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Cambodian Upper Secondary School Students' Attitudes towards Science: Trends and Patterns

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Abstract

Attitude towards science is the issue with long standing attention and interest in science education research because it is crucial for not only teaching science but also for understanding students' future participation in science. This study examines trends and patterns of Cambodian upper secondary school students' attitudes towards science. The data for the study was collected from 455 students of 11th grade using survey instrument measuring six constructs of attitudes towards science. The results depicted that students have higher positive attitudes towards the importance of science on society, practical work in science and enjoyment on practical work in science; but they tended to have lower rating scale on self-concept in science and science learning and also displayed lower scale on attitudes towards future participation in science. Certain students' attitudes towards science patterns were indeed embedded significant differences between male and female, science and social science tracks, and urban and non-urban. To enhance students' attitudes towards science, both school and home environment should enhance more practical work in science classes and encourage more participation in science related activities.

1. Introduction

With the current global development of science and technology in this fourth industrial revolution, greater demand for more students in science related majors has been one of the priority concerns, and this is particularly pertinent in Cambodian context which is striving for the Asian integration and for the shifting of the country economic development trend from agriculture, garment, tourism, and construction dependence to a broad-based industrial and technology-oriented economy, (Royal Government of Cambodia [RGC], 2015). Yet, the main problem is a well-documented gap between needs and reality for the human resource in science fields. While the earlier related to society having greater requirement than ever for highly educated people in science due to the challenging economic, environmental and technological development, the later related to the lower number of students pursuing in science related fields at higher education (Japan International Cooperation Agency [JICA], 2016).

Aiming at building a strong background competence on science and mathematics at upper secondary school and be more orientated in choosing science majors in higher education, Ministry of Education, Youth and Sport (MoEYS) has implemented the tracking system since 2010 (MoEYS, 2010). This bifurcation required all 11th graders of upper secondary school to study in either science track or social science track. Statistically, since the beginning of its implementation, science track has caught more interests of students than social science track. Statistically, nearly 80% of the students choose to study in science track while the share of students in social science track has just jumped to about 20% in this last academic year (MoEYS, 2017). On the contrary, Cambodia Development Resource Institute (CDRI) (CDRI, 2018) reported that while the number of students in the higher education institution increased from 13,461 in 1996 to 219,069 in 2016, or from 1% to 12% of youth-aged cohort, fewer than 20% of them majored in science related fields. This highlights the mismatch and imbalance of students in science fields (ADB-ILO, 2015).

Theoretically, to enhance the influx of human resource in science fields, it is vital to view how science is taught at school and how the approach affects students' attitudes and willingness to future participate in any science field (Answer, et al., 2012; George, 2006; OECD, 2016; Weinburgh, 2000). Studies have also consistently shown that attitudes towards science played an active role in determining both students' participation in science learning (Garder, 1975; Kind, et al., 2007; Osborne, et al., 2003) and their performance in science (Cannon & Simpson, 1985; Han, 2017; Weinburg, 1995). As such, with the long term widespread of the decline interest in science, which Dainton (1968) termed the phenomena as "swing from science" and with the increasing recognition of the importance of scientific knowledge and its culturally significance, the investigation of students attitudes towards science as Osborne, et al. (2003) termed "urgent agenda for research", has been a substantive feature of the works of science education research community for decades. However, the concept of attitudes and attitudes towards science is somewhat nebulous, often poorly articulated and not consistently understood and the research results are difficult to transfer not only from one society to another but also from one time period to another (Kind, et al., 2007; OECD, 2016; Schreiner & Sjoberg, 2006). As such, it is indispensable to regard attitudes towards science as a characteristic of the context in which it has been conducted and should also be an ongoing issue to be explored in the current and future educational situation.

It is no exception in Cambodian context. The mismatch has, in particular, significant impacts on the current situation of the need of human resource supporting current phase of economic development and has, thus, given rise to the quest among educators and scholars to understand students' choice to transit from science track at upper secondary school to science fields at higher education (see, for example, CDRI, 2018; Eng & Szmodis, 2016; Kao, 2013; Pen, 2011) and how attitudes towards science is contributing to that academic choice. Unfortunately, none of the studies have examined extensively on the level of upper secondary school students' attitudes towards science both inside and outside classroom sub-constructs. Little is known about intact students' experience in science has shaped their attitudes towards science subjects in general and the trends and patterns of that attitude in particular. The paucity of empirical evidence as such is surprising given to the growing demand of graduates in science or the so-called Science Technology Engineering and Mathematics (STEM) fields. Thus, providing information about the trends and patterns of students' attitudes towards science subjects is vital for educators when developing educational programs that can effectively mediate students' low attitudes towards science and the imbalance in students' choice of majors at higher education.

2. Purpose of the study

This study seeks to explore the extent of Cambodian upper secondary school students' attitudes towards science and to examine the patterns of their attitudes across personal characteristics (gender, geographical origin, and bifurcation at school) divide. Two questions guide this study:

1. What is the level of Cambodian upper secondary school students' attitudes towards different science sub-constructs?
2. How do different groups of students exhibit their levels of attitudes towards science?

