AC 2011-2099: MATH CURRICULUM IN A SET OF K-5(8) AND K-12 STEM PRE-ENGINEERING TEACHER PREPARATION PROGRAMS

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Applied Math Curriculum for Elementary and Secondary Integrated STEM teacher preparation programs

Abstract
In this paper we describe the mathematical components of integrated Science-Technology-Engineering-Math (STEM) teacher preparation programs at our institution. We believe the level of mathematical content is high compared to similar programs elsewhere. We are of the opinion that the multidisciplinary nature of our programs (all four elements of STEM) are beneficial. Preliminary course surveys and measurements of math anxiety and teaching self-efficacy indicate that the integrated STEM teacher candidates do experience substantial improvements over the course of their curriculum.

Introduction

Our institution supports two Science, Technology, Engineering and Mathematics (STEM) teacher preparation programs. One program, referred to as the Math/Science/Technology (MST) program, is an elementary [preK-5] program and was started in 1998. The second program is a secondary 6-12 "Technology Education/Pre-engineering education" (TE/PreEE) program and has its roots in industrial arts education dating back to the 1930s. More detailed descriptions of each of these programs have been previously reported.[1-3] Both programs require substantial coursework in all four elements of STEM, as well as integrated-STEM (i.e.- how to use multiple STEM elements together in K-12 curriculum/activities). Students in both programs also acquire substantial experience in integrating non-STEM subjects with STEM subjects. In 2006 our department completed a redesign of our "Technology Education" curriculum to integrate more M&S into our Technology & Engineering (T&E) courses, resulting in our current "pre-engineering" curriculum. Even though this redesign was focused on our secondary program, it directly impacted our K-5 program since our T&E curriculum is shared between the two programs. The curricular modifications were defined with the help of an external advisory board and were previously reported.[3] A key input from the advisory board was to add more emphasis on analysis; that is, analysis-based decisions in design. A key element involved with improved analytical skills is mathematical ("numerical") skills. The purpose of this paper is to describe the extent of mathematical content in our STEM curriculum and to review preliminary results of the impact of this content.

Motivation:
We believe that mathematical skills (aptitude and affect) are critically important for both of our teacher preparation programs. A few reasons are listed below.

1) Analytical skills are important in problem-solving, and mathematical ("quantitative") skills are key to good analytical skills. Basic mathematical skills like counting, measurement, scaling, basic statistical reasoning or simple evaluation of expressions are important in problem-solving and certainly occur often in everyday life. That is, more comfort and skill in applying mathematical skills (the "M") results in more effective problem-solving. [4]

2) Several studies have reported all-time low performance for K-12 students in both math and science at a national level. A recent update on the National Academies report "Rise above the Gathering Storm" indicated that K-12 students in the USA ranked 48th in the world in terms of math and science capability.[5] Pertinent statistics are also available by looking at the quantity and success of remedial math courses offered by Community Colleges.[6-8] Enrollment in community colleges has grown quickly, currently supporting approximately ½ of all college students in the USA. In a study of 27 community colleges across the USA (~46,000 students), it was found that 70% of the new students were referred into remedial math courses, and nearly half of these were referred into a level that was 3-levels below college algebra. Less than 25% of these community college students passed their math requirements within 3 years. Lower mathematical skills certainly impacts 4-year colleges as well. Our goal of graduating future teachers with higher math skills is consistent with improving mathematical skills of K-12 students.

3) Improvements in K-12 student capabilities may also be impacted by changes in standards and teaching methods. Some of these changes may include more multidisciplinary and/or problem-solving approaches (sometimes referred to as "21st Century skills"). In our State, 21st Century skills have recently been added to the standards, so teachers will have an immediate need for multidisciplinary and problem-solving teaching skills. Both our elementary and secondary TE/PreEE majors are being prepared to integrate math, and the other STEM components, into the classroom to support such broader standards.

4) Both affect and aptitude in math and science are largely determined by the middle school years, a grade range that clearly impacts our K-5 graduates since it is in these earlier grades where improvements can be best impacted. [9 Reference!]

