



# Science as Interests but not for Career: Understanding High School Students' Engagement in Science in Abu Dhabi

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## ABSTRACT

Understanding high school students' engagement in science is important for the Emirate of Abu Dhabi. Drawing on data from the ROSE Survey conducted in Abu Dhabi schools in 2013, this paper used a multi-dimensional framework to explore associations between high school students' engagement in science and a range of student psychosocial and behavioral factors. The results of multi-level regression revealed that students' emotional and cognitive engagement in science was most strongly related to students' confidence in abilities in science, students' perceived benefits of S&T, students' views about science and scientists, student's out-of-school experience, and the job orientation of self-actualization. Students' future career aspiration in science was also associated with students' gender, grade, and socioeconomic background, which highlighted the role of social values, gender socialization, and family cultural capital in understanding students' occupational engagement in science. These factors and policy implications were discussed in the light of international research findings and the empirical context of Abu Dhabi where the transformation of socioeconomic development is taking place.

**Keywords:** students' engagement in science, science education, ROSE survey, Abu Dhabi

## INTRODUCTION

Due to the growing concern of the declining engagement of students in science at both high school and university levels especially in the developed countries (Lyons, 2006; OECD, 2006; Osborne & Dillon, 2008; Tytler, 2007), the topic of students' attitudes towards science and technology (S&T) has been continuously investigated over the past decades (Bennett &

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### **State of the literature**

- Growing literature in this field indicates that students' engagement in science is influenced by a wide range of factors;
- There is a lack of an integrated, multi-dimensional approach in understanding students' engagement in science as a dynamic and multifaceted process;
- Few work has examined students' engagement in science in the Gulf Cooperation Council (GCC) context.

### **Contribution of this paper to the literature**

- It adopts a multi-dimensional model to understand students' emotional, behavioral, and cognitive engagement in science;
- It contributes to our understanding of how various factors impact the engagement of high school students in science and science education in Abu Dhabi and beyond;
- It contributes to the extant literature by highlighting the importance of viewing student level factors as the function of the interaction of socioeconomic, cultural, and contextual forces.

Hogarth, 2009; Gardner, 1975; Germann, 1988; Osborne, Simon, & Collins, 2003). Among those more recent research initiatives, the Relevance of Science Education (ROSE) Survey is a Norwegian research project with an international comparative orientation aiming to gauge the relevance and importance of S&T and science education as perceived by young pupils (Schreiner & Sjøberg, 2004). The findings of the ROSE Survey show an overall positive attitude to S&T among students of 15 years old around the world in more than 30 countries. Those more developed countries in the study observe a relatively low level of students' interests in school science, as well as students' reluctance to take S&T as their future occupation with an evident gender gap (Sjøberg & Schreiner, 2010).

In the Emirate of Abu Dhabi, the Abu Dhabi Economic Vision 2030 sets out a comprehensive economic development plan. In the course of economic development and industrial diversification, Abu Dhabi is keen to follow a S&T-based development approach, which consequently highlights the importance of science education. Among the major purposes of science education in Abu Dhabi, the importance of increasing the recruitment of scientists, technologists, and engineers should not be underestimated.

In April 2013, the Abu Dhabi Education Council (ADEC) administered the ROSE Survey to assess students' attitudes and views of science and science education. Preliminary analyses of the survey results suggest that while Abu Dhabi seemingly does not suffer from the crisis in science education in terms of students' interests and participation in science classes, the future recruitment of S&T specialists is likely to be a concern. Many students in the survey indicated little intention to become a scientist or to work in technology as a future career (ADEC, 2013a). Students' perceptions of S&T and the factors affecting their engagement with it both as an interesting subject and as a potential career, therefore, deserve further

research. Such studies could shed light on how to find productive ways forward for the development of a more engaging school science education in Abu Dhabi.

The ROSE Survey affords an opportunity to build a multi-dimensional model to understand students' emotional, behavioral, and cognitive engagement in science. Drawing on data from the Abu Dhabi ROSE Survey 2013, this paper intends to contribute to our understanding of how various factors impact the engagement of Abu Dhabi's high school students in science and science education. Focusing on the psychosocial and behavioral features of students, this paper examines the relationships of students' reports of engagement in science with their perceptions of science, future job orientation, out-of-school activities, as well as student and school characteristics. In this study, students' perceptions of science, job orientation, and engagement in science are seen as being shaped by the wider socioeconomic and cultural context.

