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Instruments for Assessing Interest in STEM Content and Careers

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Two new instruments created to assess perceptions of Science, Technology, Engineering, and Math (STEM) disciplines and careers are analyzed and found to have respectable to excellent internal consistency reliability, as well as good content, construct, and criterion-related validity for the areas assessed. Cronbach's Alpha for the individual scales on the STEM Semantics Survey and the STEM Career Interest Questionnaire ranged from .78 to .94 across the eight constructs represented. These scores were judged to be acceptable to assess anticipated changes resulting from Middle Schoolers Out to Save the World (MSOSW) ITEST project activities, and are believed to be worthy of use by other ITEST projects.

Introduction

The Innovative Technology Experiences for Students and Teachers (ITEST) program was established by the National Science Foundation in direct response to the concern about shortages of information technology workers in the United States. The primary goal of the ITEST initiative is to seek solutions to help ensure the breadth and depth of the Science, Technology, Engineering, and Mathematics (STEM) workforce. ITEST projects may include students or teachers in kindergarten through high school age. While the primary focus of many ITEST projects is the implementation of a program (whether teacher professional development or direct services to youth), all of the projects need to consider their impact on participants and how to measure that impact. ITEST projects face the research challenge of "assess[ing] and predict[ing] inclination to participate in the STEM fields and … measure[ing] and study[ing] the impact of various models to encourage that participation" (NSF, 2009). The development of appropriate instruments to measure interest and mastery in STEM areas is important for determining the overall effectiveness of the ITEST initiative. One particular challenge facing ITEST projects is how to verify increased student interest in or induction into STEM careers within a short amount of time. A typical three-year ITEST project funded by the National Science Foundation (NSF) does not last long enough to track long-term changes in practice for participating teachers, much less does it allow for the tracking of participating students through high school, college, and career. Therefore, the evaluator of an ITEST project is typically faced with reporting some indication of increased interest in STEM careers rather than actual induction into STEM careers.

In order to address this challenge, the Middle Schoolers Out to Save the World (MSOSW) ITEST Project (2008 – 2011), spent its first year focused on the development of reliable and valid instruments to assess interest in STEM content areas and STEM careers. While the project provides professional development to teachers, the outcome of interest is changes in student STEM career interest, and instruments were developed toward that end, This paper focuses on the measurement properties of two instruments: the STEM Semantics Survey and the Career Interest Questionnaire, which are intended to serve as major indicators for perceptions of STEM disciplines and careers. The STEM Semantic Survey is a 25-item instrument that measures interest in science, technology engineering and mathematics as well as interest in STEM careers more generally. The Career Interest Questionnaire is a 12-item instrument that measures interest in careers in broad science areas. The STEM Semantics Survey has the benefit of being appropriate for both teachers and students, while the Career Interest Questionnaire targets students only. The paper describes the internal consistency reliability, as well as the content, construct, and discriminant validity, for each of the instruments, and concludes with a discussion of the suitability and potential utility of these instruments for assessing perceptions of and interest in STEM careers in the context of ITEST and similar projects.

LITERATURE REVIEW

A primary goal of the ITEST initiative has been to increase the nation's number of highly capable scientists in STEM areas with an ultimate result of increasing the United States' competitive edge as we enter the 21st century. To maintain high visibility in the technology-oriented market of the 21st century, the U.S. must produce highly capable scientists. The importance of STEM education is highlighted in President Obama's new STEM initiative, "Educate to Innovate" (The White House, Office of the Press Secretary, 2009). In his November 2009 press release, President Obama stated, "Reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation is essential to meeting the challenges of this century. That's why I am committed to making the improvement of STEM education over the next decade a national priority." Friedman (2005) indicates that society is becoming more and more knowledge based, technological and international. Lubinski and Benbow (2006) indicate that the physical and social systems within which people operate are becoming more complex and dynamic. Countries that maintain a competitive edge and prosper will be countries that are the most effective in developing their human capital and in nurturing individuals with the capabilities of developing new ideas and innovations. According to WorkSource (2007), "80% of US manufacturers experienced a shortage of STEM workers in 2007." Our current economic situation accentuates the need to identify workers that have the potential to bolster our industries and provide job opportunities for our citizens.

