Factors Affecting Cambodian Upper Secondary School Students' Choice of Science Track

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Abstract

Upper secondary school years have been considered as a critical period for attracting students into future science-related majors and careers; yet, Cambodia is facing a worrisome decline trend in the students' choice of science track. Through the lens of the making of engineers and scientists conceptual framework, the study aims to investigate the factors affecting Cambodian upper secondary school students' choice of science track. With self-rating questionnaire survey, which randomly covered 751 students from nine upper secondary schools in three provinces of Cambodia, the researcher collected data on three significant factors namely individual ability and personality, family background and encouragement, and upper secondary school experience and support. Binary Logistic Regression analysis revealed that performance in science and mathematics subjects, attitudes towards science, plan to major in STEM, time spent self-studying in science and mathematics subjects, family encouragement, mother's education, and school location significantly predicted students' choice of science track. Some important implications for promoting science track choice were also discussed.

Keywords: Cambodia, science, tracking, upper secondary school

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Factores que Afectan la Elección de Carreras Científicas en Estudiantes Camboyanos de Educación Media Superior

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Resumen

Los grados terminantes de educación media superior han sido considerados un periodo crítico para atraer estudiantes a carreras relacionadas con la ciencia, a pesar de esto, Camboya actualmente sufre de una preocupante tendencia descendente en estudiantes eligiendo carreras relacionadas con las ciencias. Con el marco conceptual de crear ingenieros y científicos, este estudio investiga los factores que afectan la elección de carreras científicas en estudiantes camboyanos en educación media superior. Con cuestionarios de auto-calificación, 751 estudiantes fueron encuestados de nueve escuelas de educación media superior en tres provincias de Camboya, el investigador recolecto información de tres factores significativos, siendo; competencia personal y personalidad, circunstancias familiares y motivación y experiencia en educación media superior y apoyo. Análisis de regresión logística binaria revelaron que el desempeño en las asignaturas de ciencia y matemáticas, apoyo familiar, nivel educacional de la madre y locación de la escuela predicen significativamente la decisión de los estudiantes respecto a carreras de ciencias. Algunas implicaciones importantes para promover las carreras relacionadas con la ciencia también fueron discutidas.

Palabras clave: Camboya, ciencia, rastreo, educación media superior

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The Fourth Cambodian Economic Forum on "Cambodian Economy in Post-Crisis Environment: Industrial Development Policy Options toward a Sustainable Economic Development" emphasized the strategic vision of the government in shifting Cambodia's economic development from dependent on agriculture, garments, tourism, and construction to a broad-based industrial and technology-oriented economy (RGC, 2015) in order to move the country to a higher-middle income country by 2030 and a high-income country in 2050. As such, Science, Technology, Engineering, and Mathematics [STEM] Education Policy was developed in 2016 (Ministry of Education, Youth and Sport [MoEYS], 2016a). The policy clearly emphasized that as Cambodia is a developing country with a growing economy, its inhabitants need to be encouraged to explore the demand of 21st century skills and thus produce more human resources in science or STEM fields in order to shift the Cambodian economy forward. However, to be more competitive in the region and in the world, Cambodia is still in a great demand for graduates in science or STEM related fields (Asian Development Bank [ADB], 2011; MoEYS, 2014a; RGC, 2015; Un & Sok, 2016; UNESCO National Education Support Strategy [UNESS], 2010) to support the country economic development.

A recent study estimated that Cambodia would need about 35,000 engineers and another 46,000 technicians by 2018 so as to maintain the percentage of GDP growth within the range of, say, 6-8 percent between now and 2020 (Japan International Cooperation Agency [JICA], 2016). Responsibly, MoEYS has been initiating policy initiatives to enhance the quality of and the students' interest in science and mathematics at upper secondary school (MoEYS, 2014a). Of those is the implementation of the tracking system. The main objective of this system is to build a strong background competence in science and mathematics at upper secondary school (MoEYS, 2010). This bifurcation requires all 10th graders to select either science or social science track for their second and third year of upper secondary school learning (grade 10th-12th). Statistically, since the beginning of its implementation, more Cambodian students chose science than social science track. Statistically, nearly 80% of them enrolled in science track while the share of students in social science track was about 20% in the past academic years (MoEYS, 2017). However, the situation is currently changing dramatically. While MoEYS targets to increase more students in science track

from upper secondary school so as to increase more enrollment in science related at higher education, the share of Cambodian students enrolling in science track has shown a worrisome decline trend. According to MoEYS statistics for the academic year 2018-2019, the percentage of Cambodian students choosing science track has significantly dropped to about only 49% while the percentage of students in the social science counterpart has jumped dramatically than ever before to 51% (MoEYS, 2019). This sheds a great concern for MoEYS in aiming to enhance science and mathematics education at upper secondary school in particular and STEM enrollment in higher education in general.

