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HOW STRONG IS THE LINK BETWEEN HIGH SCHOOL STREAMING AND UNIVERSITY MAJOR CHOICES?

Introduction

With the advent of the fourth industrial revolution, the global economy has become more reliant than ever on technology. This increases the demand for competent graduates in science, technology, engineering and mathematics (STEM). Countries that outperform in education and/or research science systems also have leading and dynamic economies (Marginson et al. 2013). This proves the importance of STEM education in improving innovation and the global competitiveness of a country. In efforts to increase the number of STEM graduates to meet current and future market demand, countries around the world have implemented streaming or tracking systems at the secondary school level. From the perspective of developing countries, the lack of STEM human resources will stagnate economic growth, making it more challenging for them to avoid the income trap. At the individual level, STEM education provides essential knowledge and skill for students to cope with rapid changes in labour market demand.

The Cambodia Industrial Development Policy 2015-2025 points out that one of the weaknesses in Cambodian industry is low technology adoption and application (RGC 2015). In light of these issues, the Ministry of Education, Youth and Sport (MoEYS) has also acknowledged the important role of STEM education and has actively promoted it in the past decade or so. For instance, the STEM Education Policy emphasises and promotes the importance of STEM fields to change and further boost Cambodia's economy (MoEYS 2016). To this end, in 2010 MoEYS introduced tracking systems at secondary school level aiming to build a strong foundation in mathematics and science among high school students who were interested in science. The belief was that this would better prepare them for their learning in STEM majors in higher education.

Tracking or streaming refers to the practice of allocating students to designated courses, programs or schools, based on their ability, interest and/or achievement (Chiu et al. 2017). Under this system, Cambodian students are required to choose either the science track or social science track at grade 11 (MoEYS 2010). While enrolment in the science track is high in high school, the enrolment rate in STEM majors in higher education is still relatively low. A low level of enrolment in STEM majors in higher education will hinder the government's effort to develop STEM talent to support Cambodia's future development. Moreover, this phenomenon could be an indication that the tracking system at high school level is not well linked to programs in higher education. Considering these issues, the purpose of this study is to explore students' learning pathways and the connection between high school tracking and major choices among Cambodian undergraduate students focusing on science-track students. It also examines the probable causes behind the decision-making of science-track students to switch to other tracks in higher education.

Overview of tracking systems

Tracking takes place at different ages or grades in different countries. Some countries begin tracking their students as early as primary school. For example, in Singapore students are put into different tracks when they are in grades 5 and 6. In Organisation for Economic Co-operation and

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Development (OECD) countries, tracking usually starts when students are 15 or 16 years old or when they are in grades 9 or 10. In Cambodia and South Korea, tracking occurs at grade 11 while in Vietnam this happens at grade 10. The reasons why students choose a specific track in secondary school have been studied extensively. High performance in science and mathematics, as well as overall academic performance, have been found to significantly contribute to students' decisions to choose a science track (Ayalon and Yogev 1997; Dustmann 2004; Paik and Shim 2013).

Tracking has many benefits for teachers, schools and students. Tracking students based on their interest or ability creates homogenous classrooms and schools in that the curriculum is designed in correspondence to the needs of the students (Chmielewski 2014) and teaching instructions are created to suit students' ability levels (Rosenbaum 1980; Hallinan 1994). Moreover, tracking helps to filter the resources necessary for each stream. Tracking is also beneficial to both low and high achievers. When studying in a mixed ability classroom, high achievers might realise a better academic performance or receive pointer specialisation education, while low achievers also gain from studying with high achievers (Meier and Schütz 2007). Studies have found that tracking students at a later age minimises the family preference factor in respect of their educational achievement (Woessmann 2009) and lowers the risk of putting them into the wrong stream (Meier and Schütz 2007), and it is not related to a lower performance level.