5) Female interest in STEM subjects continues to be a problem, as represented by fewer female students choosing STEM majors in college and STEM careers. A recent study of K-5 grade students verified that math anxiety follows like-gender (female) role models.[10] In this study students of teachers with high math anxiety also had higher math anxiety. This like-gender effect impacts a large number of female K-5(8) students because the large majority of K-5 teachers are female, and each female teacher will have 12-15 female students every year over a 15-30 year career. Our teacher preparation programs contain a relatively large fraction of females so if our program can reduce anxiety and increase comfort and aptitude in math (and in STEM in general) then this will have an amplified beneficial effect on K-12 students.

Math Curriculum

Our curricular changes with respect to additional math can be divided into the following three categories: (i) Direct math courses taught by the math department, (ii) Distributed math through out the T&E courses offered by our Technological Studies Department and (iii) an "Engineering Math" course also taught by Technological Studies Department.

I. Direct Math Content:

Math requirements vary for each program, so the requirements are described separately below for each major. Also included are descriptions of required science courses since science can involve learning new math, but very likely in using (applying) math.

Secondary TE/PreEE (6-12):

The math requirements for the TE/PreEE major are Calculus-A. Calculus-A is the same one-semester calculus course that is required of science and engineering majors. To the author's knowledge, this is the only TE program in the USA that requires calculus. The science requirement for the TE/PreEE major is Physics-I. Physics-I is the same 1-semester calculus-based physics course that is required of science and engineering majors.

TE/PreEE students rarely take more math and science than described above. However, it is the department's desire, as well as the desire of some TE/PreEE students, to be able to take more courses in math and/or science to enable middle school certification in math or science.

Elementary (K-5):

At our institution all elementary education students must choose an education major. There are four possibilities for their education major: (i) Elementary, (ii) Early Childhood, (iii) Special education, and (iv) Deaf & Hard of Hearing. Additionally, a beneficial policy that our State requires is that all education majors must choose a disciplinary major. There are 11 possible majors, 8 non-STEM and 3 STEM. Popular majors are STEM, English, Psychology and Woman & Gender Studies. In Spring of 2010 the K-5 STEM major became the largest single disciplinary elementary education major. A requirement for all STEM elementary education majors is to choose a Specialization. The choices are Technology & Engineering (T&E), Math or Science (either Biology, Physics or Chemistry). Therefore, for an elementary education major the amount of math and science can vary, depending on their choice of Specialization. The make-up of students with respect to Specialization is approximately as follows: T&E (60%), Math (25%) and Science (15%). In this section we talk only about the minimum level of math and science (i.e. T&E Specialization students). Students with either a math or science Specialization will clearly have additional M & S content and experiences. Students with a math or science specialization take five T&E courses, while students with either a technology specialization take 7-8 T&E courses.

There are two required math courses and one required math methods course for the elementary education major. The two required math courses are Calculus-A and a course in "math content for the elementary classroom." The math methods course covers effective methods to teach math concepts in elementary grades. The methods course is not considered a "math content" course by the State. Most elementary STEM majors also take 2 additional math content courses so that they meet the State requirement for certification to teach math in middle school. [In our State, elementary majors can qualify for middle-school endorsements in math and science by successfully completing: (i) their undergraduate education major, (ii) completing 15 credits of course work in the discipline and (iii) passing the appropriate content knowledge Praxis™ test.] The additional two math content courses are typically a second course on elementary-level math content, a beginning statistics course or an engineering math course.

There are three required science courses and one required science methods course for the STEM elementary education major. There are no specific science courses required, nor is there a lab requirement. The science methods course covers effective methods to teach science concepts in elementary grades. Most elementary STEM majors also complete an additional fourth science course, enabling a middle school endorsement in science. The typical science courses are 100 level courses supported by the School of Science. The options for 100-level science courses are (i) Cancer, Genes and the Environment, (ii) Physical, Earth and Space Science, (iii) Geology, (iv) Astronomy and (v) Meteorology. These 100-level courses are particularly well-suited for K-5(8) due to their combination of breadth, depth and application.