For decades, concerns have increased among policy makers and researchers with respect to the decline of students' interest in science and their decision to study science worldwide (Zuniga et al., 2005; Kinyota, 2013; Li & Kuan, 2018; Myeong & Crawley, 1993; Paik & Shim, 2013; Shim & Paik, 2014). In particular, researchers have sought to understand the more fundamental causes of the decline in science enrollment and the decline in scientific literacy (Kinyota, 2013; Myeong & Crawley, 1993; Shim & Paik, 2014; Shimpkins et al., 2015). It is no exception in Cambodian context. The low enrollment has significant impacts on the current need of human resources supporting the current phase of the country economic development and has thus given rise to the quest among educators and scholars to understand students' choice of major at higher education (e.g., Eng & Szmodis, 2016; Kao & Shimizu, 2019; Pen, 2011; Peou, 2017) and how upper secondary school tracking is contributing to that academic choice. However, until recently none of the studies have examined extensively at the fundamental level of upper secondary school students' track choice (science versus social science). Little is known about how variables at individual ability and personality, family background and encouragement, and upper secondary school experience and support contribute to explain Cambodian students' choice of science track. The paucity of empirical evidence as such is surprising given to the decline of students in science track and the growing demand of graduates in science or STEM majors at higher education in the developing context like that of Cambodia.

The upper secondary school science has been considered as a critical period for attracting students into science as it is significantly correlated with their post-secondary educational choices (Dustmann, 2004; Kinyota, 2013;

Maltese & Tai, 2011; Li & Kuan, 2018; Shim & Paik, 2014; Shimpkins et al., 2015). Also, some researchers (e.g., Myeong & Crawley, 1993; Paik & Shim, 2013; Welch, 1985) maintained that students' science track choice is one of the much-needed research areas within respective context. Therefore, the central question guides the current study is

   • What factors are affecting Cambodian upper secondary school students' choice of science track?

Literature Review

Tracking: Definition and Types

For decades, studies have consistently claimed that early track choice could have important consequences on future academic trajectories and labor market outcomes (Darolia et al., 2018; Dustmann et al., 2017; Kerr et al., 2013; Li & Kuan, 2018; Lucas, 1999; Myeong & Crawley, 1993; Oakes, 1986). Though studies have also defined tracking in various ways (LeTendre et., 2003; Gamoran & Mare, 1989), current study adopts the ground breaking definition of tracking by Oakes (1986) which refers to the process whereby students are divided into categories so that they can be assigned in groups to various kinds of classes. Put simply in the context, it is the process whereby Cambodian upper secondary school students are put in different track of science and social science for their grade 11th and 12th education.

   Although the definition of tracking—conventional or selective—is, to some extent shared around the world, countries seemed to differ widely on the type, the degree, and the age at which students begin to be tracked (Darolia et al., 2018; Dustmann et al., 2017). For instance, some countries track students into differing-ability schools as early as the age of 10 (e.g., Austria, Germany, Hungary, and the Slovak Republic). By contrast, others including Canada, Japan, Norway, Sweden, Korean, the United Kingdom, and the United States essentially keep their entire lower secondary school system comprehensive (Hanushek & Wößmann, 2006; Organisation for Economic Co-operation and Development [OECD], 2004) and the tracking begins when students are 16 years old (Woessmann, 2009). Furthermore, the multiple forms and understanding of tracking has ultimately led a group of scholars to study and

summarize the tracking into five main types as shown in Table 1.

Table 1
Typology of curricular differentiation across the nations

Type 1: *School type*	Differentiation in the organizational forms of schooling (e.g., vocational versus academic high school).
Type 2: *Course of study*	Provision of more than one formal paths that students may follow within a given school or school type (e.g., technical high schools have distinct core classes for their chemistry and electrical engineering course of study.
Type 3: *Stream*	Differentiation occurs over time in terms of the number and difficulty of course assigned to different streams (e.g., liberal art versus science stream in Japanese high school). Other terms include tracking or lanes.
Type 4: *Ability grouping*	Grouping occurs within one class or grade or "pulled out" to study elsewhere, on the basis of some measure or estimation of students' ability (e.g., ability-based reading group, gifted and talented programs).
Type 5: *Geographical location*	Differentiation in curricular offerings, instructional quality, and opportunity to learn differ by geographic area where schools are located (This is most prominent in the U.S).

Adapted from LeTendre et al. (2003)

Tracking in Cambodian Academic Upper Secondary School

Based on the afore-mentioned definition and types illustrated in Table 1, tracking in Cambodian context typically falls into type 1 and type 3. In type 1, at the end of grade 9th students could choose between technical and vocational or academic upper secondary general education track (JICA, 2016; UNESCO, 2014). This type is beyond the scope of the current study. Type 3,