#### FACTORS INFLUENCING STUDENTS' ENGAGEMENT IN SCIENCE

Students' engagement in science has been explored through emotional, behavioral, and cognitive dimensions (Fredricks, Blumenfeld, & Paris, 2004; Hampden-Thompson & Bennett, 2013; Woods-McConney, Oliver, McConney, Schibeci, & Maor, 2014). Extant literature suggests that students' engagement in science is a dynamic and multifaceted process and is influenced by a wide range of factors (Aschbacher, Li, & Roth, 2010; Cleaves, 2005; Osborne et al., 2003). These factors include, among others, interests in science, perceptions of science, perceived ability in science, benefit for future study or career paths, the learning context, the content and relevance of curriculum, pedagogy and assessment, and the role of significant individuals including family, teachers and peers (National Foundation for Educational Research, 2011).

Research has found that high school experiences, abilities, and interests in science often predict student's pursuit of a science major (Halpern, Benbow, Geary, Gur, Hyde & Gernsbacher, 2007; Kahle & Lakes, 1983; Sadler, Sonnert, Hazari, & Tai, 2012; Wang, 2013). Children's interest in science is influenced by not only the science subjects, but also the learning context in which they experience science (Bathgate, Schunn, & Correnti, 2013; Jacobs, Finken, Griffen, & Wrightm, 1998). Out-of-school science experiences, for example, could help promote the image of science education (Braund & Reiss, 2006). Woods-McConney et al. (2014) found that out-of-school science activities recorded the strongest association with Canadian and Australian high school students' engagement in science. However, Cerinsek, Hribar, Glodez, & Dolinsek's (2013) study of factors influencing Slovene students' choice of studying science courses showed that self-fulfillment, future career priorities, and interest in science mattered more than key persons and out-of-school experiences.

While the studies of Tai and his colleagues (Maltese & Tai, 2010; Tai, Liu, Maltese, & Fan, 2006) showed that students who developed their interest in science were more likely to pursue future educational opportunities and a science-related career, other researchers cautioned that students' positive experiences did not necessarily translate directly into career

aspirations in science (Bennett & Hogarth, 2009; DeWitt, Archer, & Osborne, 2014). Bennett, Hampden-Thompson, & Lubbe (2011) illustrated that students were driven more by the extrinsic rewards of science education, as students reported that the primary reason for their uptake of post-compulsory chemistry and physics studies was the pursuance of desirable tertiary courses or careers.

Some studies stress the important role that key persons play in influencing students' engagement in science and such influence is often interacted with gender stereotypes (Andre, Whigham, Hendrickson, & Chambers, 1999; Bøe, 2012; Breakwell and Beardsell, 1992; Hazari, Sonnert, Sadler, & Shanahan, 2010). Gender as a structural element tends to associate with future career priorities of pupils in a most significant way (Osborne et al., 2003), as several studies show that girls prefer occupations that are intensive in interpersonal activities while boys look for occupations that render them high income, power and fame (Eccles, 2009; Halpern et al., 2007; Jones, Howe, & Rua, 2000). Among those science career options, as shown in the study of Sadler et al. (2012), boys show greater interest than girls in an engineering career while girls prefer health related careers. Osborne et al.'s (2003) literature review, however, suggests that gender stereotyping in science has changed.

Teaching and learning science cannot be isolated from the context. As far as the classroom learning context is concerned, the levels of enjoyment and engagement of students in learning are influenced by subject content, teacher characteristics, teaching approaches, opportunities for participation in the learning activities, and the learning environments (Hampden-Thompson & Bennett, 2013; National Foundation for Educational Research, 2011; Velayutham & Aldridge, 2013). Darby's (2005) ethnographical investigation of science students' perception of teachers' pedagogy approach showed that both instructional and relational aspects of pedagogy were effective in influencing students' science experience. A longitudinal study of a small group of students in Australia revealed that students' interests in science were substantially affected by teachers' pedagogy and personality while ability level and science topics showed small effects (Logan & Skamp, 2013). In their study of 11-16 year old students, Häussler & Hoffmann (2000) argued that the context was more important than the content in influencing students' interest in physics.

Moreover, the relevance of school science education can be broadened beyond the classroom level to include the societal context that is perceived by children (Murphy, Murphy, & Kilfeather, 2011). Students in secondary education often pay much attention to societal challenges and the human dimensions of S&T (Baram-Tsabari & Yarden, 2005; Sjøberg & Schreiner, 2010). Häussler & Hoffmann's (2000) research also indicated that students valued the socioeconomic context of physics higher than those emotional, intellectual, and qualifying contexts.