3. Literature Review

For decades, a problem that has been raised when studying attitudes towards science is the definition of attitude itself (Francis & Greer, 1999; Germann, 1988; Osborne, et al., 2003). The controversy seems to be that there are many concepts that are related to attitudes towards science that may not be included in each definition. However, the most common definition that has involved in describing attitudes is the one which includes the three components of cognition, affect, and behavior. As such, attitudes towards science in this study, according to (Bagozzi & Burnkrant, 1979; Gardner, 1975; Kind, et al., 2007; McGuire, 1985; OECD, 2016; Yara, 2009), refers to the feelings, beliefs, and values held about science that may be school of science, the impacts of science on society, or science careers.

The concerns about attitudes towards science were not new. Nearly five decades ago, Ormerod and Duckworth (1975) had begun their reviews and emphasized that among the factors that had been lessening or swinging students away from science was due to the lessening of their attitudes towards science. A lot more researches into attitudes towards science, thus, had been conducted and confirmed that such attitudes, which consisted of a large number of sub-constructs, contributed in level to an individual occupied towards science performance and future participation in science (Freedman, 1997; Kind, et al., 2007; Osborne, et al., 2003; Papanastasiou & Papanastasiou, 2004). To support this, studies by (Breakwell & Beardsell, 1992; Brown, 1976; Crawley & Black 1992; Gardner, 1975; Haladyna & Koballa Jr., 1995; Olsen & Shaughnessy, 1982; Woolnough, 1994, as cited in Osborne, et al., 2003; Woolnough, et al., 1997), which incorporated a range of constructs into their measures on attitudes towards science including perception of science teachers, anxiety toward science, the importance of science, self-esteem at science, motivation towards science, enjoyment of science, and the nature of science classroom environment, found that students with low self-rating in the attitude measures were likely to have lower performance in science and lower interest in science related majors.

On the other continuum, to have a unified measure on attitudes towards science, the discussions and critiques about measure of attitudes towards science has also been one of the priority research interests among scholars. Findings on attitudes towards science, as stated by some researchers (Barmby, et al., 2008; Blalock, et al., 2008; Khalili, 1987; Kind, et al., 2007) are difficult to compare across studies due to the unstandardized definitions and measurements used to measure the constructs. As consequent, different instruments were used to measure different aspects of attitudes towards science which some researches analogous to the fable about the blind men and the elephant.

First, in 1978, one of the pioneer and commonly used instrument in this measure was the Test of Science Related Attitudes (TOSRA) (Fraser, 1978). The questionnaire which consisted of 70 items measuring on seven sub-constructs—the social implication of science, the normality of scientists, attitudes towards inquiry, adaptation of scientific attitudes, enjoyment of science lessons, leisure interest in science, and career interest in science—was developed to measure high school students' attitudes towards science with the test-retest reliability range from .64 to .93 (Fraser, 1981). Though TOSRA has been used often, it has been criticized occasionally for low level of discriminant validity. While the measurement has been used by ten follow up published studies, the measurement scored only 19 out of 22 score on components of psychometric evidences (Khalili, 1987; Blalock, et al., 2008). Later in 1996, Attitudes Towards Mathematics Survey (ATMS) was developed to measure the students' attitudes towards mathematics (Unfried, et al., 2015). However, ATMS was validated with the measurement of high school and college students' behavioral and cognitive engagement in mathematics only. In 2007, Kind, Jones, & Barmby, thus, developed and validated another attitudes towards science measure. The measure covered seven main science sub-constructs: learning science in school, self-concept in science, practical work in science, science outside of school, future participation in science, importance of science, and general attitudes towards school science with a total number of 48 items with five-likert scale rating. Then, in 2011, another measure of students attitudes towards science, Affective Elements of Science Learning Questionnaire (AESLQ) consisting of 35 items measuring four subscales of science confidence, science interest, science self-concept, and school of science, has been formally developed and tested on two high school chemistry classes (Williams, et al., 2011). Yet, no validity evidence was provided (Unfried, et al., 2015). Thus far, since there were diverse measures used to verify students' attitudes towards science, findings are somewhat controversial.

Though there have been diverse measures, attitudes towards science itself are strongly determined differently by three independent constructs: self-related variables, teacher, and learning environment (Freedman, 1997; Zacharia & Barton, 2003; Papanastasiou & Papanastasiou, 2004). Consequently, there have been some agreements on attitudes reference to personal characteristics. From gender perspective, male students were cited to have higher positive attitudes towards science than female students (Crisp & Nora, 2006; Francis & Greer, 1999; George, 2000; Hodson & Freeman, 1983; OECD, 2016; Simpson & Oliver, 1990). In a sense, it was discovered that male exhibited significantly higher positive attitudes towards science than female. Studies reported that, over time, female had lower rating attitudes towards science were more likely to be related to their self-concept and their concepts of male dominance in science classes and careers (Handley & Morse, 1986; OECD, 2016). However, it is not always the case for all science subjects. Weinburgh (1995) revealed that boy usually showed more positive attitudes towards only physics and chemistry because their interest is much more on speed, electric circuits and technological application in physic.