Statistics available on the U.S. Department of Education's Institute of Education Sciences (IES) website for National Center for Education Statistics (NCES) shows that an education major graduate in 1992-93, the most recent year that data was available, completed an average number of 6.3, 10.4 and 0.3 semester credits in math, science and engineering, respectively.[11] A STEM elementary education major compares very well with these figures because they complete typically at least 16 credits in math, 16 credits in science and 20 credits in T&E content.

II. Distributed Math Content:

Like many colleges and universities our teacher preparation curriculum can be divided into three areas: (i) Liberal Studies, (2) Core Curriculum (major) and (3) Professional Curriculum. For the STEM education majors the core curriculum consists of a substantial level of math, science and T&E content. In this section we describe the mathematical content covered in the T&E content courses and attempt to quantify this level.

The content portion of our T&E curriculum is divided into three strands; (i) Design, (ii) Mechanical and (iii) Electrical. Additional math has been included in all three strands. However, most of the additional math has been incorporated into the mechanical and electrical strands. The mathematical/quantitative content included in these three strands are described below. [Courses marked with an asterisk (*) are required T&E courses for all K-5 STEM education majors. Courses marked with a superscript plus sign ($^+$) are common courses for students with a technology specialization.]

(i) Design Strand:

There are 7 courses in this category. The math content in these courses is described below.

- Creative Design*: This course is focused on creative design and building, so most of the math content is primarily restricted to measurement.

- Engineering Design$^+$: This course is focused on 3-dimensional Computer Aided Design (CAD), so most of the math content is limited to calculations using the CAD software.

- Multimedia Design*: This course is focused on 2-dimensional layout and learning a variety of software skills. This course contains minimal math content.

- Architectural & Civil Engineering Design+: This course covers a wide variety of topics. One of the topics covered, for ~1.5 days, is the statistics of human factors and its usefulness in design.

- Prototyping Laboratory: This course requires students to complete the design and prototyping of a variety of projects utilizing a variety of 3-dimensinal fabrication tools. The strong design component contains a substantial measurement and calculation component due to numerous and subtle calibrations and corrections that are required to successfully prototype projects.

- Manufacturing Systems: Minimal math content is required in this course.

- Facilities Design+: Minimal math content is required in this course

(ii) Mechanical Strand:
There are 4 courses in this category. The math content in these courses is described below.

- Structures & Mechanics*: This course covers materials, structural (static) design and mechanisms. Topics include the materials science (stress & strain), forces and vectors as related to static structural design and dynamic mechanism design (simple machines, gears, pulleys … etc.). This majority of this course contains math and the application/use of math.

- Mechanical Systems Design: This course is focused on creative design and building, so most of the math content is primarily restricted to measurement and basic calculations required for builds.

- Materials Processing Lab: This course is focused on building, so most of the math content primarily consists of measurement, scaling, working with angles, calculating items like area (board feet) and feed rates.

- Biotechnology+: This course gives an in depth overview of a large variety of technological applications in biological, medical and environmental science. Therefore, there is a substantial level of the math content. The math content consists of measurement and functional evaluation.

(iii) Electrical Strand:
There are 3 courses in this category. The math content in these courses is described below.

Analog Circuits & Devices+: This course contains a high level of science (of electricity) and math. Math content includes functional evaluation, calculations, linear functions, trigonometry, and a small level of calculus.

Digital Electronics[+]: This course contains a high level of math content. Math content includes counting, binary math (including decimal-to-binary conversion and negative number representations), base-N systems and Boolean algebra & logic.

Robotics & Controls Lab: This course focuses on the design and build of simple control circuits, robotics and microprocessor-based subsystem designs. This course contains minimal math content.

A summary of the math content in the curriculum is given in Table 1.

Table 1 Summary of math content for courses in the three T&E strands.

