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Development of an Instrument to Assess Attitudes Toward Science, Technology,

Engineering, and Mathematics (STEM)

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Abstract

There is a need for more students to be interested in science, technology, engineering, and mathematics (STEM) careers to advance U.S. competitiveness and economic growth. A consensus exits that improving STEM education is necessary for motivating more students to pursue STEM careers. In this study, a survey to measure student (grades 4-6) attitudes toward STEM and STEM careers was developed and administered to 662 students from two STEM-focused and three comprehensive (non-STEM focused) schools. Cronbach's alphas for the whole survey and subscales indicated a high internal consistency. Statistically significant difference in means between students attending the STEM-focused and comprehensive schools on the two subscales of the survey and the overall survey were found. However, the explained variance for these results was approximately 1%. The survey is a useful tool to assess efficacy of STEM education programs on student attitudes toward STEM and STEM careers.

Development of an Instrument to Assess Attitudes Toward STEM

The need for more U.S. students to be involved in science, technology, engineering, and mathematics (STEM) careers has been extensively documented (National Science Board, 2007). Employment projections for occupation groups show that from 2010 to 2020 life science occupations (i.e., genetic scientists) will grow 20%, engineering occupations will increase 27%, and computer and mathematical occupations will grow 22% (Lockard & Wolf, 2012). Even though science and engineering bachelor's degrees represent about one-third of all bachelor's degrees awarded in the past 15 years in the U.S. (National Science Board, 2010), this number is not enough to fill the positions that are open. Thus, more graduates with STEM degrees will be needed in order to maintain America's competitive position in this global economy (National Science Board, 2007; President's Council of Advisors on Science and Technology, 2012). However, current reports show that interest in STEM subjects and careers among students is modest (Knezek, Christensen, & Tyler-Wood, 2011; President's Council of Advisors on Science and Technology, 2012). Thus, increasing students' learning of STEM subjects and practices and developing positive attitudes toward STEM have become major goals for K-12 STEM education in the U.S.

Students' attitudes toward STEM are an important factor influencing student motivation to learn STEM subjects and pursue a STEM career (Maltese & Tai, 2011). While there has been considerable research conducted about student attitudes toward science (Osborne, Simon, & Collins, 2003) and mathematics (McLeod, 1994), there is little research available about student attitudes toward technology and engineering. Furthermore, although a variety of valid and reliable instruments measuring student attitudes toward STEM learning are available (Blalock et

al., 2008), these instruments were developed to measure attitudes toward one of the STEM subjects; thus they follow the assumption that students learn STEM subjects only through traditional, separated STEM education.

Recently, several instruments have been developed to measure student attitudes toward all four STEM subjects at once; however, those instruments do not include items about integrated STEM education which focuses on merging the four STEM subject areas (e.g., Oh, Jia, & Lorentson, 2012; Sjaastad, 2012; Tyler-Wood, Knezek, & Chrstensen, 2010). While less attention has traditionally been paid to integrated STEM education and its effect on student attitudes toward STEM learning and careers that appears to be changing (National Research Council [NRC], 2009). A related question is whether there are differences in the attitudes of students from STEM-focused schools where integrated STEM education approaches commonly used and comprehensive (non-STEM-focused) schools where, in general, traditional STEM education approaches used.

Thus, the primary purpose of this study was to develop a new instrument designed to measure students' (grades 4-6) attitudes toward STEM, whereas a secondary purpose was to investigate differences among the attitudes of students' from STEM-focused and comprehensive schools.

Literature Review

Integrated STEM Education

The theoretical framework guiding the development of the survey in this study is the STEM integration research paradigm (Authors, in press a). Within this paradigm, STEM integration is defined by the purposeful merging of the disciplines of science, technology, engineering, and mathematics in order to: (1) deepen student understanding of STEM disciplines

