EXPLORING MIDDLE SCHOOL STUDENTS' ATTITUDES AND INTEREST IN TECHNOLOGY, ENGINEERING AND MATHEMATICS SUBJECTS

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Exploring Middle School Students' Attitudes and Interest in Technology, Engineering and Mathematics Subjects

Synopsis:

This paper focuses on data collected as part of a larger longitudinal mixed-methods study exploring the impact of STEM outreach workshops, and highlights gender differences in students' attitudes and interest in mathematics, technology, and engineering topics.

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Introduction and Objectives

Science, technology, engineering, and mathematics (STEM) education is critical to and supportive of many education reforms being undertaken today. STEM is not a separate reform movement; rather, it is an emphasis which stresses a multidisciplinary approach for a) better preparing all students in STEM subjects, and b) increasing the number of postsecondary graduates who are prepared for STEM occupations (Conference Board of Canada, 2013; National Research Council, 2013). A major goal of the STEM agenda is to improve the proficiency of all students in STEM, despite their choice not to pursue STEM careers or postsecondary studies. Currently, Canada's participation in STEM education at the postsecondary level is awarded a C grade, based on Canada's relatively low proportion of graduates in these fields (Orpwood, Schmidt, & Jun, 2012). There is general consensus that one of the origins of these trends resides in STEM preparation in the early grades, specifically at the elementary level. Thus, elementary science education has come under increased attention as educators, researchers, and policy makers have united around the notion of the important foundational role elementary science plays in later success in STEM education (Duschl, Schweingruber, & Shouse, 2007). Issues with inadequate STEM preparation in the early grades ultimately play a role in high school course choices, and ultimately post-secondary and career choices (DeCoito, 2015).

Through half-day STEM workshops, this longitudinal study explores the effectiveness of outreach programs in terms of their potential to affect STEM interest in the early grades This paper addresses student attitude and interest in mathematics, technology, and engineering topics across grades 6, 7 and 8.

Theoretical Framework

There are many factors affecting STEM preparation in the early grades. For example, failure to motivate student interest in math and science is prevalent in most K–12 systems, as math and science subjects are disconnected from other subject matter and the real world, and students often fail to see the connections between what they are studying and STEM career options (AAAS, 2001; Singh, Granville, & Dika, 2002) . Most of what students learn about the real-world connections to math and science is relegated to the once-a-year field trip to a museum or planetarium. Yet these students rely on technology every day in smart phones, computers, and televisions without understanding the underlying connections to math and science. Helping students see the connections between math and science and future career opportunities is a critical aim of the STEM pipeline (Blickenstaff, 2005; Maltese & Tai, 2011). Motivating interest in math and science requires improved teaching strategies in the classroom and opportunities outside the classroom to demonstrate linkages between math and science, real-world applications, and future careers (Singh, Granville, & Dika, 2002; Tella, 2007).

Clearly, determining factors that lead to better STEM preparation is important, including programs and initiatives to encourage students to continue their studies in mathematics and science and to consider careers in engineering, science and technology (Rahm, Martel-Reny, & Moore, 2005). There has been widespread support for outreach programs and informal learning opportunities STEM enrichment (Thomasian, 2011). Outreach programs provide valuable experiences that ignite interest and demonstrate how math, technology, engineering and science connect to everyday life and careers, and allow students and teachers to expand their skills through inquiry processes.

Method

A mixed-methods design (Mills, Durepos, & Wiebe, 2010) was utilized for this longitudinal study to answer specific research questions related to STEM outreach. The Middle School (6-8th) Student Attitudes toward STEM Surveys (S-STEM - validated and tested for reliability through the National Science Foundation (Erkut & Marx, 2005)) consist of Likert-scale questions probing students' confidence and attitudes toward math, science, engineering and technology, and 21st century learning respectively. Final items in the surveys explore students'

attitudes toward 12 different STEM career areas. The larger study included teachers, students, and administrators from 83 grade 6, 7, and 8 classrooms (approximately 1980 students) in 4 schools in a local school board. Data sources included pre-post S-STEM surveys; workshop observations; and student reflections on workshops. Surveys were administered at the beginning and end of the school year. Survey data were analysed using ANOVA and descriptive statistics in SPSS. This paper focuses on student survey data in Phase I of the study and explores student attitude and interest in mathematics, technology and engineering topics amongst middle school students.