Strand	**Math content or application of math**
Design	Overview of math content- Arithmetic: ~20% Measurement: ~55% Calculations, Eval. of expressions: ~15% Prob. & Statistics: ~10%
Mechanical	Overview of math content- Arithmetic: ~20% Measurement: ~30% Calculations, Eval. of expressions: ~20% Geometry, Algebra, Vectors, Trig.: ~30%
Electrical	Overview of math content- Arithmetic: ~20% Measurement: ~30% Calculations, Eval. of expressions: ~10% Logic: ~40%

From the above overview it is estimated that the T&E curriculum gives an effective math / quantitative content of 3-5 courses for the secondary STEM program students (they are required to take all of the T&E curriculum), while the K-5 MSTstudents attain an additional 2-3 courses worth of mathematical content. These levels of additional content does *not* count an Engineering Math course which the large majority of students take, and is discussed separately later in this paper. Even without accounting for any synergies between the four STEM components, this is a substantial level of additional mathematical content, and importantly, is math-in-context. For example, this level of multi/interdisciplinary STEM content has been proposed as the reason for substantial decreases the math anxiety level of our K-5 STEM major teacher candidates. [1]

III. Engineering Math Course:

An engineering math course is required of our secondary TE/PreEE students and is taken by a large majority of our K-5 STEM students. We are of the opinion that our students need focused time on mathematical skills so we designed and implemented an "engineering math" course. Many of our students tend to have fairly high math-SAT scores (~643 for the K-5 STEM major) and also get A's & B's in college-level calculus, so one might conclude that they are quantitatively literate. However, our experience tells us that this is certainly not the case. It is our observation that students are adept at memorizing math processes, many of which are easily later forgotten. Not surprisingly, however, our students (and we believe most students) are not adept at, or comfortable with, applying the math that they do know in real-world situations. This leads to the title of our course, "Engineering Math," where the focus is on applying math not simply learning additional, and unused, math processes. The goals of the Engineering Math course are to increase students' abilities in applying math skills in real-world technology and engineering situations and to increase students' comfort in applying math skills. It is also assumed that if these two goals are met that the students' affect and aptitude in math will increase. An intention of the Engineering Math course is to excite the students about how math has benefited their lives (Human existence) in a large way, and that the mathematical skills that they already know can solve very useful problems. Stated differently, the goal of the course is to increase the quantitative literacy of the students. Cognitive research also suggests that creating a venue that successfully convinces students that a subject has value, in this case math, is linked to how humans best learn, justifying an "applied" element to all school subject matter.

An overview of this course is presented Table 2. In this course we purposefully cover a variety of applications and math with the intent of keeping the interest-level high, while also allowing a variety of mathematics topics to be encountered. Application areas include civil engineering, blood/fluid flow, education (grading, assessment/evaluation and education research), genetics, electronics, finance (time value of money), measurement, mechanics, ballistics/dynamics, biology, and chemistry. Math/quantitative topics covered include large & small numbers, trigonometry, units analysis, probability & statistics, structured programming (Excel), rates-of-change and exponential functions. A substantial amount of time is spent on learning Excel since this will be a powerful tool throughout the course and in the students future after their degree is completed. Excel skills are also motivated by its highly widespread use by practicing engineers and scientists. Excel also gives an effective means to cover applied probability and statistics, a topic that is not covered in detail elsewhere in the curriculum.

Table 2 Overview of Engineering Math course for STEM education majors.

History	• Ancient record (& related to cognitive dev. of humans)
	    o Counting 20,000 – 70,000 years ago
	    o Prime #'s, sexagesimal system, zero/neg. #'s
	• Modern Math
	    o 4-color map problem ←→ computer/tele. networks

Math to Start
(Brief reviews)
	• Big & Small #'s (Powers of 10 & abbreviations)
	• Lines
	• Trigonometry
	• Non-Rectangular Coord. (application of trig.)
	• Excel (highly used calc.'n software for engineers)
	    o Calculation, functions, slopes (calculus)
	    o Graphing, data-representation, curve-fitting

	o Prob. & stat.

Probability/ Statistics	• Real world
	• Chance / genetics
	• Histograms, ave./mean, median, Gaussian dist., std. dev.,
	• Decision-making/comparison (t-tests)
	• Variability/error
	    o Calculation of
	    o Accuracy/precision
	    o Measurement (relate variability to probability)

Physics/ Mechanics	• Static systems (sum of forces equal zero) • Vectors, forces, trig. • Solving systems (free-body diagrams → algebra) o Simple braces, simple truss as intro to bridges • Dynamics (velocity, acceleration: Ballistics)
Biology/ Chemistry/ Technology/ Finance	• Logarithmic functions o widely used function in engineering • Population growth & Product Life cycles • Financial systems / behavior

Sprinkled throughout this course are 4-5 active "labs." These labs require students to solve more open-ended problems, typically in teams of 2-3 and typically outside of the classroom. Write-ups and / or presentations are also required. Descriptions of labs used to-date are presented below.

