The Relationships between Students' Perceptions of Science and Their Career Aspirations in STEM (Science, Technology, Engineering, and Mathematics)

Xiaoqing Kong[1]

Robert H. Tai[1]

Xitao Fan[2]

[1] Curry School of Education, University of Virginia, Charlottesville, VA, USA

[2] Faculty of Education, University of Macau, Macao, China

Paper presented at the annual conference of the American Educational Research Association

April-May, 2013, San Francisco, California

The Relationships between Students' Perceptions of Science and Their Career Aspirations in STEM (Science, Technology, Engineering, and Mathematics)

Abstract

This study is to investigate the underlying factors of students' reported perceptions of science, and whether those factors are associated with students' STEM (science, technology, engineering, and mathematics) career interest. Survey data from about 1200 middle school students across five states were collected. Factor analyses were conducted to extract underlying factors from the observed questions about students' perceptions of science. Logistic regression analyses were used to examine the relationships between the underlying factors and students' STEM career interest. Results indicate that students' perceptions of science could be grouped under several underlying factors, some of which were significantly related to STEM career interest. The findings are discussed in relation to their consistency, or lack thereof, with other studies in this area.

Perspective and Objective

It is important to investigate the relationships between students' ideas about learning science and their career expectations in the fields of science, technology, engineering and mathematics (STEM). For STEM workforce development, it is crucial to encourage as many students as possible to consider future STEM careers. Students' perceptions of science and science learning in early age are often considered as key factors that may lead young students into the STEM workforce pipeline (National Academy of Sciences, 2007). Therefore, it is necessary to examine the extent to which students' early ideas about learning science relate to their future career expectations in the STEM-related fields. Among various types of perceptions, interest in science and attitudes towards science are two primary and evident indicators for the quality of science education research (Koballa, Jr. & Glynn, 2007; Osborne, Simon, & Collin, 2003). Many researchers make an effort to keep students interested in science or having positive attitudes towards science, with the ultimate goal of encouraging students to choose the STEM-related fields as future careers (Eijck & Roth, 2009; Johnson, 2011).

Interest can be defined as "a content-specific motivational characteristic composed of intrinsic feeling-related and value-related valences" (Schiefele, 1991, p. 299). Interest in science is a primary affective factor of science education and can be influenced by multiple aspects, such as students' school science experiences (Aschbacher, Li, & Roth, 2010). Attitudes refer to the feelings that a person possesses about an object based on his or her belief of that object (Kind, Jones, & Barmby, 2007). Some researchers discuss that students hold dichotomous attitudes towards science: emotional states towards science and recognition of importance of science in the society (George, 2006; Kim & Song, 2009). Among various influencing factors, school performance plays an important role in forming students' attitudes towards science (Bhattacharyya & Mead, 2011). Career choice is the decision that students make after the process of developing certain traits or personalities. Guiding students to the STEM-related careers is the ideally ultimate goal of maintaining them in the STEM pipeline (Bui & Alfaro, 2011; Kanter & Konstantopoulos, 2010). In order to improve the STEM workforce and to strengthen the nation's economic competitiveness in the future, it is important to engage young people to choose STEM-related fields as their future careers (U.S. Department of Education, 2007).

Many researchers assume that students' interest and attitudes towards science might predict career interest in the STEM-related fields, and thus try different ways to make students

engaged in science learning (Aschbacher et al., 2010; Kanter & Konstantopoulos, 2010). But few are completely sure about whether there is an actual relationship between students' perceptions and ideas about learning science and their STEM career interest. Additionally, some researchers tend to combine interest and attitudes together to illustrate one construct—students' levels of engagement in science (Guzzetti & Bang, 2011; Hong, 2010). Although interest and attitudes towards science are both primarily affective constructs of science learning, interest emphasizes how students like learning science; whereas attitudes focus on how students think about learning science. Additionally, there may be some other important factors in the affective dimension of science learning (Simpson, Koballa, Jr., Oliver, & Crawley, 1994). So far, many researchers have investigated students' interest in science, attitudes towards science, and career choice in STEM-related fields respectively (Brown, 2002; Kind et al., 2007; Schiefele, 1991). Few researchers, however, pay attention to the relationships among those three constructs or even other affective factors (Archer et al., 2010).

