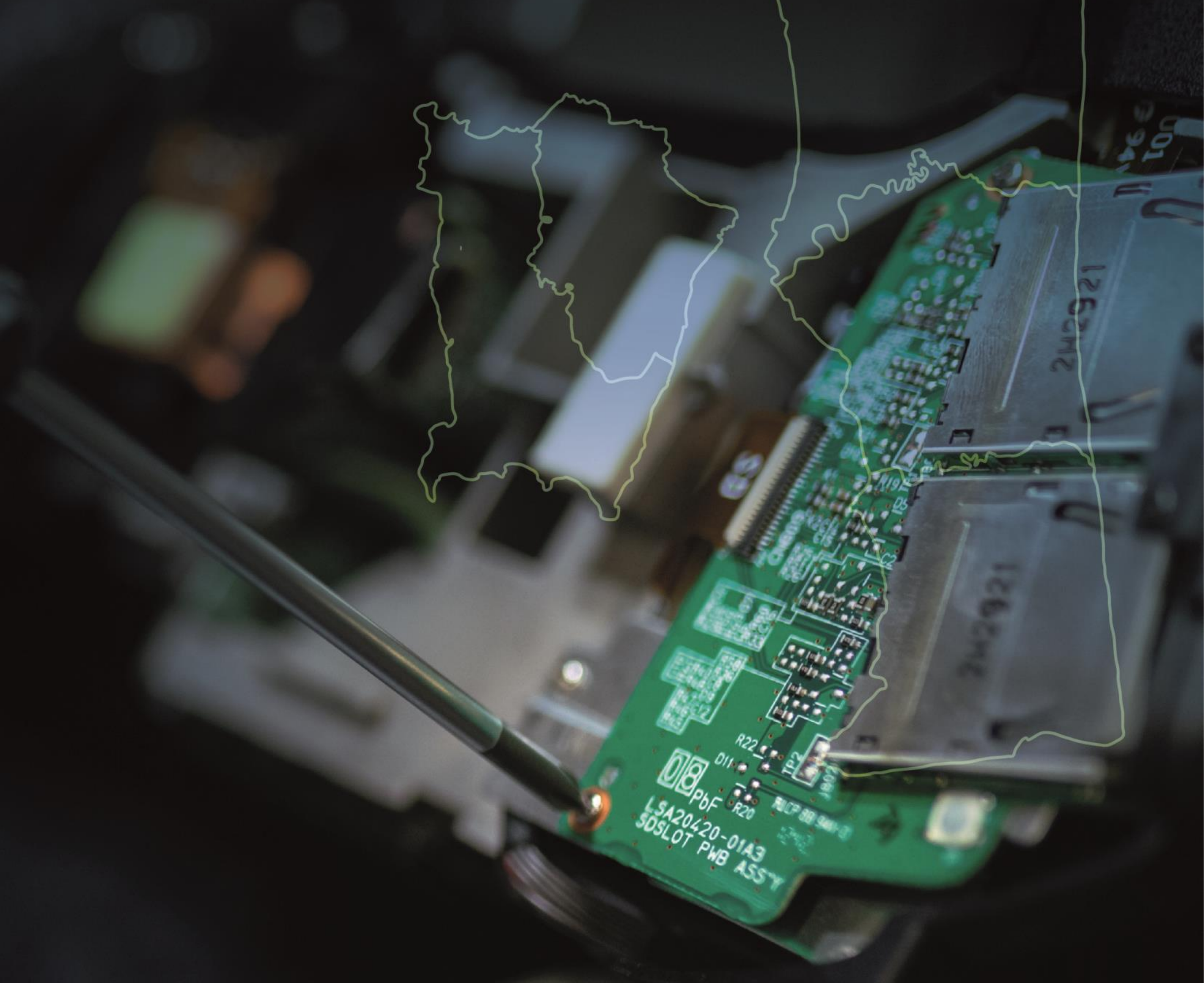
Students' Choice of STEM Study in Secondary and Tertiary Education in Penang



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The institutes of higher learning who participated in the survey were (in alphabetical order):

Disted College Penang
INTI International College Penang
Penang Skills Development Centre (PSDC)
Tunku Abdul Rahman University College
UOW Malaysia KDU
Wawasan Open University

The secondary schools which participated were (in alphabetical order):

SMJK (P) China Perempuan Pulau Pinang
SMJK Chung Ling
SMJK Chung Ling Butterworth
SMJK Heng Ee
SMJK Jit Sin
SMJK Phor Tay
SMK (L) Methodist
SMK (P) St. George
SMK Al-Irshad
SMK Bukit Jambul
SMK Convent Green Lane
SMK Datuk Onn Butterworth
SMK Kepala Batas
SMK Permatang Tok Jaya
SMK Seberang Jaya
SMK Seri Nibong
SMK Simpang Empat
SMK St. Xavier
SMK Tunku Abdul Rahman
SMKA Al Mahsoor (L)
SMS Tun Syed Sheh Shahabudin

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Background

The rise in manufacturing investments over the last three years indicates a growing need for a STEM workforce in Penang. Given the economy is driven by the state's technology-intensive manufacturing arm, the shortage in skilled manpower remains a challenge. Industries such as high-tech manufacturing, precision engineering and automation, medical devices, and life sciences have long experienced difficulty filling vacancies and retaining high-skilled workers owing to a shortage in the STEM labour market.

Despite the urgent need for STEM workers, the share of STEM graduates continues to fall. Within a span of 10 years, their percentage of Penang's public universities had fallen by 9.5%. The percentage of STEM graduates stood at 41.2% in 2017, well short of the government's goal of 60%. The shrinking pool of skilled STEM workers is beginning to show negative effects on industry efforts to innovate and, if not adequately addressed, may cause whole industries to stagnate in the near future. Ultimately, the shortage of STEM graduates affects the state's competitiveness in the global marketplace, as well as Malaysia at large.

This study was undertaken with the objectives of understanding how students perceive science or STEM subjects at the upper secondary school level and the college level, and what factors motivate into pursuing a STEM education, and ultimately, a STEM career—or what factors discourage them away from this career path. Based on student preferences, the study also attempts to forecast the potential characteristics of the STEM workforce in the future. Finally, based on the study's findings, recommendations for improving STEM uptake at both secondary and tertiary level are provided.

Data and methodology

The study covered 22 education institutions in Penang: 17 secondary national schools and five tertiary private institutions. A total of 956 upper-secondary students and 432 tertiary students were involved in the survey. The survey covered all types of schools, namely high-performance schools (HPS), Cluster Schools of Excellence (CSE), and Non-HPS/CSE. The perspectives of educators were collected by means of focus group discussion with secondary school science teachers and a survey with department heads from institutes of higher learning. The findings presented in this report include detailed descriptive statistics and the results of logistic regression models, which were used to understand how different factors affected the likelihood of students choosing STEM education.

Reasons for lack of interest in science

This study found that a majority of upper-secondary students from the science stream were interested in science, and performed better in all science subjects except Additional Mathematics. Their interest in science rises if their parents' highest education level is tertiary, and if their parents are working in science-related jobs. Although only 21 science students were not interested in science, they understood that studying in the science stream can provide them with more opportunities and better job prospects. Moreover, a portion of these students were forced to study in the science stream because of the influence of parents, friends, or teachers, as well as their ability to do well in exams.

Interestingly, non-science students also claimed to have interest in science, but decided against enrolling in the science stream because arts-stream subjects are relatively easier to understand compared with science subjects. In addition, they also see science as a hobby but the arts stream gives them better career options. While parents and teachers also play a part in advising students in choosing the arts stream, students with high self-efficacy in their career orientation were aware of their educational pathways that lead them to the aspired careers. For example, as highlighted by students, particularly from non-HPS/CSE institutions, fields such as computer science and information technology do not necessarily require them to study science subjects such as Biology, Physics, and Chemistry, as these subjects would not assist them in achieving their career goals.

