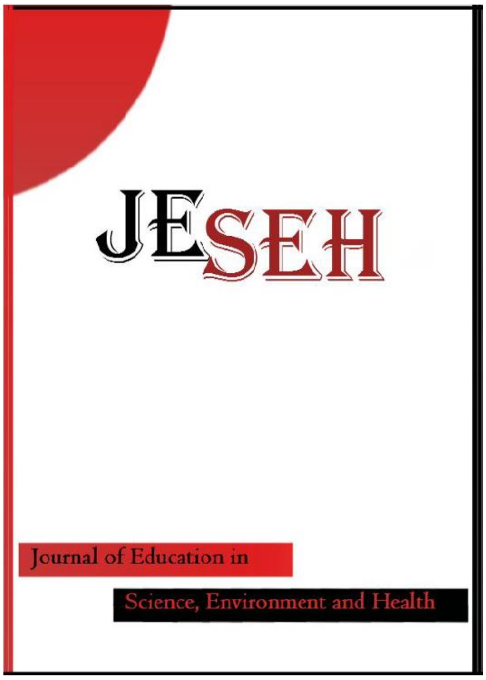

ISSN: 2149-214X

Journal of Education in Science, Environment and Health

www.jeseh.net

Relationship of Middle School Student STEM Interest to Career Intent

Rhonda Christensen, Gerald Knezek
University of North Texas

To cite this article:

Christensen, R. & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science, Environment and Health (JESEH), 3*(1), 1-13.

Journal of Education in Science, Environment and Health
Volume 3, Issue 1, 2017 ISSN: 2149-214X

Relationship of Middle School Student STEM Interest to Career Intent

Rhonda Christensen, Gerald Knezek
University of North Texas

Article Info

Article History

Received:
01 April 2016

Accepted:
16 August 2016

Keywords

STEM Education
STEM interest
Career intent
Gender
Climate change

Abstract

Understanding middle school students' perceptions regarding STEM dispositions, and the role attitudes play in establishing STEM career aspirations, is imperative to preparing the STEM workforce of the future. Data were gathered from more than 800 middle school students participating in a hands-on, real world application curriculum to examine the relationship of the students' interest in STEM and their intentions to pursue a career in a STEM field. Among the middle school students who completed surveys for the MSOSW project, 46.6% expressed a desire to pursue a career in STEM at the time of the post test. Regarding alignment of positive interest in STEM with intent to purse a STEM career, middle school students who have stated that they plan to pursue a career in STEM, also show higher dispositions toward STEM and STEM career measures. Gender differences were also examined, resulting in the finding that middle school males generally have greater intent to pursue a career in STEM, and also show more positive interest in STEM areas. However, females appear to more positively react to the project activities presented in this study than males, so over the course of a project year females tend to "catch up." This is true regarding assessed STEM interest as well as stated intent to pursue a career in STEM. These findings provide additional contributions to the growing base of knowledge about the importance of middle school aspirations for STEM careers.

Introduction

A recent study by the American College Testing service (ACT) found a large gap between student interest in Science, Technology, Engineering and Mathematics (STEM) subjects and the intent to take difficult courses required for a STEM major and obtain a job in the chosen field (ACT, 2015). ACT researchers observed that far too many STEM-interested students are not well prepared to succeed in the rigorous college math and science coursework required of STEM majors. Teachers and curriculum can influence both proficiency and interest in STEM content. Researchers at the Donahue Institute at the University of Massachusetts analyzed effective programs aimed at increasing student proficiency and interest in STEM careers and found that among the common characteristics were challenging, hands-on, real-world learning activities mediated by an engaged, knowledgeable teacher (Bouvier, 2011). Proficiency and interest in STEM must be initiated before students reach secondary school and begin choosing their courses. The authors of the study presented in this paper have been assessing middle school student interest in STEM content and careers for six years. The purpose of this paper is to contrast middle school interest in STEM with intent to pursue a STEM career, in hopes of shedding further light on the types of gaps between interest and intent that exist at the middle school level.

Literature Review

Research on the relationship between student interest in and the pursuit of STEM careers has increased in recent decades. One reason for the lack of the pursuit of STEM careers is that students may lack exposure to the career possibilities in the STEM fields at an early enough age and therefore lack the information they need to consider a career in a STEM field. Various strategies for connecting early interest in and pursuit of STEM careers include project-based and hands-on learning that involve personal and real world relevance (Christensen & Knezek, 2015). One study concluded that students do not see science as being personally relevant to them and need opportunities for career awareness to realize that a career in science is a viable option (Palmer, 1997).

One study seeking to determine a link between elementary students' perceptions and career interests included both student drawings of a scientist as well as student interviews (Buldu, 2006). While the researcher examined the sterotyping of scientists, the conclusion was that student images of a scientist are important indicators of their future plans regarding science (Buldu, 2006). Related research with middle school students found that their occupational preferences and career aspirations are strongly linked to their images of careers (Gottfredson, 1981). Using data from the National Educational Longitudinal Study (NELS), Tai, Liu, Maltese and Fan (2006) found that students who indicated an interest in a career in science when they were in middle school were three more times likely to graduate from college with a science degree.

A study conducted by the Girl Scouts of America compared females interested in STEM fields to those who were not interested in STEM fields. The researchers (Modi, Schoenberg, & Salmond, 2012) found that those who were interested in STEM fields were higher achievers, betters students, had stronger support systems and had exposure to STEM fields. Other factors that have been shown to influence females' perceptions of pursuing a career in STEM are stereotypes regarding performance in mathematics and science areas (Walton & Spencer, 2009; Nguyen & Ryan, 2008) social and cultural cues that discourage girls (Bisland et al., 2011), as well as a lack of confidence in the ability to persevere through difficult material (Dweck, 2006; Halverson, 2011).

This study was guided by the following research questions examined within the context of the pre-post, treatment versus comparison group context of the Going Green! Middle Schoolers Out to Save the World (MSOSW) project:

1. What level of STEM career interest exists among middle school students in the Going Green! MSOSW Project?
2. To what extent is intent to have a career in STEM aligned with interest in STEM for MSOSW students?
3. What differences in level and alignment are attributable to intervening variables such as gender?