The development of science interest is further influenced by cultural dispositions that are socially acquired in fields outside school (Aikenhead, 1996; Upadhyay, 2006; Xu, Coats, & Davidson, 2011). Lyons (2006) attributed students' enrolment decision in post-compulsory

science to the influence of supportive family relationships and views about school science. Likewise, Aschbacher et al. (2010) found that higher science achievers tended to come from more affluent families possessing a range of economic, social, and cultural resources to support achievement.

Through employing the Bourdieuan concept of 'family habitus', Archer, DeWitt, Osborne, Dillon, Willis, & Wong (2012) stressed the social and cultural embeddedness of children's formation of science aspirations. In their portrait of middle class 'science families', 'the alignment between family habitus, capital, and the child's personal interests and identifications produces a strong, mutually reinforcing consensus, which is also embodied and realized through emotional bonds and practices', whereas the poor provision of family cultural infrastructure and resources for working class children prevents them from building on their nascent interest in science (Archer et al., 2012, p. 892). Anderhag, Emanuelsson, Wickman, & Hamza (2013), however, argued that in Sweden the socio-economic background of high school students offered only partial predictive power to their application frequencies to the Swedish Natural Science Programme.

Taken together, these research findings suggest that no single factor could adequately account for students' choice of science education and career, nor could the economic views. Economic approaches often link students' learning decisions to present or future benefits, giving inadequate consideration of the fact that those intrinsic and extrinsic factors of science education are shaped by the socioeconomic forces at the macro, meso, and micro levels. The argument that the motives of students are jointly determined by the intrinsic interests of students and the extrinsic rewards that students expect from the learning thus tends to overlook the complexity of the social process involved in learning.

Despite the burgeoning literature in this field, research on students' interests in science lacks an integrated, multi-dimensional approach. While several researchers (Hampden-Thompson & Bennett, 2013; Woods-McConney et al., 2014) have recently utilized data from the Programme for International Student Assessment (PISA), few studies conducted in the ROSE Project framework have attempted to associate students' engagement in science with students' social, psychological, and behavioral constructs. Moreover, few work has examined these issues in the Gulf Cooperation Council (GCC) countries where the social-demographic contexts are unique in terms of the dominance of migrant workers in the labor market, the multi-cultural social and work environment, the underdeveloped S&T industries, and gender socialization.

In the light of the gaps in the literature, this present paper adopts a multiple-level model and addresses the following two main research questions:

- 1) What are the factors that account for students' engagement in science in the context of Abu Dhabi?
- 2) To what extent is students' engagement in science associated with student characteristics such as gender and ability, and explained by students' psychosocial

and behavioral features such as perceptions of science, job orientation, and out-of-school activities?

## DATA AND METHODOLOGY

The standard ROSE questionnaire is comprised of 245 items grouped under the following sections: 1) What I want to learn about; 2) My future job; 3) Me and the environmental challenges; 4) My science classes; 5) My opinions about science and technology; and 6) My out-of-school experiences. Some of these questions are capable of capturing students' opinions of societal challenges and the human dimensions of S&T. The responses to these questions are measured by a four point Likert rating scale such as from 'not interested' to 'very interested'. In addition, the survey includes a few questions pertaining to gender, age, nationality, and the socio-economic background of the student. While the ROSE questionnaire has been used by researchers in various national contexts, reviews were conducted by Abu Dhabi-based researchers and curriculum specialists, as a result of which a few minor amendments were made to the questionnaire to ensure that the items were appropriately phrased to suit the socioeconomic context of the Emirate of Abu Dhabi.

Although the ROSE Project recommends that the target students be of 15 years old and the sampling unit be a school class from a stratified random sample of schools, the Abu Dhabi ROSE Survey was designed to generate a bigger sample capable of representing all the high school students and schools that had science classes on offer. In the 2012-2013 academic year, there were in total 51,934 grade 10-12 students in all the schools in the Emirate of Abu Dhabi. Within each school, four students were selected from one class for each grade (from grade 10 to grade 12) to take part in the survey. Schools were instructed to randomly select the class and the student participants within the class. This resulted in a sample of 2,544 grade 10-12 students from 228 schools across three education zones: Abu Dhabi, Al Ain, and Al Gharbia. Students were asked to complete the questionnaire in classrooms and returned the completed questionnaires to the teacher who administered the survey. A total of 1,942 filled questionnaires were received, achieving a response rate of 76.3 percent. The average age of the students in the sample was 16.3.

In this study, the dependent variables of student engagement in science are consisted of measures of students' interests in science classes, students' instrumental motivation to learn science, and students' career aspirations in science (Hampden-Thompson & Bennett, 2013). These three measures reflect chiefly the emotional, affective, and cognitive aspects of engagement. Effort was also made to generate three variables of student' perceptions of S&T, four variables of student' future job orientation, two out-of-school science activity variables, four student characteristic variables, and two school characteristic variables. The dependent variables and some independent variables are indices, which were tested for reliability using Cronbach alpha.