by contextualizing concepts, (2) broaden student understanding of STEM disciplines through exposure to socially and culturally relevant STEM contexts, and (3) increase student interest in STEM disciplines to expand their pathways for students to entering STEM fields (Authors, in press a). This integration has national and international support ranging from policy documents such as national reports and state standards to research results that indicate integrated STEM is improving STEM education. For example, the National Council of Teachers of Mathematics (NCTM) challenges mathematics educators to teach their content in ways that engage students in meaningful, real-world settings (NCTM, 2000). Technologies (both digital and non-digital) are being increasingly integrated in mathematics (NCTM, 2000), science (NRC, 2012), and career and technical education (International Technology and Engineering Educators Association, 2007) settings. The recently published frameworks document for K-12 science education (NRC, 2012) states that "engaging in the practices of science and engineering during their K-12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today" (p. 9). Furthermore, the integration of STEM disciplines into K-12 education has the potential to markedly increase student interest, motivation, and achievement in these fields due to the relevance to real world problem solving (NRC, 2009). The goal of the development of the survey in this study was to operationalize the integrated nature of STEM in order to measure students' attitudes toward STEM and STEM integration.

Attitudes Research in STEM

Attitudes research in STEM has been mostly limited to attitudes toward each discipline separately. The following section will provide background on research done on student attitudes

toward each of the disciplines of STEM. This will be followed by a review of the limited research on attitudes toward STEM.

Attitudes research in science has a long history (Osborne, Simon, & Collins, 2003). The importance of attitudes has been increasingly recognized in recent years due to the decline in interest of students in pursuing science-related careers. During the last decade, several studies show how positive attitudes toward science lead students to pursue science careers (e.g., Maltese & Tai, 2011). The review of the literature shows that the term attitude has different meanings in those studies. For example, while some studies (e.g., Moore & Sutman, 1970) focus on "attitudes toward science" others (e.g., Atwater, Wiggins, & Gardner, 1995; Coulson, 1992; Wang & Berlin, 2010) focus on "scientific attitudes" (Osborne et al., 2003). There is a basic distinction between the two (Gardner, 1975). A scientific attitude can be defined as "an opinion or position taken with respect to a psychological object in the field of science" (Moore & Sutman, 1970). Items such as "The values of science lies in its theoretical products," "Scientific laws cannot be changed," "Scientific explanations can be made only by scientists" (Moore & Sutman, 1970, pp. 93-94) are included in scientific attitudes surveys. The meaning of an individual's attitude toward science involves feelings, opinions, beliefs, and likes toward the various aspects of the field of science (Krynowsky, 1988). According to Munby (1983), attitudes toward science careers, science instruction, and science at school can be included in the instruments. Items such as, "I like to do science experiments in class," "I usually understand what is taught in my science class," "The material in science textbook is hard for me" (Wang & Berlin, 2010, p. 2423) are commonly included in attitudes toward science instruments. Identifying which aspects of attitudes to measure is critical in designing valid and reliable instruments to measure student attitudes.

Over the past 40 years, research on student attitudes toward mathematics has been also subject to many studies (McLeod, 1994; Zan, Brown, Evans, & Hannula, 2006). The majority of the attitude studies in mathematics education focus on the relationship between student attitudes toward mathematics and achievement (Ma & Kishor, 1997). A few studies also show the influence of student attitudes toward mathematics on pursuing mathematically-related careers (e.g., Thorndike-Christ, 1991). As in the case of attitude research in science education, clarifying the concept and definition of attitudes is critical in developing valid and reliable instruments and interpreting research results in mathematics education research. According to McLeod (1994), during the first decade of research on attitudes toward mathematics, most studies focused on "students' responses to [mathematics] as taught in schools" (p. 637); however, "studies of attitudes soon broadened to include research on beliefs about mathematics and more intense emotional reactions to [mathematics]" (p. 637). As the conceptualization of attitudes in mathematics education has changed, complexity of issues investigated and measured by the studies have changed over time.

While attitude studies have always been one of the main research areas in science and mathematics education, studies of attitudes of students have recently started to receive attention in the areas of technology and engineering education. Since technologies, particularly digital technologies, have become fundamental tools in schools, more research concerning the student attitudes toward technology has begun to take place in the literature. Several instruments developed to measure K-12 students' attitudes toward digital technologies (e.g., Frantom, Green, & Hoffman, 2002). Measuring student attitudes toward digital technologies is critical in finding ways to assist students with concerns and anxieties about using digital technologies. When it comes to engineering, since engineering has recently become a part of national science education

standards (Achieve, 2013; NRC, 2012) and 37 states have included engineering either explicitly or implicitly in their science education standards (Authors, 2013), engineering education has become an emerging research area. However, the majority of the recent research on K-12 engineering focuses on the creation and implementation of engineering instructional materials and instructional practices. There are very few valid and reliable instruments that measure student attitudes toward engineering (e.g., Wright & Terry, 2010).

