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Development of the Educational and Career Interest Scale in Science, Technology, and Mathematics for High School Students

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Abstract The Educational and Career Interest scale, a self-report instrument measuring high school students' educational and career interest in STEM, was developed and validated in two studies conducted during 2010 and 2011. Study 1 included data from 92 high school students, in which exploratory factor analysis (EFA) was conducted with an initial item pool of 20 items. EFA identified three factors: educational and career interest in science, educational and career interest in technology, and educational and career interest in mathematics. Study 2 utilized data from 658 students to revisit the three-factor model using confirmatory factor analysis. The two studies provide strong evidence that the scale is both valid and reliable.

Keywords Educational and career interest · STEM · Factor analysis · Instrument development

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Introduction

Interest has been considered to be an important aspect of learning and achievement for about a century. Research has been conducted based in both philosophical and psychological perspectives. In the early twentieth century, utilizing a philosophical and pedagogical approach, Dewey discussed interest as a motive that engaged children toward an occupation and the gaining of experience (Jackson 1990). Subsequently, framed in a psychological perspective, Atkinson (1957) first defined interest in value (called incentive value), as having an important relationship to motive. He believed that the relationship of incentive value to motive could be helpful to predict achievement. For Atkinson, motive was identified as the intention used by individuals to approach success and avoid failure. Later researchers expanded on this work to provide two major approaches to conceptualize interest based on empirical studies (Krapp et al. 1992; Parsons and Goff 1980).

Krapp et al. (1992) proposed three constructs of interest: personal interest (disposition), situational interest (interestingness of contextual factors) and interest as a psychological state (combination of actualized personal interest and situational interest). Parsons and Goff (1980) conceptualized interest as task value in four constructs: attainment value (importance of a task), intrinsic value (enjoyment in conducting a particular task), utility value (task value to achieve short- and long-term goals) and cost (lost opportunities as a result of participating in another task). Eccles and Wigfield (1995), the pioneers of expectancy and value theory, distinguished and defined interest in two different domains: intrinsic interest and utility value (extrinsic interest). Intrinsic interest was defined as a person's subjective interest or enjoyment from performing the activity (Chen and Liu 2008; Eccles and Wigfield 1995). Utility value was used to identify a person's extrinsic interest in the usefulness of a task toward accomplishing future goals, such as going to college or getting a job (Ormrod 2006; Schunk et al. 2007; Wigfield 1994). An individual's intrinsic interest and utility value in certain tasks were identified to predict motivational indices and performance: mental effort (Jacobs and Eccles 2000; Schunk et al. 2007), performance (Deci and Ryan 1985; Oh and Dembo 2010; Schunk et al. 2007; Wigfield 1994), choice of activities (Eccles and Wigfield 1995; Schunk et al. 2007; Wigfield 1994), persistence (Schunk et al. 2007; Wigfield 1994), engagement (Alexander 2004; Jacobs and Eccles 2000), attention (Ainley et al. 2002; McDaniel et al. 2000; Hidi et al. 2004; Schunk et al. 2007), goal achievement (Harackiewicz et al. 2000; Harackiewicz and Durik 2003; Pintrich and Zusho 2002; Senko and Harackiewicz 2002), cognition (Schiefele 1996), and level of learning (Harackiewicz et al. 2002; Renninger and Hidi 2002; Schunk et al. 2007).

In the educational setting, it is important that both students and teachers understand the level of intrinsic interest and utility value a student holds in learning particular subjects, developing a career in specific areas or attending college for certain majors. For a student to be competitive in the twenty-first century, researchers, educators, and policy leaders emphasize the importance of student intrinsic interest and utility value in learning knowledge and skills, obtaining careers, and studying in college in STEM-related areas (Tyler-Wood et al. 2010). Success in STEM-related areas requires that students be provided with educational settings to nurture their intrinsic interest and utility value in STEM. It is critical that educators have the necessary tools to measure and understand student intrinsic interest and utility value and modify or develop pedagogical approaches or contexts to optimize student learning in these areas.