The index for students' interests in science was constructed based on students' responses about their level of agreement with the following four statements: 1) School science is interesting; 2) I like school science better than most other subjects; 3) I think everybody should learn science at school; and 4) I would like to have as much science as possible at school.

Students' responses to the following eight statements led to the construction of the index for students' instrumental motivation to learn science: 1) School science has opened my eyes to new and exciting jobs; 2) The things that I learn in science at school will be helpful in my everyday life; 3) I think that the science I learn at school will improve my career chances; 4) School science has made me more critical and skeptical; 5) School science has increased my curiosity about things we cannot yet explain; 6) School science has increased my appreciation of nature; 7) School science has shown me the importance of science for our way of living; and 8) School science has taught me how to better take care of my health.

The index for career aspirations in science was derived from students' responses about their level of agreement with the following two statements: 1) I would like to become a scientist; and 2) I would like to get a job in technology.

Several variables were constructed to reflect the influence of social and cultural forces on students' perceptions. Among the three indices of variables of students' perceptions of S&T, the index of benefits of S&T was derived from students' responses to the following six questions: 1) Science and technology are important for society; 2) Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.; 3) Thanks to science and technology, there will be greater opportunities for future generations; 4) Science and technology make our lives healthier, easier and more comfortable; 5) New technologies will make work more interesting; and 6) A country needs science and technology to become developed.

Reflecting students' understanding of societal challenges and the role of S&T, the index of contentions about the impact of S&T summons the values of students' responses to the following six arguments: 1) The benefits of science are greater than the harmful effects it could have; 2) Science and technology will help to eradicate poverty and famine in the world; 3) Science and technology can solve nearly all problems; 4) Science and technology are helping the poor; 5) Science and technology are the causes of the environmental problems; and 6) Science and technology benefit mainly the developed countries.

The index of views about science and scientists was built on the responses of students to the following four questions: 1) Scientists follow the scientific method that always leads them to correct answers; 2) We should always trust what scientists have to say; 3) Scientists are neutral and objective; and 4) Scientific theories develop and change all the time.

Four traits of students' future job orientations (**Table 1**) were classified from their responses about the importance (from 'not important' to 'very important') of the activities and qualities associated with their potential future occupation. These future job orientation types include 1) Self-actualization; 2) Work creatively; 3) Leisure priorities; and 4) Power and glory.

**Table 1.** Summary of some dependent and independent variables indices

Index of Variables	Items	Summated original Mean	Reliability
<b>Dependent Variables</b>			
Interests in science classes	4	3.03	0.741
Instrumental motivation to learn science	8	3.15	0.866
Career aspirations in science	2	2.81	
<b>Independent Variables</b>			
Confidence in abilities in science	2	2.82	
Perceptions of science -- Benefits of S&T	6	3.44	0.828
Perceptions of science -- Contentions about the impact of S&T	6	2.87	0.691
Perceptions of science -- Views about science and scientists	4	2.83	0.610
Future job orientation – Self actualization	5	3.54	0.741
Future job orientation – Work creatively	3	3.23	0.613
Future job orientation – Leisure priorities	3	3.17	0.603
Future job orientation – Power and glory	4	2.79	0.675
Out-of-school experiences – Overall	61	2.73	0.931
Out-of-school experiences -- ICT	8	3.43	0.874

Note: Cronbach values are sensitive to the number of items in the scale.

In addition to gender (female = 1, male = 2), grade, and the number of books at home, student characteristic variables also include an index of student's confidence in abilities in science, which was composed of students' responses to the following 2 questions: 1) School science is a difficult subject; and 2) School science is rather easy for me to learn.

Two indices of student's out-of-school activities were also derived from students' responses to the frequency (from 'never' to 'often') of engaging in a range of out-of-school activities. The overall out-of-school experiences index was based on students' responses to all the activities asked in the ROSE Survey, while the Internet and Communication Technology (ICT) activities index was based on their responses to 8 activities related to the use of computer, mobile phone, and Internet. Preliminary analysis showed that Abu Dhabi high school students' out-of-school science experiences largely concentrated on ICT activities (ADEC, 2013a). These student variables together capture students' attributes, perceptions, behaviors, and indirectly the impact of the socioeconomic context.

The school characteristic variables include school zone that indicates different levels of economic development and urbanization (Abu Dhabi = 1, Al Ain = 2, Al Gharbia =3) and school type (public = 1, private = 2).