From teaching and learning environment, findings from previous studies also showed that students' attitudes towards science generally declined over the period of middle school and high school years (George, 2006; OECD, 2016; Simpson & Oliver, 1990). The studies have also consistently indicated that, as the attitude scale was linked to the numbers of science class taken, it is possible that the decline in students' attitudes towards science could be related to the different types and levels of science course students are taking at school. Tracking system has, thus, been proved to have significant impact on students' attitude towards science. In a sense, students who were in the science track were able to experience and involve more in science and mathematics courses, which consequently lead to higher attitudes in science related courses in the future (Marginson, et al., 2013; Myeong, et al., 1991).

In locality perspective, in nationality debate, studies showed that attitudes towards science are not the same (Awan, et al., 2011). The attitude in general and attitudes towards science in particular, vary remarkably in different parts of the world and students' nationality is proved to affect this variation (Ye, et al., 1998). The first striking finding was that, compared to developed countries, children in developing countries appeared to be more interested in science and science related topics. In the narrower geographical area perspective, results also showed two contrasting schools of debate. Measuring on the same constructs of attitudes towards science using TOSRA, Anwer, et al. (2012); George (2000); Serin and Mohammadzadeh (2008); Papanastasiou and Papanastasiou (2004) consistently verified the stance that students from non-urban area seemed to rate higher on attitude scales compared to students originated from urban area. However, some other studies (see, for example, Hammrich, 1998; Zacharia & Barton, 2004), due to environmental advantage, contradicted that urban origins usually had higher attitudes towards science than the ones from the non-urban locality. These debates have, thus, laid the gaps for further research in particular for the developing context like Cambodia.

4. Research Methods

4.1 Participants

A total sample of 455 11th grade students (male = 279, female = 176) of seven upper secondary schools located in Phnom Penh and two provinces (Kampot and Kep) of Cambodia participated in the survey. One important justification for selecting this sample is that according to Ministry of Education, Youth and Sport (2010), by the end of 10th grade, students must choose to study in either science track or social science track for their 11th and 12th grade of upper secondary school. From this academic decision, the 11th grade students, might have a clearer picture of what they meant by science oriented and social science oriented and will be more able to response to the questions on science related attitude scales more effective and reliable. Also, 11th graders from the two different study tracks have been exposed to different levels of science class and learning environment which is significant for different groups comparison.

Students were selected by mean of multi-stage cluster random sampling method. To ensure the true representation of the population, 25 provinces of Cambodia were ranked according to the number of grade 12th students in the academic year 2017-2018 (Statistics compiled by Department of General Education, MoEYS, 2017). One province in the highest quintile, one in the middle quintile, and one in the lowest quintile were selected. Schools in each province were then divided into two strata—urban and rural/non-urban schools (located 40-50 kilometers from provincial center). Each stratum was then further divided into two sub-strata, i.e., science track and social science track classes. All students in each class were cluster-selected to be the sample of the study. Table 1 presents the profile of the selected sample.

Table 1. Student profile ($N = 455$)

Variables	N	%
Gender		
Male	279	61.3
Female	176	38.7
Study Track		
Science	254	55.8
Social Science	201	44.2
Geographical origin		
Urban	190	41.8
Non-urban	265	58.2

4.2 Instrument and measures

Data was collected using a self-reported questionnaire. The questionnaire measured students' background characteristics and six constructs of attitudes towards science. Students' background characteristics were specifically consisted of gender (1 = male, 2 = female), study track at upper secondary school (1 = science track, 2 = social science track) and geographical origin (1 = urban, 2 = non-urban). Urban students origin in this present study were targeted to those students who are studying at upper secondary schools in Phnom Penh city; whereas those who are studying at upper secondary schools in the other provinces were marked as non-urban in geographical origin.