In order to identify students with academic and career potential in STEM areas, instruments for assessing perceptions of and interest in STEM careers must be developed, because a careful review of existing career interest instruments found a gap in instrumentation which measures interests in STEM careers. Whitfield, Feller, and Wood (2008) have identified ten instruments that are effective at determining career interests. At least four of these instruments have normative data gathered on elementary and middle school students. However, the focus of the instruments is on general career interest and not specific to STEM careers. With the current limits in instrumentation, documenting change in STEM interest in younger students is most difficult.

In addition to the lack of STEM-focused career interest instruments, most existing instruments focus on assessing career interest at the high school level and beyond. There are very few instruments that measure career interest for younger students, with language appropriate for students in elementary and middle school. When working with younger students, the ease of use of instrumentation is a critical issue; to be used effectively, the instruments must be easy to administer, succinct, and easy to understand.

The *Mental Measurements Yearbook* is designed to assist professionals in selecting appropriate instrumentation in a broad range of social science areas. The series, initiated in 1938, purports to provide the most recent factual information, critical reviews, and comprehensive bibliographic references on the construction, use, and validity of all new and revised commercially published tests in English (Buros Mental Measurement, 2007). The Yearbook currently covers more than 4,000 commercially-available tests in categories such as personality characteristics, developmental level, behavioral assessment, neuropsychological characteristics, achievement, intelligence, aptitude, speech and hearing ability, and sensory motor skills. While almost all instruments focus exclusively on science, rather than the broader field of STEM, a search of *Mental Measurements* yielded one assessment, The Scientific Orientation Test (SORT, 1995), that would seem appropriate for ITEST projects such as MSOSW. The SORT, developed in Australia, was designed to measure attitudes toward several science-related topics for students in grades 7 through 12, and has been used for over 30 years in Australia. Rogers (2007) expresses some concern with the use of the SORT for two reasons. In the intervening three decades since the test's inception, much has changed concerning science curriculum and attitudes towards science education, and Rogers suggests the instrument is in need of updating. In addition, although the test has been widely used in Australia, there has been limited use of the instrument in the United States.

Although the *Mental Measurements Yearbook* is a standard for researchers and practitioners in the field seeking to measure gain in academic areas, there are a few additional instruments that have been used by researchers interested in attitudes toward science and science achievement. One such instrument was developed by Novodovorsky (1993) after a review of literature resulted in her conclusion that "many existing instruments are based on ill-defined theoretical constructs, and include statements that do not appear to be assessing the single construct of attitude toward science." After an item analysis, her initial 60 item scale was honed down to 20 items describing three factors:

1. Interest in science classes and activities in science classes
2. Confidence in the ability to perform science tasks
3. Interest in science-related activities outside of school.

The items were found to yield good reliability, but inadequate information was reported for the construct and criterion related validity of the instrument.

Ornstein (2006) used Novodvorsky's instrument to determine if the frequency of hands-on experimentation influenced student attitudes towards science. Although some gains were noted by the instrumentation, analyzing the data by class did not reveal a significant difference between classes having and classes lacking hands-on laboratory activities. Ornstein indicates that her data may not show significance due to the small sample size. However, lack of validity and sensitivity of her instrumentation cannot be ruled out as a factor in the results she obtained.

As described here, none of the instruments reviewed meets the needs of identifying STEM career interests at the elementary and middle school level. Instruments that do exist tend to target high school students, tend to focus on science rather than STEM, and are in need of updating. Given the lack of updated, reliable, and valid instruments to measure STEM career interests, it is critical that instruments of this type be developed if we are to establish the effectiveness of STEM professional education on teachers, and through them on the students they teach.

ABOUT THE MSOSW PROJECT

The MSOSW project trains middle school students to measure standby power. Standby power consumption is an issue in all U.S. homes. Electronics and appliances that remain plugged in or in standby mode typically consume between 5% and 26% of household energy (Ross & Meier, 2000), and may consume up to 40% of the energy used in U.S. homes (US Department of Energy, as cited by Magid, 2007).

In the MSOSW project, approximately 600 sixth and seventh graders from middle schools in Alaska, Louisiana, Hawaii, Maine, Texas and Vermont are scheduled to provide comparison data and/or monitor home energy use under supervision of their teachers in the MSOSW project. The data are being used by student participants in the MSOSW project to develop optimum scenarios for conserving energy and reducing production of greenhouses gases in local communities.