Method

Environment for STEM-Focused Intervention

The Going Green! Middle Schoolers Out to Save the World (MSOSW) project has the primary goals of developing middle school students' interest in STEM content areas and raising students' perceptions and attitudes toward STEM careers. MSOSW aims to direct middle school students' enthusiasm for hands-on activities toward long-term interest in STEM while guiding them to solve real-world problems. Students in this project were instructed by their teachers to use energy monitoring equipment to audit standby power consumed by electronic devices in their homes and communities.

Standby power (also called "vampire power") is the electricity consumed by many appliances when they are plugged in but "turned off" (U.S. Department of Energy, 2011). Many appliances consume some electricity while not performing any useful function. Televisions, game consoles, home computers, coffee makers and microwaves are a few of the appliances that commonly consume standby power. The U.S. Department of Energy has estimated that over the lifetime of a typical home appliance, 70% of the power consumed will be when the appliance is turned off (U.S. Department of Energy, 2011). During MSOSW project activities, sixth and seventh grade students learned to measure the vampire power consumption of various appliances in their homes. After measuring standby power, students gathered their data together with classmates in spreadsheet projections to explore energy conservation plans that could lower a family's monthly electric bill and reduce the greenhouse gas emissions that contribute to global climate change. Students shared their results with other participating middle school students from across the United States by contributing to a shared project wiki.

Participants

Data were gathered from treatment and comparison students during the 2013-2014 school year. Pre test data were gathered from 813 students at the beginning of the school year primarily during September – October. When treatment groups completed their unit, these students completed the post test surveys. Comparison students provided post test data in April and May of 2014. Post test data were received from 916 students. Gender distribution was almost equal between males and females with 53.9% males and 46.1% females. A slightly increased percentage of females were among the completed surveys at post test time, compared to pre test time, with 51.9% males and 48.1% females at the time of post test data collection. Male versus female post test data percentages were very close to the U.S. national distribution of 51.2% male and 48.8% female published for the age group 10-14 years in the 2010 U.S. Census (2010).

Instrumentation

The instruments used in this study were the STEM Semantic Survey and the Career Interest Questionnaire (CIQ) and are included in the appendices. The survey battery also included one item to capture students' interests in pursuing specific types of STEM careers. MSOSW participants selected one choice from the following career-oriented question: I plan to have a career in: (1) Science, (2) Technology, (3) Engineering, (4) Mathematics, (5) Other. In addition, demographic items including gender were gathered from the participants.

STEM Semantic Survey

The STEM Semantics Survey was adapted from Knezek and Christensen's (1998) Teacher's Attitudes Toward Information Technology Questionnaire (TAT) derived from earlier Semantic Differential research by Zaichkowsky (1985). The five most consistent adjective pairs of the ten used on the TAT were incorporated as descriptors for target statements reflecting perceptions of Science, Math, Engineering and Technology. A fifth scale representing interest in a career in Science, Technology, Engineering, or Math (STEM) was also created.

Internal consistency reliabilities for the five scales of the STEM Semantics Survey typically range from Alpha = .90 to Alpha = .94 for students such as those participating in this study (Tyler-Wood, Knezek & Christensen, 2010). These reliability estimates fall in the range of "excellent" according to guidelines provided by DeVellis (1991). The five scales had five items each and each item was presented as semantic adjective pairs (fascinating: mundane; exciting: unexciting; and so forth) to describe STEM dispositions and career attitudes.

Career Interest Questionnaire (CIQ)

The Career Interest Questionnaire (CIQ) is a Likert-type (1 = strongly disagree to 5 = strongly agree) instrument composed of 13 items on three scales. This instrument was adapted from a longer instrument developed for a Native Hawaiian Studies project promoting STEM interest in Hawaii (Bowdich, 2009). The subscales of the CIQ document students' perceptions of being in an environment that is supportive of science careers (four items, referred to as Interest), students' intent to pursue educational opportunities that would lead to a science career (five items, referred to as Intent), and the perceived importance of science careers overall (four items, referred to as Importance).

Cronbach's alpha for the CIQ typically ranges from .70 to .93 across subscales (Christensen, Knezek, & Tyler-Wood 2014), and thus falls in the range of "respectable" to "excellent" according to guidelines by DeVellis (1991). Internal consistency reliability for the overall 13-item instrument typically approaches or surpasses .90.

Aspirations for STEM Careers

In addition to the instruments described, one item was also included to capture students' interests in pursuing specific types of STEM careers. MSOSW participants selected one choice from the following career-oriented question: *I plan to have a career in: (1) Science, (2) Technology, (3) Engineering, (4) Mathematics, (5) Other.* For analysis purposes of the paper, data were recoded as STEM and non-STEM interest in a career by coding any of the individual STEM areas as STEM and the "Other" as non-STEM.

Survey Instrument Reliabilities

Cronbach's alpha for the scale reliabilities are listed in Table 1. The reliabilities for pre and post were similar for this group of students with slightly less reliability for post test (end of year). The STEM Semantic scales ranged from .85 to .90 at pretest time. The CIQ parts ranged from .79 to .93 at pretest time.

Table 1. Instrument reliabilities by scale for pretest and posttest

	No. Items	Pretest	Posttest
STEM Semantics Survey			
Science STEM	5	.87	.88
Technology STEM	5	.85	.86
Engineering STEM	5	.90	.90
Mathematics STEM	5	.87	.87
Career STEM	5	.90	.89
Career Interest Questionnaire			
CIQ Part 1	4	.85	.83
CIQ Part 2	5	.93	.92
CIQ Part 3	4	.79	.74
CIQ All			

Results and Discussion

Research Question 1: Level of Interest and Intent

Among the middle school students who completed surveys for the MSOSW project, 44.9% (n = 365 / 813) expressed a desire to pursue a career in STEM at the time of the pretest, while 46.6% (n = 427 / 916) expressed a desire to pursue a career in STEM at the time of the post test. Thus one answer to research question one is that 45-47% of middle school students stated they plan to have a career in science, technology, engineering, or mathematics, when presented with a choice of selecting one of these four STEM areas, or "other".