The above-mentioned studies are limited to assessing student attitudes toward science, mathematics, technology, or engineering, and they focused on traditional STEM education rather than integrated STEM education. In recent years, several instruments that are so called STEM attitude surveys have been developed and validated (e.g., Oh, Jia, Lorentson, & Labanca, 2012; Sjaastad, 2012; Tyler-Wood, Knezek, & Chrstensen, 2010). While items related to science, technology, engineering, and mathematics are included in these surveys, no specific items that measure student attitudes toward integrated STEM education were included. In this study, we developed an instrument to measure student attitudes toward traditional and integrated STEM education. Furthermore, in this study, attitudes toward STEM address STEM learning, STEM careers, and social implications of STEM.

STEM Integration in Schools

Student learning of STEM subjects is closely related to STEM programs and the schools that students attend. While conceptions of what STEM entails vary among researchers, educators, and policy makers, there are two commonly accepted approaches to STEM education (Breiner, Johnson, Harkness, & Koehler, 2012; Sanders, 2009). The first approach, traditional STEM education, views STEM as four separate fields taught as traditional disciplinary courses (science, mathematics, engineering, and technology). The second approach, integrated STEM education,

"includes approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (Sanders, 2009, p. 21). Importantly, the National Academies of Engineering (NAE) views engineering as a critical component of integrated STEM education and encourages K-12 teachers to use engineering as a vehicle to teach science, mathematics, and technology concepts (NRC, 2009).

Both traditional and integrated STEM education approaches are used in comprehensive (non-STEM focused) schools and STEM-focused schools in the U.S. The report *Successful K–12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics* report (NRC, 2011) defines three types of STEM-focused schools: selective STEM schools focus one or more STEM fields and accept highly talented and motivated students through a selective admission process; inclusive STEM schools are organized around one or more STEM fields but have no selective admission; and schools with STEM-focused career and technical education prepare students for STEM careers by allowing students to explore practical applications of STEM subjects. While much of the available research on student learning and teaching practices comes from comprehensive schools, research has been under way to shed new light on the nature and value of STEM education approaches used in STEM-focused schools and the impact of these schools on student STEM learning and attitudes toward STEM (NRC, 2011).

The Study

Development of the Survey

We followed a widely recommended approach to scale development outlined by DeVellis (2003). Initially, we reviewed the literature on STEM integration as well as current instruments that measure student attitudes toward STEM fields. This helped us to identify items that are

commonly measured (e.g., I enjoy learning science) and led us developing an initial pool of 28 items. To assess content validity, we sent the survey containing 28 items to two STEM specialists in K-5 schools, two K-12 teachers (one middle school and one elementary), and two educational researchers who conduct research on STEM integration in K-12 school settings. They reviewed the items for relevance, ambiguity, and similarity and provided recommendations to change or add items. As a result of these reviews, we reworded several items and added four new items. All responses to the 32 items were scaled from *Strongly Disagree* = 1 to *Strongly Agree* = 5.

Participants

Data were collected from 662 students in five schools (three STEM-focused, two comprehensive). For all respondents, participation was voluntary. Students filled out the survey during their science class or engineering class near the end of the school year and there was no missing data. Of the 662 students, 57 (8.6%) were 4th graders, 332 (50.2%) were 5th graders, and 273 (41.2%) were 6th graders (see Table 1). 69.4% (n=459) of the students attended regular comprehensive schools and 30.6% (n=203) of the students attended STEM-focused schools. [Table 1 inserted here]

Students were not randomly selected. In previous research work, we designed and implemented a year-long science and engineering integration workshop for teachers of grades 3-6 in 2010-2011 (Authors, in press b). Over 200 teachers participated in the workshop. Through convenience sampling, we identified ten teachers from this large group of participants. From ten teachers, five of them were willing to administer the survey to their students.