The original value ranges for both dependent and independent indices differ substantially. In order to facilitate data analysis, the indices were normalized to have a mean of 50 and a standard deviation of 10. The correlations between these indexes are in the range of small to medium strength. Hierarchical Multiple Regression was used to estimate the association between those independent variables and students' engagement in science. A series of models were estimated to explain the relationships between students' engagement in



**Table 2.** Regression coefficients for students' interests in science classes

	Models				
	I	II	III	IV	V
<b>Perceptions of S&amp;T</b>					
Benefits of S&T	0.355**	0.295**	0.276**	0.234**	0.230**
Contentions about the impact of S&T	0.010	0.021	0.011	-0.008	-0.004
Views about science and scientists	0.131**	0.146**	0.120**	0.138**	0.141**
<b>Future job orientation</b>					
Self-actualization		0.146**	0.147**	0.120**	0.119**
Work creatively		0.022	0.004	0.014	0.014
Leisure priorities		-0.091**	-0.103**	-0.061*	-0.061*
Power and glory		-0.073**	-0.077**	-0.046	-0.045
<b>Student out-of-school science activities</b>					
Out-of-school experiences – Overall			0.143**	0.123**	0.124**
Out-of school experiences – ICT			-0.013	-0.021	-0.024
<b>Student characteristics</b>					
Confidence in abilities in science				0.386**	0.384**
Gender				0.025	0.024
Grade				0.010	0.011
Number of books at home				0.054*	0.054*
<b>School characteristics</b>					
School location					0.026
School type					0.028
<b>Adjusted R square</b>	0.182	0.203	0.217	0.365	0.365

\*\* p=0.01; \* p=0.05

science and various students' characteristics, perceptions, and behaviors. All differences reported are statistically significant at the 0.05 level unless stated otherwise.

## RESULTS AND DISCUSSION

**Tables 2-4** report the regression coefficients for student's interests in science classes, students' instrumental motivation to learn science, and students' career aspirations in science respectively. Five models were estimated. Model 1 included only the indices of students' perceptions towards S&T. From Model 2 to Model 5, the indices of students' future job orientation, students' out-of-school science activities, student characteristics variables, and school characteristics variables were entered step by step. Model 5 represents the full model in which all the independent variables are included.

In general, the full model is significant, explaining 36.5 percent of the variance in student's interests in science classes [ $F(15, 1179) = 46.729, p < .0005$ ], 37.2 percent of the variance in students' instrumental motivation to learn [ $F(15, 1175) = 47.977, p < .0005$ ], and 22.0 percent of the variance in students' career aspirations [ $F(15, 1179) = 23.411, p < .0005$ ].

**Table 3.** Regression coefficients for students' instrumental motivation to learn science

	<b>Models</b>				
	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>V</b>
<b>Perceptions of science</b>					
Benefits of S&T	0.367**	0.282**	0.251**	0.228**	0.230**
Contentions about the impact of S&T	0.096**	0.104**	0.094**	0.079**	0.075**
Views about science and scientists	0.155**	0.161**	0.132**	0.140**	0.137**
<b>Future job orientation</b>					
Self-actualization		0.179**	0.176**	0.155**	0.156**
Work creatively		0.033	0.012	0.018	0.017
Leisure priorities		-0.011	-0.027	-0.005	-0.005
Power and glory		-0.082**	-0.087**	-0.063**	-0.065**
<b>Student out-of-school science activities</b>					
Out-of-school experiences – Overall			0.167**	0.164**	0.161**
Out-of-school experiences – ICT			-0.006	-0.007	-0.002
<b>Student characteristics</b>					
Confidence in abilities in science				0.248**	0.251**
Gender				-0.033	-0.031
Grade				0.029	0.027
Number of books at home				0.012	0.017
<b>School characteristics</b>					
School location					0.031
School type					-0.021
<b>Adjusted R square</b>	0.261	0.291	0.313	0.372	0.372

\*\* p=0.01; \* p=0.05

The index of students' perceptions of S&T stood out as one of the most important predictors for students' engagement in science, accounting for 18.4 percent of the variance in students' interests in science classes, 26.3 percent in students' instructional motivation in science, and 12.6 percent in students' career aspirations in science. The index of students' future job orientation and students' out-of-school science activities also made a significant contribution. After controlling for students' future job orientation and students' out-of-school activities, student characteristics index was capable to explain an additional 14.8 percent, 6.0 percent, and 4.7 percent respectively of the variance in the three dependent variables. The contribution of student characteristics appeared to be less substantial in explaining the variance in students' cognitive engagement in science. School characteristics did not make a unique contribution, except for in explaining the variance in students' career aspirations.