Student attitude was measured by six attitude constructs, a modified version of attitudes towards science measure developed by Kind, et al. (2007), consisting of 39 items: learning science in school (6 items), practical work in science (8 items), science outside of school (8 items), importance of science (5 items), self-concept in science (7 items), and future participation in science (5 items). The last construct—general attitudes towards science (9 items)—in the original measure was not included because of the contextual mismatched and the construct, for correlation purpose, was mainly the combination of items in the previous six constructs. Overall, the six constructs were measured on a five-point Likert scale with 1 denoting a negative response and 5 denoting a positive response (1 = strongly disagree, 2 = disagree, 3 = neither disagree or agree, 4 = agree, 5 = strongly agree). The measure by Kind, et al. (2007) was adapted instead of other tools for two main justifications. First, in practical aspect, the original concept for developing the measure was to evaluate the impacts of the lab in a lorry initiative of the United Kingdom. The concept is similar to the so-called STEM Bus initiative that has also been implementing in Cambodian context. Secondly, in theoretical aspect, the constructs covered both in classroom, outside classroom, and a wider social context of science. To be more specific, the first three constructs aimed to examine students' attitudes towards science learning activities in different contexts—classroom, practical work, and outside the classroom. It is believed that each of these contexts represented meaningful "objects" that students were likely to have formed belief about (Kind, et al., 2007). The next construct was included to examine students' belief in the value of science in a wider social context. While science self-concept is believed to form attitudes towards the subject, future participation is similarly regarded as the students' attitudes towards engaging more with science in the future. To ensure the relevance and internal validity of the measure within Cambodia context, exploratory factor analysis using principle axis factoring with Varimax and Kaiser Normalization in rotation was employed. The analysis produced eight distinct factors: future plan in science (6 items), self-concept in science and science learning (8 items), practical work in science class (6 items), importance of science on society (6 items), self-interest in science activities outside school (4 items), enjoyment of practical work in science (3 items), difficulty of science subject (3 items), and extracurricular activities in science (3 items) with all Eigenvalue greater than 1 (See Appendix). Overall, the factors explained 63.37% of the total variance for factor analysis with the overall Cronbach's $\alpha = .94$. Prior to carrying out the reliability calculation and factor analysis, all negatively worded items were also reverse-coded.

4.3 Data analysis

The collected data was analyzed in two stages. First, because the researcher was interested in examining the students' attitudes trends in the developing context like that of Cambodia, descriptive statistics using mean scores from students' original rating value on the scales was used as a main tool for an illustrative purpose. Secondly, to examine the level of students' attitudes towards science reference to the differences of students' profiles, independent sample t-test was used accordingly. Because students' attitudes towards science was measured by how much they rated themselves, each construct was computed to get the mean score using factors score derived from the exploratory factor analysis. To be more precise, the factors loaded as one construct in exploratory factor analysis were computed to get the mean score of each construct that will later be used for the main analysis.

5. Findings

5.1 Trends of students' attitudes towards science

The results of research question 1 are illustrated in Figure 1. As can be seen, Cambodian upper secondary school students exhibited low to moderate level of attitudes towards science constructs. The most noticeable attitude constructs that the students showed higher positive attitudes towards is the importance of science on society ($M = 3.69$, $SD = .60$), followed by enjoyment of practical work in science ($M = 3.51$, $SD = .78$), practical work in science class ($M = 3.35$, $SD = .70$), self-interest in science activities outside school ($M = 3.34$, $SD = .71$), future plan in science ($M = 3.04$, $SD = .85$), difficulty of science subject ($M = 2.97$, $SD = .78$). However, the variables which Cambodian students exhibited lower attitudes towards are self-concept in science and science learning ($M = 2.88$, $SD = .67$) and extracurricular activity in science ($M = 2.52$, $SD = .72$). Overall, the trend of Cambodian students' attitudes towards science is as interesting as expected. While most students tended to believe that science plays a very importance role in the society and that they are more likely to be interested in practical work of science and science activities

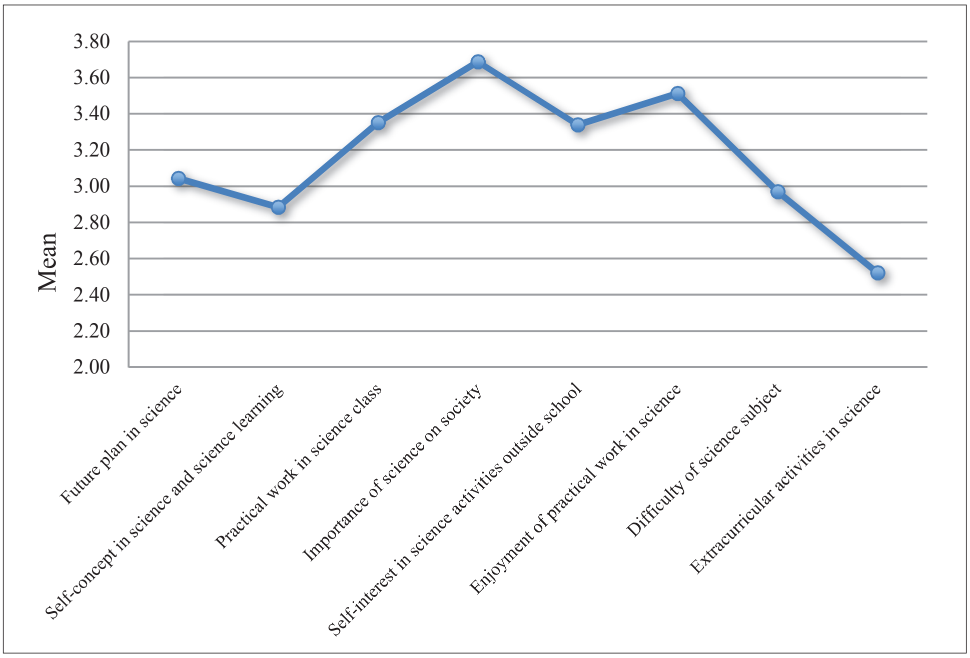

Figure 1. Mean of each Attitudes towards Science Construct.

outside school, they seemed to have lower self-concept in science and science learning which, as consequent, influenced their future plan in science.