The corresponding middle school student dispositions toward a career in STEM were captured in their Semantic Differential ratings of "To me, a career in STEM is …" on a 1 (least positive) to 7 (most positive) scale. At the time of the pretest, the mean rating for the 813 respondents was 4.93 (STD = 1.62) while at the post test time the mean rating for the 916 respondents was 5.02 (STD = 1.50). Since the middle (neutral) rating on a 7-point Semantic Differential scale is 4.0, the mean ratings of 4.93 at pretest and 5.02 at post test both represent slightly positive dispositions toward a career in STEM.

If we accept "I plan to have a career in science, technology, math, or engineering" as a middle school student's indication of intent to have a career in STEM, and we accept the Semantic Differential STEM disposition as a middle school student's indication of interest in a career in STEM, then we can formulate expected values (most probable occurences) for any one student for each. In particular, the expected *interest* in STEM for any one student in the MSOSW data sample is slightly positive (upper edge of 4/6 possible intervals = 66th percentile), while the expected *intent* that any one student in the MSOSW data sample plans to have a career in STEM is less than 50%.

Research Question 2: Alignment of Interest with Intent

Research question two addresses the extent to which intent to have a career in STEM is aligned with interest in STEM. This is first addressed through analysis of variance to examine whether the STEM dispositions of middle school students who stated they plan to have a career in STEM, are more positive than the dispositions of those who indicated preference for a career other than STEM.

Overall ANOVA for STEM Career Planned vs. Other

When assessed at the aggregate data level (treatment and comparison, pre and post combined), large differences were found between group means for students who identified themselves as planning to have a career in STEM versus those who did not. These differences were significant ($p < .0005$) on all eight STEM disposition indices gathered from the STEM Semantics and the CIQ. This finding encouraged the research team to examine whether hypothesized differences based on project objectives, such as pre-post changes in STEM dispositions, and treatment versus comparison effects, might be influenced by whether or not the student participants viewed themselves as STEM career candidates. The research team also sought to examine whether participation in project activities influenced student interest in STEM as a Career. These issues will be examined in this section.

ANOVA Comparing STEM Career Planned vs. Other, Pre and Post.

Tables 2 and 3 contains results of analysis of variance of STEM disposition data from all Going Green! MSOSW students at the pretest time, before any of the students had participated in project activities, and also an analysis at post test time. As shown in Tables 2 and 3, at the pretest time, students who indicated they were interested in a career in STEM were significantly (p < .0005) more positive on all eight recorded STEM-related measures. At the post test time, all eight measures remained more positive (p < .001) for students who indicated they planned to have a career in STEM. This can be viewed as a form of cross-validation of the single-item indicator of career intent, in that high dispositions toward STEM would be expected to accompany intent of interest in STEM as a career. These findings are graphically displayed in Figures 1 and 2.

Table 2. Oneway analysis of variance for non-STEM versus STEM pre and post on STEM semantic measures

		Pretest				**Posttest**			
		N	Mean	SD	Sig	N	Mean	SD	Sig
STEM Science Scale	NonSTEM	447	4.54	1.52		488	4.69	1.44	
	STEM	364	5.28	1.34		426	5.35	1.35	
	Total	811	4.87	1.49	.000	914	4.99	1.43	.000
STEM Math Scale	NonSTEM	445	4.27	1.60		483	4.22	1.59	
	STEM	363	4.72	1.60		426	4.57	1.63	
	Total	808	4.48	1.61	.000	909	4.39	1.62	.001
STEM Engineering Scale	NonSTEM	445	4.38	1.51		480	4.31	1.58	
	STEM	363	5.36	1.49		423	5.19	1.53	
	Total	808	4.82	1.58	.000	903	4.72	1.62	.000
STEM Tech Scale	NonSTEM	443	5.22	1.46		485	5.44	1.40	
	STEM	365	5.76	1.30		425	5.84	1.32	
	Total	808	5.46	1.42	.000	910	5.63	1.38	.000
STEM Career Scale	NonSTEM	448	4.31	1.57		487	4.44	1.42	
	STEM	364	5.70	1.33		427	5.69	1.30	
	Total	812	4.93	1.62	.000	914	5.02	1.50	.000