While tracking provides significant benefits, it also presents concerns. Tracking perpetuates educational inequality (Gamoran and Mare 1989; Lucas 1999; Oakes 1985) due to rigidness in the institutional structure of academic and vocational tracks, hence discouraging mobilisation between tracks (Chmielewski 2014). Besides, in a stratified education system, disadvantaged students tend to be put into the least academically-oriented or demanding learning environments (Van de Werfhorst and Mijs 2010).

The tracking system in Cambodia

MoEYS first incorporated the tracking system within Cambodian education in 2010 to sharpen STEM education in upper-secondary education and to promote STEM majors at post-secondary level. The tracking system in Cambodian education takes the forms of school type and stream. Tracking by school type happens at the end of grade 9 or lower-secondary school, when students can choose either to enrol in technical and vocational school or in academic upper-secondary school (JICA 2016; UNESCO 2014). Tracking by stream takes place at the end of grade 10 when students have to choose between science and social streams and starts from grade 11. Regardless of prior academic performance, Cambodian students are allowed to choose their track of interest. Students on both tracks share four common subjects, namely Khmer literature, a foreign language (English or French), mathematics, and physical education. In addition, the science-track students are required to study pure science subjects, including chemistry, physics, biology, earth and environmental subjects, while social-track students need to study the social science subjects of morality and civics, history, economics and geography. Moreover, in the science track, mathematics classes take up five hours per week and have a full score of 125, while the rest of the subjects cover only three hours each and have full score of 75 each. In contrast to the science track, in the social science track mathematics class is cut down to just three hours with a full score of 75, while the rest of the science subjects are allocated only two hours per week with full score of 50 each. Thus, the tracking system allows students to develop and refine their knowledge and interests. In the past, the majority of high school students opted for the science track, but recent data suggests the reverse trend with more and more grade 12 students choosing the social track. Statistics show that approximately 80 percent of students have chosen the science stream throughout the past academic years since the implementation of the tracking system (MoEYS 2017). However, in the academic year 2018-2019, only around 49 percent of the students enrolled on the science track (MoEYS 2019).

Despite the increase in enrolment in higher education, less than 20 percent of students chose engineering and science majors in higher education due to low awareness of, attitudes towards, and achievement in science among Cambodian senior high school students (CDRI 2018). A study conducted by Kao and Shimizu (2019) revealed that factors that affect the science track choice of Cambodian upper-secondary students include performance in science and mathematics subjects, attitudes towards

science, a plan to major in STEM, time spent studying science and mathematics subjects, family encouragement, mother's education, and school location. Studies also revealed that an influential predictor of students' choice of STEM majors in higher education was evident among students who were on the science track in upper-secondary school who took science and mathematics courses and achieved high performance in these courses (Erdogan and Stuessy 2015; Sahin et al. 2017).

Methodologies

This study employs descriptive statistics to examine student persistence in STEM, using an undergraduate student survey conducted by CDRI in 2020 with 1,338 students at 21 higher education institutions (HEIs) in Cambodia. The student survey gathered a wide range of data including students' characteristics, educational backgrounds, and information related to their higher education majors. A two-stage sampling method was employed in the selection process. The first stage was to randomly select the HEIs using systematic sampling with probability proportional to the total student enrolment. Lists HEIs and enrolment statistics were obtained from MoEYS and the Ministry of Labour and Vocational Training (MLVT) on which the first-stage sampling frame was based and constructed. Later, student lists at the selected HEIs were obtained for the second-stage stratified random sampling. A total of 36 students were dropped as they had completed their high school before the introduction of the tracking system, leaving 1,302 for our analysis.

As mentioned earlier, tracking in Cambodia starts from grade 11. There are possibilities for students to change track in grade 12 from science to social science or vice-versa. In the study, the high school track is defined as the track students took when they were in grade 12. Majors in higher education were coded based on the classification by MoEYS reported in the Education Congress Report. However, since the details of major MoEYS classifications are not available to the public, the authors also used the Classification of Instructional Programs (CIP) 2020 as a reference. Based on the MoEYS classification, STEM majors include agriculture, basic science, engineering, health, and information technology (IT), while non-STEM majors are business-related, foreign languages, law, social science and arts, and tourism.