Factors affecting students' motivation in science uptake

Students' choices of study are determined by four internal and external factors. The internal factors include parental and peer influences while the external factors comprise teachers' pedagogical strategies and the school environment. All these factors could shape students' self-efficacy level towards science learning.

Parents' perceptions towards science can play a role in students' educational decisions. Upper-secondary students were more likely to be associated with their parents' current jobs and the highest level of education attained. If their parents have a tertiary education and their current jobs are related to science, particularly their fathers, the students were more likely to choose the science stream. In contrast, mothers appeared to play a greater role at the tertiary level, and their children were more likely to choose a non-STEM education if the mother did not have higher education. In short, more students were likely to follow in the footsteps of their mothers at the tertiary level regardless of their previous stream of study at the upper-secondary level.

Peer influences are particularly more significant at the upper-secondary level compared with the tertiary level; tertiary students may be more mature in making educational decisions than their upper-secondary cohorts. The peer effect is positively related to the likelihood of students choosing the science stream. High-performing students have the potential to motivate their peers who themselves are not as motivated to pursue the science stream. Male students were more likely to be influenced by their friends compared with female students.

An effective module in the teachers' pedagogical strategies can motivate students to learn science subjects. To instill students' interest in learning science, teachers use real-life examples to help students understand difficult concepts and theories. This is proven to be an effective measure as students have commended teachers for using this approach to ease their understanding of difficult subject matters. Given the difficulty of science subjects, cultivating inspiring and enthusiastic science teachers are urgently needed; these teachers should be trained to identify barriers to science learning. Challenges faced by science teachers include inadequate teaching time, teacher-centered teaching methods, overly long syllabus, high student-teacher ratio, outdated textbooks, exam-based learning, lack of qualified science and mathematics teachers, and lack of professional training and development (see Chapter 5).

The school environment is another factor motivating students to learn science. It comprises STEM-engagement activities and classroom facilities, which are made available in schools. STEM-engagement programmes, including internal and external programmes, were lowly rated by upper-secondary students. In particular, HPS and non-HPS/CSE are urged to organise more external programmes to increase students' participation in STEM activities. While some schools did organise visits to events organised by the Penang Science Cluster and the Penang Tech Dome, more than half of the students surveyed said they have never taken part in these events, or were even not aware of their existence. More promotional strategies are needed to increase the visibility of science events and centres among the students and the public.

For classroom facilities, while students rated the availability of highly supportive and complete laboratories and science tools quite highly, science and mathematics teachers said that science laboratories need to be upgraded and continuously maintained to provide a conducive learning environment. More interactive and hands-on science activities should be integrated into science classes to stimulate fun and lively lessons, which can also be maintained through technology-assisted learning.

Students' self-efficacy towards science can be nurtured in early childhood education. Our survey found that parents were the most influential actors in their children's science-learning experience, followed by the internet and teachers. Students with higher self-efficacy are more determined to achieve their science education and career goals. Meanwhile, students with lower self-efficacy still attend science classes owing to parental and peer influences. This group of students have a higher chance of dropping out of the sciences at the tertiary level or in their future careers. Therefore, parents and teachers are encouraged to assist students to build up their interest and self-esteem in pursuing a STEM education by using online resources such as YouTube, search engines (e.g. Google, Yahoo!, etc.), Wikipedia, and science websites.

Potential characteristics of a future STEM workforce

Science students generally favour life sciences over physical sciences. While most science students have plans to remain in STEM fields at the tertiary level, a quarter of them would be interested in life-science-related courses such as Biotechnology, Biomedical, and Medicine. High demand for life-sciences-related jobs is to be expected due to students' preferences in Biology over Chemistry and Physics subjects, specifically in health issues.

Meanwhile, the gender gap is manifested in education and career choices. Female science students selected Biology, Medicine, and Pharmacy as their top-three courses. Although there were still a fairly large proportion of male students interested in life sciences, most selected physical sciences at the tertiary level, such as engineering. Human capital flight can be prevalent if job opportunities in life sciences are not made available in the state. In other words, more student-engagement programmes and workshops are necessary to avoid graduate unemployment, skills mismatches, and underemployment in the future.

STEM courses should not be restricted to school leavers from the science stream. Given the limited pool of science students, opportunities in STEM education and careers can be opened to non-science stream students at the upper-secondary level. Some non-science students were aware of the university requirements for computer science and information technology courses, which do not require science subjects. In contrast, none of the science students chose computing and digital technology courses at the tertiary level. As the number of computing professionals need to be increased in almost all industries over the next decade, more concerted efforts are needed to realise the potential of non-science students in STEM.

Starting salary is a pull factor for tertiary STEM students who decide against continuing with a science career, followed by long-term salary prospects and career growth. Although parents still play a part in students' career decisions at the tertiary level, their roles are less prevalent among STEM students who plan to work in non-STEM careers. This shows that those who wished to switch to non-STEM careers have higher self-efficacy and greater goal commitment. This is more significant among high-performing science students. A lack of information related to STEM careers could be the cause of students finding non-STEM careers more attractive.

Measures to increase STEM uptake

The study proposes measures to increase students' participation in science and STEM workforce based on information and feedback gathered from interviews with students, teachers, and stakeholders. Strategies to decrease STEM dropouts amongst high performers are also recommended. A causal loop diagram has been designed to present factors affecting students' interest level in science, their current and future choices of study, and their career plans. This diagram highlights the main issues and challenges, as well as the interrelationships between different components of this study, and proposes measures to address these issues (Figure 0.1).

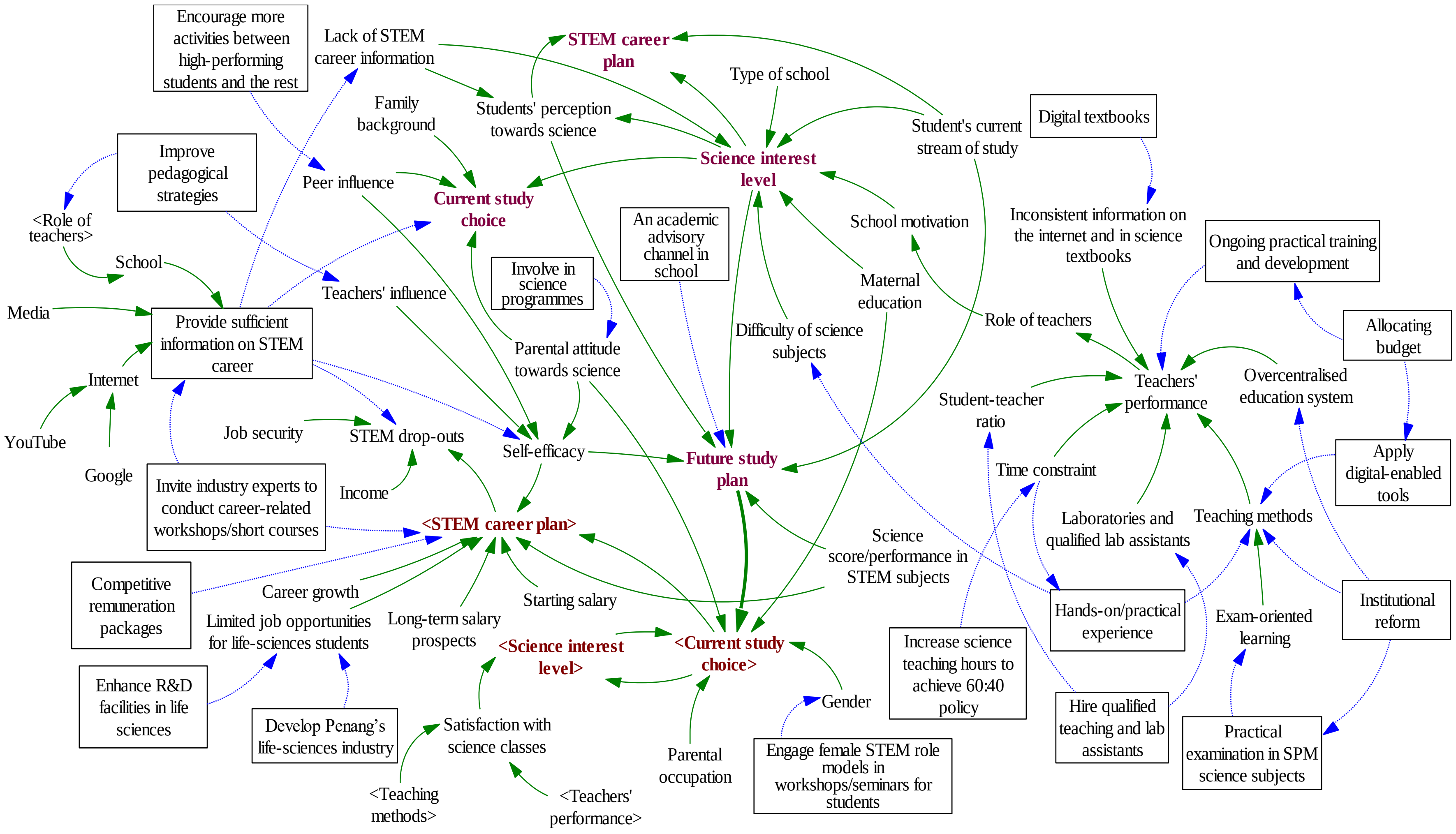
The major barrier to students' participation in science appear to be a lack of interest in science, the absence of qualified teachers, and the absence of a school environment that would allow students to become engaged in science subjects. There are also issues related to the current educational system. These barriers can be addressed by changing students' perception of the sciences by improving teaching methods, teachers' performance, pedagogical strategies, and the school environment. Establishing an academic advisory channel and conducting workshops and short courses with industry experts can also increase the interest level of students and provide them with career information. Moreover, parents' perceptions need to be changed; involving parents in science programmes is recommended. Overall, institutional reforms are required for the systematic improvement of the education system. The education system is recommended to be decentralized, and decision-making authority, responsibility, and tasks need to be transferred from higher to lower organisational levels.