The five schools that participating students are attending are located in suburban areas of a Midwest state. While in all five schools students learn about STEM subjects, the approaches

used for STEM education are different. In comprehensive schools A, B, and C, students learn about engineering in science classes; a separate engineering class is not offered in these schools. Science and engineering are taught in the science classes, while mathematics and technology are taught at separate times. On the other hand, STEM schools A and B offer a separate engineering class in which students learn about engineering and engineering design processes. This class includes complete engineering challenges that are tied to grade level appropriate science and mathematics concepts and require students to use or develop technologies. Thus, in these two STEM schools, integrated STEM education approaches are used.

Data Analysis

Following recommended practice we computed descriptive statistics for each item to identify problematic features (e.g., ceiling or floor effect). We then examined the data for evidence of factors corresponding to the constructs used to guide item writing. We employed exploratory factor analyses (EFA) and initially computed Bartlett's test of sphericity ($\chi2 =$ 7078.3, degrees of freedom [df] = 496, p < .001) and the Kaiser–Meyer–Olkin measure of sampling adequacy (.892). These results suggested a factor analysis was appropriate (Comrey & Lee, 1992).

An important feature of EFA is that the variety of methodological choices can produce a factor structure that is highly dependent on these choices. Factor structures that appear across a range of methodological choice are likely to be more credible and useful. Thus our examination of the data employed multiple methods to assess the sensitivity of our results to specific methodological choices. Specifically, we (a) factor-analyzed both Pearson product-moment correlations (appropriate for continuous data) and polychoric correlations (appropriate for ordinal variables with relatively few categories) (b) used two widely recommended methods of factoring

(principal axis, maximum likelihood) (c) used two methods of rotation (varimax which assumes the factors are uncorrelated, oblique which allows factors to be correlated). The results of these analyses were similar except for some differences in factor loadings between varimax and oblique rotations but these did not substantially impact our efforts to identify and name factors. For simplicity, we report a single set of results based on the results of maximum likelihood factoring of Pearson correlations with varimax rotation (i.e., factors assumed to be uncorrelated).

Results

Factor Analysis Results

An initial factoring found eight factors with eigenvalues greater than 1.0, suggesting an eight-factor structure. However, an examination of the associated scree plot (Comrey & Lee, 1992) suggested a four-factor solution. Fitting models that extracted five, six, or seven factors produced similar results to those found for four factors in eigenvalues, fit tests, and factor loadings (correlation between each item and factor). Thus we fixed the number of factors at four.

Table 2 shows the factor loadings after varimax rotation (i.e., factors are uncorrelated). Items with loading of less than 0.40 on all factors were eliminated (Items 14, 15, 16, and 29). While there is no widespread agreement on a specific cutoff, using 0.40 means that only items in which $0.40^2 = 16\%$ of the variance in an item is explained by a factor were retained (Tabachnick & Fidell, 2012).

 [Table 2 inserted here.]

A total of 28 items were retained with a four-factor structure that is summarized in Table 2. Bolded loadings in Table 2 represent the primary factor an item loads on whereas non-bolded loadings represent a secondary factor. For example, item 1 loaded only on factor 1. Five items showed evidence of primarily loading on one factor but did not quite reach the cutoff of 0.40

(items 3, 6, 10, 13, and 31). However, we included these five items because conceptually they were consistent with other items reflecting factor 1, or 2. Items 23 and 25 were treated as loading on two factors.

Using the factor loadings results we identified four factors (i.e., subscales): (a) personal and social implications of STEM, (b) learning of science and engineering and the relationship to STEM, (c) learning of mathematics and the relationship to STEM, and (d) learning and use of technology.

The Cronbach reliability of the items for each subscale was 0.87 for factor 1 (13 items), 0.87 for factor 2 (11 items), 0.80 for factor 3 (3 items), and 0.77 for factor 4 (3 items). The Cronbach's alpha for the entire survey was 0.91. All of the reliabilities are above commonly acceptable levels and suggest that student responses to the survey show strong evidence of consistency.

Next we constructed factor scores on each of the four factors that represented a student's score weighted by the factor loadings (Tabachnick & Fidell, 2012). These were used to look for differences between grades and males and female. The absence of grade and sex effects would suggest there is no relationship between these variables and survey responses, a desirable outcome since ideally survey responses would be unrelated to a student's grade or sex.