Findings

Math

The Math section of the S-STEM asks students to consider their self-efficacy in math, including their grades, ability to tackle advanced problems, and their general level of ability. The average of students' scores on both the pre- and post-survey are reported in Table 1.

Table 1   *Students' average pre- and post-scores on the Math section of the S-STEM at both time points*

	Pre-Survey			Post-Survey		
	Mean	SD	Variance	Mean	SD	Variance
Overall	3.5742	.73434	.539	3.5700	.91261	.833
Male	3.569	0.7459	0.556	3.719	0.8804	0.775
Female	3.580	0.7218	0.521	3.406	0.9199	0.846
Grade 6	3.61	0.7692	0.592	3.539	0.9151	0.837
Grade 7	3.519	0.7179	0.515	3.569	0.8849	0.783
Grade 8	3.6	0.7094	0.503	3.607	0.9434	0.89

The main effect for Math score by gender was statistically significant ($F(1, 1642) = 23.728$, $p<$ .001). Overall, male students (M=3.643, SE=.020) scored higher than their female peers (M=3.502, SE=.021). There existed no significant change in students' Math scores over time ($F(23, 1642) = .085$, $p =.771$). Only gender was shown to have a significant impact on Math scores across time ($F(1, 1642)=34.234$, $p<.001$) (Figure 1). Although male and female students had relatively similar scores at the first time point, male students have significantly higher scores

at the second time point ($F(1, 1642)=47.891$, $p<.001$). Both male and female students' scores changed significantly over time. Male students' scores increased significantly ($F(1, 871)=14.345$, $p<.001$), while female students' scores decreased significantly ($F(1, 793)=17.556$, $p<.001$). Figure 2 depict changes in students' scores divided by grade. No single grade showed a significant change in scores over time.
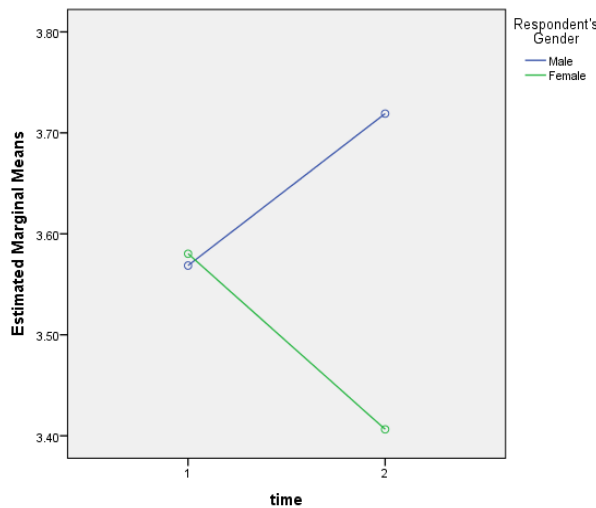

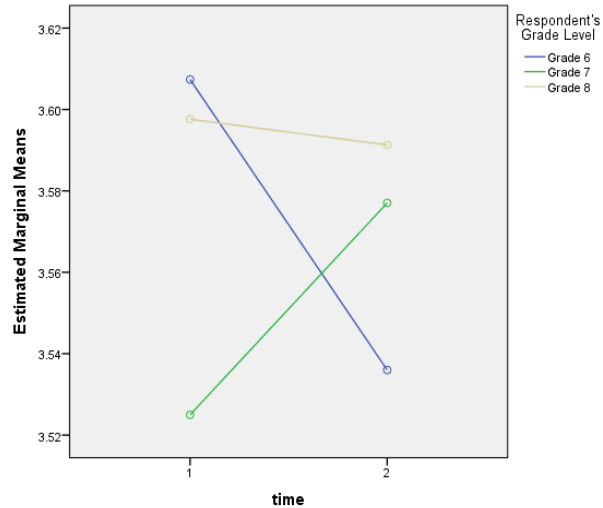*Figure 1*. Change in students' Math scores over time, by gender.