The study found that a lack of quality education, job opportunities—especially for life-sciences students—and attractive remuneration packages for STEM jobs may cause students to leave the state or country, leading to a brain drain. The quality of education and facilities at universities need to be improved, and R&D facilities need to be enhanced, especially in life sciences. Information on STEM market demand need to be disseminated by holding mandatory courses for students at the secondary level and/or inviting recruitment consultants to explain the current job market. Firms are also recommended to offer competitive remuneration packages to attract talents and retain STEM graduates.

Results revealed that the gender gap is relatively high in STEM education and the workforce. It is found that female students prefer life sciences over physical sciences, and it is recommended that female students be exposed to more female role models in STEM. Moreover, offering female-only apprenticeships by firms in addition to their usual programs for STEM students might also attract more women to participate in STEM education and the workforce.

Job security and income were found to be the main reasons for dropping out of the sciences, especially among high-performing students. The low-efficacy and reduced confidence over success in STEM careers can lead to drop-outs in science courses. The study proposes that more information about STEM careers should be given to students.

Figure 0.1 Causal loop diagram for factors affecting student's choice of study and future careers



1 Introduction

1.1 The study

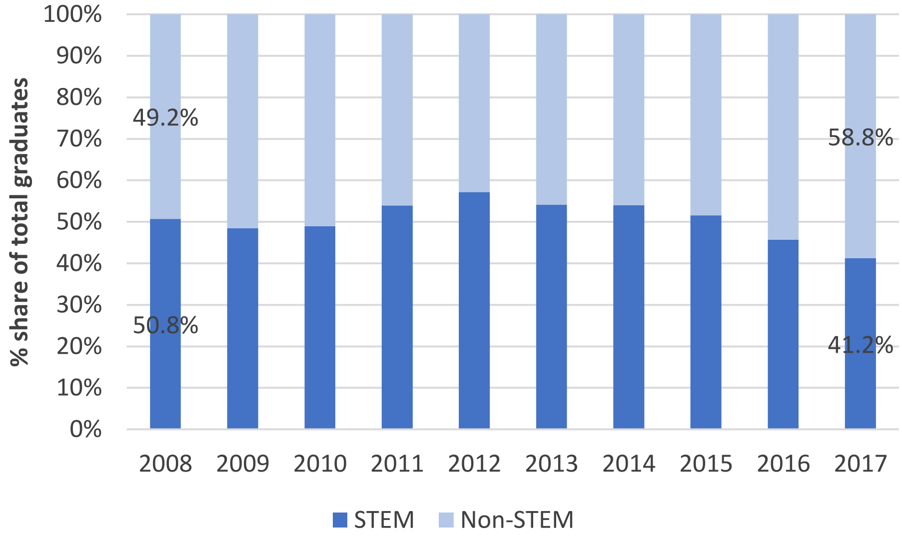
Penang Institute is in collaboration with Penang Science Cluster to conduct a study on factors affecting students' education and career decisions in relation to Science, Technology, Engineering, and Mathematics (STEM). This study is the result of anecdotal evidence pertaining to the shortage of STEM graduates in Penang, and understanding the reasons leading to this shortage is essential to ensuring a sufficient supply of STEM workers in the future.

1.2 Background

The shortage of STEM workers has been constantly debated for many years in Penang. According to the Penang Skilled Workforce Study undertaken by Penang Institute, more than half of the job vacancies advertised on Jobstreet are related to STEM, which are largely found in the areas of product development, manufacturing process, software design, quality management, and information technology. This finding is in line with Penang's key economic structure, where the manufacturing sector is one of the main drivers of the state's economy. The industries with hard-to-fill vacancies include high-tech manufacturing, precision engineering and automation, medical devices and life sciences, and global business services. Interestingly, many firms indicated that replacing employees who have left the company and the expansion of existing company activities have been the main reasons to advertise high-skilled positions. Under a constrained labour market, the former evidently shows a significant degree of worker mobility, which is likely due to a shortage in high-skill labour.

While the demand for STEM graduates remains strong, the share of non-STEM graduates continues to surpass that of STEM graduates. Since 2008, the share of STEM graduates produced by the public university in Penang has dropped by 9.5% to 41.2% in 2017 (Figure 1.1). There is also a large and growing pool of non-STEM graduates that are not able to be absorbed in the job market; more unemployed graduates are observed to have been from Arts and Social Sciences courses compared with courses like Science and Information, Communications and Technology, and this trend has been on the rise in the last five years.

Figure 1.1 Distribution of STEM and non-STEM graduates by public university in Penang



Note: STEM includes Science, Mathematics and Computing, and Engineering, Manufacturing, and Construction. Non-STEM courses include Education, Humanities and Arts, Social Sciences, Business and Law, and Services.
Source: Planning, Research and Policy Coordination Division, Ministry of Higher Education.

Anecdotally, it is said that the constant changes to curriculum modules, parental pressure, and subject difficulty are among the reasons students opt to study non-science subjects (Shirazi, 2017). However, no study has been conducted in Penang to understand why students prefer non-science subjects during their tertiary education. Apart from external factors, poor academic performance has also prevented students from entering the science stream in secondary school (Nasa & Anwar, 2016). For example, only 30% of Form Three secondary school students have qualified to attend science-stream classes—a long way from the country's targeted 60:40 ratio since 1970.

The growing shortage of STEM graduates runs counter to the state's need for innovation in the manufacturing sector. Identifying factors influencing the choice of STEM and non-STEM subjects among students is imperative to building a better understanding of the root causes of the shortage of STEM graduates. A proper pool of STEM graduates can be made ready to match the growing needs of industries in Penang, along with improved investment expansions.