(1) "Regional Tunnel:" Students are given a brief description of a regionally located tunnel, as well as a picture of the tunnel. The tunnel actually consists of two tunnels, one north-bound and one south-bound tunnel. One tunnel is rectangular in cross-section while the other is round. Students are formed into 3-person teams and asked to give a presentation on the history of the tunnel and to devise a series of age-appropriate math problems related to the tunnel (K-2, 3-5, 6-8 & 9-12). [*Some points of this activity are: (i) the value of using locally prominent items/structures in STEM activities, (ii) practice defining age appropriate problems/activities and (iii) connect Technology & Engineering to math (the circular tunnel was constructed more recently with a very different technology).*]

(2) "Olympics:" Students are given examples of a few countries and their performance in Summer Olympics over time. Students are asked to determine if there are any characteristics that might tend to explain how many total medals a country would win, and to verify their theories. They are also asked to comment on countries that break any trends. [*A countries <u>Population</u> and <u>Wealth</u> largely determine success in Olympics, with some clear exceptions. An exercise in applying logic to a practical situation, utilizing several mathematical methods.*]

(3) "Green Hall" Students need to estimate the height of the top of a weather vane (in

metric) located on top of the key administrative building on campus using only an English system tape measure, a ruler and any object(s) found "typically in nature." [*Practice using measurement and a variety of math (trig., scaling ... etc.) in the real world. This activity has been successful in showing the students that they are not so effective in applying simple math to applied situations because approximately 80% of the teams make substantial errors (see description later on in this section)*]

(4) "Bungee Barbie" Teams are given a Barbie doll and 5 large rubber bands and are asked, through experimentation, to determine how many bands will be needed to give Barbie a thrilling bungee drop off of an exposed parking garage wall without damaging her. There are approximately 10-13 bands required to produce a successful bungee drop. Students are asked to repeat the exercise for a substantially heavier Barbie, where her weight is increased by 30% by adding ballast. [*A popular activity stolen from a local community college math professor. This activity involves a lot of measurements and the ability to perform extrapolations (in Excel).*]

(5) "Tire Reliability" Students are asked to pretend to be an engineering team that is being paid handsomely to comment / educate a company on the reliability of a variety of their tires. Students are given large data sets (of time to failure) for one known reliable set of tires and three populations where their reliability is unknown. Teams are required to write a letter to their client summarizing their results. [*This is a modified version of a model-eliciting activity obtained from Purdue University, where we have reduced the math requirements. This activity is given late in the course, and is practice with the use of histograms and descriptive statistics to ascertain the traits of reliable behavior. The write-up for this activity is fairly extensive, often requiring a re-write due to the students not organizing their thoughts well enough in the letter to the client.*]

(6) "Married w/ Finances" Married teams of 2 are formed and asked to complete a variety of calculations using Excel that include income, expenses and savings over their lifetime. They are required to take on a mortgage for their purchased house, to have children, to send their children to college and to, hopefully, retire with enough money. [*This is a practical exercise in the exponential growth (or decrease) of money over time. This is typically a particularly emotional experience for many students because "financial realities" typically start to surface. (How much money will they need to retire or to send their children to college? How much money do they really spend to buy a $300,000 home?*]

Can students successfully apply math?