which is the focus of the current study, ultimately was aimed to build a strong background competence in science and mathematics at upper secondary school and to provide clearer pathways for students to choose academic majors in higher education (MoEYS, 2010). This bifurcation takes place at the end of grade 10th—the first year of upper secondary school—so that all 11th graders are enrolling in either science or social science track. The key differences between these two tracks laid in the core focus-subjects, the extent of emphasis on curriculum content, the number of teaching hours, and the subject and the scoring method in the examination. While the focus of the former track is on science subjects (physics, chemistry, biology, earth and environmental science) and mathematics, the focus of the latter track is on Khmer literature, history, geography, and moral studies. For example, in science track, the learning hours is five sessions/hours per week for mathematics and three hours each for all science subjects and the total score of is 125 and 75 for mathematics and each science subject respectively. However, in social science track, three and two sessions/hours per week with the full score of 75 and 50 are allocated for mathematics and each science subject respectively (MoEYS, 2010; 2011). This scoring method is also applied in baccalaureate examination. Moreover, while the students from science track have to take all science subjects, the students from social science track take only one lucky-draw-selective science subject (usually the draw was earth and environmental science) in the baccalaureate examination.

Factors Affecting Choice of Science Track at Upper Secondary School: Empirical Evidence

A large body of literature on the determinants of students' track choice confirmed that in addition to individual preference, there were other factors affecting students' choice of science track (Chen, 2013; Dustmann, 2004; Li & Kuan, 2018; Myeong & Crawley, 1993; Paik & Shim, 2013; Woolnough, 1994). In this token, this research was thus guided by the hypothesis, a synthesis of the conceptual framework of Woolnough (1994) and extant literature, that students' choice of track at upper secondary school is influenced by students' ability and personality (individual), by the values placed on science by society (family characteristics, in this sense), and by experience and support from school (school environment).

First, from the individual ability and personality perspective, science and mathematics related ability was often evaluated as individual's primary ability. Students who are good at science and mathematics were reckoned to be smart and competitive (Li & Kuan, 2018; Smith, 2011; Shin et al., 2017). Consequently, their academic performance was reported to significantly affect their educational track choice. In general, better performance in science and mathematics tended to encourage students to choose science track. Studies have also confirmed that not only the students' performance in science and mathematics but also the overall academic performance explained students' choice of track (Ayalon & Yogev, 1997; Dustmann, 2004; Paik & Shim, 2013). Students with high academic achievement were more likely to choose science track over humanities/social science. Significantly, though the students' track choice was primarily based on individual preference rather than their academic performance, students from the science track were generally reported to have higher positive academic performance than their counterparts (Chen, 2013; Kinyota, 2013; Kwak, 1993; Li & Kuan, 2018; Myeong & Crawley, 1993; Paik & Shim, 2013).

The relationship between interest attributes, future relevance, self-confidence, attitudes (difficulty and practicality of science), and success expectancy with choice intentions and actual choice has often been cited (Myeong & Crawley, 1993; Stokking, 2000). Science track members were found to have higher positive scores on mathematics, science and general science self-concept, and attitudes measures (Kinyota, 2013; Myeong & Crawley, 1993). For example, it was also found that interest, appreciation, and self-confidence decreased for students not choosing physics, where they did not for students choosing physics. Students' attitudes towards physics was found to influence their choice of the subject (Stokking, 2000).

Furthermore, students' subject matter preferences also explained their choice of tracks. Students who preferred social science related subjects were more likely to choose humanities/social science track while the students who preferred science subjects were more likely to choose science track. This also applied to their long-term interests in choosing science related major at the university (Kwak, 2009; Shin et al., 2017; Shin et al., 2018; Yoon, 2009). Expectancy value judgment related to aptitude and desired college major were strongly positive for science track group. In general, students' choice of track at upper secondary school was based on subject matter preferences and their

planned college majors (Paik & Shim, 2013). Although students determined their college majors late in secondary school education, it appears that their decision-making was expedited once they chose upper secondary school tracks. The process facilitated the students to narrow down their future college majors.

Gender was frequently reported as a significant predictor on students' science track choice (Gamoran, 1992; Paik & Shim, 2013). Although the selection of curriculum track is mainly students' personal behavior, a study in Taiwan found that the choice was deeply influenced by the gender role expectations and the credentials (Li & Kuan, 2018). Female students were more likely to choose social science track while male students had more tendency towards science track (Chen, 2013; Croxford, 1994). Female students were stereotyped as disliking mathematics and science and, thus, were likely to think that they were not good at the subjects. However, Stokking (2000) also claimed that gender on its own was not a major predictor on the persistence in science any longer, if the other predictors were accounted for.

Second, from family influence, studies have revealed that early educational choices were more likely to be determined by family background and encouragement (Brunello & Checchi, 2007; Woessmann, 2009). Based on the perceived opportunity and further education, parents and relatives tended to encourage their children to join science (Dustmann, 2004; Kinyota, 2013; Shin et al., 2015; Shin et al., 2017). More significantly, based on their perceptions of subjective norms from their families, students applied for any track that were even against with their intentions. It was reported that parents' influence was stronger for science track than for social science track. If parents favor social science track, they may not force their children to comply with their wishes. However, if the parents favor the science track, they will be more determined that their children choose the science track (Myeong & Crawley, 1993). Besides, social background, which was often measured by parental education, had also been reported to significantly contribute to the change in individual interest in science (Dustmann, 2004; Mattoo, 2013; Stokking, 2000). Educated parents may feel that they have more resources (financially and academically) to support their children than parents with lower educational background. A recent study observed that mother's education level was more influential than father's education level (Arslan, 2016). Students were more likely to choose science track when their mothers had

higher level of education and it mattered even most if they had studied in STEM majors (Kwak, 1993). However, a study conducted by Myeong and Crawley (1993) found that the lower the mothers' level of education, the more likely the students chose the science track.