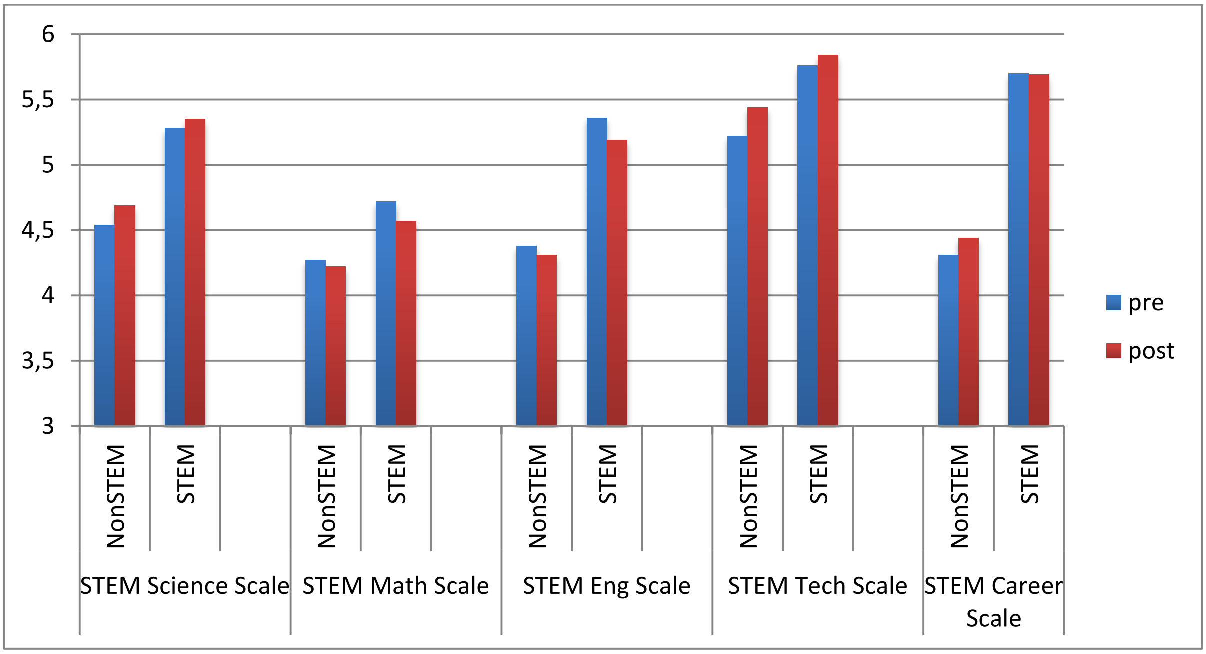

Figure 1. Comparison of STEM semantic ratings for NonSTEM versus STEM career plans, before and after treatment activities

Table 3. Comparison of non-STEM versus STEM student groups on career interest questionnaire measures before and after treatment activities

		Pretest				Posttest			
		N	Mean	SD	Sig				
CIQPart1	NonSTEM	446	2.63	.87		487	2.71	.88	
	STEM	363	3.40	.91		426	3.40	.948	
	Total	809	2.98	.97	.000	913	3.03	.970	.000
CIQPart2	NonSTEM	446	2.64	.89		488	2.73	.90	
	STEM	363	3.43	.96		425	3.53	.943	
	Total	809	2.99	1.01	.000	913	3.10	1.00	.000
CIQPart3	NonSTEM	446	3.37	.86		488	3.49	.84	
	STEM	363	3.81	.85		424	3.93	.75	
	Total	809	3.57	.88	.000	912	3.70	.83	.000
CIQ All	NonSTEM	446	2.86	.77		488	2.96	.74	
	STEM	363	3.54	.81		426	3.61	.78	
	Total	809	3.17	.85	.000	914	3.26	.82	.000

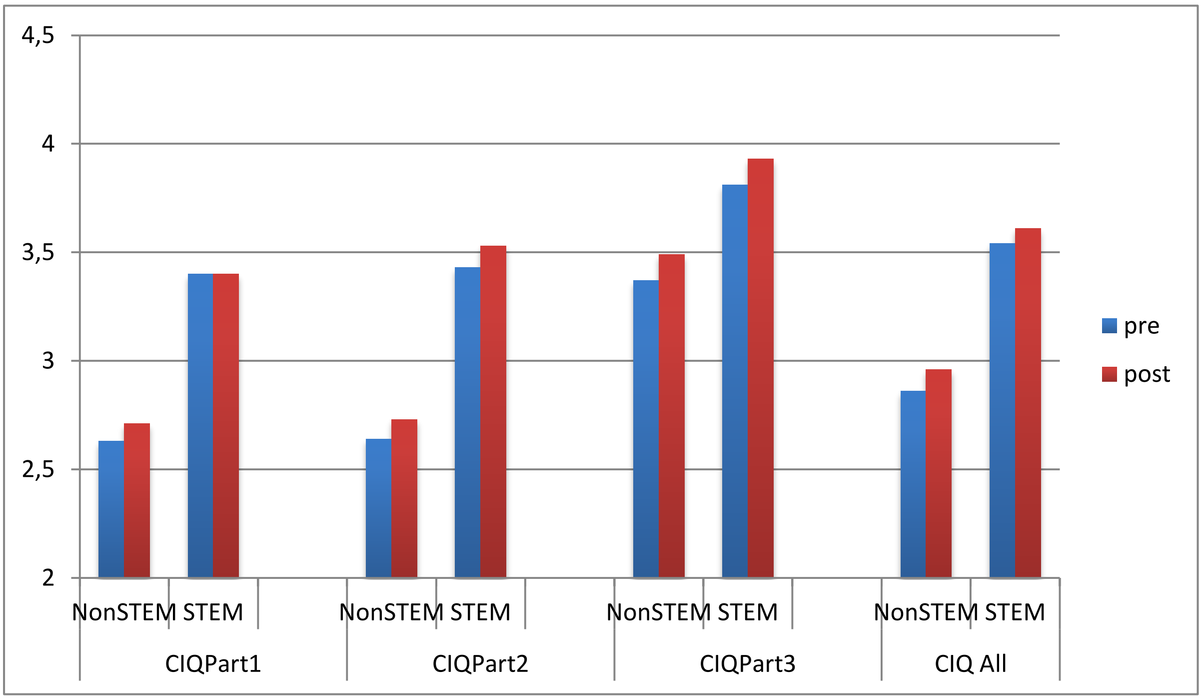

Figure 2. Comparison of non-STEM versus STEM on career interest questionnaire measures, pre and post project activities

Viewing these findings regarding alignment of positive interest in STEM with intent to purse a STEM career, we conclude that with regard to research question 2, middle school students who have stated that they plan to pursue a career in STEM, also show higher dispositions toward STEM and STEM career measures.

Research Question 3: Effects Due to Gender

Male vs. Female Plans to Have a Career in STEM

Table 4 illustrates changes in the students' preference for careers in STEM vs. non-STEM by gender, during the school year. As shown in the non-STEM rows of the table, the proportion of males versus females remained constant from pre to post. Overall, a greater percentage of males indicated preference for STEM careers at both the pre and post test time periods, but the proportion of females planning a STEM career increased from 36% at pretest to 41% at the post test time frame.