1.3 Objectives

The objectives of this study are to:

i. Examine how students perceive science/STEM subjects

ii. Determine internal and external factors influencing students in choosing the science stream among upper-secondary students and STEM courses among higher-education students

iii. Identify internal and external factors demotivating students from choosing the science stream or STEM subjects

iv. Identify reasons for high academic performers dropping out of science classes

v. Envisage the potential characteristics of STEM supply in the future through students' preferences in science subjects and areas of science

vi. Provide recommendations to address the shortage of STEM supply towards achieving sustainable growth of STEM sectors in Penang

1.4 Scope of the study

This study focuses on factors affecting students' choice of science study in Penang's secondary schools and universities and colleges. The scope of this study comprises:

i. Indicators for choice of study

ii. Students' personal and academic characteristics

iii. Students' perceptions towards the science stream/STEM subjects

iv. Students' perceptions towards the adequacy of existing provisions for science-related facilities and activities in schools

v. Teachers' perceptions towards the interest of students in science subjects

vi. Teachers' perceptions towards the availability of science facilities at schools

vii. Policy recommendations to increase the number of science students in Penang

2 Data and methodology

This chapter discusses the study's research framework and provides a detailed explanation of data collection and the methodology adopted.

2.1 Research framework

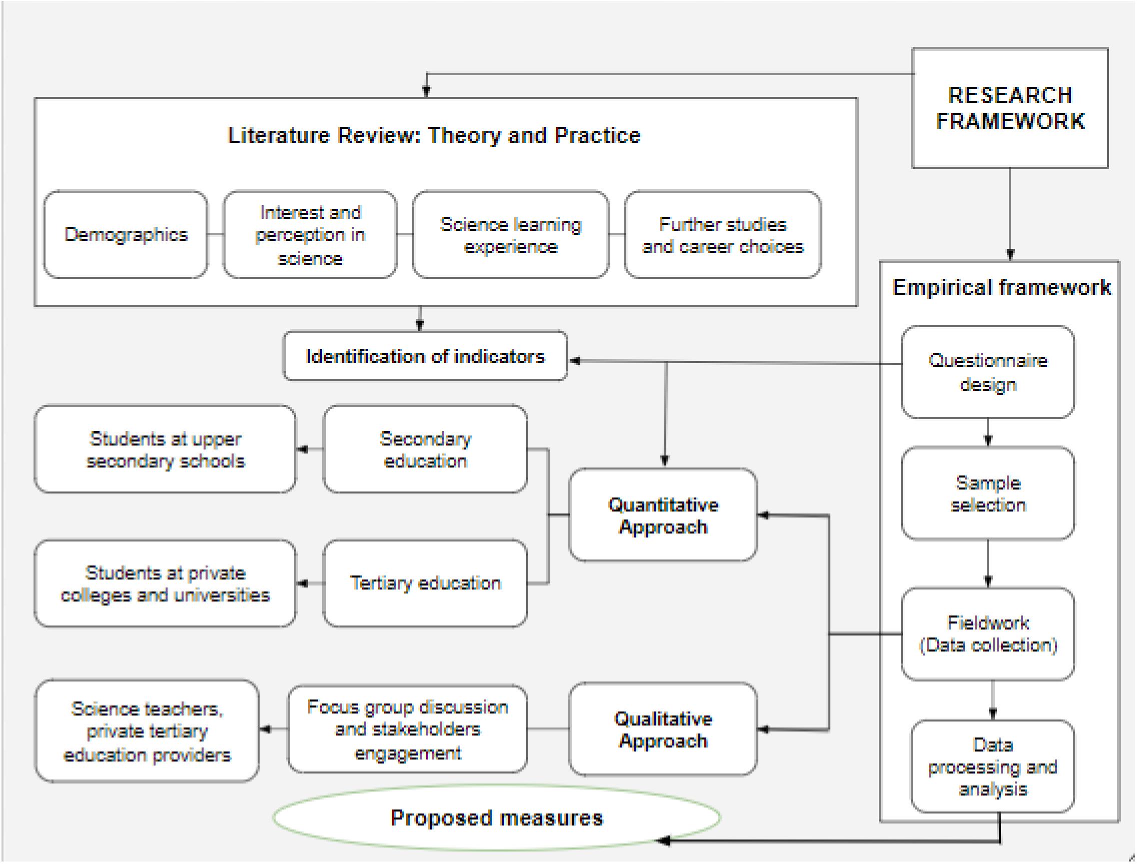
This study was divided into five phases: literature review, questionnaire design and sample selection, fieldwork, data processing and analysis, and discussion and proposed measures (Figure 2.1). After a comprehensive desk research and identifying the main indicators, two independent sets of questionnaires for secondary and tertiary students were developed to capture students' personal and academic characteristics, as well as their perceptions towards science subjects and careers. Each set of questionnaires offered information with distinctive objectives in examining factors influencing students' decisions regarding science education.

This research applied quantitative and qualitative data collection approaches and consisted of three main parts:

a. Computer-assisted interviews with science and non-science students from secondary schools in Penang;
b. Computer-assisted interviews with STEM and non-STEM students in private higher education institutions; and
c. A focus group discussion with teachers and stakeholders.

The survey results were analysed using both descriptive and inferential statistics. A logistic regression model was applied to investigate the factors affecting students' interest in the sciences, choice of study, and future career in secondary and tertiary education. Measures to increase science interest and STEM participation were then proposed.

Figure 2.1 Research framework



2.2 Data collection

A computer-assisted self-interviewing (CASI) system was applied for the survey data collection. Respondents were given a laptop to enter their responses. The data collection was carried out between 2 July 2019 and 29 November 2019 (including the pilot study). The questionnaire was available in English and the approximate length was 20 minutes.

Surveys were conducted in 17 secondary schools and five tertiary private colleges/universities in Penang; 965 upper-secondary students and 432 tertiary students participated. The list of schools and colleges/universities interviewed in this study are presented in Table 2.1 and Table 2.2, respectively.

Table 2.1 List of secondary schools interviewed

High-performance school (HPS)	
1	SMK (P) St. George
2	SMK Al-Irshad
3	SMK Bukit Jambul
4	SMS Tun Syed Sheh Shahabudin
Cluster Schools of Excellence (CSE)	
5	Chung Ling High School
6	SMJK (P) China Perempuan Pulau Pinang
7	SMJK Chung Ling Butterworth
8	SMJK Jit Sin
9	SMK Convent Green Lane
10	SMK Seri Nibong
11	SMK Dato' Onn Butterworth
12	SMKA Al Mashoor (L)
Non-HPS/CSE	
13	SMJK Heng Ee
14	SMJK Phor Tay
15	SMK (L) Methodist
16	SMK St Xavier
17	SMK Tunku Abdul Rahman

Table 2.2 List of private colleges/universities interviewed

1	Wawasan Open University (WOU)*
2	UOW Malaysia KDU*, **
3	Tunku Abdul Rahman University College*
4	INTI International College Penang
5	Penang Skills Development Centre (PSDC)

Note: * Penang campus
** Previously known as KDU University College

2.2.1 Sample selection

Because of the limited budget and resources available, the questionnaires were administered to schools and private higher education institutions based on selection criteria such as stream, gender, and strata. The sample selection for each category is elaborated below:

a) *Students who are currently participating in science and non-science streams in secondary schools*

There are 128 government- and government-aided secondary schools in Penang. Given that religious education, technical education, and vocational colleges offer different curriculums compared with the national secondary school system, only national secondary schools were considered in this study. The interview sample was selected from 102 secondary schools in Penang, with 53% of the schools located in urban areas and the remaining 47% in rural areas.