In terms of individual variable, several independent variables constantly made a statistically significant contribution. Among them, students' confidence in abilities in science registered the largest contribution in explaining the variance in student's engagement in science [for students' interests in science classes (beta = .384,  $p < .0005$ ), for students' instructional motivation to learn science (beta = .251,  $p < .0005$ ), and for students' career aspirations in science (beta = .187,  $p < .0005$ )]. This is followed by students' perceived benefits

**Table 4.** Regression coefficients for students' career aspirations in science

	<b>Models</b>				
	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>V</b>
<b>Perceptions of science</b>					
Benefits of S&T	0.110**	0.131**	0.157**	0.140**	0.147**
Contentions about the impact of S&T	0.138**	0.135**	0.113**	0.104**	0.093**
Views about science and scientists	0.190**	0.175**	0.136**	0.145**	0.138**
<b>Future job orientation</b>					
Self-actualization		-0.099**	-0.072*	-0.071*	-0.069*
Work creatively		0.189**	0.164**	0.169**	0.167**
Leisure priorities		-0.072*	-0.077*	-0.052	-0.052
Power and glory		0.028	0.019	0.024	0.021
<b>Student out-of-school science activities</b>					
Out-of-school experiences – Overall			0.177**	0.156**	0.152**
Out-of-school experiences – ICT			-0.130**	-0.116**	-0.097**
<b>Student characteristics</b>					
Confidence in abilities in science				0.181**	0.187**
Gender				0.101**	0.105**
Grade				0.056*	0.051*
Number of books at home				0.048	0.057*
<b>School characteristics</b>					
School location					0.035
School type					-0.063*
<b>Adjusted R square</b>	0.123	0.150	0.171	0.216	0.220

\*\* p=0.01; \* p=0.05

of S&T, students' views about science and scientists, student's overall out-of-school experience, and self-actualization, which all significantly contributed to the explanation of the variance across the board.

On students' interests in science classes (**Table 2**), data suggest that students who indicated the priorities for leisure in their future job orientation were less likely to show interests in science, while students who had more books at home were more likely to do so. There was an insignificant negative association between students' out-of-school ICT experiences and their interests in science classes. After controlling for the effect of student characteristics, the negative relationship between students' power and glory job orientation and their interests in science classes became insignificant.

On students' instrumental motivation to learn science, the coefficients contained in **Table 3** suggest that although considerably more students in the survey were skeptical about the role of science and education in assisting the poor, in eradicating poverty, and in addressing environmental problems, students' perceived impact of S&T still maintained a statistically significant positive relationship with students' motivation to learn science, further highlighting the role of the extrinsic benefits associated with S&T.

On the long-term cognitive engagement of students -- future career aspiration in science (**Table 4**), it is clear that more variables recorded a significant predictive power, including all four student characteristics variables. Gender and grade which did not make a unique contribution in the other two dependent variables emerged as useful predictors for students' future career choice in science. Compared to females, male students were reportedly more likely to enter a S&T career in the future. High school students also tended to be willing to commit themselves to a science career as they progressed along the grades. 'Number of books at home' as a proxy for family socioeconomic background positively influenced students' future career engagement in science.

These findings are generally consistent with the literature. Numerous research has identified the following factors that have important influence on students' educational and occupational aspirations: parental attitudes towards science (Andre et al., 1999), attitudes towards school science (Cleaves, 2005; Osborne et al., 2003), perceptions of science and scientists (Bennett & Hogarth, 2009). Other work highlights that gender, ethnicity, and social and cultural capital are also likely to be related to aspirations (DeWitt et al., 2011; Hampden-Thompson & Bennett, 2013). Although this current study does not examine directly and adequately the issues of parental attitudes, ethnicity, social and cultural capital, limited evidence derived from the student characteristics illustrates the influence of family social-economic status. Moreover, this study illustrated that some of these factors registered varying degree of association with different aspects of students' engagement. Notably, structural elements such as gender, grade, and school type tend to exert more influence on students' career aspirations in science than on the emotional and instrumental motivation aspects of engagement.

In this study, the significance of 'school type' in predicting students' career aspirations in science needs to be noted in relation to ethnicity and culture. Public school students in Abu Dhabi, who are predominantly Emiratis, showed higher career aspirations in science than their private school counterpart who are often comprised of diversified nationality and ethnical groups. Data constraints do not allow this current study to exam this further. It may be tentatively hypothesized that Emiratis students are motivated more by their positive perceptions of S&T, while expatriate students may have to consider more the pros and cons of getting into a science career.