The 19 teachers who work with the project were selected through their school districts. The participating districts have longstanding collaborative partnerships with the project investigators. Teachers receive professional development prior to teaching the MSOSW curriculum. Teacher training consists of an initial face-to-face two-day summer training retreat in Stowe, Vermont where teachers are introduced to the MSOSW project and project goals are delineated. Teachers receive training on the use of equipment designed to measure energy consumption. Training is provided by experts in energy consumption and the project staff. During the two-day summer training workshop the project staff works with the teachers to develop guidelines for collecting student data. Energy awareness experts and project personel work with teachers to develop, modify, and review energy lesson plans. Once back in the classroom, students and teachers use online software tools to record and analyze their data and create projections of future energy use. Project personel establish platforms for facilitating communication among teachers, researchers and project staff. Procedures are established by project personel that allow students and teachers to communicate their results within the project via information communication technologies such as e-mail discussion boards, Excel spreadsheets and optimization modeling environments.

MSOSW was funded to create interest and prepare middle school students for STEM careers; to inform middle school students, their families, and their teachers about and promote monitoring of home and community energy consumption; and to produce model scenarios and activities that can be disseminated to educators nationwide, enabling classrooms beyond the MSOSW project to use the resources. Research is being conducted on the effects of the project on students' and teachers' changes of attitudes and interests in STEM disciplines (with a focus on science) through comparisons with matched, untreated schools. This paper describes the results of the first year of MSOSW, which focused on developing instruments and procedures to assess growth in STEM career interest among treatment groups participating in the project in years two and three.

SUBJECTS FOR THIS STUDY

While the target population of the full-scale MSOSW project will be middle school teachers and their students in Alaska, Hawaii, Louisiana, Maine, Texas and Vermont, for the instrument development portion of the project the sample was drawn from the following groups:

1. A combined 6^{th} - 8^{th} grade sample from a Hawaii summer STEM enrichment class and a Vermont middle school classroom during May - June 2009 (n=60).
2. Teacher/ Liaison Participants in the summer 2009 training sessions for MSOSW teachers and project personnel in Vermont during June 2009 (n=11);
3. Teacher preparation candidates at a large Midwestern university who were enrolled in a technology integration course during the spring of 2009 (n=58);

4. NSF ITEST Project Principal Investigators and Evaluators attending the 2009 ITEST Summit annual meeting in Washington, DC during February 2009 (n=29); and
5. Teacher Educators (faculty) attending the Society for Information Technology and Teacher Education Conference in South Carolina during March 200 (n=14).

The validation sample for the study in this paper resembles the demographics of the schools which will participate in the MSOSW project. Student participants from Vermont attended a relatively small, rural, combined middle and high school facility. The majority (97%) of the student population is white with small percentages of African-American (1%), Asian (1%), and Hispanic (1%) students. Approximately 10% of all students in the school qualify for free and reduced lunch. The University of Hawaii Laboratory School was established as a model school design that provides comprehensive education to all students. It serves 420 students from Kindergarten to Grade 12. Students are selected by lottery with equal number of male and female students from every sector in Hawaii, encompassing all income levels and socioeconomic classes. The sample represents a cross-section of individuals who vary in level of participation in STEM education and career opportunities. This sample was chosen to provide comparative data that will compare the rating scores of MSOSW project participants (students and teachers) to individuals with various levels of achievement and career interests in STEM. In addition, the STEM professionals' ratings are intended to set a target level of performance on the instruments—that is, the average performance level of adult STEM professionals. The STEM Semantics Survey was administered to the full sample, and the Career Interest Questionnaire to the sample of middle school students.

DATA ACQUISITION / INSTRUMENTATION

Data were gathered from the two classes of middle school students in four areas: the STEM Semantics and Career interest measures under study, as well as technology attitudes and learning disposition. Reliability and validity of the technology attitudes and learning disposition measures had previously been established for students in the MSOSW project age range, so the focus for the current analysis was on the STEM Semantics and Career Interest instruments.The data was collected from the middle school students through an online data acquisition system developed at the university heading the project. The STEM Semantics Surveys for the other groups in this study were gathered through paper and pencil surveys.

INSTRUMENT DEVELOPMENT

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, technology, engineering and mathematics (each separately). A fifth scale representing STEM career interests was also created. Each of the five scales has five Semantic Perception adjective pairs (see Figure 1).