5.2 Patterns of students' attitudes towards science

5.2.1 Gender

While the overall trends of students' attitudes towards science was illustrated in Figure 1, in response to research question 2, it is critically important to look into its possible discrepancies that can masked between and among certain characteristics of the students. Table 2 presents the patterns of students' attitudes towards science by gender divide. As can be seen, on all constructs, male students indicated higher positive attitudes towards science than female students. To be more precise, male and female students seemed to give the same value towards the importance of science on society and self-interest in science activities outside school. The same was true for the other extracurricular activities in science. However, male and female did, indeed, differ significantly with respect to their future plans in science. Male students seemed to have higher aspiration to participate in science in the future (M = 3.17, SE = .83) than what female students do (M = 2.84, SE = .84). This difference is significant t (453) = -4.07, p<.001. There is also significant difference between male (M = 2.96, SE = .04) and female (M = 2.76, SE = .05) students in term of self-concept in science and science learning t (453) = -3.06, p<.01, practical work in science class t (453) = -3.05, p<.01, enjoyment of practical work in science t (453) = -3.53, p<.001, difficulty of science subject t (453) = -2.90, p<.01 with male students being likely to be the dominant group in all instances.

Table 2. Students' Attitudes towards Science by Gender Divide

Attitude construct	Gender	Mean	SD	*t*	Sig.
Future plan in science	Male Female	3.17 2.84	.83 .84	-4.07	0.000***
Self-concept in science and science learning	Male Female	2.96 2.76	.63 .71	-3.06	0.002**
Practical work in science class	Male Female	3.43 3.33	.67 .73	-3.05	0.002**
Importance of science on society	Male Female	3.73 3.62	.59 .61	-1.79	0.074
Self-interest in science activities outside school	Male Female	3.36 3.30	.70 .73	-.87	0.385
Enjoyment of practical work in science	Male Female	3.61 3.35	.74 .81	-3.53	0.000***
Difficulty of science subject	Male Female	3.05 2.83	.74 .79	-2.90	0.004**
Extracurricular activity in science	Male Female	2.56 2.46	.70 .74	-1.47	0.142

**p<.01; ***p<.001

5.2.2 Study track

Academically, inquiry into how different groups of students exhibited their attitudes towards science was also made with reference to their study tracks at upper secondary school. As mentioned earlier, from the academic year 2010, MoEYS has introduced the tracking system requesting all grade 10^{th} students to choose either science or social science track for their 11^{th} and 12^{th} grades. As indicated in Table 3 below, in all instances, students from science track exhibited higher positive value on attitudes towards science than their counterparts. To be precise, students from science track indicated significant difference between students from social science track in their future plan in science, self-concept in science and science learning, practical work in science class, importance of science on society, self-interest in science activities outside school, enjoyment of practical work in science, difficulty in science, and extracurricular activity in science with p<.001. Among all, within the science track group, students indicated higher positive attitudes towards the enjoyment of practical work in science, followed by the importance of science on society and the practical work in science class constructs.

Table 3. Students' Attitudes towards Science by Study Track Divide

Attitude construct	Study Track	Mean	SD	*t*	Sig.
Future plan in science	Science	3.45	.72	13.50	**0.000*****
	Social science	2.53	.71		
Self-concept in science and science learning	Science	3.25	.50	16.57	**0.000*****
	Social science	2.42	.57		
Practical work in science class	Science	3.64	.54	10.74	**0.000*****
	Social science	2.99	.71		
Importance of science on society	Science	3.86	.54	6.99	**0.000*****
	Social science	3.48	.60		
Self-interest in science activities outside school	Science	3.53	.63	6.85	**0.000*****
	Social science	3.09	.73		
Enjoyment of practical work in science	Science	3.90	.64	15.02	**0.000*****
	Social science	3.01	.63		
Difficulty of science subject	Science	3.27	.63	10.46	**0.000*****
	Social science	2.59	.75		
Extracurricular activity in science	Science	2.74	.72	7.96	**0.000*****
	Social science	2.24	.61		

***p<.001

5.2.3 Geographical origin

As one of the sub-purpose of exploring how students from different backgrounds exhibited their attitudes towards science, the study was also investigating the attitudes difference reference to the geographical origin. The basic assumption is that students being from areas other than capital city (Phnom Penh) of Cambodia would exhibit lower attitudes towards science than their counterpart due to different level of accessibility to teaching facilities and the teaching practices of science teachers in the city and that of the schools condition and teachers' practices in the provinces.