Result

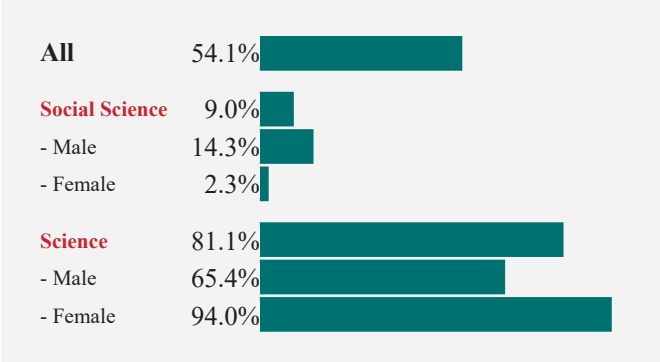
From our survey data, when they were in the final year of their high school, 62.52 percent of the university students sampled opted for the science track, and the remaining 37.48 percent chose the social science track. In contrast, when it came to major choices in higher education, only 15.1 percent enrolled in STEM majors. The contrasting statistics suggest that a large proportion of science-track students decided to switch to the social science track (STEM majors) in higher education.

Figure 1 indicates the ratio of students who switch their tracks by high school track and gender. Overall, less than half of the students remained on the same track. However, when students are grouped into social and science tracks, it is clear that those who changed track mostly switch from the science track to non-STEM majors. More than 80 percent of science-track students switch to enrol in non-STEM majors in higher education, while the switching rate of social-track students is less than 10 percent. The difference is even more extreme among female students. Less than 3.0 percent of females on the social track switched to STEM majors, while 94.0 percent of science-track females changed to non-STEM majors.

Figure 2 breaks the STEM and non-STEM majors down into disciplines according to high school track and gender. The results show that the most popular non-STEM disciplines include business-related majors, which accounted for more than 40 percent, while in STEM it is computer science or IT. Business-related majors attract students from both the science- and social science tracks roughly equally. The percentage of female science-track students who decided to enrol in business-related majors is even slightly higher than that relating to females from the social science track - at 59.1 percent and 56.7 percent, respectively. Enrolment in STEM is concentrated in IT and engineering majors, while enrolment in basic science and health are still low. We also observe that some social-track students also switch to STEM majors in higher education, but the majority are males. Most of the students who switch from the social track enrolled in IT majors.

As the major switch among science-track students is very high, it is intriguing to know if there is any connection between student academic performance in high school and major choices in higher education. Using the sub-sample of students

Figure 1: Track switching by high school track and gender



choosing the science track at grade 12, this study examines the switching rate according to overall performance and performance in mathematics at the Grade 12 National examination. The results in Figure 3 panel A show little differences in the switching ratio according to the level of overall performance. In the upper category (41 students who scored grade A or B), 82.2 percent of science-track students changed to non-STEM majors in higher education. This switching ratio is roughly the same at the lower category (468 students who scored grade E or lower) at 81.6 percent. The analysis by gender shows that, for male science-track students, those who achieved grade C had the lowest switching rate at 57.4 percent. Higher performing female science-track students also had lower switching rates but the difference is minimal. The results from performance in mathematics are illustrated in Panel B. This suggests that grade D science-track students have the highest switch rate, while the upper and lower performers in mathematics have relatively lower switch rates. Analysis by gender shows a similar pattern, although male students are more likely to take STEM pathways in higher education.