This study is to investigate the underlying affective factors of students' perceptions and ideas about learning science, and whether there are significant relationships between the underlying factors and students' career interest in the STEM-related fields. The two research questions for this study are:

What is the underlying structure of students' reported perceptions and ideas about learning science?

To what extent are the perceptions and ideas about learning science reported by middle school students significantly related to whether they choose the STEM-related fields as future careers?

Data and Methods

Survey data were collected from eight middle schools in five states over a two-year period, with topics including students' various perceptions and ideas about learning science and their future career plans. The questions related to students' perceptions and ideas about learning science were adapted from an existing attitudinal measure: modified Attitudes towards Science Inventory--mATSI (Weinburgh & Steele, 2000). Participants in the project consist of two consecutive cohorts (sixth to seventh grade cohort and seventh to eighth grade cohort). The data used in this study include the surveys from all seventh grade students: the first year surveys from seventh to eighth grade cohort and the second year surveys from sixth to seventh grade cohort. Table 1 presents the descriptive statistics of the participants by cohort. As for the first research question, exploratory and confirmatory factor analysis (EFA and CFA) were used to examine the underlying factors (constructs) of the survey items measuring perceptions and ideas about science learning. As for the second research question, logistic regression analysis was used to investigate the relationships between the factors of students' perceptions and ideas and their choice of STEM-related careers.

Results and Discussion

Based on the EFA for the 7-8 cohort data, three factors were extracted. Table 2 shows the 19 survey questions grouped under the three factors based on the variables' factor loading pattern with respect to each of the three factors. Therefore, the three factors were tentatively labeled as the "interest factor", the "unease factor", and the "attitude factor" respectively. We then used CFA to evaluate this three-factor model in the 6-7 cohort data. Findings from CFA suggest that two variables (16a and 12e in Table 2) have relatively small loadings and appear to have little

relationship with the unease factor logically. After the two variables are removed, CFA results showed good model fit for the three-factor structure. Finally, we manage to extract three underlying factors out of students' reported perceptions and ideas about learning science.

Table 3 presents descriptive statistics for the percentages of students who reported a career interest in science and engineering (SE) and in science, engineering or *medicine* (SEM) respectively. It is noted that a considerable percentage of students selected medicine as their future career field, with the percentage increased from about 10% for SE choice to about 28% when medicine was included (SEM). Table 4 presents two logistic regression models in the 7-8 cohort data. In the first model, we consider whether students plan to work in SE only as the outcome variable. In the second model, we treat whether students expect to work in SEM as the outcome variable. In both models, the interest factor and the unease factor are significantly associated with students' career selection in the general STEM-related fields after demographic information is considered. That is to say, students who are more interested in learning science are significantly more likely to report a career interest in the general STEM-related fields. Students with stronger feelings that it is difficult to learn science are significantly less likely to indicate a career interest in the STEM-related fields.

However, the two models in Table 4 demonstrate different results in terms of the relationship between students' attitudes towards social importance of science and their STEM career interest. In the first model, students with more positive attitudes towards the contribution of science to the society are significantly more likely to report a career interest in SE. In the second model, however, there is no significant relationship between the attitudes towards science and students' career interest in SEM. In other words, the attitude towards the social significance of science is not a consistent factor in terms of associating with students' career interest in the general STEM-related fields. In order to further examine our results above, we conducted the same regression analyses in the 6-7 cohort data (Table 5). By comparing Tables 4 and 5, we can infer that the results from the 6-7 cohort data confirm our previous findings.

Conclusion

Based on factor analyses, we grouped students' reported perceptions and ideas about learning science into three categories: interest in science, unease about learning science, and attitudes towards social significance of science. Students' interest and attitudes towards science are always considered as primary affective factors in science education research (Koballa, Jr. & Glynn, 2007; Osborne et al., 2003; Schiefele, 1991). In this study, students' unease about learning science was shown to be another affective construct about science learning. In future studies, researchers are recommended to focus on the topic of how comfortable students feel about actually doing science and its relationship with other affective factors.