This course has been taught seven times since Spring-2007 with 15-26 students per class. The Green Hall activity has been completed every semester, and is implemented near the beginning of the course. We believe the results of this activity show how our students have difficulty in applying math. Students are asked to estimate the height of the top of the weather vane situated atop of a dome that is set back from the front of the building by ~40 feet. There is no restriction on what type of math is used to provide the height estimate but student teams are only allowed the use of basic measurement tools. Students typically use similar triangles and trigonometry to solve the problem. [By design, students are given the Green Hall problem immediately after we have completed a review of trigonometry. So, the intended "subliminal" inclination is for students to use trigonometry.] Out of 40 teams completing this activity approximately 80% make fairly fatal flaws in applying their math, leading to significant errors. By enlarge, the most common mistake is that the students only measure to the front of the building, so they do not obtain the proper length for one side of their large triangle. To estimate this amount of set-back, teams would need to walk over to the side of the building and measure how far back the weather vane is from the front of the building. Students are more than capable of "doing" the trigonometry processes correctly but are not nearly as successful at applying the math in a real-world context.

Characterization of math anxiety, and beliefs:

There were a series of assessments completed that pertain to the impact of the mathematical content and activities in our integrated STEM programs. Reviews of these assessments are presented below: (1) course surveys from an Engineering math course and (2) math anxiety & teaching beliefs.

(1) Engineering Math Course

A course that contains a high level of applied mathematical content and activities is the Engineering Math course. Moreover, this course is taken by the large majority of our K-5 MSTmajors and is required of our secondary STEM majors. It would therefore be very useful to characterize the impact of this specific course.

(a) Interest in subject

However, as a part of a standard survey taken in every course at our institution, students are asked about their "interest level in the subject matter." Even though these questions do not pertain directly to anxiety, they do give an indication of students' level of comfort/affect with the material. Over a period of 4.5 years this course was taken by 140 students (class sizes of 15-to-26). Specifically, students were asked to gauge their: (i) "Level of interest in the subject matter prior to the course" and (ii) "Level of interest in the subject matter after taking the course." Figure 3 shows the percentage of students, by semester, that expressed a high or very high level of interest in the subject matter before and after the course. These data indicate that the percentage of students that have a high-level of interest in the subject matter increases due to the course. This dynamic is better quantified by looking at the "conversion" percentage: "what percentage of those students that had a low or very low level of interest in the subject matter before the course "converted" to a high or very high level of interest after the course? These results are shown in Figure 4, and indicate that 20-35% of these "low interest" students are converted to "high interest" students. "Interest" in a subject matter is directly related to affect, and may also serve as a rough indicator of anxiety levels.

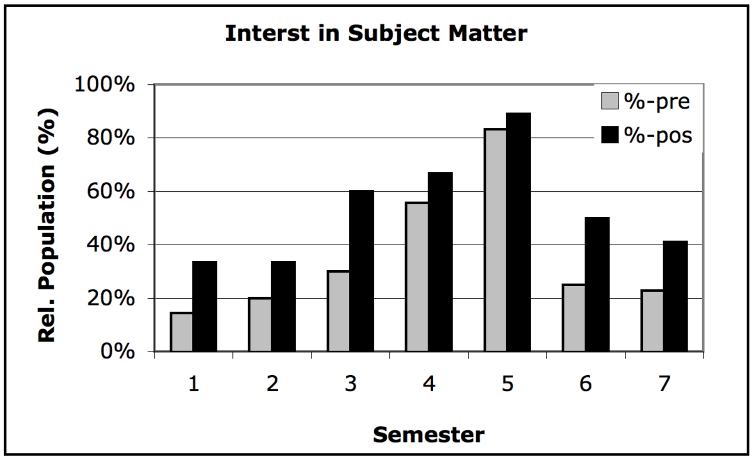

Figure 4 Percentage of students, by semester, that expressed a high or very high level of interest in the subject matter before and after the course. [N=140]