Likewise, research elsewhere has shown that students' achievement and/or perceived ability in science impact on their attitudes towards science (Bennett & Hogarth, 2009; Gill & Bell, 2011; Osborne et al., 2003; Stokking, 2000). Unlike other countries where boys tend to perceive themselves as having higher abilities in science than girls (Andre et al., 1999; Jovanovic & King, 1998), in Abu Dhabi girls generally outperform boys in science courses (Pearson, 2013). As shown by this study, gender registered no influence in students' interests in science and motivation to learn science. Therefore, the findings of this study suggest that it is students' perceived ability in science rather than gender that influences their attitudes towards science. We, nevertheless, agree with Halpern et al. (2007) that many sociocultural

factors may cause gender differences in science achievement and ability. Moreover, gender would make a difference when it comes to Abu Dhabi high school students' future occupational engagement in S&T.

Researchers point out that only a small proportion of students usually claim that they would take up a S&T job in the future (Bennett & Hogarth, 2009; Jenkins & Nelson, 2005). In their three year survey of UK Year 9 students' attitudes to science, Bennett & Hogarth (2009) showed that more young people in the UK, particularly girls, gradually lost their engagement in science as they progressed through secondary school. Oon & Subramaniam's (2013) study of Singaporean students indicated that in spite of students holding positive attitudes towards physics, they were reluctant to pursue a physics-based career. One of the important socioeconomic factors -- the remuneration of S&T occupations -- has been raised as a reason for the low engagement in a science career (Woolnough, 1993). Oon & Subramaniam's (2013) study, however, disputed the claim of students' negative views about the career prospects of physics graduates in Singapore, and implied that it may be attributed to parental and peer influence.

The Abu Dhabi ROSE survey shows that while 61.8 percent of students in the sample reportedly disagree that school science is a difficult subject, a substantial proportion of them think otherwise (ADEC, 2013a). Similar to what has been found in other countries (Gill & Bell, 2011; Oon & Subramaniam, 2013), many students in Abu Dhabi tend to perceive science as a hard to learn subject and feel that it is hard to pursue it as a career. More importantly, it is not only the capability to learn science subjects that matters, but possibly also their concerns about how they could land and progress in a science career.

It is relevant to refer to the findings of a survey that ADEC conducted in 2013 to investigate the opinions of Emirati science students at the UAE University about their future career especially in teaching. The survey results showed that 90 percent of the 125 respondents, out of which 118 are females, preferred to work in government and/or semi-government sectors. Moreover, salary, job security, and interesting and challenging work topped the list of the most important factors for their employment (ADEC, 2013b). To what extent S&T occupations in Abu Dhabi are proven to be interesting, well-paid, and secure remains unclear, especially given the segmented labor market. Students may perceive science occupations unfavorably or are reluctant to construct a science related identity that is not well recognized in the local social context (Archer et al., 2010; Holmegaard, Madsen, & Ulriksen, 2014).

Therefore, we have to further factor in the following in the reflection on students' engagement in science careers in the context of Abu Dhabi: 1) the lack of well-established S&T occupations and their remuneration levels relative to those of government jobs which are preferred by jobseekers; 2) the lack of adequate labor market information for career decision making; 3) students' job preference, especially Emirati students; 4) the gender perspective; 5) the lack of role models in science; and probably 6) weak parental support and peer influence. In addition, S&T occupations are perhaps still stereotyped by the society as men's jobs. Most of these issues are deeply rooted in the prevailing socioeconomic relations.

This study also observed a significant negative association between students' out-of-school ICT experiences and their future career engagement in science. It is clear that high school students in Abu Dhabi are quite competent in using IT tools (Badri, Al Rashedi, Yang, Mohaidat, & Al Hammadi, 2014), and students' out-of-school ICT activities seem to be part of their daily routine leisure activities. Linking this to students' reported job orientation of leisure priorities that was negatively related to their future career engagement in science (**Table 5**), we may posit that students' concentration on ICT activities after school reduces the time that they could otherwise spend on other science activities, and thus makes them less likely to develop and pursue an interest in a science career. This also suggests that the popularity of students' out-of-school ICT activities in Abu Dhabi does not offer a meaningful indicator for assessing students' engagement in science.

The two school characteristics variables included in this study recorded insignificant influence in the models. The school location variable was consistently positively associated with students' engagement in science, appearing to support the global observation where students from less developed countries and areas reported higher level of interest in science than students from more developed societies (Sjøberg & Schreiner, 2010). But the association was weak. However, most probably the failure to generate more relevant school variables is to be partly blamed here. Research has demonstrated the important role of classroom-level teaching and learning activities (Hampden-Thompson & Bennett, 2013; Logan & Skamp, 2008).