Figure 2. Changes in students' Math scores over time, by grade. No significant changes over time

Engineering and Technology

The Engineering and Technology section of the survey is the only section which provides students with a description of what it means to be an engineer or a technologist. The nine items then probe students' interest in various aspects of engineering and technology fields, such as electronics, designing, building, and fixing things, and the mathematics knowledge required to be successful in these fields. The average of students' scores is provided in Table 2.

Significant main effects were found for both grade, and gender. Ignoring effect of gender, grade level had a statistically significant effect on students' Engineering and Technology scores ($F(3, 1642) = 3.335$, $p =.036$). However, no significant difference exists between any pair of grades. The main effect of gender was also statistically significant ($F(1, 1642) = 64.841$, $p < .001$). At both time points, male students ($M=3.773$, $SE=.019$) scored higher than their female

peers (*M*=3.547, *SE*=.020). Additionally, there exists a significant interaction effect for grade and gender (*F*(2, 1642)=6.030, p=.002).

Table 2 *Students' average pre- and post-scores on the Engineering and Technology section of the S-STEM at both time points*

	Pre-Survey			Post-Survey		
	Mean	SD	Variance	Mean	SD	Variance
Overall	3.6968	.80454	.647	3.6427	.81178	.659
Male	3.680	0.8228	0.677	3.864	0.7892	0.623
Female	3.715	0.7842	0.615	3.399	0.7657	0.586
Grade 6	3.703	0.8596	0.739	3.665	0.8376	0.702
Grade 7	3.73	0.7562	0.572	3.656	0.8148	0.664
Grade 8	3.646	0.7944	0.631	3.599	0.7763	0.603

There is a significant change in students' Engineering and Technology scores over time, and pre-scores (*M* =3.697, *SD*=.8045) were significantly higher than post-scores (*M*=3.643, *SD*=.81178) (*F*(1, 1642) = 6.025, *p*=.014). Gender had a significant impact on Engineering and Technology scores across time (*F*(1, 1642) = 90.660, *p*<.001), although grade level did not (*F*(1, 1642) = .106, *p*=.900). Changes in the average scores are depicted in Figures 3 and 4. No significant interaction effects existed between any of the groups across time.
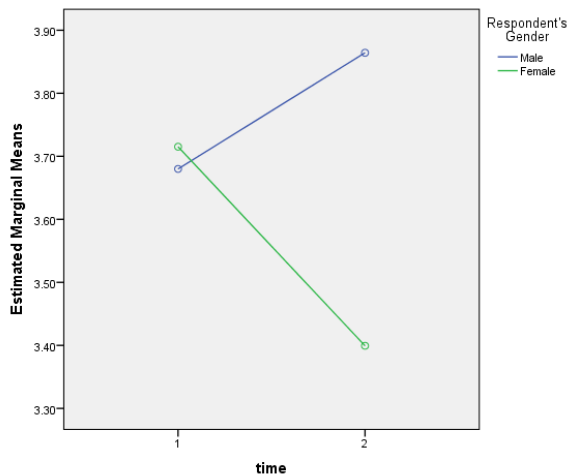