Third, from school experience and support perspective, the support from teachers in general and science and mathematics teachers in particular influenced the students' decision of science track choice. Science and mathematics teachers were critical in inspiring students to follow them into mathematics or science. Psychologically, the students saw them as a role model (George-Jackson, 2012; Kinyota, 2013; McPherson, 1969). However, the other study in South Korea reported that teachers were ranked the lowest among the major references on the Korean students' normative belief scales. Science and mathematics teachers exerted the least social pressures on students to pursue further study in science and mathematics (Myeong & Crawley, 1993). Moreover, school locality difference also contributed to different level of students' aspiration in science. Woolnough (1994) revealed that due to cultural differences between rural and urban, students from rural schools tended to have lesser degree of interest in science than the students from urban schools.

Research Methods

Research Samples and Sampling

A total sample of 751 grade 11th students (male=331, female=420) from nine upper secondary schools located in Phnom Penh (*N*=353) and two provinces (*N*=398) (Kampong Cham and Battambang [located 124 and 291 kilometers from Phnom Penh respectively]) of Cambodia participated in the survey. One significant justification for selecting this sample is that according to MoEYS (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 concept of what they meant by science track and social science track, will be more able to sensitize to the consequences of their track choice, and would provide more detail information on the measurement. Also, 11th graders from the two different academic tracks will be exposed to different

levels of science lessons and learning environment which is significant for group comparison. Empirically, Simpkins et al. (2015) claimed that upper secondary school is the first time when students could drop out of science coursework which could inadvertently close door to science majors; any intervention should begin at this point.

Students were selected by mean of multi-stage cluster random sampling. To ensure the true representation of the population, 25 provinces of Cambodia were ranked according to the statistic of grade 12th enrollment for the academic year 2017-2018 (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 city or 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 samples of the study.

Variables and Measures

This study sought an investigation on whether and how Cambodian upper secondary school students determined their science track choice through the lens of Woolnough (1994) conceptual perspective: individual ability and personality, family background and encouragement, and upper secondary school experience and support. The dependent variable was coded dichotomously (0=social science track, 1=science track). See Table 2 for the descriptions of the variables included in the regression analysis.

Table 2.
List of variables included in the regression analysis

Variables	Definitions/Measures
Dependent	
Tracking	0=social science track, 1=science track
Independent	
Gender	0=female, 1=male
Time spent self-study in mathematics	Average number of hours per week
Time spent self-study in physic	Average number of hours per week
Time spent self-study in chemistry	Average number of hours per week
Time spent self-study in Khmer	Average number of hours per week
Performance in science subjects	1=poor/fail, 2=average, 3=fair good, 4=good, 5=very good, 6=excellent
Performance in social science subjects	1=poor/fail, 2=average, 3=fair good, 4=good, 5=very good, 6=excellent
Science and math outcome expectation	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Science and math self-efficacy	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Science as a practical subject	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Science and math self-concept	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Important of science on society	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Interest in science at school	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Science activities outside school	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Future plan in science	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Plan to major in STEM	0=no, 1=yes

Table 3 *(continue)*

Variables	Definitions/Measures
Father's education	1=did not finish high school; 2=completed high school, 3=completed an associate degree, 4=completed a bachelor's degree, 5=completed a master's degree; 6=completed a doctoral degree
Mother's education	1=did not finish high school; 2=completed high school, 3=completed an associate degree, 4=completed a bachelor's degree, 5=completed a master's degree; 6=completed a doctoral degree
Father majored in STEM	0=no, 1=yes
Mother majored in STEM	0=no, 1=yes
Father in STEM occupation	0=no, 1=yes
Mother in STEM occupation	0=no, 1=yes
Relatives in STEM major	0=no, 1=yes
Family income	1=lower than 200$, 2=200$-300$, 3=400$-500$, 4=more than 600$
Family encouragement	1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree
Science and math teachers' support	1=never, 2=almost never, 3=some of the time, 4=most of the time, 5=almost always, 6=Always
Interactive science and math classes	1=almost never, 2=sometimes, 3=often, 4=very often
Dummy school location	0=province, 1=Phnom Penh

Specification of Data Analysis Method

Binary Logistic Regression, Enter Method, was employed to estimate the effects of independent variables on the likelihood of the Cambodian students' choice of science track at upper secondary schools. To address the issue, block recursive model that makes explicit assumptions about the causal order of

individual, family, and upper secondary school level variables was employed. Specifically, as illustrated in Table 3, the independent variables were entered into three "blocks":

Table 3.
Methods of estimation

Model	Block of independent variables in the regression model
1	I (Individual Factor)
2	I (Individual Factor) + II (Family Factor)
3	I (Individual Factor) + II (Family Factor) + III (Upper secondary school Factor)

By using block recursive model, the total effects of individual level variables on choice of science track (*model 1*) and the net effects of individual as mediated by family background (*model 2*) and the effects of upper secondary school (*model 3*) variables on science track choice can be determined.