The Career Interest Questionnaire is a Likert-type (1 = strongly disagree to 5 = strongly agree) instrument composed of 12 items on three scales (Figure 2). The three scales measure the following constructs: perception of supportive environment for pursuing a career in science, interest in pursuing educational opportunities that would lead to a career in science, and perceived importance of a career in science. The instrument was adapted from a longer instrument developed for a Native Hawaiian Studies project promoting STEM interest (focusing on science) in Hawaii. Adaptations of the instrument were based on a comprehensive analysis completed by Bowdich (2009). The instrument was used with the permission of Bowdich.

The Career Interest Questionaire (CIQ) was selected to fulfill a particular MSOSW research team goal of including a brief, reliable, and construct-valid instrument in an education-friendly, Likert-type format – one that could be used to cross-validate and further enrich some portion(s) of the STEM Semantics Survey analyses. Although the CIQ was created for career interest in science and the items selected were used as written, the research team envisioned that the instrument's original form, once confirmed to be useful for science, could be easily modified to address any STEM discipline.

FINDINGS: INTERNAL CONSISTENCY RELIABILITY

STEM Semantics Scale Reliabilities (Cronbach's Alpha)

Internal consistency reliabilities for the combined group (n = 174) on perceptions of science, math, engineering, technology, and STEM as a career ranged from Alpha = .84 to Alpha = .93. These numbers are in the range of "very good" to "excellent" according to guidelines provided by DeVellis (1991). Reliabilities for all scales are listed in Table 1.

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

Figure 1. STEM Semantics Survey

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

Figure 2. Career Interest Questionnaire

Table 1
Internal Consistency Reliabilities for STEM Semantics Survey Scales

Scale	Number of Items	Alpha
Science	5	.84
Math	5	.88
Engineering	5	.92
Technology	5	.91
STEM Career	5	.93

Career Interest Questionnaire Reliabilities (Cronbach's Alpha)

Cronbach's Alpha for the 60 students completing surveys ranged from .78 to .94. These values fall in the range of "respectable" to "excellent" according to guidelines by DeVellis (1991). Internal consistency estimates for each of the three scales of the Career Interest Questionnaire are listed in Table 2.

Table 2
Internal Consistency Reliabilities for Career Interest Scales

Scale	Number of Items	Alpha
Perception of supportive environment for pursuing a career in science	4	.86
Interest in pursuing educational opportunities that would lead to a career in science	5	.94
Perceived importance of a career in science	3	.78
All items	12	.94

VALIDITY

Content Validity for STEM Semantic Perception and Career Interest Questionnaires

Both the STEM Semantics Survey and the Career Interest Questionnaire were reviewed and refined in multiple iterations by the MSOSW project team (including teachers) and members of the project advisory committee, the latter of which included the external evaluators. In the case of the STEM Semantics Survey, the major concern expressed by the reviewers was whether some of the wording in the original instructions was too difficult for sixth graders, and whether the descriptive adjective “mundane” was meaningful at the sixth grade level. This resulted in rewriting the instructions with less difficult vocabulary, and in agreement among the advisory committee members to add the word “ordinary” in parentheses next to the word “mundane” wherever the descriptive adjective appeared, for the middle school version of the questionnaire. For the Likert-style Career Interest Questionnaire, the advisory committee settled on using only the well-validated items in the Bowdich (2009) study, even if this meant having a relatively small number (3) represent a construct, rather than attempting to write new items for version 1 of the questionnaire. Examiners were in agreement that the final form of both instruments should be capable of measuring the intended constructs.

Construct Validity for STEM Semantic Perception and Career Interest Questionnaires

Exploratory factor analyses (Principal Components Extraction, Varimax Rotation, Suppressed Display of Loadings < .5) were completed on the STEM Semantics items and the Career Interest items, using the available 2009 data. These analyses were conducted in order to determine if the structures derived from other researchers’ sets of data remained intact with the students and teachers involved with the MSOSW project. Five factors were requested to be extracted for the STEM Semantics items (see Table 3), and three were requested for extraction from the Career Interest items (see Table 4). The results of these analyses indicated that in every case the items loaded on the hypothesized factors. That is, the items targeted for assessing semantic perception of science, math, engineering, technology, and STEM career interests were most strongly associated with the intended construct in every case (see Table 3). Similarly, the items targeted for assessing the three factors associated with the Career Interest Questionnaire were also most strongly associated with the intended contruct (see Table 4). These results provide credible evidence toward re-affirming the conjectured structure and reconfirming the constructs derived from other projects’ data. Note, however, that these encouraging findings are not as strong as if a sample size sufficiently large to warrant confirmatory factor analysis had been in place. Confirmatory factor analysis (a stronger validation technique) is planned for the larger data set to be gathered in 2010.