To successfully measure student intrinsic interest and utility value in STEM areas, it is imperative that a valid and reliable instrument be utilized. Surveys that assess general interest in any domain do not accurately measure high school student intrinsic interest and utility value when used specifically in STEM-related areas (Tyler-Wood et al. 2010). As a result, researchers have stressed the importance of developing a STEM domain-specific instrument that examines student intrinsic interest and utility value in learning in STEM-related subjects and careers (Tyler-Wood et al. 2010; Bong 2001). Although there are several valid and reliable scales measuring interest (Career Training Concepts, Inc 1987; Knapp et al. 1995; Lewis and Rivkin 1999; Pintrich et al. 1991) and attitudes toward STEM learning for high school students (Bryan et al. 2011; Leeming and Dwyer 1995; Sjøberg and Schreiner 2005; Tapia 1996; Wareing 1982), there is no valid and reliable scale specifically measuring intrinsic interest and utility value for high school students' learning in STEM-related subject areas, careers, and majors in college. Intrinsic interest and utility value are both important motivational factors that predict student performance (Deci and Ryan 1985; Oh and Dembo 2010; Schunk et al. 2007; Wigfield 1994) and choices of particular tasks (Eccles and Wigfield 1995; Schunk et al. 2007; Wigfield 1994). They are two distinct constructs measuring different interests. However, it has not been studied whether intrinsic interest and utility value fall into two constructs or one when they are measured in STEM domain specific for high school students.

As discussed previously, interest appears to be domain specific. Task value theory categorizes interest into intrinsic interest and utility value in a particular domain and hypothesizes that intrinsic interest and utility value are independent of each other. This assumption that intrinsic interest and utility value are distinctive constructs has not yet been tested for high school students in STEM domain.

This study develops, tests, and validates an instrument to examine the perceptions of high school students' intrinsic interest and utility value in learning STEM contents, pursuing STEM careers, and majoring in STEM in college. In our scale development, we define *educational interest* as measuring intrinsic interest of high school students in learning in STEM subjects and *career interest* as examining their utility value in developing a STEM career or attending college for STEM majors. The hypotheses that guide the study include:

1. High school students perceive educational and career interest specific to STEM subjects.
2. High school students perceive educational interest and career utility value as two distinct interests in STEM domains.

The following section discusses the theoretical framework of interest in task value and the three approaches on interest including personal interest, situational interest, and interest as a psychological state.

Conceptualization of the Educational and Career Interest Dimensions in STEM

Domain-specific constructs used by high school students in STEM to assess relationship to interest examined in the current study include science, technology, engineering, and mathematics. The domain and intrinsic interest and utility value constructs were utilized to develop initial items and refined with both content and construct validations.

Interest

Interest (intrinsic interest) and utility value are two constructs described in expectancy and value theory. Although these constructs have sometimes been considered to represent one task value construct, (Eccles and Wigfield 1995; Ormrod 2006; Pintrich and Schunk 2002; Wigfield 1994; Zimmerman 2000), for the purpose of our research and, in line with task value theory, (Deci and Ryan 1985; Lepper et al. 2005) interest and utility value are considered to be two distinct constructs.

Interest refers to the student's evaluation of how interesting and how useful the task is (Wigfield and Eccles 2000). Intrinsic interest comes from a person's innate interest in a task. Utility value is the perceived usefulness of a task because of its congruence with a person's future plans or career goals. Utility value is considered to be similar to extrinsic motivation as is defined as completing a task to attain particular goals (Pintrich and Schunk 2002). A person may not hold intrinsic interest in performing a particular activity, but may value it in order to move forward to the next stage that is meaningful to his or her current or future life (Chen and Liu 2008).

Interest Being Domain Specific

Interest is further classified according to the level of a person's interest in a specific domain. The person's interest interacts with the quality of activities, materials, tools, and the levels of content knowledge in that domain (Tobias 1994). Researchers (Krapp et al. 1992) have conceptualized interest from three different perspectives: personal or individual interest as disposition, interestingness of contextual or environmental features, and interest as a psychological state. These perspectives are grounded in interest as domain specific—in other words, a person experiences joy, flow, or positive feelings due to his or her interest and prior knowledge in a particular subject, topic or activity.

Personal Interest

Interest has been found to be quite stable toward particular domains when studied from the personal or individual perspective reflecting dispositional and motivational characteristics and trait-like characteristics (Krapp 2002; Schiefele 1996; Schiefele and Rheinberg 1997). A person with interest in a certain domain is more likely to be engaged in its content or topic over time (i.e., interest in sports, science, music, computers) (Hidi and Renninger 2006; Krapp et al. 1992). Hidi and Renninger (2006) define interest as "relatively enduring predisposition" (p. 113).