Table 4. Male vs. female percentage of students planning STEM career

	Pretest		Post test	
	Male	Female	Male	Female
STEM	64.1% n= 234	35.9% n = 131	58.8%, n = 251	41.2%, n = 176
NonSTEM	45.5% n = 204	54.5% n = 244	45.4%, n = 222	54.6%, n = 267

Treatment vs. Comparison Groups

As shown in Table 5, already at the time of the pretest, comparison group females who indicated interest in a non-STEM career path were much higher in dispositions toward Science than the treatment females who selected the non-STEM career path. The magnitude of the difference was an effect size (Cohen's d) of (4.60-3.90)/1.49 = .47. This is a moderate effect according to guidelines published by Cohen (1988). Reasons for this level of pre-treatment difference are currently unknown.

Positive Effects on STEM Career Intent for Treatment Group Females

Also shown in Table 5, and graphically illustrated in Figure 3, is that for the treatment group of female students, the pre-post gains in dispositions toward Science during the school year of energy monitoring activities were almost identical whether the females began the project year with an intent to have a career in STEM or not. For the males (not illustrated), the effect was very different, in that those who began the year with an intent to have a career in STEM became more positive in their dispositions toward Science during the treatment school year, but the males who began their year not intending to pursue a career in STEM had no significant pre-post change in their dispositions toward Science.

Table 5. STEM semantics science measure for males and females by treatment and comparison

STEM/Non	Treatment/Comparison	Pre/Post	Male	Female
STEM	Treatment	Pre	5.29	5.61
		post	4.90	5.81
	Comparison	pre	5.16	5.41
		post	5.31	5.39
NonSTEM	Treatment	Pre	4.85	3.90
		Post	4.75	4.36
	Comparison	Pre	4.57	4.60
		Post	4.68	4.74

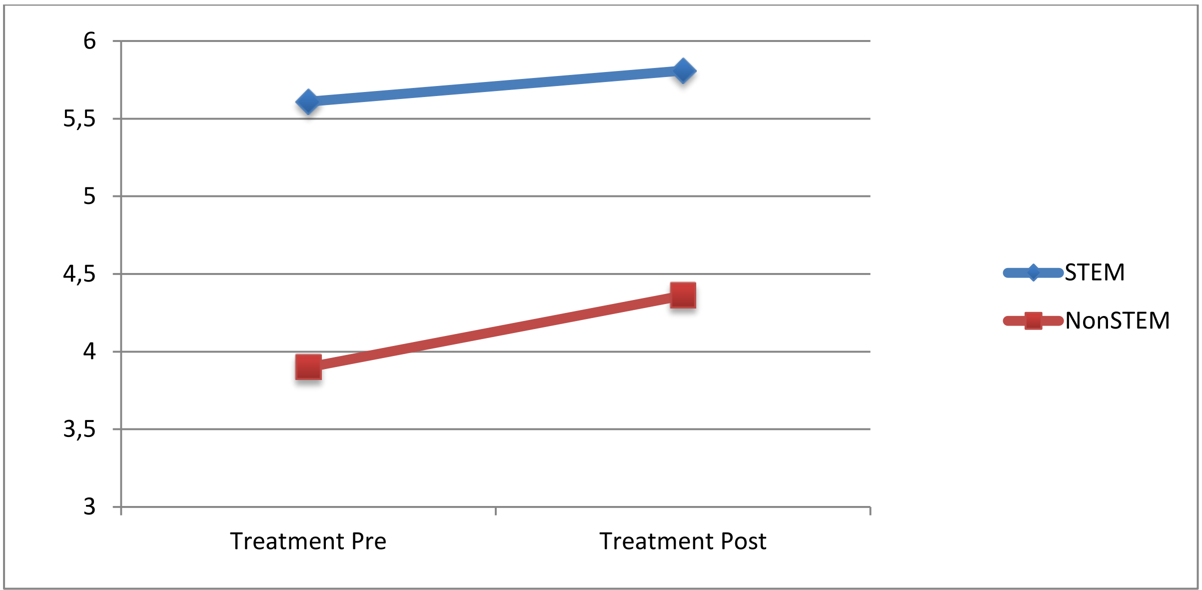

Figure 3. Pre-post changes for females on the STEM science indicator by whether they selected a STEM career or non-STEM career (treatment students)

Positive Effects on STEM Career Interest for Treatment Group Females

As shown in Table 6 and graphically displayed in Figure 4, females who were in the treatment group also gained in their interest in a STEM career from pre to post whether they indicated an interest in STEM as a career path or not. However, females who indicated their interest in a STEM career increased more in their positive dispositions toward STEM as a career than the females who indicated an interest in a non-STEM career. The trends (not illustrated) were not the same for the males, and were not consistent for males with regard to treatment and comparison group pre-post changes in dispositions toward STEM as a career.

Table 6. STEM semantics career measure

STEM/NonSTEM	Treatment/Comparison		Male	Female
STEM	Treatment	Pre	5.87	5.68
		Post	5.34	5.96
	Comparison	Pre	5.67	5.70
		Post	5.64	5.79
NonSTEM	Treatment	Pre	4.24	3.56
		Post	4.25	3.75
	Comparison	Pre	4.32	4.48
		Post	4.56	4.47