Using an ANOVA and a Type I error rate of .05 the average factor scores of students did not vary across grades for subscales or the overall survey, suggesting (at least statistically) that grade differences can be ignored. Male and female students differed on the "Learning of science and engineering and the relationship to STEM" subscale ($F = 6.61$, $p = .010$) as well as the overall survey ($F = 6.13$, $p = .014$), but the fact that Sex explained only 1% of the variation in these scores suggests these effects are negligible.

School Comparison Results

We next used the factor scores to explore differences between students in STEM-focused vs. comprehensive schools. There was a statistically significant difference in means between students attending the STEM-focused and comprehensive schools on the "Personal and Social Implications of STEM" subscale (F = 5.89, p = .009), the "Learning of Science and Engineering and the Relationship to STEM" subscale (F = 5.17, p = .023), and the overall survey (F = 8.15, p = .004). Once again, however, the explained variance for these results was approximately 1% suggesting that the two types of schools did not differ on the survey in an important way.

Discussion

The purpose of this paper was to develop an instrument to measure attitudes of students toward STEM and STEM integration in STEM-focused schools and comprehensive schools. The results of the factor analysis and reliability analysis show that the survey developed in this study is a useful tool to measure students' attitudes toward STEM and STEM integration. Given the attention that has been paid to STEM education in the U.S. (National Science Board, 2007; President's Council of Advisors on Science and Technology, 2012), it is important to measure students' attitudes toward STEM. Results of the survey can be used to inform schools, programs, and STEM education approaches since student responses would provide information about STEM learning.

The survey developed in this study is different from the existing surveys that measure student attitudes toward STEM (e.g., Oh et al., 2012; Sjaastad, 2012; Tyler-Wood et al., 2010). For example, Tyler-Wood, Knezek, and Christensen (2010) developed the STEM Semantics survey that measures interest in STEM at the elementary and middle school level. This 25-item instrument includes five scales (science, technology, engineering, mathematics, and STEM

career interests) and each scale has five semantic perception adjective pairs. While the instrument is a useful tool to measure students' attitudes toward STEM, student responses do not provide information about students' perceptions about integrated STEM education since all items in the survey were written as students learn STEM subjects through traditional STEM education. The educational and career interest scale developed by Oh, Jia, and Lorentson (2012) measures high school students educational and career interest in STEM. The instrument includes 20 items. From 20 items, 12 items measure students' interest in science, mathematics, technology, and engineering, respectively while eight items assessed students' interest in STEM. However, after the authors conducted exploratory factor analysis, the three items related to engineering were removed since they did not load for a construct. Finally, Sjaastad (2012) designed and validated an instrument to measure significant persons' (e.g. mentor, self) influence on attitudes toward STEM. While the instrument was developed based on a strong theoretical model, it does not include items about STEM teaching and learning approaches. We believe that STEM teaching and learning approaches (traditional vs. integrated) hold important roles in students' attitudes toward STEM, thus we included several items that are related to STEM education approaches. Items related to STEM learning address either traditional STEM learning in which students explore STEM subjects as individual subjects or integrated STEM learning in which students explore STEM subjects through integrated approaches. The items that represent integrated STEM education included: "Learning engineering helps me learn science, mathematics, or technology," "Learning science helps me learn mathematics, engineering, or technology," "Learning mathematics helps me learn science, engineering, or technology," "Learning mathematics helps me learn science, engineering, or technology," and "To learn engineering, I have to be good at science and mathematics."

The study revealed four constructs (factors): personal and social implications of STEM, learning of science and engineering and the relationship to STEM, learning of mathematics and the relationship to STEM, and learning and use of technology. These constructs were expected since in STEM-focused schools engineering is integrated into science classes while mathematics and technology are taught as separate, individual subjects. In previous research, it has also found that student interest in or attitudes toward STEM is domain-specific (Oh et al., 2012; Tyler-Wood et al., 2010). While Oh et al. (2012) study revealed three constructs: educational and career interest in science, educational and career interest in mathematics, and educational and career interest in technology, Tyler-Wood et al. (2010) study revealed four constructs: science, engineering, mathematics, and technology. The reason the factors in the current study differ from those two might be that items related to integrated STEM education were included in the survey.