Situational Interest

Another approach used to examine interest is situational interest. Situational interest refers to a person's present interest in the environment and is considered to result from contextual factors such as tasks, activities, tools, materials, or content of texts that make a particular domain interesting (Krapp et al. 1992). Novel tasks, activities, tools, materials, or some texts may stir a person's interest more than dry or mundane ones. An individual's situational interest is impacted by a certain domain while his or her personal interest is related to the specific contextual factors of that domain. This approach takes into account specific features of environments, (i.e., laboratory experiences, classroom activities, computer-based projects, digital media), that generate situational interest (Schunk et al. 2007). Situational interest is not just the temporary interestingness of the context that arouses a person's curiosity or positive emotions, but is tied to the specific content of a subject and the structural factors of environments or tools that make interest last longer and eventually lead to personal interest.

Interest as Psychological State

The psychological state of an individual is impacted by both actualized individual interest and situational interest (Schunk et al. 2007). A person's situational interest in a certain domain is considered to interact with and relate to the individual personal interest. These two factors interact to determine a person's psychological state to be interested in a certain domain. Particular features of environments generate the psychological state of interestingness in a particular domain to an individual (Krapp et al. 1992). Some researchers (Renninger 1992; Tobias 1994) conceptualize interest within the relationship to a person's knowledge in a certain domain as interest interacts with the levels of content knowledge. Interest involves both a person's knowledge and value of a particular topic and activity. When a person has a high level of knowledge and value in an area, it is reflective of a higher level of interest in his or her psychological state (Renninger 1992). Renninger considered interest to be attraction to a topic if the value of the activity is high and knowledge of the topic is low. In contrast, Tobias (1994) argues that a person can present high interest in a certain topic although he or she has a low level of knowledge. This may be more typical for children, who are in the process of learning and developing knowledge in a particular domain. They are at the transitory stage in their course of learning and acquiring knowledge. Thus, children can still show high level of interest with low knowledge in a particular domain, topic, or activity.

The following section describes the procedures that were employed in the development of the Educational and Career Interest scale.

Scale Development Procedures

The creation of the Educational and Career Interest scale occurred in a series of stages including generation of an item pool, expert review, focus group interviews, and field testing. The initial scale development process started in 2009 and included the qualitative examination of student interest and utility value in STEM activities conducted over 3 years of evaluation of a blended learning STEM academy in Connecticut (Lorentson 2010a, b, c) and an initial review of research related to the measurement of interest and K-12 STEM education in Connecticut and nationally (Sax 1997; National Governors Association 2007; Carnegie Corporation 2009; Pea et al. 2008). An initial pool of 27 items was generated.

In 2010, additional literature review was conducted, which resulted in a new pool of 23 items. Subsequently, two focus group interviews were conducted in the spring of 2011 with (a) experts in STEM areas, and (b) high school students separately to solicit their feedback on items that measured high school students' career and educational interest in STEM. Based on information collected from the focus group interviews, the items were revised again. Finally, a scale of 20 items assessing high school students' educational and career interest in STEM was tested in two studies.

Literature Review

After selection of the initial pool of 27 items, three researchers with expertise in STEM education and motivation were invited to review the items. In response to the experts' feedback, 13 items were eliminated from the scale and an additional 9 items were created applying the task value theory to select, review, revise, and create the items. The language and content of the existing items was also revisited based on task value theory and the literature of intrinsic interest and utility value as well as revised for clarity and readability. At that point, the scale consisted of 23 total items: 11 intrinsic interest items and 12 utility value items. The intrinsic interest items included: 3 items in taking courses in science and technology-related areas, 3 items in science and technology-related careers, 1 item in enrolling in science and technology programs in higher education, and 4 items in learning in science, technology and mathematics. The utility value items included: 8 items measuring the usefulness of current science and technology courses in learning in other areas, and 4 items examining the usefulness of the current science and technology courses in career and college preparation.