Table 3

Rotated Component Matrix (Factor Loadings) for the STEM Semantics Survey

	Component				
	1	2	3	4	5
Science_1	.885				
Science_3	.879				
Science_2	.861				
Science_5	-.842				
Science_4	-.665				
Career_5		.842			
Career_2		-.840			
Career_1		-.820			
Career_3		.809			
Career_4		.800			
Engineering_1			.872		
Engineering_4			.859		
Engineering_2			.840		
Engineering_5			-.788		
Engineering_3			-.545		
Mathematics_3				.914	
Mathematics_4				.890	
Mathematics_2				.881	
Mathematics_1				-.787	
Mathematics_5				-.619	
Technology_3					-.827
Technology_4					.757
Technology_1					.755
Technology_5					.725
Technology_2					-.694

*Negative loading indicate factors with a reversed scale.

Table 4

Rotated Component Matrix for the Career Interest Questionnaire

	Component		
	1	2	3
CIQ6 education*	.921		
CIQ7 education	.852		
CIQ5 education	.851		
CIQ9 education	.844		
CIQ8 education	.736		
CIQ4 supports**		.900	
CIQ2 supports		.849	
CIQ1 supports		.781	
CIQ3 supports		.759	
CIQ11 career***			.888
CIQ12 career			.886
CIQ10 career****	.501		.670

*Education = interest in pursuing opportunities that would lead to a career in science.
**Supports = support environment for pursuing a career in science.
***Career = perceived importance of a career in science.
****CIQ10 was related to components 1 and 3. CIQ10 was placed with component three since component 3 displayed the higher relationship.

Discriminant Validity for the STEM Semantics Survey

Sufficient data were gathered to explore differences in the group mean (average) scores for the five groups who took the STEM Semantics Survey in 2009. As noted above, there were five groups:

1. Grade 6-8 students in two middle school classrooms (n=60).
2. Teacher/ Liaison Participants in the MSOSW summer 2009 training sessions (n=11);
3. Teacher preparation candidates enrolled in a technology integration course (n=58);

4. NSF ITEST Project Principal Investigators and Evaluators (n=29); and
5. Teacher Educators (faculty) attending the SITE Conference (n=14).

As shown in Table 5 and graphically displayed in Figure 3, the perceptions of ITEST summit participants (ITEST project principal investigators and evaluators), technology faculty (SITE attendees), and MSOSW teachers were generally higher than those of university pre-service teacher candidates or MSOSW middle school students. Perhaps predictably, because of identified career paths within the sampling groups of professionals, the ITEST summit participants were highest among the groups completing surveys when the focus was restricted to perceptions of engineering[1], the technology educators (SITE attendees) were highest among the groups when the focus was restricted to perceptions of technology, and the math and science middle school teachers (MSOSW teachers) had the most positive perceptions of science and math, among the groups sampled, when the focus was restricted to these individual disciplines, respectively. When all faculty/adults were combined, this composite group was significantly higher than the undergraduate pre-service candidates in all categories ($p < .003$). Furthermore, as shown in Table 6, teacher preparation candidates were lower ($p < .05$) than all groups with STEM professional careers (SITE attendees and ITEST summit participants), and the middle school students were lower than all groups with STEM professional positions, in all measures except for in math and engineering. With regard to perceptions of math and engineering, MSOSW middle school students were not significantly different from SITE attendees (technology educators). The university pre-service candidates were not significantly different from the middle school students in their perceptions of STEM disciplines and careers, with the exception of math and engineering, where the middle school students had more positive perceptions when compared to pre-service teacher candidates. These preliminary results indicate that the STEM Semantics Survey is capable of measuring stable psychological constructs with sufficient consistency to assess changes in teacher and student perceptions resulting from project activities during years 2 and 3 of the MSOSW Project.