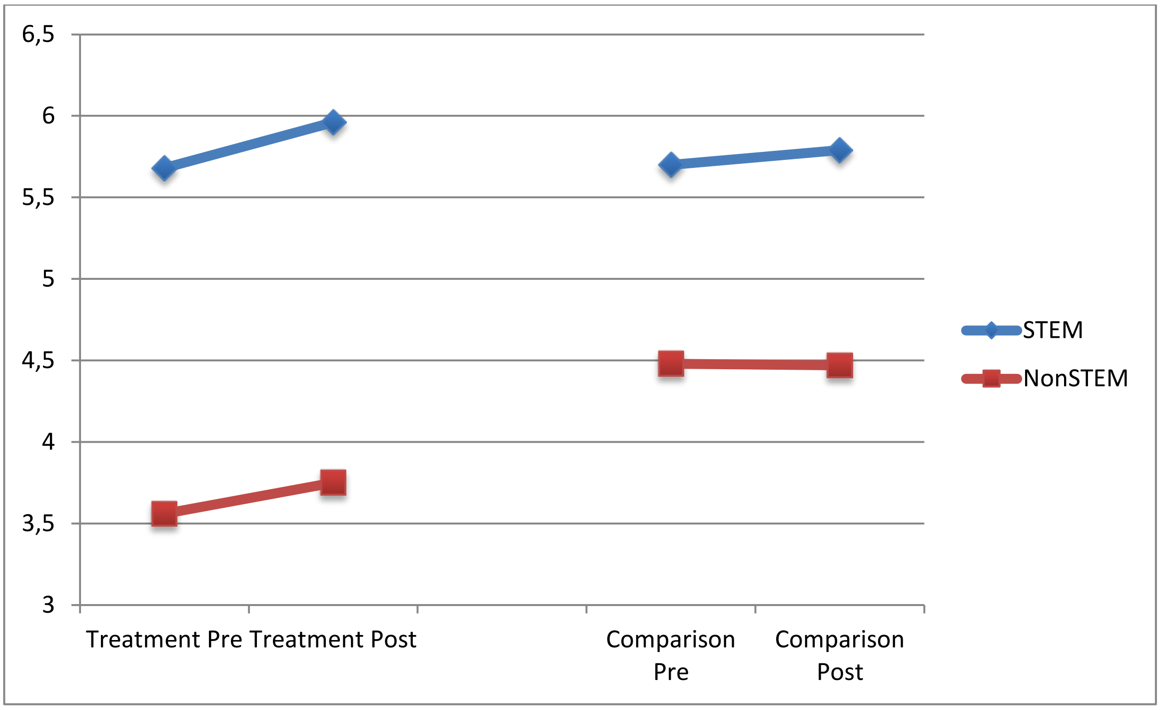

Figure 4. Pre and post comparison on STEM semantics career measure for females who selected STEM as a career plan versus those who chose a non-STEM career plan

Positive Effects on Career Interest Questionnaire Importance Subscale for Treatment Group Females

As shown in Table 7 and graphically displayed in Figure 5, female gains pre to post also became more positive when the chosen indicator is CIQ part 3. This subscale indicator is known as Career Interest Questionnaire Importance (Peterman, Kermish-Allen, Knezek, Christensen, & Tyler-Wood, 2016) and has previously been found to be especially meaningful to female students in that it contains a strong component of "making a difference in the world." (Ceci, Williams, & Barnett, 2009; Christensen, Knezek, & Tyler-Wood, 2015). Trends shown in Figure 5 from the CIQ Importance subscale parallel the major findings shown in Figure 4, from the STEM Semantic Career Interest scale. Female students tend to become more positive in their interests in a STEM career after having participated in the MSOSW hands-on science activities, whether they began the school year with an intent to have a career in STEM or not. For male students the effect is not as consistent and needs more research to identify clear trends.

Table 7. CIQ Part 3 interest in a science career

STEM/NonSTEM	Treatment/Comparison		Male	Female
STEM	Treatment	Pre	3.85	3.97
		Post	3.52	4.21
	Comparison	Pre	3.76	3.85
		Post	3.93	3.97
NonSTEM	Treatment	Pre	3.41	3.49
		Post	3.35	3.65
	Comparison	Pre	3.24	3.46
		Post	3.40	3.56

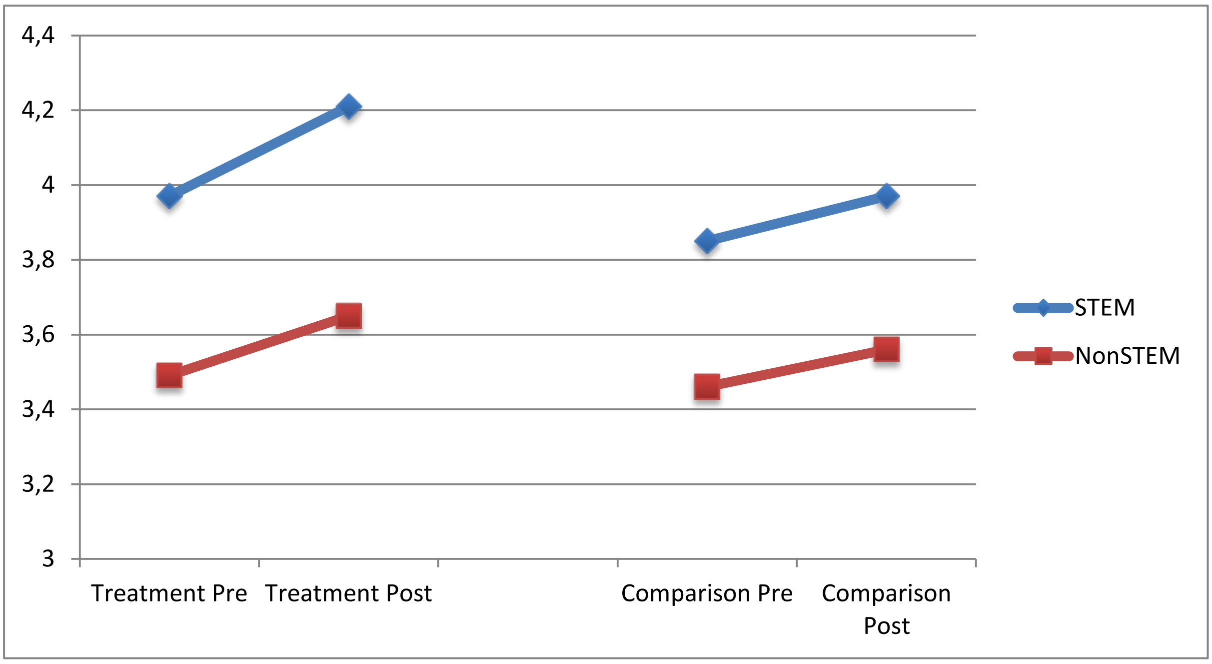

Figure 5. CIQ part 3 pre-post comparisons for females in treatment and comparison by whether they chose STEM as a career plan or another non-STEM career plan

Viewing these findings regarding gender as a whole, we conclude that with regard to research question three, gender differences do exist regarding intent to pursue a STEM career as well as level of interest in STEM as a career. Middle school males generally have greater intent to pursue a career in STEM, and also show more positive interest in STEM areas. However, females appear to more positively react to the MSOSW activities presented in this study than males, so over the course of a project year females tend to "catch up." This is true regarding assessed STEM interest as well as stated intent to pursue a career in STEM.