Expert Focus Group Interview

The 23-item scale and interview questions were sent to nine experts in STEM education including professors, teachers, chairs of math and science, science education specialists, and science curriculum specialists for their review. Specific assignment was listed in a worksheet and guided by the following questions: (1) Does the overall scale include the essential elements of career and education interest in STEM? If not, what changes do you recommend? (2) Is each item clearly linked to students' interest in STEM? If not, what are your recommendations for change? (3) Does each item clearly communicate the intended meanings? If not, what are your recommendations for change? and finally, (4) Is the language of each item both clear and concise? If not, what are your recommendations for change? These STEM education experts participated in a 90-min focus group interview. In February of 2011, during the interview, these experts were asked to review all items in the Educational and Career Interest Scale and to discuss the four questions listed above. The interview resulted in the creation of one new item measuring students' interest related to getting good grades in STEM-related courses in high school to pursue STEM-related degrees or careers. Language and content were modified to examine all STEM areas including engineering and mathematics. A total of 24 items were produced.

Student Focus Group Interview

Additionally, in March of 2011, a 45-min student focus group interview examining the 24 items in the scale was conducted with 11 high school students in Connecticut. This focus group interview included two groups of students. One group was taking STEM-related blended learning courses, and the other group was taking traditional STEM-related courses. The student focus group interviews were centered on the clarity and understanding of each item in the scale: (1) How well do you understand what the question is asking and (2) Are the words in the question clear to read? Based on the discussion in the student focus group, four items with activities and concepts that students were not familiar were removed, and the language and content was revised again. As a result, a total of 20 items were generated.

Field Testing

In the final stage of the scale development, the 20-item scale generated from the previous revisions was tested with 92 high school students. Exploratory factor analysis was conducted with the data from this study to identify the most valid items and factors in the scale. After the EFA study, a new version of the scale with 9 items was tested in another study with 658 high school students to validate the structure of the scale. The two studies are described in detail in the following sections.

Study 1: Exploratory Factor Analysis

Method

Participants

Participants included 92 high school students who studied in one urban high school in Connecticut. Of the 92 students, 39 (42 %) were female. The ethnical composition, as reported by the participants, was 9 (10 %) White and 83 (90 %) African American 25.86 % students were from STEM academy and the rest from traditional program.

Procedures

In June 2011, all participants were administered a 25-min online survey about their educational and career interest in STEM, in the computer room of their school. Parent information sheets were distributed a week before the administration day. Student assent forms indicating the purpose and voluntary nature of the study and confidentiality were distributed and collected right before the survey administration. Each student was assigned to a computer and was required to fill out the survey individually. The survey was administered by a staff member from the study team, who stayed with the participants throughout the survey and was responsible to answer questions that potentially arose by the participants.

The Educational and Career Interest in STEM Measure

The measure included 20 items. Among them, 12 items assessed students' interest in science, mathematics, technology, and engineering, respectively (three items for each subject), and 8 items assessed students' interest in STEM as a whole. Students were required to respond to the items using a xranging from 1 (not at all true) to 7 (very true).

Analytic Strategy

Exploratory factor analysis (EFA) was conducted with the *Educational and Career Interest in STEM measure* to explore the dimensionality of the measure and identify items and factors that did not fit into the measure. The analysis followed a three-step process. The first step was factor structure assessment, in which the number of the factors in the measure was identified. The factor number was decided based on the examination of scree plot, eigenvalues, the goodness of fit of various factor models, and parallel analysis. Model fit indices such as standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), comparative fit index (CFI), and the Tucker-Lewis index (TLI) were used as the criteria of the goodness of fit. Conventionally, SRMR smaller than 0.05, RMSEA smaller than 0.06, CFI larger than 0.96, and TLI larger than 0.95 are considered to be a good fit (Hu and Bentler 1999), whereas SRMR smaller than 0.08, RMSEA smaller than 0.1, CFI larger than 0.90, and TLI larger than 0.90 are considered to be an acceptable fit (Brown and Cudeck 1993). The value of chi-square was also provided; however, chi-squares are often biased by sample size. Therefore, χ^2/df was calculated and a value close to 2 indicates a good fit of the model (Bentler 1995; Byrne 2001). In terms of parallel analysis, a factor was retained when its eigenvalue obtained from the real data was equal or larger than the one from the simulation data (Timmerman and Lorenzo-Seva 2011).