Nevertheless, this hypothesis was not supported in most instances of attitudes towards science variables in this study. As can be seen in Table 4, overall, students from the non-urban area (province) seemed to have higher positive attitudes towards science than students who are in the urban area (Phnom Penh). To be more specific, there is significant difference between urban and non-urban students' attitudes towards science on the scale of future plan in science t (453) = -4.86, $p<.001$; practical work in science

Table 4. Students' Attitudes towards Science by Geographical Origin

Attitude construct	Locality	Mean	SD	*t*	Sig.
Future plan in science	Urban	2.82	.82	-4.86	**0.000*****
	Non-urban	3.20	.84		
Self-concept in science and science learning	Urban	2.85	.68	-.87	0.382
	Non-urban	2.91	.66		
Practical work in science class	Urban	3.26	.72	-2.23	**0.026***
	Non-urban	3.41	.68		
Importance of science on society	Urban	3.67	.60	-.56	0.572
	Non-urban	3.70	.59		
Self-interest in science activities outside school	Urban	3.16	.73	-4.64	**0.000*****
	Non-urban	3.47	.67		
Enjoyment of practical work in science	Urban	3.44	.79	-1.59	0.113
	Non-urban	3.56	.77		
Difficulty of science subject	Urban	2.81	.78	-3.74	**0.000*****
	Non-urban	3.08	.74		
Extracurricular activity in science	Urban	2.50	.73	-.52	0.601
	Non-urban	2.54	.72		

*p<.05; **p<.01; ***p<.001

class t (453) = -2.23, p<.05; self-interest in science activities outside school t (453) = -4.64, p<.001; and difficulties in science subject t (453) = -3.74, p<.001 with students from non-urban areas exhibited significantly higher positive attitudes in all these instances.

6. Discussions

This study points to a few, but emerging findings with respect to the realities of Cambodian upper secondary school students' attitudes towards science. Practically speaking, with the current development of science and technology, of all the other instances, students displayed a higher level of awareness in science and technology particularly on its importance on society. This is a really interesting sign as according to Cambodia's national science and technology master plan 2014-2020 of the Royal Government of Cambodia (RGC, 2013), Cambodia has only 17 science and technology researchers and 13 technicians per million of its population. The policy illustrated that this was due to the fact that Cambodia's social awareness of science and technology is generally low. However, the results of the study indicated a different trend of students' awareness of science and technology in general and the importance of science and technology on society in particular. Another interesting finding is that the students showed more positive attitudes towards the enjoyment of practical work in science and the practical work in science class. According to (Marginson, et al., 2013; Freedman, 1997; Papanastasiou & Papanastasiou, 2004), teaching method of problem solving, inquiry, critical thinking and creativity should be considered because they can enhance both students' attitudes towards and practical competency in science related fields. In Cambodian upper secondary school context, it is generally reported that the practical work particularly in science class is of concern. However, with the current improvements of MoEYS, this teaching practice is upgrading. For instance, From 2000 to 2005, JICA implemented several projects such as Secondary School Teacher Training Project in Science and Mathematics (STEPSAM), which aimed at improving the science and mathematics teaching functions and capabilities of the country's National Institute of Education (NIE), which trains high school teachers, Project for Improving Science and Mathematics Education at Upper Secondary Level (ISMEC), implemented from 2005 to 2008, and STEPSAM II was carried out from 2008 to 2012 (Center for Research and Development Strategy, 2015). Thus, this might have influenced on the improvement of science and mathematics education in Cambodia and enhanced students' attitudes towards the practical work in science in the long run. On the other continuum, the result also revealed the emerging trend of Cambodian students' self-interest in science activities outside school which include science movies on TV, reading science magazines, and other science activities. Besides these self-interest activities, students also exhibited moderate level of attitudes towards extracurricular activities in science. Some students participated in the survey have experienced the so-called STEM bus and STEM festival which would enhance their attitudes towards science subjects at upper secondary school. Has been implementing for a few years, STEM bus (modeled from lab in a lorry in the British context), travels to high schools across the country to exhibit science expo as well as to promote awareness and interest in STEM majors to secondary schools (MoEYS, 2018). Empirically, Barmby, et al. (2008) and Forsthuber, Motiejunaite, and de Almeida Coutinho (2011), reported that Lab in a Lorry has been significantly contributing to building students' interest in and attitudes towards practical work of science and science learning in school. In this regards, with the same vein of implementation as Lab in a Lorry, STEM Bus in Cambodian context might also have contributed to enhance students' interest in and attitude towards science in general and attitudes towards extracurricular activities in science in particular, which has been portrayed in this study. On the contrary, as the result of further analysis, it has shown that there is significant positive relationship between science as one of the difficult subjects and self-concepts in science and science learning (r = .49, p<.001). In this regard, students exhibited lower scale of attitudes towards self-concept in science and science learning might be due to the fact that science is perceived as one of the difficult subjects. As consequent of the low self-concepts in science and science learning, most students seemed not to give more priority to pursue science related majors and careers which might thus led to lower level of future plan in science (r = .70, p<.001). There is an interesting reflection in this finding. At the upper secondary school about 80 per cent of the students are taking science class (MoEYS, 2017; 2018); however, might be because they perceived that science as difficult, together with the lower self-concept in science and science learning, their future plan in science is generally low (r = .48, p<.001) As evidence, CDRI (2018) reported that while the number of students in the higher education institution increased fewer than 20% of them pursue science related majors at higher education.