Results

Descriptive Results

Table 4 illustrates the descriptive statistics (*Mean[M], Standard deviation[SD], and Minimum and Maximum*) of the three-dimension variables included in Binary Logistic Regression. Descriptive statistics showed some basic findings related to individual students and the characteristics of the other dimension variables. First, the dependent variable of the current study is choice of track—science versus social science. Among the total sample of 751, 61.8% were in science track and 38.3% were in social science. There seemed to be an unbalance on students in the two tracks because there were only science classes in two selected new generation schools in Phnom Penh and Kampong Cham province. Of the independent variables, since gender was measured dichotomously, mean score calculation was not applicable. However, based on descriptive statistics it was revealed that 56% of the sample were female while 44% were male. Next, time spent self-studying

mathematics and science subjects was the average hours per week each student spent self-studying at home. On average students spent a few hours (M=3.45, SD=2.96) on mathematics, (M=2.55, SD=2.32) on physics, (M=2.40, SD=2.11) on chemistry, and (M=2.86, SD=2.50) on Khmer literature. With regards to the academic performance, based on MoEYS grading guideline, most students had lower performance in science and mathematics subjects (M=2.33, SD=.81) than social science subjects (M=2.99, SD=.75). With this just above average performance, though the samples seemed to have higher level of science and mathematics outcome expectation (M=3.83, SD=.65), they tended to have moderate level of science and mathematics self-efficacy (M=2.97, SD=.69). Most of note, on the attitudes towards science sub-constructs, students had higher view on the practicality of science subjects (M=3.53, SD=.78), lower science and mathematics self-concept (M=2.76, SD=.72), higher attitudes towards the importance of science on society (M=3.79, SD=.64), higher attitudes towards science at school (M=3.32, SD=.78), higher attitudes towards science activities outside school (M=3.46, SD=0.69), and future plan in science (M=3.30, SD=1.03). Interestingly, 57% of the sample planned to major in STEM while 43% did not have any plan.

On the other continuum, on the family level factors, most of the students' fathers tended to have finished upper secondary school (M=1.95, SD=1.39) while their mother had even lower level of education (M=1.59, SD=1.07). Also, a lower percentage of them majored in STEM and even fewer working in STEM related occupation—lower than 10%. Another predictor of family factor, family monthly income, seemed to fall somewhere between 200 US dollars to 400 UD dollars (M=2.11, SD=1.07). Lastly, reflected to the supportive culture of Cambodia, students received high level of encouragement and support from their family (M=3.36, SD=.67).

Last from upper secondary school level factors, students also seemed to have received high support from their science and mathematics teachers on their choice of science track (M=4.14, SD=.88). However, the teaching of science and mathematics lessons were not very interactive (M=2.84, SD=0.51). Lastly, based on dummy coded variable, 52.9% of the samples were from upper secondary schools located in the provinces while only 47.1% were from those in Phnom Penh, the capital city of Cambodia.

Table 4.
Descriptive results of the variables included in the logistic regression model

Variables	Mean	SD	Minimum	Maximum
Dependent				
Tracking	-	-	0	1
Independent				
Individual factors				
Gender	-	-	0	1
Time spent self-study in mathematics	3.45	2.96	0	24
Time spent self-study in physic	2.55	2.32	0	21
Time spent self-study in chemistry	2.40	2.11	0	21
Time spent self-study in Khmer	2.86	2.50	0	21
Performance in science subjects	2.33	.81	1	5
Performance in social science subjects	2.99	.75	1	5
Science and math outcome expectation	3.83	.65	1	5
Science and math self-efficacy	2.97	.69	1	5
Science as a practical subject	3.53	.78	1	5
Science and math self-concept	2.76	.72	1	5
Important of science on society	3.79	.64	1	5
Interest in science at school	3.32	.78	1	5
Science activities outside school	3.46	.69	1	5
Future plan in science	3.30	1.03	1	5
Plan to major in STEM	-	-	0	1
Family factors				
Father's education	1.94	1.39	1	6
Mother's education	1.59	1.07	1	6
Father majored in STEM	-	-	0	1
Mother majored in STEM	-	-	0	1
Father in STEM occupation	-	-	0	1
Mother in STEM occupation	-	-	0	1
Relatives in STEM major	-	-	0	1
Family income	2.11	1.07	1	4
Family encouragement	3.36	.67	1	5

Table 4 *(continue)*

Variables	Mean	SD	Minimum	Maximum
Upper Secondary School factors				
Science and math teachers' support	4.14	.88	1.60	6
Interactive science and math classes	2.84	.51	1	4
Dummy school location	-	-	0	1