The second step was the assessment of item quality. An item of good quality should show acceptable loading and no cross loading. Loading size larger than 0.60 was considered to be high and larger than 0.45 was considered acceptable. Additionally, loading size larger than 0.35 in over one factor was considered as cross loading (Pett et al. 2003; Silvera et al. 2001; Tabachnick and Fidell 2001). In the third step, the quality of each factor was examined. Factors with less than 2 items indicated a poor quality (Pett et al. 2003). Finally, items and factors with poor quality were eliminated, and the three EFA steps were repeated with the remaining items.

Mplus (version 6.1; Muthen and Muthen 1998–2010) was used to generate scree plot, eigenvalues, and the model fit indices. Although Likert scale variables are categorical in nature, when using seven categories they are treated as continuous variables (Johnson and Creech 1983). Maximum likelihood estimation was used to a correlation matrix. The potential factors in the measure were assumed to correlate with each other, and thus, oblique rotation was applied to reach an interpretable solution. Parallel analysis was conducted with FACTOR version 80.02 (Lorenzo-Seva and Ferrando 2011).

Results

Round 1

The first round analyses revealed four factors that had an eigenvalue larger than 1. The scree plot also showed that from the third factor on, the fractions of the total variance that could be explained by each successive factor dramatically reduced. The RMSEAs (from 0.16 to 0.12) were high for the one-factor, two-factor, three-factor, and four-factor solutions. SRMR was high for a one-factor solution, acceptable for a two-factor solution, and good for the three-factor and four-factor solutions. CFIs were larger than 0.90 for a four-factor solution. χ^2/df was smaller than 3 for a two-factor, a three-factor and a four-factor solution (Table 1). The result of parallel analysis indicated that only in the first two factors, the eigenvalues obtained from the real data were equal or larger than those from the simulation data (Factor 1: actual eigenvalue = 53.1, parallel = 12.9; Factor 2: actual eigenvalue = 11.1, parallel = 11.1).

Next, item quality was assessed with the two-factor, three-factor, and four-factor solutions. For the two-factor solution, 80 % of the items had high loadings (0.60 or above) and 5 % of the items did not load in any factors. There were no cross-loaded items in this model. For the three-factor solution, 70 % of the items had high loadings (0.60 or above). Ten percent of the items cross-loaded in two factors. In the four-factor solution, 60 % of the items had high loadings (0.60 or above), 5 % of the items did not load in any factors, and 5 % of the items cross-loaded in two factors. The above analyses showed that the two-factor and three-factor solutions resulted in higher quality of items than the four-factor solution. Therefore, the two-factor and three-factor solutions were retained for further analyses.

In the two-factor model, the items related to interest in science, math, and STEM were loaded together in one factor, and the items related to interest in technology and engineering were loaded together in the other factor. In the three-factor model, the items related to interest in science and STEM were loaded together in one factor, the items related to interest in technology and engineering were loaded together in another factor, and the items related to interest in mathematics were loaded in another factor. Theoretically, however, STEM items should either load to a separated factor or equally load with the four subject factors. Therefore, all eight STEM items were deleted. Another round of factor analysis was conducted with the remaining 12 items (see Table 1).

Round 2

The second round analyses revealed three factors that had an eigenvalue that was close to or larger than 1. The scree plot showed that the amounts of the total variance that could be explained by each factor radically dropped after the third factor. The RMSEAs (from 0.21 to 0.14) were high for the one-factor, two-factor, and three-factor solutions, and acceptable (0.10) for a four-factor solution. SRMR was high for a one-factor solution, acceptable for a two-factor solution, and good for the three-factor and four-factor solutions. CFI were larger than 0.95 for the three-factor and four-factor solutions. χ^2/df ration was less than 2 for a four-factor solution. The result of parallel analysis revealed that the eigenvalue obtained from the real data was larger than those from the simulation data only in one factor (actual eigenvalue = 53.7, parallel = 20.30).

Next, item quality was assessed with the three-factor and four-factor solutions since most of the above indices support the two models. In the three-factor solution, all items had high loadings (above 0.60), but 33 % of the items cross-loaded in two factors. All items in the four-factor model clearly loaded in each of the four factors and all had loadings larger than 0.60. Therefore, the four-factor model was selected for the measure, which explained 83 % of the total variance. The three items related to interest in mathematics were loaded together to Factor 1, three items related to interest in technology were loaded together to Factor 2, three items related to interest in engineering were loaded together to Factor 3, and three items related to interest in science were loaded together to Factor 4 (see Table 2).