The results also showed divergent features of students' attitudes towards science that emerged within students' gender dynamics. Overall, adding on the findings by (Crisp & Nora, 2006; Francis & Greer, 1999; Hodson & Freeman, 1983; OECD, 2016; Simpson & Oliver, 1990) this study revealed that male students seemed to have higher attitudes than female students towards science. Among all, the most advantageous aspects that male students had over female were a clearer future plan in science, self-concept in science and science learning, practical work in science class, enjoyment of practical work in science, and the perceived difficulty of science subjects at school. The most noticeable pattern of the differences relative to gender was on the enjoyment of practical work in science sub-construct with male (*M* = 3.61, *SE* = .04) exhibited significantly higher than female (*M* = 3.35, *SE* = .06), p<.001. Contextually, these differences may partly be due to cultural perception of Cambodian people, especially the parents of the students, that science is usually male dominant fields. The finding is also supported by the empirical justifications that female have lower attitudes towards science because of their science self-conception and their conception of their minority aspects in science class (Handley & Morse, 1986; OECD, 2016). More of note, in Cambodian context, the term science is prejudiced as male dominated job (Mark, 2016; Kaing, 2016) and thus female students themselves tended to swing away from science. For example, according to MoEYS (2017) only about 34% of Cambodian upper secondary school female students are taking science track in their upper secondary education. This, to a greater extend, indicated the lower interest and attitudes towards science among female students. Moreover, since science subjects are usually perceived as difficult and as female students in Cambodia high school (age 18-22) usually spend their spare time from school supporting the family daily routine (cleaning and cooking, to name a few), they might not have enough time to spend on those difficult subjects of science at home. As consequent, this might influence their science performance and their attitudes towards science in the long run.

From the system level perspective, tracking system at upper secondary school exhibited significant impact on enhancing students' attitudes towards science. To be more specific, the results showed that students from science track indicated significantly higher positive attitudes towards science than those students of social science track. More critically, among all, the construct which denoted significant difference between these two groups is also on the enjoyment of practical work in science class in which science track (*M* = 3.90, *SE* = .04) compared to social science track (*M* = 3.01, *SE* = .04), p<.001. One of the generally understood reasons is that students in science track are exposed more to science and mathematics lessons. According to the announcement number 23 of MoEYS, students in science track need to take five hours/sessions of mathematics per week while the social science need to take only three hours/sessions per week. This is in accordance with the results in the other contexts (George, 2007; Myeong, et al., 1991; OECD, 2016; Simpson & Oliver, 1990) which claimed that the number of science and mathematics classes taken at school is positively linked to the level of attitudes towards science in general and participation in future science in particular. As evidenced from this study, regression analysis revealed that as practical work of science increases, the students' attitudes towards science also increases. A significant regression equation was found (F (1, 453) = 830.96, p<.001), with an R^2 of .647). Thus, greater exposure to science and mathematics, particularly on practical work of science, has greater influence on students' positive attitudes towards science.

Another interesting debate among researchers is the different pattern of students' attitudes towards science relative to the geographical origin. The study confirmed that students from non-urban area illustrated higher positive attitudes towards science constructs than the ones from urban area. In a broader sense, this result is in consistent with the review of the students' attitude reference to nationality perspective which claimed that developing country exhibited higher attitudes towards science than developed country (Ye, et al., 1998) and that students from non-urban area exhibited higher attitudes towards science than students from urban area (Anwer, et al., 2012; George, 2000; Serin & Mohammadzadeh, 2008). These results come as a surprise as the latter is presumed to be at advantage in access to more science interest driven activities and facilities. However, in Cambodian context, there might be a few interesting anecdotes to explain this phenomenon. First, it is generally believed that science subjects are more oriented to become science teacher at upper secondary school. Also, because students need to adjust to the norm of the parents, especially from the non-urban area, who believed that becoming teacher is one of the most secure and permanent job (civil servant), they are more likely to exhibit higher attitudes towards science in this long run aspiration. Another possible explanation is that science subjects are considered to be ideal for better future among non-urban students for better future and career and to have a superior socio-economic status consequently (Anwer, et al., 2012; OECD, 2016). Therefore, non-urban students show significantly higher attitudes towards science than urban ones. On top of this, one of the striking differences between urban and non-urban is self-interest in science and science activities with (*M* = 3.16, *SE* = .05) of the former and (*M* = 3.47, *SE* = .04), p<.001 of the latter. This might be due to the fact that non-urban students are exposed more to natural environment in which they could discover more to enhance their attitudes towards science than the urban counterparts.

