEM 101: Intro to tomorrow's jobs. *Occupational Outlook Quarterly*, *58*(1), 2-12.

Zembal‐Saul, C., Krajcik, J., & Blumenfeld, P. (2002). Elementary student teachers' science content representations. *Journal of Research in Science Teaching*, *39*(6), 443-463.