The ACT report (2015) pointed out that approximately 34% of students nationwide have a stated and measured intent to pursue a STEM career. In this study, approximately 64% of the students were measured to have a positive interest in STEM (> 4.0 on STEM Semantic scale of STEM as a Career), while 46% reported that they planned to pursue a career in STEM. Three hundred fifty-two (352) of 916 middle school students (38%) in the 2013-2014 MSOSW project reported at the end of the school year that they both planned to have a career in STEM, and also had their interest in STEM as a career measured as positive (> 4.0) on 7-point Semantic Differential Scale. This 38% can be compared with the 34% reported in the ACT (2015) study and reiterates hope that the current group of middle school students across the USA, or at least those with science teachers willing to voluntarily participate in energy consumption and CO_2 production teaching and learning activities, are poised to become a STEM workforce pool of the future larger than previously reported.

Nevertheless, even with the optimistic outcomes reported in portions of this paper, there is still much work to be done. Females in the MSOSW Project were impacted by hands-on project activities that have a real world focus whether or not they expressed an interest in a STEM career. This is an important finding because even if they do not pursue a career in a STEM field, having positive dispositions toward STEM may impact the decisions they make as informed citizens, including but is not limited to those who will be future parents. Further disaggregation of the same data reported in the previous paragraph (not shown), indicated that the percentage of females who had high dispositions (interest) in STEM as a career (47%) was already somewhat lower than for males (53%), and when the added restriction of planning to have a career in STEM was added, the gap widened to only 42% of those with stated and measured intent to pursue STEM as a career being female, while 58% were male. This returns the discussion to the opening statement of this paper, that the ACT (2015) study had identified a gap among young people across the USA, between their measured interest in STEM as a career versus their stated intent to pursue STEM as a career. The findings of the current study concur with the findings of the ACT. The current study findings also identify that the gap is especially large for females, while also indicating that hands-on, real-world, make-the-world-a-better-place activities like those featured in the MSOSW project are especially effective in promoting stated and measured intent to pursue a career in STEM – whether or not the middle school students come to their MSOSW project classrooms with a plan to pursue a career in STEM – if the participants are female.

Conclusion

Attitudes formed during middle school have a large influence on students' academic performance (Liu, Horton, Olmanson, & Toprac, 2011), which in turn affects students' career aspirations (Choi & Chang, 2011). Therefore, understanding middle school students' perceptions regarding STEM dispositions is crucial to preparing our future STEM workforce as well as future citizens. The outcomes of the current study concur with the ACT findings that a gap exists among young people across the US regarding positive interest in STEM as a career versus stated intent to pursue a STEM career. The findings from the current study also provide evidence that progress can be made toward eliminating the existing gender gap in STEM career interest and intent, and, in particular that hands-on-science activities such as those embedded in the MSOSW project are particularly effective in enhancing STEM career interests among middle school girls. This is true for girls whether they begin project activities planning to purse a career in STEM, or not. Additional studies are needed to confirm these findings for different age groups of students and learning activities or school environments..

Acknowledgements

This research was funded in part by the NSF ITEST grant #1312168.

References

Amercian College Testing Service (ACT) (2015). *The Condition of STEM 2015.* Retrieved February 25, 2016 from http://www.act.org/stemcondition/15/.

Bisland, M., Kekelis, L., McCreedy, D., Koster, E., Gupta, P., & Roman, C. (2011). *Science Museum Roundtable*. Discussion at the NCWIT K-12 Alliance Summit, New York.

Bouvier, S. (2011). Increasing student interest in science, technology, engineering, and math (STEM): Massachusetts STEM pipeline fund programs using promising practices. Report prepared for the Massachusetts Department of Higher Education by the University of Massachusetts Donahue Institute. Retrieved from http://www.cssia.org/pdf/20000062-IncreasingStudentInterestinScience,Technology,Engineering,andMath(STEM).pdf

Bowdich, S. (2009). *Analysis of Research Exploring Culturally Responsive Curricula in Hawaii.* Paper presented to the Hawaii Educational Research Association Annual Conference, February 7, 2009.

Buldu, M. (2006). Young children's perceptions of scientists: A preliminary study. *Educational Research, 48*(1), 121-132.

Ceci, S.J., Williams W.M., & Barnett, S.M. (2009). Women's underrepresentation in science: Sociocultural and biological considerations. *Psychological Bulletin* 135(2), 218-261.

Christensen, R**.** & Knezek, G**.** (2015). Active learning approaches to integrating technology into middle school science classrooms: Reconceptualizing a middle school science curriculum based on 21st century skills. In X.Ge, D. Ifenthaler, & J.M. Spector (Eds.). *Full Steam Ahead: Emerging Technologies for STEAM*. New York: Springer Academic.

Christensen, R., Knezek, G., & Tyler-Wood, T. (2015). Gender differences in high school dispositions toward science, technology, engineering and mathematics careers. *Journal of Computers in Mathematics and Science Teaching*, *34*(4), 395-408.

Christensen, R., Knezek, G., & Tyler-Wood, T. (2014). Student perceptions of Science, Technology, Engineering and Mathematics (STEM) content and careers. *Computers in Human Behavior*, *34*, 173-186. doi:10.1016/j.chb.2014.01.046.

Choi, N., & Chang, M. (2011). Interplay among school climate, gender, attitude toward mathematics, and mathematics performance of middle school students. *Middle Grades Research Journal*, *6*, 14.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

DeVellis, R.F. (1991). *Scale development*. Newbury Park, NJ: Sage Publications.