Finally, correlation analysis was conducted with the four factors, which revealed a strong correlation (0.76) between Factor 2 (interest technology in) and Factor 3 (interest in engineering). Based on correlation results and subsequent consultation with students and teachers in the participating schools, we determined that students do not have a clear conception of engineering, most likely because it is not explicitly taught in high school. Based on this information, we believe that the items related to engineering may not be valid and thus may give noise to this scale. The three items related to interest in engineering were deleted, and another round of factor analysis was conducted with the remaining 9 items.

Table 1 Goodness of fit indicators for one-, two-, three-, and four-factor solutions (Round 1)

Factor solution	x^2	Df	χ^2/df	RMSEA	SRMR	CFI	TLI
1	590.86	170	3.48	0.16	0.09	0.71	0.68
2	422.23	151	2.80	0.14	0.06	0.82	0.77
3	341.41	133	2.57	0.13	0.05	0.86	0.80
4	265.58	116	2.29	0.12	0.04	0.90	0.83

Table 2 Goodness of fit indicators for one-, two-, three-, and four-factor solutions (Round 2)

Factor solution	x^2	Df	χ^2/df	RMSEA	SRMR	CFI	TLI
1	273.62	54	5.07	0.21	0.11	0.69	0.62
2	141.38	43	3.29	0.16	0.06	0.86	0.78
3	96.37	33	2.92	0.14	0.04	0.91	0.82
4	47.57	24	1.98	0.10	0.03	0.97	0.91

Table 3 Goodness of fit indicators for one, two, three, and four-factor solutions (Round 3)

Factor solution	x^2	Df	χ^2/df	RMSEA	SRMR	CFI	TLI
1	188.46	27	6.98	0.26	0.12	0.64	0.52
2	70.39	19	3.70	0.17	0.06	0.89	0.78
3	15.78	12	1.32	0.06	0.02	0.99	0.80
4	No convergence						

Round 3

The third round analyses revealed three factors that had an eigenvalue that was close to or larger than 1. The scree plot showed that the amounts of the total variance that could be explained by each factor radically dropped after the fourth factor. The RMSEAs were high for the one-factor and two-factor solutions, and acceptable for a three-factor solution. SRMR was high for a one-factor solution, acceptable for a two-factor solution, and good for a three-factor solution. CFI and TLI values were larger than 0.95 for a three-factor solution. χ^2/df ratio was smaller than 2 for a three-factor solution. The results (see Table 3) of parallel analysis revealed that the eigenvalue obtained from the real data was larger than those from the simulation data only in one factor (actual eigenvalue = 57.3, parallel = 27.1).

Since most of the above indices supported a three-factor solution, further investigation was carried with the three-factor solution only. All items (Table 4) in the three-factor model clearly loaded in each of the three factors and all except two items had loadings larger than 0.60. Therefore, the three-factor model was selected for the measure, which explained 78 % of the total variance. The three items related to interest in mathematics were loaded together to Factor 1, three items related to interest in technology were loaded together to Factor 2, and three items related to interest in science were loaded together to Factor 3. Then, correlation analysis (Table 5) was conducted with the three factors, which revealed a medium correlation (0.46–0.53) between the factors and indicated a distinguished but related relationship of the factors.

Study 2: Confirmatory Factor Analysis (CFA)

Method

Participants

This study included 658 students from 31 high schools in Connecticut; 15 of them are suburban schools, 13 urban schools, and 3 rural schools. Forty percent of the students were female, 57 % of the students were male, and 3 % of