Admitting that most critical comments made by Stokking (2000) on modeling the choice of subjects in education remain valid, we tentatively conclude that students' engagement in science generally, and future career orientation in science particularly, appears to be attributed to a wide range of factors, more than what this study is able to cover. Nevertheless, the significant contributions made by students' perceptions of S&T, students' future job orientations, out-of-school activities, and some student characteristics elements have provided support to the argument that it is necessary to understand science learning and education in concrete contexts or as a socially constructed process, in which socioeconomic and cultural forces shape the way students view and engage in science.

## CONCLUSIONS AND POLICY IMPLICATIONS

This study attempts to identify some salient psychosocial and behavioral elements of Abu Dhabi high school students that influence their emotional and cognitive engagement in science. While we acknowledge that the dependent measures do not represent all the perspectives of students' engagement in science and the independent variables do not cover all the dimensions of learning contexts and student characteristics, effort has been made to align them with some education, psychological, and sociological theories and literature.

Overall, this study has found that students' confidence in abilities in science, students' perceived benefits of S&T, students' views about science and scientists, student's out-of-school experience, and the job orientation of self-actualization are among the best set of variables to

predict students' engagement in science in Abu Dhabi. Students' career engagement in science, however, also has something to do with gender stereotypes and socialization.

The reform of science education globally has seen a shift towards constructivist approaches such as inquiry-oriented learning and teaching and away from traditional didactic approaches (Anderson, 2002; Luera & Otto, 2005). The recently initiated Abu Dhabi School Model is an example and has been gradually rolled out in the Emirate. Corresponding international and national policy recommendations aiming to reform science education often include measures that help raise a greater recognition of students' learning strategies, develop innovative curricula and engaging teaching methods, identify matching assessment, and above all improve the development of high quality teachers (Osborne & Dillon, 2008; Tytler, 2007). As the Emirate of Abu Dhabi focuses the reform efforts on improving student achievement, it is important to know whether the policy levers aimed at improving curricula, pedagogy, and teacher quality are associated with the amount and quality of inquiry-oriented instruction that students are exposed to.

In the meantime, the social constructionist perspective suggests that the Abu Dhabi School Model has to face and respond to the societal changes. It may remain vulnerable when being confronted by the prevailing socioeconomic values and contexts, and therefore requires a more enabling environment for its benefits to thrive. The issue of building a conducive S&T education environment in Abu Dhabi that is capable of delivering a strong supply of scientists and technologists goes beyond schools and classrooms. Policy interventions may not work effectively unless the underlying mechanisms functioning at the supply side, including engendered occupational preferences by students and their family, are fully understood.

While there is a need to make school science more engaging and easy to learn to students, another important thing to do is to look for connections that can help build upon the positive experiences of science education and sustain students' engagement in science. Science educators may have to re-embed school science, often seen as learning purely for knowledge, into the social context to make it a socioeconomic enterprise (Häussler & Hoffmann, 2000).

One of the issues that science educators tend to ignore is the influence that experiences outside school have on students' engagement in science, as shown by this study. Perhaps more importantly, Abu Dhabi will have to work on the family, community, and labor market institutions levels to generate support for students' science learning and long-term engagement in science. Given that Abu Dhabi does not have established industries and occupations in S&T and the labor market implications of pursuing a S&T career are not clearly known to students and their parents, the benefits of schools working together in sustainable partnerships with industry and the community are to be pursued as a medium-term solution. It is important that high school students have opportunities to link with industry at an early stage and to discover possible career paths in science.

Due to data constraints, this present study does not examine the influence of school and classroom level learning activities and environments on students' motivation and

engagement. Likewise, it fails to capture the influence of significant persons and parental support. More meaningful socioeconomic variables therefore are required to construct a model that could better test the social constructionist argument of science education. A comprehensive and integrated model, such as the Structural Equation Modeling, is also needed to further explore the causal relationships between various constructs.

Furthermore, the analysis of the dynamic and multifaceted science learning and students' engagement in science requires a more nuanced and empirically-based understanding of the ways in which science and science education is understood, interpreted and negotiated by students both at and out of school. The application of some sociological perspectives will be beneficial for us to highlight the important role of structural forces, agency, contextual contingency, and path-dependence in science education and in students' engagement in science, and to understand how the learning context is organized, how significant individuals are generated and received, and how scientists and science occupations are perceived.

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