Only the upper-secondary-school students were considered in this study. According to the Ministry of Education, Penang has a total of 39,125 upper-secondary-school students (18,340 science and 20,785 non-science students) as of June 2018. Approximately 48.8% are male students while 51.2% are female. A total sample size of 965 with a 3%[1] margin of error was collected. A stratified random sampling method was used to reduce sampling error. In addition, the selection of schools was subjected to approval from the Education Policy Planning and Research division in the Ministry of Education (MOE) and endorsement from the Penang Education Department. The composition of population and the secondary-student sample are shown in Table 2.3 and Table 2.4 respectively.

Table 2.3 Population of students in secondary schools in Penang by strata, stream and gender

Stream	Urban			Rural			Total
	Male	Female	Total	Male	Female	Total	
Science	4,698 (12%)	4,846 (12%)	9,544 (24%)	4,323 (11%)	4,473 (11%)	8,796 (22%)	18,340 (47%)
Non-science	4,787 (12%)	5,432 (14%)	10,219 (26%)	5,294 (14%)	5,272 (13%)	10,566 (27%)	20,785 (53%)
Total	9,485 (24%)	10,278 (26%)	19,763 (51%)	9,617 (25%)	9,745 (25%)	19,362 (49%)	39,125 (100%)

Source: Ministry of Education, as of June 2018.

Table 2.4 Sample size for students in secondary schools by strata, stream, and gender

Stream	Urban			Rural			Total
	Male	Female	Total	Male	Female	Total	
Science	147 (15%)	182 (19%)	329 (34%)	117 (12%)	156 (16%)	273 (28%)	602 (62%)
Non-science	86 (9%)	143 (15%)	229 (24%)	45 (5%)	89 (9%)	134 (14%)	363 (38%)
Total	233 (24%)	325 (34%)	558 (58%)	162 (17%)	245 (25%)	407 (42%)	965 (100%)

b) Students who are currently taking STEM and non-STEM majors in tertiary education

According to the 2016 Profile of Private Higher Education Institutions published by the Ministry of Higher Education, a total of 23 private universities, colleges, and college universities are operating in Penang, offering various STEM and non-STEM courses at certificate, diploma, and bachelor levels.[2]

[1] At 95% confidence level.

[2] There exists a discrepancy in total number of higher-education institutions published in the 2016 Statistics of Private Higher Education Institutions and the 2016 Profile of Private Higher Education Institutions. While a total of 28 private institutes of higher learning was recorded in the former publication, the latter provides detailed information with regards to students' intake, enrolment, and graduates of specific private institutes of higher learning. Therefore, the latter publication is our main reference point.

A stratified random sampling method was also applied to the tertiary-student sample. In 2016, the total number of student enrolments was 17,300 students. As many as 69.5% of these students enrolled in non-STEM courses; 5.5% took general courses such as A-levels and other pre-university courses; and only 25% registered in STEM courses.[3] In general, STEM courses continue to be more popular among male students than female.

For our sample selection, we considered only 16,350 students enrolled in either STEM or non-STEM courses. Table 2.5 presents the composition of population and the tertiary sample. A total of 432 students were involved in the interview. With a 95% confidence level, the margin of error is estimated to be about 4.7%.

Table 2.5 Population (N) and sample size (n) for students in private institutes of higher learning

Gender	Field of study				Total	
	STEM		Non-STEM			
	N	n	N	n	N	n
Male	2,919 (67.5%)	149 (80.5%)	4,742 (39.4%)	87 (35.2%)	7,661 (46.9%)	236 (54.6%)
Female	1,407 (32.5%)	36 (19.5%)	7,282 (60.6%)	160 (64.8%)	8,689 (53.1%)	196 (45.4%)
Total	4,326 (26.5%)	185 (42.8%)	12,024 (73.5%)	247 (57.2%)	16,350 (100.0%)	432 (100.0%)

Note:

1. Percentage in parentheses represents the share of students by gender and stream.
2. Students taking other general courses are excluded.

Prior to the launch of fieldwork, a pilot study was carried out with 4.8% (46 respondents) and 8.8% (38 respondents) of the secondary and tertiary samples, respectively. The same methodology was used both for the pilot study and the full launch of the research project. The pilot study helped to verify the translation, validity, and reliability of the questionnaire. Minimal changes were made to the questionnaire following the pilot study; as a result, the answers obtained during the pilot study were used as part of the final sample.

2.2.2 Focus group discussion and stakeholder engagement

The study also collected feedback and insights from secondary-school teachers in relation to the perception and interest of students in learning science subjects. This carried out through a focus group discussion where an open-structured questionnaire was distributed among 21 science and mathematics teachers[4] during the discussion to validate the survey information gathered from the student survey. In addition, participants were given an opportunity to discuss the readiness of science facilities in schools as well as the provisions made available by schools as an instrument for learning.

[3] The STEM and non-STEM fields are Penang Institute's own classification based on the courses.

[4] At least one representative from each surveyed school attended the focus group discussion.

In addition, expert interview with PSDC and WOU was undertaken as a supplement to the results found through student survey and focus group discussion. The aim was to obtain in-depth qualitative information and insights into factors affecting students' choice of STEM study in tertiary education and issues faced.

2.3 Methodology

The logistic regression model was used to examine factors affecting students' interest level, choice of study, and future careers. The regression model was fitted to all students, including high-performing students.[5]

2.3.1 Model specification

The analysis employed both ordinal and binomial logistic regressions, depending on the nature of the dependent variables, to identify significant factors affecting students' interest level in science, choice of study, and future career choices.

Dependent variables

In line with the research objectives, the study aims to identify significant predictors for:

1) Science interest level (*interest*);
2) Current choice of study (*stream* or *field*);
3) Choice of future studies (secondary students only) (*futurestudy)*; and
4) Future career choice (*futurecareer)*.

The descriptions of these dependent variables are presented in Table 2.6.

[5] High-performing science students are defined as those who had an average score of A- or better in their upper-secondary results for STEM (science and maths) subjects.

Table 2.6 Description of dependent variables involved in the study

Dependent variables	Description	Type of variables	Model used
interest	Student's level of interest in science	Ordinal: 0 – Not interested at all 1 – Rather not interested 2 – Neither interested nor disinterested 3 – Rather interested 4 – Very interested	Proportional odds model (POM) OR Partial proportional odds model (PPOM)
stream/field	Secondary students' current stream of study/tertiary students' current field of study	Binary: 0 – Non-science/Non-STEM 1 – Science/STEM	Binary logistic regression
futurestudy	Whether the student intended to further study in STEM courses. Students who were undecided at the time of survey were excluded from the modelling.	Binary: 0 – Non-STEM 1 – STEM	Binary logistic regression
futurecareer	Whether the student intended to engage in the STEM career field in the future. Students who were undecided at the time of survey were excluded from the modelling.	Binary: 0 – Non-STEM 1 – STEM	Binary logistic regression

Independent variables

Various factors are associated with science uptake at the school and college/university levels. According to previous studies, these factors included cost of studying (Langen & Dekkers, 2005), school selectivity (Smithers & Robinson, 2005), availability of qualified and enthusiastic teachers (Smithers & Robinson, 2007), opportunities to experience science-related careers (Bennett et al., 2013), gender (Murphy & Whitelegg, 2006), perceived usefulness of STEM subjects (Jenkins & Nelson, 2005), enjoyment (Lyons, 2006), self-efficacy (Schunk & Pajares, 2002; Vidal Rodeiro, 2007), school experience (Rutter, 1983), and teacher's influence (Urdan & Schoenfelder, 2006).

Drawing from a rich body of literature, this study looked at the following factors: gender, current/past field, type of school, parental education and occupation, perceived motivation from school, satisfaction with science classes, academic performance in STEM subjects, parents' attitude towards science, peer influence, and knowledge of STEM careers. Since interest in science and current stream of study are likely to affect future study choices and career choices, these two variables were analysed as independent variables as well.