Table 4 Factor loadings of the three-factor solution

Items	Factor 1	Factor 2	Factor 3
Q9			
I am interested in taking courses that help me learn more about SCIENCE	0.00	0.34	0.45
Q18			
I am interested in working in a career that allows me to use SCIENCE-related skills or knowledge	0.03	0.32	0.51
Q23			
I would like to learn SCIENCE-related knowledge and skills because they can be useful to help me be prepared for college	−0.06	−0.00	1.04
Q10			
I am interested in taking courses that help me learn more about TECHNOLOGY	−0.14	0.80	0.01
Q19			
I am interested in working in a career that allows me to use TECHNOLOGY-related skills or knowledge	−0.10	0.95	−0.01
Q24			
I would like to learn TECHNOLOGY-related knowledge and skills because they can be useful to help me be prepared for college	0.02	0.79	0.14
Q12			
I am interested in taking courses that help me learn more about MATHEMATICS	0.88	−0.13	0.01
Q21			
I am interested in working in a career that allows me to use MATHEMATICS-related skills or knowledge	1.05	0.00	−0.19
Q26			
I would like to learn MATHEMATICS-related knowledge and skills because they can be useful to help me be prepared for college	0.66	0.03	0.11

Table 5 Intercorrelation matrix of factors

	Mathematics	Technology	Science
Mathematics	1.00		
Technology	0.51	1.00	
Science	0.53	0.46	1.00

Table 6 Goodness of fit indicators for the CFA model

x^2	Df	χ^2/df	RMSEA	SRMR	CFI	TLI
93.04	24	3.88	0.09	0.07	0.97	0.95

Table 7 Intercorrelation matrix of CFA factors

	Mathematics	Technology	Science
Mathematics	1.00		
Technology	0.51	1.00	
Science	0.56	0.53	1.00

the students did not report their gender. Students were also asked to report their ethnicity in the survey. Sixty-eight percent of the students (based on self-report) were White, 14.6 % Hispanic or Latino, 5.9 % African American, 3.3 % Asian, 1.1 % Pacific Islander, 0.3 % American Indian or Alaska Native, and 5.8 % other. Approximately 1 % of the students failed to report their ethnicity. Participants were recruited from both traditional program and the STEM academy. However, the academy students took the survey before program was launched.

Procedure

Participants were group administered a 40-min online survey which included the 9 items of the Educational and Career Interest in STEM measure, in the computer rooms of their schools. Parent consent forms and student assent forms, addressing the voluntary nature and confidentiality of the study, were distributed and collected before the administration day. Participants were required to fill out the survey individually.

The Educational and Career Interest in STEM Measure

After previous EFA, eight items assessing students' interest in STEM as a whole and three items related to students' interest in engineering were removed from the original measure. The nine items that tap into students' interest in science, mathematics, and technology, respectively, were administered in Study 2. The items were rated in a 7-point Likert scale ranging from 1 (not at all true) to 7 (very true).

Table 8 Cronbach alphas

Factors	Study 1 $n = 92$ α	Study 2 $n = 658$ α
Interest in Science	0.83	0.89
Interest in Technology	0.87	0.88
Interest in Mathematics	0.87	0.87
Total	0.88	0.88

Analytic Strategy

Confirmative factor analysis (CFA) was conducted with the revised Educational and Career Interest in STEM measure using Mplus (version 6.1; Muthen and Muthen 1998–2010). The purpose of CFA was to verify the proposed construct of career and education interest in STEM measure resulting from the previous EFA. The CFA in this study used an ML estimation approach to a correlation matrix. Model fit indices, including standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), comparative fit index (CFI), and the Tucker-Lewis index (TLI), were used as the criteria of the goodness of fit. Chi-square and χ^2/df were also provided.

Results

Confirmatory Factor Analysis of the Educational and Career Interest in STEM Scale

The three-factor model explored in Study 1 was analyzed with CFA. The model fit indices show in Table 6 indicated an acceptable fit of the model: χ^2/df is close to 2; RMSEA is smaller than 0.10; CFI and TLI were equal or larger than 0.95; SRMR is smaller than 0.08. The correlations of the three factors (Table 7) were medium (0.51–0.56), which indicated they were separate but related constructs.

Reliabilities

Cronbach's alphas were calculated to examine the reliability of the measure in the two studies. As shown in Table 8, the alphas for the whole measure (0.88) and each subscale (>0.80) indicated a high internal consistency. The alphas also remained consistent across the two studies.

Comparison Between Hypothesized and Observed Factors

Literature on interest measurement does not have an agreement on the construct of interest scales. Task value theory argues that interest contains two independent constructs: intrinsic interest and utility value. Others address that interest is grounded in a particular domain or subject. Consequently, we formed two different hypotheses about the construct of the Educational and Career Interest scale. In hypothesis 1, the scale contains two factors: (1) interest in science, technology, engineering, and mathematics, and (2) utility value in science, technology, engineering, and mathematics. In hypothesis 2, the scale contains four factors: (1) educational and career interest in science, (2) educational and career interest in technology, (3) educational and career interest in engineering, and (4) educational and career interest in mathematics.