The strong association between interest in science and students' STEM career interest resolves the inconsistency in previous studies (Archer et al., 2010; Aschbacher et al., 2010). The strong relationship between unease about learning science and career interest in the STEM-related fields reemphasizes the conclusions from previous studies (Becker, 2010; Hassan, 2008). However, our results suggest that, when the interest factor and the unease factor were already in the mode, the statistical relationship between the attitude factor and students' STEM career interest is not consistent. This finding is somewhat inconsistent with some previous studies (Haselhuhn & Andre, 1997; Kanter & Konstantopoulos, 2010; Khoury & Woss, 1985), while underscoring the conclusions of some other studies (Bhattacharyya & Mead, 2011; Kitts, 2009). In future studies, researchers should give more focus on increasing students' levels of interest

and making students more comfortable in learning science, than on maintaining students' positive attitudes towards the importance of science to the society.

References

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education, 94*(4), 617-639.

Aschbacher, P. R., Li, E., & Roth, E. J. (2010). Is science me? High school students' identities, participation and aspiration in science, engineering and medicine. *Journal of Research in Science Teaching, 47*(5), 564-582.

Becker, F. S. (2010). Why don't young people want to become engineers? Rational reasons for disappointing decisions. *European Journal of Engineering Education, 35*(4), 349-366.

Bhattacharyya, S., & Mead, T. P. (2011). The influence of science summer camp on African-American high school students' career choices. *School Science & Mathematics, 111*(7), 345-353.

Brown, D. (2002). *Career choice and development*. San Francisco, CA: John Wiley & Sons, Inc.

Bui, N. H., & Alfaro, M. A. (2011). Statistics anxiety and science attitudes: Age, gender, and ethnicity factors. *College Student Journal, 45*(3), 573-585.

Eijck, M. V., & Roth, W.-M. (2009). Authentic science experiences as a vehicle to change students' orientations toward science and scientific career choices: Learning from the path followed by Brad. *Cultural Studies of Science Education, 4*, 611-638.

George, R. (2006). A cross-domain analysis of change in students' attitudes toward science and attitudes about the utility of science. *International Journal of Science Education, 28*(6), 571–589.

Guzzetti, B. J., & Bang, E. (2011). The influence of literacy-based science instruction on adolescents' interest, participation, and achievement in science. Literacy Research and Instruction, 50, 44-67.

Haselhuhn, C.W., &T. Andre. (1997, March). *Relationships of gender, science self-efficacy, attitude, and subjective norm to intended enrolment in high school biology, chemistry, and physics.* Paper presented at the 70th NARST International Conference, Oak Brook, IL.

Hassan, G. (2008). Attitudes toward science among Australian tertiary and secondary school students. *Research in Science & Technological Education, 26*(2), 129-147.

Hong, Z. (2010). Effects of a collaborative science intervention on high achieving students' learning anxiety and attitudes toward science. *International Journal of Science Education, 32*(15), 1971-1988.

Johnson, R. C. (2011). Using summer research to attract pre-college underrepresented students to STEM fields. *Council on Undergraduate Research Quarterly, 31*(3), 7-15.

Kanter, D. E., & Konstantopoulos, S. (2010). The impact of a project-based Science curriculum on minority student achievement, attitudes, and careers: The effects of teacher content and pedagogical content knowledge and inquiry-based practices. *Science Education, 94*(5), 855-887.

Khoury, G.A., & B.E. Voss. (1985, April). *Factors influencing high school students' science enrolments patterns: Academic abilities, parental influences, and attitudes toward science.* Paper presented at the 58th NARST International Conference, French Lick Springs, IN.

Kim, M., & Song, J. (2009). The effects of dichotomous attitudes toward science on interest and conceptual understanding in physics. *International Journal of Science Education, 31*(17), 2385-2406.

Kind, P. M., Jones, K., & Barmby, P. (2007). Developing attitudes toward science measures. *International Journal of Science Education, 29*(7), 871–893.

Kitts, K. (2009). The paradox of middle and high school students' attitudes towards science versus their attitudes about science as a career. *Journal of Geoscience Education, 57*(2), 159-164.

Koballa, Jr., T. R., & Glynn, S. M. (2007). Attitudinal and motivational constructs in science learning. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 75–102). London: Lawrence Erlbaum Associates.