Factors Influencing Science Track Choice

Table 5 presents the result of estimation of Cambodian upper secondary school students' track choice. In this regard, to ease the statistical interpretation of logistic regression results, three mechanisms for data reading were employed. Firstly, to see if the model is a significant fit of the data, the *-2log-likelihood* statistic and its associated chi-square statistics should be examined. This could be obtained from the analogue of *Cox & Snell R square* or *Nagelkerke R square*. In statistical term, the proportion presents the amount of variance in students' choice of science track accounted for by a combination of variables under individual, family, and upper secondary school level factors. However, the interpretation in this current study is based on *Cox & Snell R square* as it is more accurate than its counterpart. Secondly, to see the relationship of each variable contributing to explain the variance in students' choice of science track, the value of *coefficient (B)* should be examined. The interpretation is based on the direction of their sign and their numerical value. For instance, in an equation where science track is the referenced category, a negative coefficient indicated that individuals who have higher value on the independent variables are more likely to choose social science than science track and vice versa. Thirdly, coefficient or odds ratio *Exp(B)*, when exponentiated and subtracted from 1, is interpreted as an indicator of the change in odds resulting from a unit of change in the predictor variables. Put simply, it explains the level of change in the likelihood of the students' choice of science track resulting from a unit of change of each significant predictor variable. For ease of interpretation, the formula *[exp(coefficient)–1] x 100* was used to convert the coefficient into percentage differences in odd.

Table 5
Significant predictors on upper secondary school students' choice of science track

Significant Predictors	Model 1		Model 2		Model 3	
	B(SE)	Exp(B)	B(SE)	Exp(B)	B(SE)	Exp(B)
Hour spent self-study in mathematics	.29(.23)**	1.34	.28(.11)**	1.32	.29(.108)**	1.33
Hour spent self-study in chemistry	.42(.16)**	1.52	.48(.16)**	1.62	.47(.163)**	1.61
Hour spent self-study in Khmer	-.41(.08)***	.66	-.38(.09)***	.68	-.36(.087)***	.70
Performance in science subjects	1.15(.22)***	3.16	1.04(.24)***	2.83	1.03(.238)***	2.81
Performance in social science subjects	-.55(.18)**	.57	-.66(.19)**	.52	-.60(.195)**	.55
Science as a practical subject	.88(.25)***	2.42	.75(.26)**	2.12	.73(.264)**	2.07
Interest in science at school	.67(.24)**	1.96	.71(.25)**	2.03	.72(.251)**	2.05
Future plan in science	.32(.16)*	1.38	.29(.17)	1.35	.29(.171)	1.33
Plan to major in STEM	.88(.25)***	2.40	.97(.27)***	2.63	1.04(.274)***	2.82
Mother's education			.40(.18)**	1.65	.43(.184)*	1.54
Family encouragement			.44(23)	1.56	.48(.231)*	1.61
School location (other provinces)					.66(.268)*	1.14
Cox & Snell R Square	.469		.483		.487	
Nagelkerke R Square	.638		.656		.662	

Note: *** when p<.001; ** when p<.01; * when p<.05

Prior to the explanation of each significant variable, it is crucial to look at the overall fit of the data to the model. Logistic regression analysis showed that the total factors that were related to upper secondary school students' choice of science track explained 47.8% of the variance in students' choice (Cox & Snell R Square=.478) (See Table 5). To be specific, individual factors accounted for 46.9% (Cox & Snell R Square=.469) of the variance. The inclusion of family background and encouragement and upper secondary school experience and support factors into the second and third regression models increased the value to 48.3% (Cox & Snell R Square =.483) and 48.7% (Cox & Snell R Square=.478) of the variance predicting choice of science track respectively. The *-2log-likelihood* ratio of the model was significant with chi-square statistics of less than .05 (*p*=.000). Most of note, the *Hosmer and Lemeshow test* chi-square value was larger than .05 (*p*>.05) meaning that there was no misspecification in the model. Statistically speaking, from elaboration of the result, it could be concluded that the model significantly fits

the data well. On the other continuum, from the theoretical perspective, it could also be concluded that the data supports the applicability of the conceptual framework on choice of science track.

In the first model, of the individual factors included, performance in science subjects (Exp(B)=3.16), science as a practical subject (Exp(B)=2.42), plan to major in STEM at higher education (Exp(B)=2.40), interest in science at school (Exp(B)=1.96), time spent self-studying in chemistry (Exp(B)=1.52), future plan in science (Exp(B)=1.38), and time spent self-studying in mathematics (Exp(B)=1.34) significantly predicted students' choice of science track. Next, the inclusion of the family factors in the second model had increased the effect size of most variables in the first model. However, it has lowered the odds ratio of performance in science subjects, science as a practical subject, and neutralized the effect of students' future plan in science. Of the variables included, only mother's education contributed to the significant value of their children science track choice (Exp(B)=1.07) with $p<0.01$. Last, the inclusion of the third model made little difference to the second model. However, while it lowered the odds ratio of mother's education, the model signified the influence of family encouragement on the choice of science track. The third model added the influence of school location on the dependent variable. Put in statistical term, a unit increase of the students in upper secondary school in Phnom Penh, resulting in an increase of about 19% of students choosing the science track (Exp(B)=1.93).