Hypothesis 1 was not supported by our current study. Intrinsic interest and utility value were found in the same rather than the different factors. On the other hand, the current study showed strong support to hypothesis 2. Students' educational and career interest in science, technology, and mathematics was found to be three separated factors, indicating the domain-specific nature of the scale. However, the items related to interest in Engineering fell out of the scale because of students' lack of familiarity with this domain. Table 9 provides a summary of these results.

Discussion

The current research examined how high school students perceive their interests in learning knowledge and skills through courses, obtaining careers, and studying majors in college particularly in STEM areas. This study revealed three domain-specific constructs in the educational and career interest in STEM scale: educational and career interest in science, educational and career interest in technology, and educational and career interest in mathematics. This result is correspondent with Tyler-Wood et al. (2010) study, which demonstrated that students' semantic perception of STEM were domain specific. According to that study, interest items fell into science, mathematics, engineering, and technology distinctively when measured in interest in subject. It is also important to note that the items measuring career interest in STEM as a whole, fell into another subscale.

However, the results from this study differ from those in Pintrich et al. (1991) study of child's task value, in which they revealed three constructs: perceptions of interest, utility value, and importance. In the current study, perceptions of interest and utility value were not found to be separated factors. The reason might be that in the Motivated Strategies for Learning Questionnaire (MSLQ), items related to utility value or perceptions of interest did not specify domains leaving them more general, "in this course," or "in this class" while specific domains were attached to the items related to utility value or perceptions of interest in the current study. This result indicated that when put together, domain-specific constructs surpassed the task theory constructs. Although interests in science, technology, and mathematics were identified as separated factors in our study, interest in engineering did not consistently load into one factor, likely resulting from students' lack of familiarity with the domain. The current study implies that in order to help high school students to be competent to pursue careers and college majors in engineering, it is recommended that they are provided with more exposures to engineering-related courses, topics, activities, tools, and materials with the guidance of qualified teachers in this subject. Interestingly, the newly released Next Generation Science Standards Framework now provides a significant position to the ideas and practices of engineering, with specific emphasis to increase student knowledge of science and engineering, so they have the skills necessary to enter careers in science, technology, and engineering (Committee on a Conceptual Framework for the New K-12 Science Education Standards

Table 9 Comparison between hypothesized factors and observed factors

Hypothesized Factors	Observed factors
Hypothesis 1	
Intrinsic Interest in Science, Technology, Engineering, and Mathematics	
Utility value in Science, Technology, Engineering, and Mathematics	
Hypothesis 2	
Educational and Career Interest in Science	Educational and Career Interest in Science
Educational and Career Interest in Technology	Educational and Career Interest in Technology
Educational and Career Interest in Engineering	
Educational and Career Interest in Mathematics	Educational and Career Interest in Mathematics

2012). This emphasis was identified by the Committee, specifically because of the lack of engineering teaching and learning occurring in K-12 classrooms.

The current study also found that items using STEM as a whole were loaded together with items related to science or mathematics. This indicates that high school students may not conceptualize science, technology, engineering, and mathematics as a unified area, further supporting the domain-specific nature of educational and career interest in high school students. The items using STEM together were eliminated at the end. The tested sample items included: “I am interested in improving my problem-solving skills that help me learn Science, Technology, Engineering or Mathematics (STEM),” and “I would like to enroll in a college or training program to study Science, Technology, Engineering or Mathematics (STEM) after I graduate from high school.” Future studies are needed to test these questions in each STEM subject. In addition, to further validate the current scale, studies involving larger sample than the current ones are also recommended.

This newly validated instrument provides educational researchers a useful assessment tool to understand high school students’ intrinsic interest and utility value, especially in science, technology, and mathematics areas. The instrument will also help teachers understand their students’ interest in each of science, technology, and mathematics subject domains, and adjust their teaching practice according to students’ interest and utility value. In addition, policy makers and program evaluators will benefit from this educational and career interest assessment tool when using it to assess program efficacy.

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