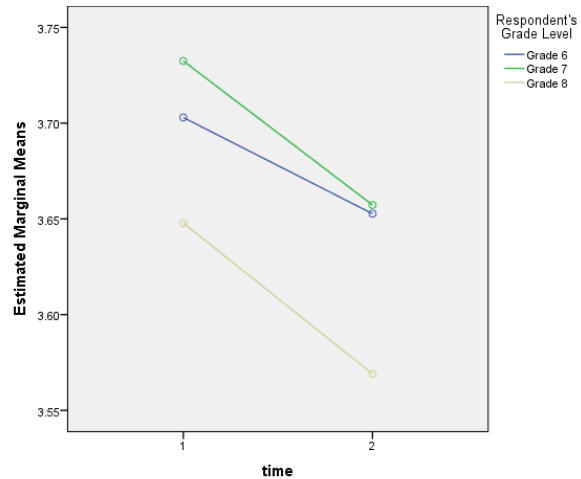*Figure 3.* Changes in students' Engineering and Technology scores over time, by gender

Figure 4. Changes in students' Engineering and Technology scores over time, by grade

Conclusions and Educational Implications

The findings of this portion of the study clearly illustrate the need for curricula that reflects integrated STEM education and professional development initiatives addressing pedagogy and content in STEM education. In addition, the importance of career awareness in STEM fields in the early grades should be highlighted. As the findings indicate, there is a gender disparity in terms of attitude and interest in STEM related areas, as well as across the grades. This study has shed some light on the potential of outreach programs to address middle school students' attitudes and interest in STEM education. We hope that over this longitudinal study, with the implementation of STEM outreach workshops over the years, student attitude and interest in STEM education will improve, especially in female students. Additional phases of the study will include interviews, which will shed more light on the quantitative data collected in the study.

References

American Association for the Advancement of Science (AAAS) (2001). *American Association for the Advancement of Science: Project 2061*. Washington, D.C: Author.

Blickenstaff, J. C. (2005). Women and science careers: Leaky pipeline or gender filter. *Gender and Education*, *17*(4), 369-386.

Conference Board of Canada (March 2013). *Education and Skills: Percentage of Graduates in Science, Math, Computer Science, and Engineering*. Retrieved from http://www.conferenceboard.ca/hcp/default.aspx

DeCoito, I. (2015). *A Longitudinal Study: Investigating the Impact of an Outreach Program on Students' Future Course Selection and STEM Career Choices*, *Phase I*. London: Western University. (170 pages)

Duschl, R., Schweingruber, H., & Shouse, A., (Eds.). (2007). *Taking Science to School: Learning and Teaching Science in Grades K-8*. Washington, DC: National Academies Press.

Erkut, S., & Marx, F. (2005). 4 schools for WIE (Evaluation Report). Wellesley, MA: Wellesley College, Center for Research on Women. Available at: http://www.coe.neu.edu/Groups/stemteams/evaluation.pdf

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: The effects of school experiences on earning degrees in STEM. *Science Education, 95*(5), 877-907.

Mills, J.M., Durepos, G., & Wiebe, E. (2010). *Encyclopedia of Case Study Research*. Thousand Oaks: Sage Publications Inc.

National Research Council (NRC) (2013). *Monitoring Progress Toward Successful K-12 STEM Education. A Nation Advancing?* Washington, DC: National Academies Press.

Orpwood, G., Schmidt, B., & Jun, H. (2012). *Competing in the 21st Century Skills Race*. Ottawa: Canadian Council of Chief Executives.

Rahm, J., Martel-Reny, M. P., & Moore, J. C. (2005). The role of afterschool and community science programs in the lives of urban youth. *School Science and Mathematics, 105*(6), 283-291.

Singh, K., Granville, M., & Dika, S. (2002).Mathematics and Science Achievement: Effects of Motivation, Interest, and Academic Engagement. *The Journal of Educational Research, 95*(6), 323-332.

Tella, A. (2007). The Impact of Motivation on Student's Academic and Learning Outcomes in Mathematics among Secondary School Students in Nigeria. *Eurasia Journal of Mathematics, Science, & Technology, 3*(2), 149-156.

Thomasian, J. (2011). *Building a Science, Technology, Engineering, and Math Education Agenda.* New York: NGA Centre for Best Practices.