There were a few limitations to our models. Firstly, we excluded some factors known to affect science uptake from our models because of a) difficulties in obtaining data directly, or b) their inclusion would cause too many observations to be dropped from the sample. These factors were the availability of qualified and enthusiastic teachers, perceived usefulness of STEM subjects, and teacher's influence. Nevertheless, we explore their relative importance in our discussions.

Secondly, we excluded peer influence from our model for interest level and career choices because peer influence within our survey was framed specifically within the context of study choices. Hence, using it as a variable to predict interest level and career choices may raise difficulties in interpretation. We also omitted STEM career information from our models for interest level and career choice because students were asked for the level of knowledge/awareness of career pathways that they had before enrolling in tertiary education. Since students are likely to have updated their information and beliefs post-enrolment, we believe that information received pre-enrolment has limited relevance to future career plans and current interest levels. Table 2.7 defines the variables used in the regression models.

Table 2.7 Descriptions of independent variables involved in the study

Variables	Description	Levels of variables (coding)*
Science interest level	Student's level of interest in science	Ascending: 0 - 4
Male	Gender of student	Male (1) Female (0)
Stream of study at upper-secondary education	Secondary stream of study	Science (1) Non-science (0)
Tertiary STEM course	Tertiary field of study	STEM (1) Non-STEM (0)
HPS	Whether the student attended a high-performing school (HPS)	HPS (1) Non-HPS (0)
CSE	Whether the student attended a Cluster school	Cluster (1) Non-Cluster (0)
Father's education	Whether the father had higher education	Higher education (1) Secondary or below (0)
Mother's education	Whether the mother had higher education	Higher education (1) Secondary or below (0)
Parents' current work	Whether the father or mother held a science-related occupation	Science-related (1) Non-science-related (0)
School motivation	Whether the student felt motivated by school to learn science	Yes (1) No (0)
Students' satisfaction on teachers' performance	Whether students are satisfied with science or STEM classes	Satisfied (1) Not satisfied/don't know (0)
Average science score	Average score of Additional Maths, Biology, Physics, and Chemistry. The scores are derived from the grades: A+: 10, A: 9, A-: 8, B+: 7, B: 6, C+: 5, C: 4, D: 3, E: 2, G: 1	Ascending: 1-10
English score	Score of English subject	Ascending: 1-10
Parents' attitude	Whether parents have asked student to choose science stream/STEM courses.	Yes (1) No (0)
Peer influence	Whether students have been influenced by friends when selecting stream of study.	Yes (1) No (0)
Information on STEM career paths before tertiary education	Ratio of students' information on STEM career pathways over non-STEM career pathways.[6]	Not aware at all (0) Aware of it/little knowledge (1) Had vast knowledge (2)
Pedagogical strategies	Factor scores of items asked when students perceived that school is motivating them in learning science**	Continuous variable
School environment	Factor scores of items asked when students perceived that school is motivating them in learning science**	Continuous variable

* For binary dummy variables, level coded as 0 is used as the reference group in the regression models.

** Factor scores generated from factor analysis

[6] Formula used: information of career paths before tertiary education = exp(average informative level of STEM careers) / exp(average informative level of non-STEM careers)

Logistic regression models

a) Proportional odds model

The proportional odds model (POM) is used when the dependent variable is ordinal in nature, as in the case of science interest level. POM is the most popular logistic regression model for analysing ordinal data. POM was used to analyse science interest level.

Let Y be an ordinal variable with J levels/categories, and $P(Y \leq j)$ be the cumulative probability of Y less than or equal to a specific level $j = 1,2, \dots, J - 1$, then the odds of being less than or equal to a specific level can be defined as

$$\frac{P(Y \leq j)}{P(Y > j)} \tag{1}$$

For $j = 1,2, \dots, J - 1$ since $P(Y > J) = 0$. The POM then models the log odds (also known as *logit*) of Y as

$$\begin{aligned} logit\ P(Y \leq j|X_i) &= \ln\left[\frac{P(Y \leq j|X_i)}{P(Y > j|X_i)}\right] \\ &= \alpha_{j0} + \beta_i X_1 + \cdots + \beta_p X_p, \end{aligned} \tag{2}$$

Where α_{j0} is the intercept of the cumulative logit model for $Y \leq j$ and $\beta_1, \dots, \beta_p$ correspond to the effects of independent variables on the log odds of Y. Notice that the $(j - 1)$ cumulative regression equations share the common set of $\beta_1, \dots, \beta_p$ coefficients as POM assumes that the relationship between X_i and Y are independent of j (cut-off level for Y).

The Brant test was used to test on the parallel regression assumption. It is a Wald test proposed by Brant (1990) which performs (i) an overall test that all β_j are equal and (ii) test of equality of coefficients for individual variables (Long, 1997). If only a subset of independent variables is found to be violating the parallel regression assumption, the partial proportional odds model (PPOM) is employed.

PPOM is an extension of the POM, which can be expressed as

$$\begin{aligned} logit\, P(Y \leq j \mid X_i) = \alpha_j + (\beta_1 + \gamma_{j1})X_1 + \ldots + (\beta_q + \gamma_{jq})X_q \\ + \beta_{q+1}X_{q+1} + \ldots + \beta_p X_p, \quad j = 1, \ldots, J-1. \end{aligned} \tag{3}$$

It relaxes the parallel regression assumption by allowing different coefficients at different cut-off levels for the violating variables, while the other variables share the common coefficients.

b) Binomial logistic regression

The study applied binomial logistic model for *current choice of study*, *choice of future studies*, and *future career choice*. For example, students were either in the science stream or non-science stream at the secondary level; or intended to pursue STEM or non-STEM careers.[7] Hence, it was sufficient to apply binomial logistic models to these variables.

The binomial logistic regression models the log-odds of Y as the linear combination of independent variables:

$$
\begin{aligned}
logit\, P(Y \mid X_i) &= \ln\left[\frac{P(Y \mid X_i)}{1-P(Y \mid X_i)}\right] \\
&= \beta_0 + \beta_1 X_1 + \ldots + \beta_p X_p.
\end{aligned} \tag{4}
$$

The coefficient β_i can be interpreted as the unit change in log odds of Y for every unit change in X_i, holding other variables constant.

We chose the most parsimonious, well-fitted model using stepwise regression, based on lowest AIC value. The modelling was carried out using the R software.

2.3.2 Profile of respondents

Secondary education

A total of 965 upper-secondary students from 17 secondary schools in Penang participated in this survey. Of these schools, four were high-performance schools (hereinafter referred to as “HPS”), eight were Cluster Schools of Excellence (hereinafter referred to as “CSE”), and five were not classified as either HPS or CSE schools (hereinafter referred to as “Non-HPS/CSE”).

Of the students surveyed, 62% studied in the science stream, and 38% were in the non-science stream. As presented in Table 2.8, 77% of students took the science stream in HPS compared with nearly 60% in the two other types of schools. More than half of respondents (59.1%, 570 respondents) were female, while 40.9% were male (395 respondents) (Table 2.8).

[7] Responses such as “Don’t know” or “Undecided” were dropped during modelling for the sake of intuitive interpretation.

Table 2.8 Number of secondary students (respondents) by type of schools, stream, and gender

	Science	Non-science	Total
HPS	**162 (76.8%)**	**49 (23.2%)**	**211 (21.9%)**
Male	50 (76.9%)	15 (23.1%)	65 (30.8%)
Female	112 (76.7%)	34 (23.3%)	146 (69.2%)
CSE	**281 (59.4%)**	**192 (40.6%)**	**473 (49.0%)**
Male	136 (72.7%)	51 (27.3%)	187 (39.5%)
Female	145 (50.7%)	141 (49.3%)	286 (60.5%)
Non-HPS/CSE	**159 (56.6%)**	**122 (43.4%)**	**281 (29.1%)**
Male	78 (54.5%)	65 (45.5%)	143 (50.9%)
Female	81 (58.7%)	57 (41.3%)	138 (49.1%)
Total	**602 (62.4%)**	**363 (37.6%)**	**965 (100.0%)**
Male	264 (66.8%)	131 (33.2%)	395 (40.9%)
Female	338 (59.3%)	232 (40.7%)	570 (59.1%)

Tertiary education

A total of 432 students from five private tertiary institutions participated in this survey. Slightly more than half were in non-STEM fields (57.2%, 247 respondents). The statistics present an obvious gender difference. About 63.1% or 149 respondents in STEM courses were male, whereas only less than 20% of the females were in STEM courses (Table 2.9).