Figure 4 lists the reasons why science-track students decided to enrol in their major subject at university, by switchers and non-switchers. This shows that students are likely to choose their majors for several reasons. The survey asked students to choose the reason that they thought had the most influence on their decision. The results showed that the same factors influenced students to switch or to remain on the same tracks. These included personal interest, the labour market, and family expectations. However, these influencing factors differed in terms of how much they affected the two groups. Personal interest tended to be more powerful among the non-switchers, with a magnitude of 13.4 percentage points higher at 68.2 percent. Interestingly, switchers were three times higher than non-switchers in making their decision based on the pressure of family expectations. Similar to the academic performance analysis earlier, performance at high school is not a key factor behind the reason why science-track students switch their majors in higher education. Only 0.2 percent of the switchers reported that they had changed to non-STEM majors on account of academic performance. Although more non-switchers think that academic performance in high school played a key role in their decision making, the percentage (1.9 percent) is still low in comparison

Figure 2: High school tracks and major choices in higher education by gender

Major in Higher Education	Science Track			Social Science Track		
	Female	Male	All	Female	Male	All
Non-STEM	94.0%	65.4%	81.1%	97.7%	85.7%	91.0%
- Business	59.1%	31.6%	46.7%	56.7%	36.6%	45.5%
- Foreign Languages	8.5%	6.0%	7.4%	7.0%	5.9%	6.4%
- Law	7.8%	11.7%	9.6%	8.8%	16.5%	13.1%
- Social Science and Art	14.8%	14.4%	14.6%	21.9%	23.4%	22.7%
- Tourism	3.8%	1.6%	2.8%	3.3%	3.3%	3.3%
STEM	6.0%	34.6%	18.9%	2.3%	14.3%	9.0%
- Agriculture	1.8%	3.3%	2.5%	0.0%	0.4%	0.2%
- Basic Science	0.0%	1.1%	0.5%	0.5%	0.0%	0.2%
- Engineering	0.7%	7.4%	3.7%	0.0%	3.7%	2.0%
- Health	0.4%	0.5%	0.5%	0.0%	0.0%	0.0%
- Information Teachnology	3.1%	22.3%	11.8%	1.9%	10.3%	6.6%

Figure 3: Science-track (high school) student switchers by grade 12 examination performance

A. Overall Performance at the Grade 12 National Examination

	All		Female		Male	
	Switcher	Obs.	Switcher	Obs.	Switcher	Obs.
Grade B and higher	82.2%	41	89.3%	26	70.6%	15
Grade C	78.8%	113	93.9%	66	57.4%	47
Grade D	80.9%	173	94.6%	93	65.0%	80
Grade E and below	81.6%	468	94.2%	256	66.8%	212

B. Performance in Mathematics at the Grade 12 National Examination

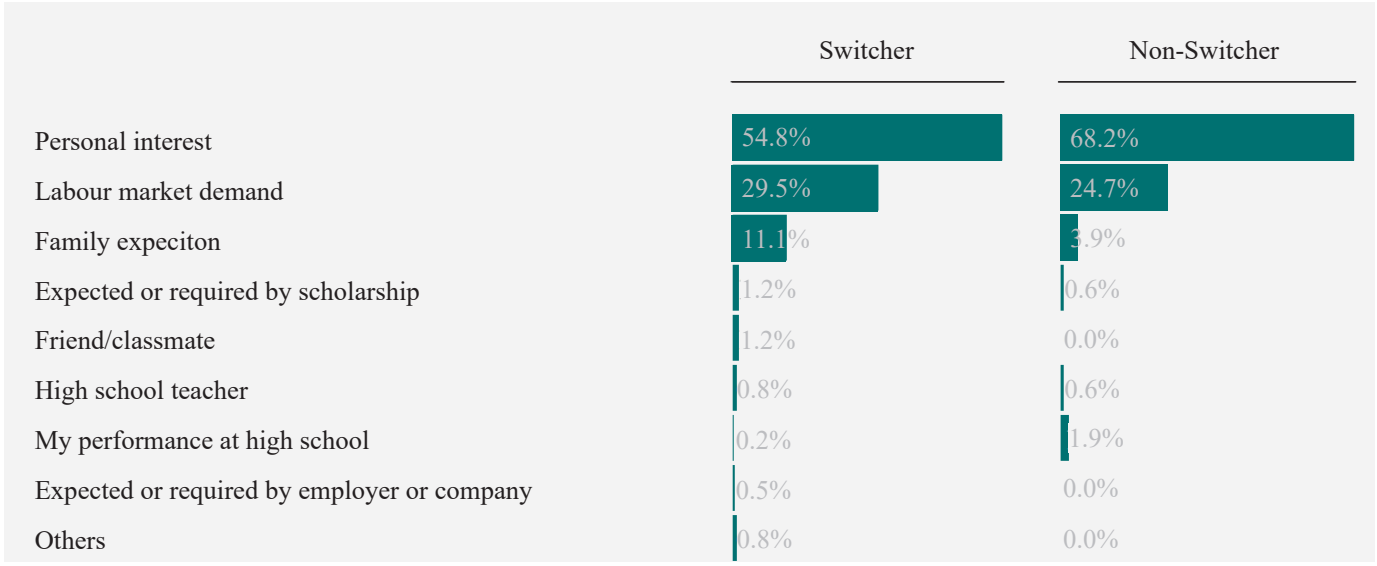
	All		Female		Male	
	Switcher	Obs.	Switcher	Obs.	Switcher	Obs.
Grade B and higher	76.6%	94	89.1%	46	64.6%	48
Grade C	78.0%	100	92.5%	53	61.7%	47
Grade D	86.1%	101	96.6%	58	72.1%	43
Grade E	86.1%	266	97.8%	138	64.1%	128
Grade F	79.5%	219	90.9%	132	62.1%	87