Table 5
Descriptive Statistics for Five Groups Completing STEM Semantics Survey

	Group	N	Mean	Std. Deviation
Science	Preservice teachers	58	5.04	1.42
	ITEST summit participants	29	6.50	0.71
	SITE attendees	14	6.27	0.96
	MSOSW teachers	11	6.62	0.54
	MSOSW students	60	5.48	1.17
Math	Preservice teachers	58	3.73	1.53
	ITEST summit participants	30	5.24	1.53
	SITE attendees	14	5.44	1.57
	MSOSW teachers	11	5.65	0.99
	MSOSW students	60	4.49	1.67
Engineering	Preservice teachers	58	3.49	1.37
	ITEST summit participants	31	5.87	1.20
	SITE attendees	13	5.31	1.35
	MSOSW teachers	11	5.62	1.12
	MSOSW students	60	4.94	1.68
Technology	Preservice teachers	58	5.56	1.02
	ITEST summit participants	30	6.31	0.90
	SITE attendees	14	6.87	0.27
	MSOSW teachers	11	6.30	0.91
	MSOSW students	60	5.69	1.33
Career	Preservice teachers	58	4.62	1.56
	ITEST summit participants	31	6.28	1.04
	SITE attendees	14	6.40	0.64
	MSOSW teachers	11	6.20	1.21
	MSOSW students	60	4.91	1.58

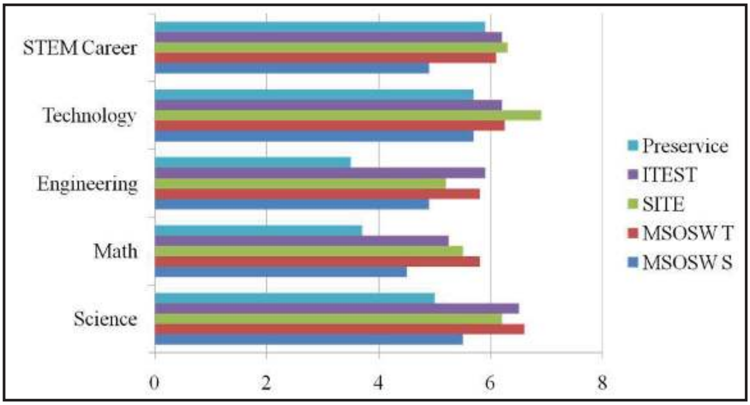

Figure 3. Semantic perceptions of five groups toward STEM content and careers

Table 6

Group Mean Contrasts for Five Samples of STEM Semantics Perception Data

	Comparison		t	df	P
Science	Preservice teachers	ITEST Summit Participants	5.22	85	0.000
	Preservice teachers	SITE attendees	3.70	70	0.003
	Preservice teachers	MSOSW teachers	3.62	67	0.001
	Preservice teachers	MSOSW students	1.85	116	0.067
	MSOSW students	ITEST Summit Participants	4.34	87	0.000
	MSOSW students	SITE attendees	2.36	72	0.021
	MSOSW students	MSOSW teachers	3.16	69	0.002
Tech-nology	Preservice teachers	ITEST Summit Participants	3.40	86	0.001
	Preservice teachers	SITE attendees	4.73	70	0.000
	Preservice teachers	MSOSW teachers	2.23	67	0.029
	Preservice teachers	MSOSW students	0.61	116	0.546
	MSOSW students	ITEST Summit Participants	2.29	88	0.024
	MSOSW students	SITE attendees	3.28	72	0.002
	MSOSW students	MSOSW teachers	1.44	69	0.153