National Academy of Sciences. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter future.* Washington, DC: The National Academies Press.

Osborne, J., Simon, S., & Collin, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079.

Schiefele, U. (1991). Interest, learning, and motivation. *Educational Psychologist, 26*(3&4), 299–323.

Simpson, R. D., Koballa, Jr., T. R., Oliver, J. S., Crawley, F. E. (1994). Research on the affective dimension of science learning. In D. Gabel (Ed.) *Handbook of research on science teaching and learning* (pp. 211–234). New York: Macmillan.

U.S. Department of Education. (2007). *Report of the academic competitiveness council*. Retrieved from http://www2.ed.gov/about/inits/ed/competitiveness/acc-mathscience/report.pdf

Weinburgh, M. H., & Steele, D. (2000). The modified attitudes toward science inventory: Developing an instrument to be used with fifth grade urban students. *Journal of Women and Minorities in Science and Engineering, 6,* 87-98.

Table 1
Descriptive Statistics for Demographic Information

	Cohort 6-7 (N = 481)		Cohort 7-8 (N = 722)	
Gender				
Female	249	51.8%	366	50.7%
Male	232	48.2%	356	49.3%
Ethnicity[a]				
Caucasian	357	74.2%	457	63.3%
Asian	22	4.6%	35	4.8%
African American	93	19.3%	94	13.0%
Hispanic	56	11.6%	218	30.2%
Pacific Islander & American Indian	37	7.7%	38	5.3%

[a]The total of all the percentages exceeds 100% because some students reported more than one ethnic group.

Table 2
Descriptions of 19 Variables in Factor Analysis

Factor	Variable	Description
Interest	12b.	Science is something I enjoy very much.
	12f.	When I hear the word science, I have a feeling of DISLIKE.
	16d.	I like the challenge of science assignments.
	16i.	I have a good feeling toward science.
	16j.	Science is one of my favorite subjects.
	16k.	I have a real desire to learn science.
Unease	12c.	I do NOT do very well in science at school.
	15f.	No matter how hard I try, I CANNOT understand science.
	15g.	I feel tense/nervous when someone talks to me about science.
	16e.	It makes me nervous to even think about doing science.
	16f.	It scares me to have to take science at school.
	16a.[a]	I often think I CANNOT complete a hard assignment in science.
	12e.[a]	Science is easy for me.
Attitude	12a.	Science is useful in helping to solve the problems of everyday life.
	15a.	Most people should study some science.
	15c.	Science is helpful in understanding today's world.
	16b.	Science is of great importance to a country's development.
	16c.	It is important to know science in order to get a good job.
	16h.	It is important to me to understand the work I do in science at school.

[a]Removed after the CFA.
Note. The questions were adapted from modified Attitudes towards Science Inventory--mATSI (Weinburgh & Steele, 2000).

Table 3
Descriptive Statistics for Career Expectations

Cohorts	Career Fields								Total
	SE		non-SE		SEM		non-SEM		
6-7	40	8.3%	441	91.7%	130	27.0%	351	73.0%	481
7-8	74	10.2%	648	89.8%	206	28.5%	516	71.5%	722

Note. SE = science and engineering; SEM = science, engineering or medicine.

Table 4
Logistic Regression Results (7-8 Cohort Data)

	Odds Ratios for Different Outcomes	
Predictor	SE	SEM
Interest Factor	1.13***	1.58***
Unease Factor	1.50*	1.29*
Attitude Factor	1.49*	1.13
Background		
Female	Included	Included
Ethnicity	Included	Included
School	Included	Included

Note. SE = science and engineering; SEM = science, engineering, or medicine.
* p < .05. ** p < .01. *** p < .001.

Table 5
Logistic Regression Results (6-7 Cohort Data)

	Odds Ratios for Different Outcomes	
Predictor	SE	SEM
Interest Factor	2.29**	1.59**
Unease Factor	2.13*	1.73***
Attitude Factor	1.48*	1.24
Background		
Female	Included	Included
Ethnicity	Included	Included
School	Included	Included

Note. SE = science and engineering; SEM = science, engineering, or medicine.
* p < .05. ** p < .01. *** p < .001.