Dweck, C. (2006). Is math a gift? Beliefs that put females at risk. In *Why Aren't More Women in Science? Top Researchers Debate the Evidence*, ed. S. J. Ceci and W. M. Williams, 47-55. Washington, DC: American Psychological Association.

Gottfredson, L. (1981). Circumscription and compromise: A developmental theory of occupational aspirations. *Journal of Counseling Psychology*, *28*(6), 545-579.

Halverson, H.G. (2011). The trouble with bright girls. *Huffington Post*, March 1. http://www.huffingtonpost.com/heidi-grant-halvorson-phd/girls-confidence_b_828418.html (accessed March 1, 2011).

Liu, M., Horton, L., Olmanson, J., & Toprac, P. (2011). A study of learning and motivation in a new media enriched environment for middle school science. *Educational Technology Research and Development, 59*(2), 249-265.

Modi, K., Schoenberg, J., & Salmond, K. (2012). *Generation STEM: What girls say about science, technology, engineering and math.* The Girl Scout Research Institute.

Nguyen, H.H.H., & Ryan, A.M.M. (2008). Does stereotype threat affect test performance of minorities and women? A meta-analysis of experimental evidence. *Journal of Applied Psychology*, *93*(6), 1314-34.

Palmer, D. H. (1997). Investigating students' private perceptions of scientists and their work. *Research in Science & Technological Education*, *15*(2), 173-184.

Peterman, K., Kermish-Allen, R., Knezek, G., Christensen, R., & Tyler-Wood, T. (2016, accepted). Measuring student career interest within the context of technology-enhanced STEM projects: A cross-project comparison study based on the Career Interest Questionnaire. *Journal of Science Education and Technology 25*(4), DOI:10.1007/s10956-016-9617-5

Tai, R., Liu, C., Maltese, A., & Fan, X. (2006). Planning early for careers in science. *Science, 312*(5777), 1143-1144.

U.S. Census Bureau (2010). Census 2010 Summary File 1. Retrieved from http://www.census.gov/prod/cen2010/briefs/c2010br-03.pdf February 27, 2016.

Walton, G.M., & Spencer, S.J. (2009). Latent ability: Grades and test scores systematically underestimate the intellectual ability of negatively stereotyped students. *Psychological Science*, *20*(9), 1132-39.

Author Information

Rhonda Christensen
University of North Texas
Denton TX 76203, USA
Contact e-mail: *Rhonda.christensen@gmail.com*

Gerald Knezek
University of North Texas
Denton TX 76203, USA

Appendices

STEM Semantics Survey

Gender: M / F

This five-part questionnaire is designed to assess your perceptions of scientific disciplines. It should require about 5 minutes of your time. Usually it is best to respond with your first impression, without giving a question much thought. Your answers will remain confidential.

ID: ________________ **School:**_____________	Use the assigned ID or the year and day of your birthday (ex: 9925 if born on the 25th day of any month in 1999.

Instructions: Choose one circle between each adjective pair to indicate how you feel about the object.

To me, SCIENCE is:

1.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane
2.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
3.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
4.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
5.	boring	①	②	③	④	⑤	⑥	⑦	interesting

To me, MATH is:

1.	boring	①	②	③	④	⑤	⑥	⑦	interesting
2.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
3.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot

To me, ENGINEERING is:

1.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
2.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane
3.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	boring	①	②	③	④	⑤	⑥	⑦	interesting

To me, TECHNOLOGY is:

1.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing
2.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
3.	boring	①	②	③	④	⑤	⑥	⑦	interesting
4.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
5.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane

To me, a CAREER in science, technology, engineering, or mathematics (is):

1.	means nothing	①	②	③	④	⑤	⑥	⑦	means a lot
2.	boring	①	②	③	④	⑤	⑥	⑦	interesting
3.	exciting	①	②	③	④	⑤	⑥	⑦	unexciting
4.	fascinating	①	②	③	④	⑤	⑥	⑦	mundane
5.	appealing	①	②	③	④	⑤	⑥	⑦	unappealing

Thank you for your time.
STEM v. 1.0 by G. Knezek & R. Christensen 4/2008

Career Interest Questionnaire

This survey contains 3 brief parts. Read each statement and then mark the circle that best shows how you feel.

ID: ______________	Use the assigned ID or the year and day of your birthday (ex: 9925 if born on the 25th day of any month in 1999.
Group: ____________	

Gender: ① Male ② Female

Part 1

Instructions: **Select one level of agreement for each statement to indicate how you feel.**
SD = Strongly Disagree, D = Disagree, U = Undecided, A = Agree, SA = Strongly Agree

	SD	D	U	A	SA
1. I would like to have a career in science.	①	②	③	④	⑤
2. My family is interested in the science courses I take.	①	②	③	④	⑤
3. I would enjoy a career in science.	①	②	③	④	⑤
4. My family has encouraged me to study science.	①	②	③	④	⑤

Part 2

	SD	D	U	A	SA
5. I will make it into a good college and major in an area needed for a career in science.	①	②	③	④	⑤
6. I will graduate with a college degree in a major area needed for a career in science.	①	②	③	④	⑤
7. I will have a successful professional career and make substantial scientific contributions.	①	②	③	④	⑤
8. I will get a job in a science-related area.	①	②	③	④	⑤
9. Some day when I tell others about my career, they will respect me for doing scientific work.	①	②	③	④	⑤

Part 3

	SD	D	U	A	SA
10. A career in science would enable me to work with others in meaningful ways.	①	②	③	④	⑤
11. Scientists make a meaningful difference in the world.	①	②	③	④	⑤
12. Having a career in science would be challenging.	①	②	③	④	⑤
13. I would like to work with people who make discoveries in science.	①	②	③	④	⑤

Thanks! CIQ Ver. 2.0 8/2013 by G. Knezek & R. Christensen. Adapted from Bowdich (2009) and Fraser (1982).