Table 6 continued

	Comparison		t	df	P
Engineer-ing	Preservice teachers	ITEST Summit Participants	8.14	87	0.000
	Preservice teachers	SITE attendees	4.33	69	0.000
	Preservice teachers	MSOSW teachers	4.48	67	0.000
	Preservice teachers	MSOSW students	5.12	116	0.000
	MSOSW students	ITEST Summit Participants	2.75	89	0.007
	MSOSW students	SITE attendees	0.75	71	0.459
	MSOSW students	MSOSW teachers	1.29	69	0.201
Math	Preservice teachers	ITEST Summit Participants	4.39	86	0.000
	Preservice teachers	SITE attendees	3.74	70	0.000
	Preservice teachers	MSOSW teachers	4.00	67	0.000
	Preservice teachers	MSOSW students	2.57	116	0.011
	MSOSW students	ITEST Summit Participants	2.07	88	0.041
	MSOSW students	SITE attendees	1.95	72	0.055
	MSOSW students	MSOSW teachers	2.24	69	0.028
STEM Career	Preservice teachers	ITEST Summit Participants	5.33	87	0.000
	Preservice teachers	SITE attendees	4.16	70	0.000
	Preservice teachers	MSOSW teachers	3.17	67	0.002
	Preservice teachers	MSOSW students	1.00	116	0.320
	MSOSW students	ITEST Summit Participants	4.35	89	0.000
	MSOSW students	SITE attendees	9.87	72	0.000
	MSOSW students	MSOSW teachers	2.56	69	0.013

Criterion-Related Validity for the Career Interest Questionnaire

Because the Career Interest Questionnaire was appropriate for administration to only the middle school students in the study, extensive cross-group (discriminant) validity analysis of the data from this instrument was not possible. However, correlations between the total scale score produced from these Likert-type items and other student learner disposition scales completed by the students were examined to assess criterion-related validity. The learner disposition measures (Computer Enjoyment and Importance, Movation and Study Habits, Empathy, Creative Tendencies, and Attitudes Toward School) that were administered for this study had been validated previously with a similar population (Knezek, Christensen, Miyashita & Ropp, 2000). As shown in Table 7, preliminary analysis indicated that STEM Career Interest, when viewed as a total scale score, was positively correlated with Creative Tendencies ($r = .53$, $p < .0005$), Computer Importance (for schooling and career) ($r = .54$, $p < .0005$), Motivation ($r = .42$, $p < .001$) and Attitudes Toward School ($r = .42$, $p < .001$). This general trend was found to be true for the group of middle school students as a whole ($n = 60$) and for each of the two classes assessed. These data collectively indicate that STEM Career Interest Questionnaire scores are positively associated with established measures in the direction anticipated.

Table 7
Correlations of STEM Career Interest with Learner Dispositions (n=60)

		Career Interest Questionnaire (Total Scale)
Computer Enjoyment	Pearson Correlation	.303*
	Sig. (2-tailed)	.019
Computer Importance	Pearson Correlation	.442**
	Sig. (2-tailed)	.000
Motivation / Persistence	Pearson Correlation	.419**
	Sig. (2-tailed)	.001
Study Habits	Pearson Correlation	.308*
	Sig. (2-tailed)	.017
Empathy	Pearson Correlation	.208
	Sig. (2-tailed)	.110

Table 7 continued

		Career Interest Questionnaire (Total Scale)
Creative Tendencies	Pearson Correlation	.528**
	Sig. (2-tailed)	.000
Attitude Toward School	Pearson Correlation	.421**
	Sig. (2-tailed)	.001

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

These sets of data collectively form the baseline data for the MSOSW Project in the area of STEM career interest. In addition to validating the instruments, as described here, the results have also established baseline levels for STEM career interest for students and pre-service teachers, as well as average levels of STEM career interest for three different groups of STEM professionals. Given these levels, project staff working with teachers and/or students could use the STEM professional career interest levels as a ‘target’ of sorts. If the perceptions of participating students move in the direction of the perceptions of STEM professionals by the end of the project, then this change in perception can be considered a successful outcome of the initiative.

Both the STEM Semantic Survey and the Career Interest Questionnaire have special properties that make them attractive for longitudinal studies of a single group and /or snapshot analyses across multiple groups. The STEM Semantics Survey, for example, has demonstrated its validity for a broad age range of participants, from grade 6 through adult. Each of the adjective pairs are presented (in a counterbalanced fashion) for every target item, allowing, for example, direct comparison of perception of science to perception of math. The Career Interest Questionnaire, on the other hand, is very easily interpreted and is in a format familiar even to sixth graders. However, the instrument is written from the learner’s perspective so completion by teachers or other adults is not appropriate. Each instrument was refined from earlier work by well-established psychometricians.