Discussion

From the elaboration and analysis of the data, the following findings emerged. At individual level, consistent with studies by (e.g., Darolia et al., 2018; Kwak, 2009; Yoon, 2009; Shin et al., 2017; Shin et al., 2018), was performance in science and mathematics subjects. A unit increase in performance in science and mathematics would lead to an increase by 31.6% in choosing science track. This implies that performance in science and mathematics in particular and the academic achievement in general contribute to the decline trend of students in science track. One, yet interesting realities to explain the phenomenon is that since 2013, education system in Cambodia particularly upper secondary education has gone through major reforms, one

of which is the reform in baccalaureate examination. Under the strict examination policy—*qualified students could pass*, only about 40% of students were capable to pass the national examination, as compared with the passing rate of approximately 80% in the past decade (MoEYS, 2014b). Evidently, about 77% of the students from social science track passed the examination compared to about 57% of the students from science track (MoEYS, 2016b). Furthermore, the achievement in mathematics and science is even of great concern. As evidence, during the 2015 national examination, out of 83,325 students, only 23.3% passed the math portion, while 41.7% passed the biology portion. As students in science track had to take more difficult science and mathematics in the examination, most students might lower their self-concept and efficacy in science and mathematics subjects and choose social science track, which is generally perceived as *easier* and having *higher* percentage to get a *pass* grade in the baccalaureate examination more than the science track. This finding also confirms what has been recently found in Korean context that not only the overall but also the science and mathematics performance was the most significant predictor of students' science track choice (Paik & Shim, 2013).

Furthermore, of the attitudes towards science constructs, science as a practical subject and future plan in science also exhibited as the second and third most influential factors in predicting Cambodian upper secondary school students' choice of science track. This finding supports the long-time discussed supposition that among the factors that had been lessening or swinging students away from science was due to the lessening of their attitudes towards science and future participation in science (Ormerod and Duckworth, 1975; Freedman, 1997; Kind et al., 2007; Osborne et al., 2003; Papanastasiou & Papanastasiou, 2004; Woolnough 1994; Woolnough et al., 1997). It was found that students with low self-rating in the attitudes towards science measures were likely to have lower performance in science and lower interest in science related majors. In this regard, the declined trend of Cambodian upper secondary school students' interest in science might be explained by the lower attitudes towards science. It was recently found that Cambodian upper secondary school students tended to have lower rating scale on all constructs of attitudes towards science (Kao, 2019).

Contradict to the other studies (e.g., Dustmann, 2004; Paik & Shim, 2013; Myeong & Crawley, 1993; Li & Kuan, 2018) this study found that gender did

not show any significant influence on students' choice of science track. However, this seems to confirm what was found in the studies by (Kim, 2006; Stokking, 2000) which revealed that gender on its own is not a significant predictor on the persistence in science any longer. Contextually, this confirms that female students' track choice is not tightly connected to their major or career choice in science as in the case of male students. Female students chose science track at upper secondary school might be due to the perception that science track provide them just an open pathway to various majors at higher education. For example, at higher education level, female students were not likely to choose science related majors compared to that of male students (Kao & Shimizu, 2019). The finding might serve as the counter argument on the culturally embedded view among general public that female students are usually not in favor of science related courses. However, reflected on the cultural influence, female students tended to have closer relation than male with their mother at home environment. In short, it could be concluded that students' personal ability and identity contributed significant roles in the students' process of making their choice of science or social science track.

Second, though subject choice could be individual preference, family background and encouragement and school experience, support, and environment are contributing indispensable influences on students' choice of science track. Of the most influential is the effect of family encouragement. An increase in family encouragement would increase the odds of students choosing science track at upper secondary school by 16%, (Exp(B)=1.61). Consistent with studies (e.g., Shimpkins et al., 2015; Shin et al., 2015), the current study reveals that family environment tended to be a significant untapped resource of support for students. For example, parents' provision of enriching experiences at home such as playing mathematics games, hobbies, science activities, and encouragement to take science and complete science homework for example, were central to students' interest in science, knowledge, and skill. Family encouragement culture is a motivating factor on students' persistent to take science since it is related to the quality of the family interaction that are intrinsically focused or emphasized on mastery goals.