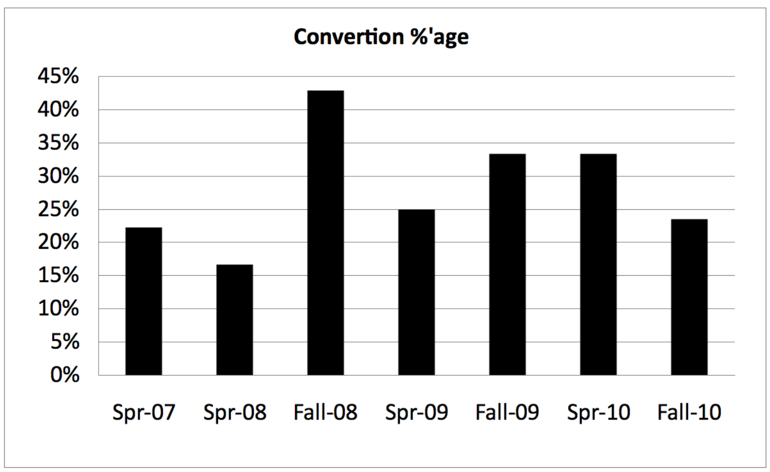

Figure 5 "Conversion" percentage of those students that had a low level of interest in the Engineering Math subject matter before the course "converted" to a high level of interest after the course

(b) Course surveys:
More recently a survey has been administered to Engineering Math students that assess in more detail their view of the course. These questions assess the students' opinions on (i) a "General" series of topics as well as (ii) "Anxiety/Nervousness." A total of 33 students have competed this survey, covering a period of two semesters.

The "General" statements were the following with possible answers of Strongly Agree, Agree, Neither Agree nor Disagree, Disagree and Strongly Disagree.

(a) This course was very useful in helping me become a better teacher.
(b) This course was very helpful in understanding how math is used to impact our human existence.
(c) This course will be very useful for me in the future for "everyday life" tasks.

(d) After this course my math skills are better.
(e) I would recommend this course to non-STEM K-5 education majors to help them become a better teacher.
(f) After this course my comfort with mathematical tasks is higher.

The responses to these general questions are summarized in Figure 8. Approximately 60-90% of the students either "Agreed" or "Strongly Agreed with the above 6 statements indicating that they think the mathematical skills they have learned are beneficial.

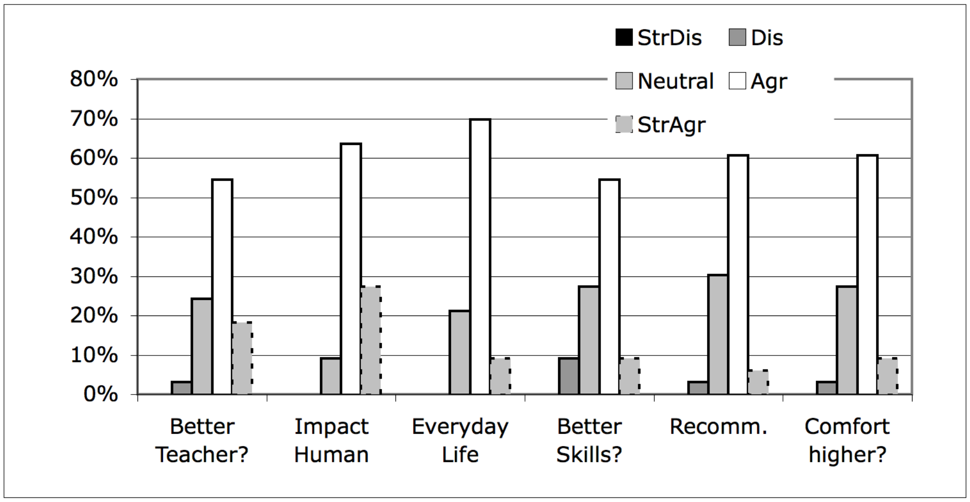

Figure 6 Percentage of those students reporting *Strongly Agree, Agree, Neither Agree nor Disagree, Disagree and Strongly Disagree* to a series of five questions [(a)-(e) above) after completing the Engineering Math course.

The "Anxiety/Nervousness" statements included in the survey are given below. The possible answers were Substantially Decreased, Decreased, Neither Increased nor Decreased, Increased and Substantially Increased.