The instruments used in the current study represent an attempt to provide updated measures for attitudes towards STEM. As noted earlier, previous instrumentation developed by Novodvorsky (1993) is a good effort at attempting to establish valid and reliable instrumentation for determining attitudes towards STEM, but recent research using the instrument (Ornstein, 2006) indicates that the instrument may be dated. The SORT provides another attempt at measuring attitudes towards STEM. Again, the items are dated (over 30 years old) and the test has limited use within the US. The instrumentation used in the current study addresses the limitations of these instruments, and provides normative data based on a 2009 sample. Both instruments have the capability of measuring changes in attitudes toward STEM in current US classrooms.

The instruments described in this paper are short, easy to use, and specifically target interests and attitudes in science and STEM. The language is appropriate for elementary through high school aged students and can be used to measure changes in interest and attitude. Instruments are available both online and in hard copy so that it is easy to implement in both formal and informal learning settings. Instruments such as these would facilitate access to important information on the state of youth participants' interests in and attitudes toward STEM, and how those interests and attitudes change over time. The STEM Semantics Survey can be used with both teachers and students to measure the impact of STEM professional development on both groups. In the specific case of ITEST, with support from the ITEST LRC and with further research to determine whether these instruments will perform acceptably across varying levels of participant age ranges and content-based activities, such instruments could be used by various projects, providing useful cross-project findings.

References

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.

Buros Institute (2007). *The seventeenth measurements Yearbook*. University of Nebraska : Buros Institute of Mental Measurements.

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

Friedman, T.L. (2005). The World is Flat. New York: Farrar, Straus, & Giroux.

Knezek, G., & Christensen, R. (1998, March). Internal consistency reliability for the teachers' attitudes toward information technology (TAT) questionnaire. In *Proceedings of the Society for Information Technology in Teacher Education Annual Conference (Eds.)* S. McNeil, J. Price, S. Boger-Mehall, B. Robin, & J. Willis, pp. 831-836. Bethesda, MD: Society for Information Technology in Teacher Education.

Knezek, G., Christensen, R., Miyashita, K., & Ropp, M. (2000). Instruments for assessing educator progress in technology integration. Denton, TX: Institute for the Integration of Technology into Teaching and Learning (IITTL).

Lubinski, D., & Benbow, D. (2006). Study of mathematically precocious youth After 35 years: Uncovering antecedents for the development of math-science expertise. *Perspectives on Psychological Science, 1* (4), 316-345.

Magid,L. (2007) Putting energy hogs in the home on a strict low-power diet. New York Times, June 14, 2007.

Meyer, G. R. (1995). Scientific Orientation Test, In *The eleventh measurements Yearbook (Vol. 11, pp.32-66).* University of Nebraska: Buros Institute of Mental Measurements.

National Science Foundation. (2009, October 29). *Innovative technology experiences for students and teachers (ITEST).* Retrieved from http://www.nsf.gov/pubs/2009/nsf09506/nsf09506.htm

Novodvorsky, I. (1993). Development of an instrument to assess attitudes toward science. (Doctorial Dissertation, The University of Arizona, 1993) *Dissertation Abstracts International*, *54*, 4054.

Ornstein, A. (2006). The frequency of hands-on experimentation and student attitudes towards science: a statistically significant relation, *Journal of Science Education and Technology*, 15(3), 285-297

Rogers, B. G. (2007). Review of the Scientific Orientation test, In *The seventeenth measurements Yearbook (Vol.17, pp. 153).* University of Nebraska: Buros Institute of Mental Measurements.

Ross, J.P., & Meier, A. (2000). In Proceedings of The Second International Conference on Energy Efficiency in Household Appliances, Naples, Italy (September).

The White House, Office of the Press Secretary. (2009, November 23). *President Obama launches "Educate to innovate" campaign for excellence in science, technology, engineering & math (STEM) education* [Press release]. Retrieved from http://www.whitehouse.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en

Whitfield, A., Feller, R., & Wood, C. (2008). *A Counselor's Guide to Career Assessment Instruments,* Broken Arrow, OK: National Career Development Association.

WorkSource. (2007). *STEM: Achieving Lifelong Career Success*, Vancouver, WA. Retrieved from http://www.swwdc.org/stem/stem_docs/STEM-brochure-email-web_5-29-09.pdf

Zaichkowsky, J. L. (1985). Measuring the involvement construct. *Journal of Consumer Research, 12*(3), 341-352.

Notes

1 Note that ITEST summit participants, within their own group, rated science and technology higher than engineering, but they were not the highest of the groups sampled in these latter two areas.

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