Most of note, mother's education contributes to the significant value of their children science track choice (Exp(B)=1.07). The study positioned on what has been debated that when an important issue such as students' track

choice is of concern, parents' last minutes persuasion tended to override students' prior intentions. Consistent with the findings by some studies (e.g., Dustmann, 2004; Kinyota, 2013; Shin et al., 2017), the current study also revealed that family background particularly educated mothers, tended to have higher level of encouragement on their children to enroll in science track than the family with mother having lower education level. Arslan (2016), Kwak (1993), and Paik and Shim (2013) also found that mother's education level is more effective than the father's education level on the choice of science. The in-depth analysis of the data also revealed that, in addition to encouragement and support from the parents in overall, female students tended to have higher encouragement and support from parents (*M*=3.37, *SD*=.064) than male students (*M*=3.34, *SD*=.708). In Cambodian context, there might be a few anecdotes to explain this phenomenon. First, Cambodian children traditionally tended to have closer connection with their mother than their father. Also, as mothers have higher education level, they might have more financial and academic resources to support their children and would also value more about science and know more about the current labor market demand. Consequently, when their children discussed the educational choice, they would be more likely to persuade their children to choose science. This might especially be unique in Asian culture where family influence still matters much on students' academic choice making.

From school experience and supportive environment perspective, the study indicated that the students from upper secondary schools in Phnom Penh (urban) were more likely to choose science track than the students from the ones in the other provinces (rural). Put in statistical term, a unit increase of the students in Phnom Penh upper secondary school, resulting in an increase of about 19% of students choosing the science track (Exp(B)=1.93). This finding is consistent with Woolnough (1994) who claimed that, due to some disadvantages, students from the rural area are on lesser interest in science than those from the urban. More significantly, the data also revealed that students in upper secondary school in the province have lower performance in science subjects (*M*=2.23, *SD*=.03) compare to (*M*=2.43, *SD*=.04) of those students who are in Phnom Penh. On the contrary the performance in social subject is higher (*M*=3.00, *SD*=.04) for the students in the province than (*M*=2.97, *SD*=.04) for the students in Phnom Penh. This supports what has been discovered in the current study that students who score high in science

and mathematics tended to choose the science track at higher odds than their counterparts. The diverse characteristics of the upper secondary schools in the urban and the rural area in term of both the quality of teachers, the availability of teaching resources, and school culture might also contribute to this phenomenon (Woolnough, 1994). Some Cambodian upper secondary schools might still at disadvantage in accessing to enough qualified teachers and adequate teaching resources and this will be even burden for rural counterparts.

Conclusion and Implications

The current study could lead us to draw the following conclusions. First, students' performance in science subjects, attitudes towards science (the practicality of science subject [fact and fun] and self-interest in science at school), and future plan to major in STEM were influential in students' science track choice. In the same token, adding the battery of knowledge on students' science track choice, the students' engagement in their academic pursuits by spending more time doing self-study at home particularly on chemistry and mathematics signified the likelihood of science track choice. Second, reflecting the cultural influence from the family on the students' academic track choice, family encouragement, as might be unique cultural influence in Asian family especially one with higher educated mother, contributed to the variance explaining students' choice of science track. Third, students who were studying in upper secondary school in Phnom Penh tended to choose science track more than their counterparts. In conclusion, the results contributed to the knowledge that the worrisome declining trend of students in science track due not only to individual ability and personality but also to cultural influence from family and the condition of upper secondary school.

  Current study has also thrown practical implications to enhance students' science track choice. First, at school environment, since science and mathematics teachers can learn practical lessons about how to attract individual students to science track. They need to realize that, in addition to enhancing the students' academic performance through their teaching practices, one of their ultimate missions is to inspire and enhance students' science self-concept. Science and mathematics teachers must not only convey scientific knowledge to the students but also put in time and effort to model

and inspire them to pursue science through addressing the specific personal beliefs that are associated with choosing science track and the culture of discussing about the importance of science. Also, because the practicality of science subjects matters in science track choice, the most significant change is framing the presentation of the material to make science and mathematics lessons, especially from early grades, more practical. Furthermore, teachers should make science and mathematics learning active. As there is limited resource, active in this concept may not merely focus on doing more experiment; however, it could simply focus on engaging students in a mixed learning activity where they could investigate the world around them.

On the other continuum, students themselves need to have clearer plan and stronger self-concept in taking science. Rather than having low self-concept in doing science and mathematics, students should have a well-informed plan for their academic endeavor and believing in themselves. This highlights the crucial significance of family cultural influence. First, parents could engage in many school related tasks to enhance their children science performance and to motivate them to take science. The process does not require parents to be the experts in science to complete the homework or to get their children's high score at school, simply they could ensure that their children have enough time and physical space to complete their science homework, do self-study in science and mathematics, or talk to them about how their science class is going. Some of the other significant activities would be creating home environment for watching science shows, bringing and explaining them at the natural museum or natural phenomena, and talking about the current events of the important of doing well in science. These would be one of the effective ways to motivate and interest students to take science at school. Also, any policy initiative to increase the share of enrollment in science track should take geographic different into consideration. Priority should be given more to the schools located in the rural part of the country. This could be done by enhancing not only the quantity but also the quality of science teaching and the other enabling conditions and supports. The findings from this study are interesting because they highlight the importance of family and upper secondary school cultural activities that may contribute to the shaping of the students' choice of science track.

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