7. Conclusion and Implications

This study attempts to illustrate overall trends and patterns of Cambodian upper secondary school students' attitudes towards science. Overall, results showed that students have become more aware of and exhibited higher positive attitudes towards the importance of science on society, enjoyment of practical work in science, practical work in science class, and science activities outside school. However, the results also revealed that students perceived that science is one of the difficult subjects, had lower self-concept in science and science learning, and exhibited moderate level of future plan in science as well as other extracurricular activities in science. On the whole, adding an additional battery of knowledge pertaining the patterns of students' attitudes towards science, the results of this study exhibited that the subjects' attitudes towards science had a meaningful significant difference considering gender, study track and geographical origin. This study positioned that male students, students from science study track, and students originate from non-urban area displayed significantly higher positive attitudes towards science than female students, students from social science study track, and students from the urban area respectively.

The study has also thrown some practical implications indicating that a positive attitude is more necessary for girl in achieving high score and for future participation in science, thus the practical need is to examine the classroom strategies that could be used to improve students' attitudes, especially of female, towards science. Moreover, in order to enhance students' attitudes towards science, school should manage to show scientific movies, visit the science and natural museums or natural parks, and enhance more practical work in science and conduct science related activities both inside and outside classroom often. Also, since teachers' instructions that make science more exciting and encouraging (e.g. practical work) has positive influence on students' attitudes towards science, science teachers' qualifications and teaching practices—a teaching practice that makes science more exciting and includes more practical work in science regularly—should also be highly fostered. This would help students to enjoy the practical work of science class, have positive feelings about science, increase their intrinsic motivation, enhance higher self-concept in science and thus have higher attitudes towards science and future participation in science. Theoretically, this study is very important in shedding light on the extant literature gap on the trends and patterns of students' attitudes towards science in the developing context like that of Cambodia.

Acknowledgement

The author would offer special thanks to the people of Japan in general and Japan International Cooperation Center (JICE) in particular, for the scholarship offered.

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Appendix

Construct	Measure	Mean	SD	Factor Loading
Future plan in science (Cronbach's α = .87)	- I would like to study science related major at university - I would like to study more science in the future. - I would like to have a job working with science. - I would like to become a scientist. - I would like to become a science teacher. - I would like to do more science at school.	3.20 3.22 3.15 3.51 3.69 3.48	1.11 1.10 1.18 1.11 1.11 .94	.73 .68 .68 .58 .57 .43
Self-concept in science and science learning (Cronbach's α = .89)	- I learn science quickly. - Science is one of my best subjects. - I get good marks in science. - In my science class, I understand everything. - I like science better than most other subjects at school. - Science lessons are exciting. - We learn interesting things in science lessons. - I look forward to my science lessons.	2.89 2.55 2.83 2.58 3.00 3.25 3.22 2.74	.86 .86 .81 .78 .99 .94 .97 .92	.70 .69 .64 .64 .53 .47 .44 .42
Practical work in science class (Cronbach's α = .85)	- Practical work in science is good because I can work with my friends. - I like science practical work because you do not know what will happen. - I would like more practical work in my science lessons. - I like practical work in science because I can decide what to do myself. - We learn science better when we do practical work. - I look forward to doing science practical works.	3.34 3.51 3.50 3.23 3.38 3.15	.88 .88 .96 .92 .96 .89	.69 .62 .55 .53 .51 .49
Importance of science on society (Cronbach's α = .84)	- Science and technology make our lives easier and more comfortable. - Science and technology are helping the poor. - Science and technology is important for society. - The benefits of science are greater that the harmful effects. - There are many exciting things happening in science and technology. - It is exciting to learn about new things happening in science.	3.58 3.80 4.00 3.41 3.73 3.60	.89 .81 .79 85 .79 .92	.66 .62 .61 .56 .48 .44
Self-interest in science activities outside school (Cronbach's α = .80)	- I like to visit science museum. - I like watching science program on TV. - I like reading science magazine and books. - I would like to do more science activities outside of school.	3.43 3.34 3.30 3.28	.85 .94 .89 .92	.70 .63 .59 .46
Enjoyment practical work in science (Cronbach's α = .73) (*These items were reverse-coded)	- Practical work in science is exciting. - Practical work in science is boring.* - I feel helpless when doing science.*	3.42 3.69 3.42	.98 .98 .95	.47 .45 .44
Difficulty of science subject (Cronbach's α = .70) (*These items were reverse-coded)	- I am just not good at science.* - I find science difficult.* - Science is boring.*	2.83 2.53 3.55	.94 .91 1.05	.73 .62 .45
Extracurricular activities in science (Cronbach's α = .56)	- I have participated in Science Festival/STEM Festival. - I have participated in the event on STEM Bus. - I have participated in science and Mathematic Club.	2.34 2.38 2.83	.91 1.02 1.02	.65 .49 .31

***Overall Cronbach's α = .94