The results of the current study also indicated that students' from STEM-focused schools have more positive attitudes toward "Personal and Social Implications of STEM" subscale and "Learning of Science and Engineering and Relationship to STEM" subscale. This result implied that an integrated STEM education approach might have positive influences on students' attitudes toward STEM. As found in previous studies, students who have positive attitudes toward science at the middle school likely pursue a STEM career (Tai, Liu, Maltes, & Fan, 2006). The relationship of attitudes toward mathematics to career interest is also found very predictive of pursing a STEM career (Thorndike-Christ, 1991). Thus, it is critical to provide students a variety of quality experiences in their STEM education programs so that they hold interest in and positive attitudes toward pursuing a STEM career.

Conclusion

The study results show that the survey is appropriate to use with students in grades four to six. The reliability analysis of the survey indicates that all four factors that revealed (personal and social implications of STEM, learning of science and engineering and the relationship to STEM, learning and use of technology) have commonly acceptable levels of reliability. This survey provides researchers and educators a useful assessment tool to measure students' attitudes toward STEM and STEM integration

Implications and Future Research

Student responses to the survey would provide insight to school, program, curriculum, or instruction efficacy. For example, knowing about students' attitudes toward STEM would help classroom teachers know more about their students and use particular curriculum materials or employ specific instructional strategies to increase student interest in STEM fields and careers. In addition, the survey can be used to investigate how the attitudes toward STEM of subgroups (i.e., gender and ethnicity) vary. Given the attention that has been paid to increase participation of girls and underrepresented groups in STEM fields, it is critical to examine differences in STEM career interest by gender and ethnicity.

In this study, we compared STEM attitudes of students from comprehensive schools and inclusive STEM-focused schools. Future research that involves attitudes of students from selective STEM-focused schools, inclusive STEM-focused schools, career and technology education schools, and comprehensive schools would provide more insight to STEM education approaches used in these different schools and effects of those approaches on students' attitudes toward STEM. As the attention paid to STEM education increases, more research is needed to find what can be done to support effective STEM education (NRC, 2011).

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Table 1

School and Student Demographics

School Type	Number of Students	Grade Level Assessed	Ethnicity (% non-white)	Free/reduced lunch
Comprehensive School A	203	6	24%	20%
Comprehensive School B	205	4-6	55%	56%
Comprehensive School C	51	5	88%	90%
STEM School A	77	5	53%	47%
STEM School B	126	5	20%	18%

Source for ethnicity and free/reduced lunch information: National Center for Educational Statistics, U.S. Department of Education

Table 2

Rotated Factor Matrix

Items	Factor			
	1	2	3	4
18. It is important to know science in order to get a good job.	**.710**			
22. It is important to know engineering in order to get a good job.	**.686**			
24. It is important to know digital technologies in order to get a good job.	**.639**			
20. It is important to know mathematics in order to get a good job.	**.581**			
27. Science, technology, engineering, and mathematics make our lives better.	**.544**			
32. Science, technology, engineering, and mathematics are very important in life.	**.542**			
26. Having a job that involves science, mathematics, engineering, or technology would help me to be successful in life.	**.517**			
30. Science, technology, engineering, and mathematics are good for the future of our country.	**.484**			
28. The benefits of science, technology, engineering, and mathematics are greater than any harmful effects that they may have.	**.464**			
25. I would like to have a job that involves science, mathematics, engineering, or technology.	**.461**	.421		
10. To learn engineering, I have to be good at science and mathematics.	**.378**			
31. When something new is discovered, I like to learn about it quickly.	**.359**			
7. I enjoy learning engineering.		**.762**		
8. I am good at engineering.		**.679**		
21. I am interested in taking more classes that involve engineering.		**.660**		
1. I enjoy learning science.		**.578**		
9. Learning engineering helps me learn science, mathematics, or technology.		**.560**		
17. I am interested in taking more classes that involve science.		**.545**		
2. I am good at science.		**.420**		
3. Learning science helps me learn mathematics, engineering, or technology.		**.379**		
6. Learning mathematics helps me learn science, engineering, or technology.		**.366**		
13. Using technology helps me learn science, mathematics or engineering.		**.349**		
4. I enjoy learning mathematics.			**.804**	
5. I am good at mathematics.			**.704**	
19. I am interested in taking more classes that involve mathematics.			**.696**	
12. I am good at using technology.				**.802**
11. I enjoy learning to use technology.				**.569**
23. I am interested in taking more classes that involve technology.	.410			**.504**