Table 2.9 Number of tertiary students by field of study and gender

	STEM	Non-STEM	Total
Male	149 (63.1%)	87 (36.9%)	**236 (54.6%)**
Female	36 (18.4%)	160 (81.6%)	**196 (45.4%)**
Total	**185 (42.8%)**	**247 (57.2%)**	**432**

3 Survey results: Secondary education

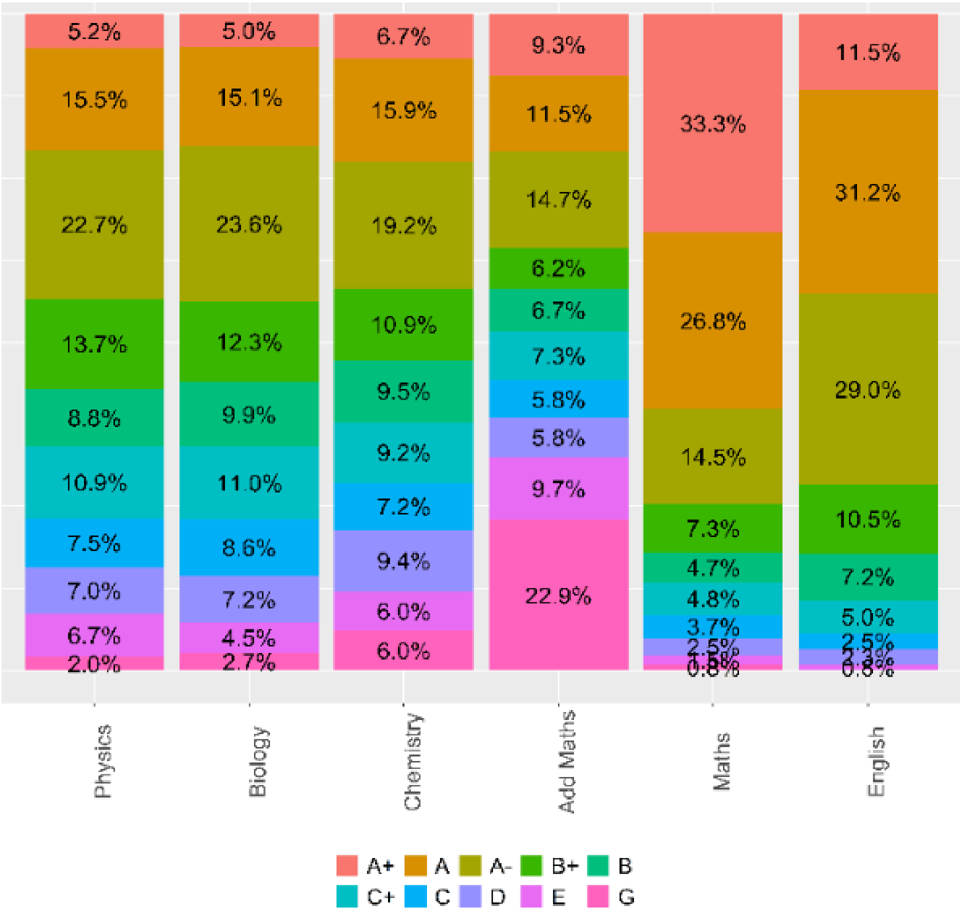
This chapter looks into the surveyed students' academic achievements and parental characteristics in persuading students to pursue science stream at secondary education. Specifically, this chapter explores factors influencing students' science interest level, student's current choice of study, students' future study plans, and their career plans.

3.1 Academic achievement of respondents

In secondary schools, 600 students from the science stream indicated their last examination results for the following subjects: Mathematics, Additional Mathematics (or Add Maths), Physics, Biology, Chemistry, and English. The academic examination results of science students are summarised as follows:

- Among the four core science subjects for science stream, Biology had the highest proportion of students scoring "A+", "A", and "A-" in their last examination (43.8%) compared with 43.4% for Physics, 41.8% for Chemistry, and 35.6% for Add Maths.
- As one of the core science-related subjects, students performed poorly in Add Maths. Nearly 23% of science students who responded to the survey failed the subject, compared with 6% in Chemistry, 2.7% in Biology, and 2% in Physics.
- In contrast, about three-quarter of students from the science stream scored "A+", "A", or "A-" in Mathematics. Less than 1% failed the subject.
- For English language competency, 71.7% of students from the science stream scored "A+", "A", or "A-"; 17.7% obtained "B+" or "B"; and 7.5% gained a credit of "C+" or "C". Additionally, 3.2% passed the English examination with a "D" or an "E". Nobody failed.

Figure 3.1 Academic achievement of students from science stream only



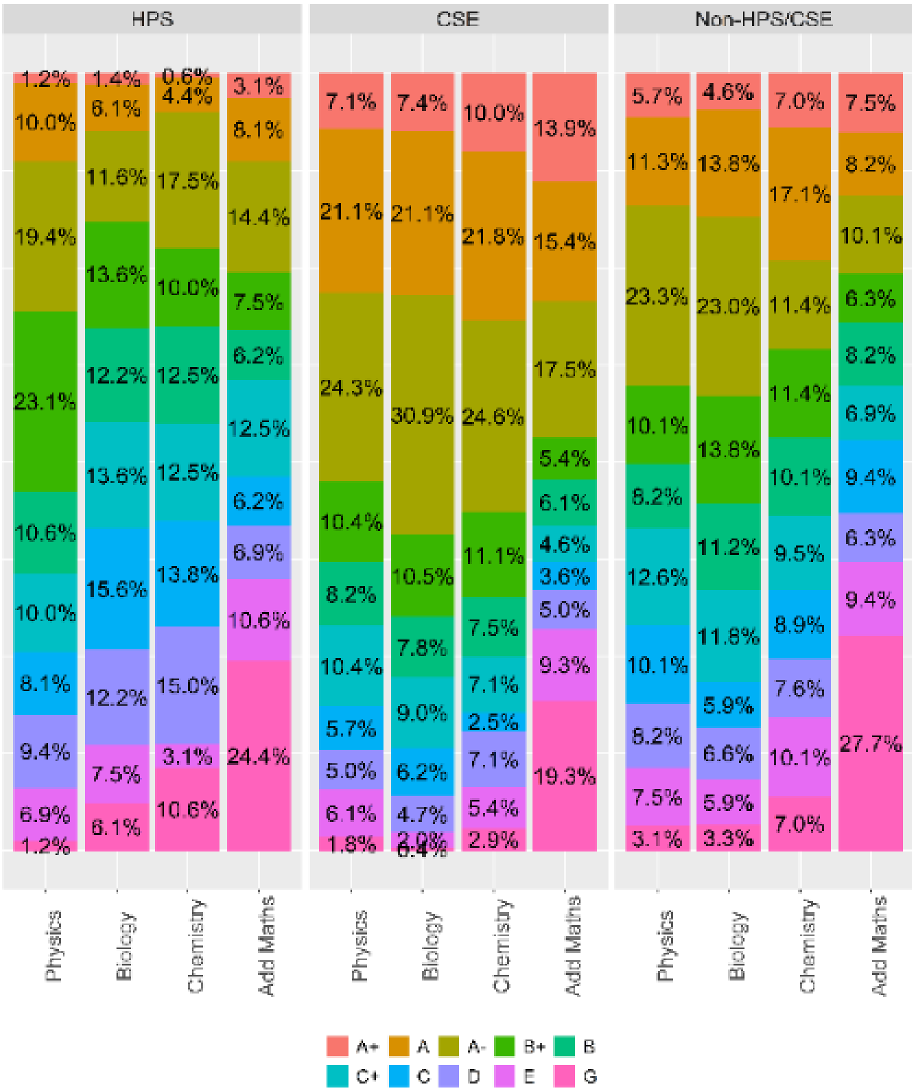
Note:

1. A credit in SPM is a "C" while a pass is a "D" or "E".
2. Out of 602 respondents from the science stream, two respondents who did not answer this question are excluded from the results. Respondents who are from the science stream but do not take a specific subject are also excluded from the results. Therefore, the total number of respondents who take Mathematics, Add Maths, Biology, Physics, Chemistry, and English are 600, 599, 555, 599, 598, and 600, respectively.