(i) Due to this course, my anxiety/nervousness with respect to teaching mathematics to K-5 students has:
(ii) Due to this course, my anxiety/nervousness with respect to teaching mathematics to 6-8 students has:
(iii) Due to this course, my anxiety/nervousness with respect to teaching mathematics to 9-12 students has:
(iv) Due to this course, my anxiety/nervousness with respect to Mentoring grade 9-12 students in math:

The responses to these questions are summarized in Figure 6. Approximately 25-35% of the students responded with either "Substantially Decreased" or "Decreased" for the questions (i) through (iv), indicating that they think their anxiety/nervousness levels are being improved. Some students did record that they thought this course increased their level of anxiety to teach math. However, this was only more prevalent for the higher grade levels. For example, the difference between the "Decrease" and "Increase" in anxiety for teach levels were as follows by grade level: K-5 (23%), 6-8 (18%), 9-12 (5%). This may not be surprising since

70-80% of the students are the K-5 STEM students which are focused on grades K-5(8).

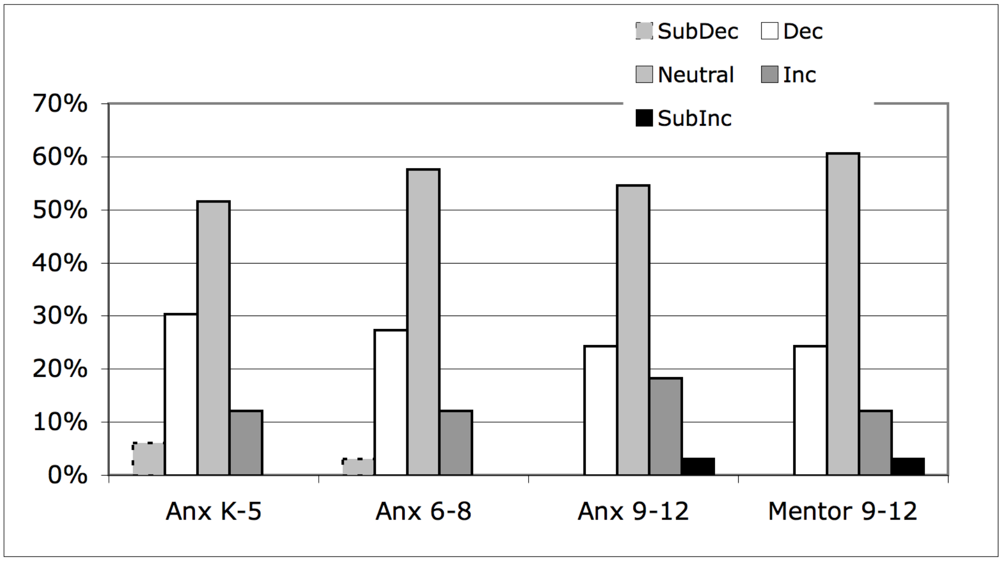

Figure 7 Percentage of those students reporting *Strongly Agree, Agree, Neither Agree nor Disagree, Disagree and Strongly Disagree* to a series of five questions [(i)-(iv) above] after completing the Engineering Math course.

(2) Anxiety & teaching beliefs:
A previously reported work indicated that the math anxiety of the K-5 MST majors drops dramatically, attaining a level that was substantially lower than the population of all non-STEM K-5 majors and a level that was statistically equal to K-5 Math majors.[1] These results imply that something in the integrated STEM program is having an effect on their math anxiety level. A similar phenomenon also occurs for math teaching self-efficacy.

To attain more depth in a subject area, the K-5 MST education majors are also required to pick one of three specializations [Math, Science or Technology/Engineering (T&E)], which requires more coursework in that subject area. An analysis of math anxiety of K-5 MST majors by specialization subcategory shows that the T&E specialization dominates the decrease in anxiety, even though the other specializations are math and science (requiring substantially more math and science).

Summary

This paper described details of the mathematical portion of the curriculum for two integrated-STEM teacher preparation programs at our institution. This level of mathematical content is, we believe, large compared to comparable teacher preparation program and likely has benefits. For example, even though our K-5 MST teacher candidates start out with modestly high math anxiety, after completing ~50% of their program, including both integrated-STEM content and a minimum of two math or math methods courses, their anxiety level drops to the same low level exhibited by K-5 Math majors. Surveys taken by students in an Engineering Math course, a course that contains a high level of applied math content compared to the rest of the T&E curriculum, suggests that affect/interest, anxiety and math skills are being substantially improved.

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