with personal interests (68.2 percent) and labour market demands (24.7 percent).

Discussion and conclusion

The study shows that about half of the students switched their learning pathways either from the science track in high school to a non-STEM major in higher education, or from social science to STEM majors. However, the vast majority of the switchers were female science-track students. Only about 6.0 percent of science-track female students chose STEM majors for their higher education. One of the reasons behind this phenomenon can be attributed to the fact that students on both tracks are required to sit different national Grade 12 examinations. It is believed that it is easier to pass the social science-track examination, leading to the notion that social science-track students are rather poor performers. For this reason, well-performing female students were likely to choose the science track even though they had no intention to enrol in STEM majors in higher education. In fact, recent studies suggest the concept that males academically outperform females is no longer valid (Chea and Ogawa 2021; Pov,

Figure 4: Main reasons for choosing their major in higher education



Kawai and Matsumiya 2021). The notion that STEM majors are for men, not for women, needs to change.

The high rate of the switching of academic majors indicates that the current high school tracking system in Cambodia does not effectively groom high school students for STEM majors in education. The high proportion of science-track students in high school, and the low enrolment rate in STEM majors in higher education, implies two possible explanations: either there is a short supply of STEM majors at HEIs, or there is a lack of interest in STEM among students. However, as some universities still have difficulties in attracting students into their STEM programs, the latter seems to be more plausible for Cambodia. Studies in STEM subjects need to be more alluring, especially for females. STEM scholarship programs for females might also be a solution to attract more females into the STEM majors in higher education.

Studies have reported that performance in mathematics at high school has led to persistence in STEM-related studies (Moakler and Kim, 2014; Semela, 2010). However, this study suggests that, in the case of Cambodia, there is little link between performance in mathematics and a major switch from science to non-STEM majors. When it comes to major decisions in higher education, personal interests and labour market demands are the key factors, while academic performance at high school has almost no influence in the decision-making process. Although entering STEM majors in higher education normally requires a strong academic background in mathematics and other science subjects - as shown in this paper and prior studies (Roth et al 2021; Chea, Hun and Son, 2021) - students' decisions in respect of the university majors they choose tend to be influenced by personal interests rather than academic performance. As a policy implication, the government needs to put further efforts into nurturing students' interest in science when they are in high school. Female students deserve special attention as they perform well academically but are very likely to switch from the science track to non-STEM majors.

This study is based on simple descriptive statistics to provide a general picture of the major switch that has not yet been explored in the Cambodian context. With this background, future studies should conduct deeper investigations into this issue using more rigorous methods to identify the factors that influence decisions of Cambodian students to remain on, or to switch, their learning pathways.

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