Students' academic achievements are categorised based on three types of schools: HPS, CSE, and non-HPS/CSE. The main findings are described below.

- On the whole, students from CSE performed better in all science-related subjects compared with students in HPS and non-HPS/CSE. About 59.4% of science students from CSE scored an "A+", "A", or "A-" in Biology; 56.4% obtained the same grades in Chemistry, 52.5% in Physics, and 46.8% in Add Maths (Figure 3.2). In contrast, no more than 42% of students from HPS and non-HPS/CSE obtained an "A+", "A", or "A-" in all science subjects.

Figure 3.2 Students' academic achievements in science subjects by type of schools

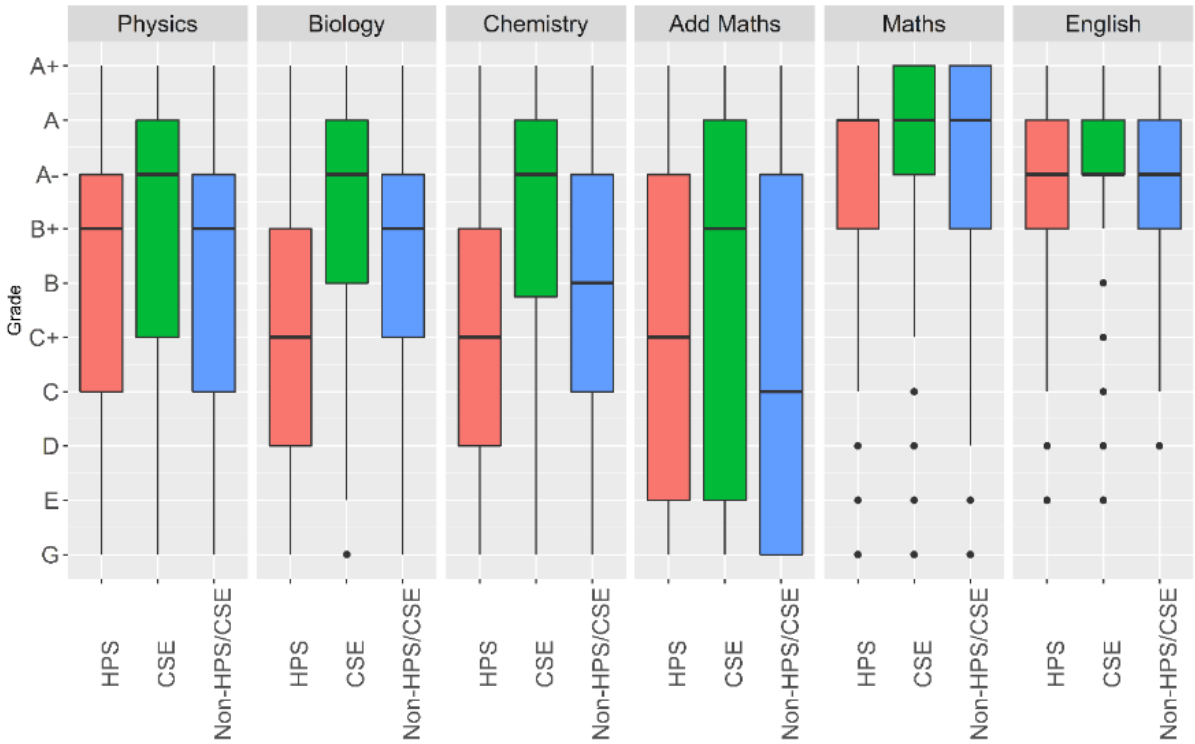


- Interestingly, science students from non-HPS/CSE scored higher grades for Biology and Chemistry compared with HPS students. About half of the science students from non-HPS/CSE scored a "B" and above in Chemistry but fewer than half of students from HPS scored the same grades in the subject (Figure 3.3). For Biology, about half of the students from non-HPS/CSE obtained a "B+" and above whereas fewer than half of students from HPS achieved the same score. No differences between HPS and non-HPS/CSE has been observed for Physics.

- Among the four science subjects, Add Maths had the highest share of students failing across all types of school. Non-HPS/CSE had the highest share of students failing the subject, standing at nearly 28% compared with 24.4% and 19.3% from HPS and CSE, respectively (Figure 3.2). This subject may be relatively more difficult compared with other science subjects.

- In addition, Add Maths had the largest variation in grades compared with other science subjects, with 75% of the students in HPS and CSE scoring between "A+" and "E" (Figure 3.3).

Figure 3.3 Whisker box plot of students' academic achievements in science subjects by type of schools



3.2 Parental characteristics

Students were asked to indicate their parents' highest education level, occupational field, and field of study. While a majority of students could reveal their parents' characteristics, some proportion of students did not know their parents' jobs and education particulars, with the majority of non-science students being unaware of their parents' details. The parents' characteristics of science and non-science students are presented below.

a. Parents' highest level of education

- Parents of science students were relatively more educated compared with parents of non-science students. Over half of the parents of science students had attained tertiary education, with a majority holding a bachelor's degree, while about 40% of the parents of non-science students were tertiary-educated (Table 3.1).
- For non-science students, over 40% of their parents attained secondary education while not more than one-third of parents of science students held secondary education. We may deduce that students are more inclined to be in the science stream as their parental education increases.
- In general, the level of maternal education was relatively higher than paternal education for both science and non-science students. This finding is particularly more apparent among non-science students where about 40% of mothers had attained tertiary education compared with

38% of fathers. Likewise, nearly 45% of students' mothers had attained secondary education compared with 41% of fathers.

Table 3.1 Percentage share of parents' highest level of education (%)

Parents' highest education level	Science students		Non-science students	
	Father	Mother	Father	Mother
Tertiary level	57.4	57.7	38.0	40.2
Ph.D	*3.2*	*1.8*	*0.6*	*0.3*
Masters	*8.8*	*7.3*	*2.5*	*3.0*
Postgraduate Diploma	*1.8*	*2.7*	*2.5*	*1.4*
Bachelor/Degree	*24.0*	*18.5*	*12.1*	*12.7*
Diploma	*9.7*	*13.8*	*10.5*	*12.9*
Certificate	*2.7*	*4.5*	*3.3*	*4.4*
Professional (ACCA, CFA)	*1.2*	*1.2*	*0.8*	*0.8*
Post-secondary (Form 6, Pre-U, A-level)	*6.0*	*7.8*	*5.8*	*4.7*
Secondary level	27.5	32.2	41.0	44.6
Primary level	2.2	1.2	3.6	2.8
No formal education	0.3	0.0	0.3	0.6
Others	12.5	9.0	17.1	11.8
Total respondents	**599**	**600**	**363**	**363**

Note: Others include students who did not know their parents' highest level of education and is not applicable if their parent(s) were divorced or had passed away.

b. *Parents' fields of study*

- Science students tended to come from families where their fathers had science backgrounds in secondary or tertiary education—43.5% of science students compared with 28.1% of non-science students (Table 3.2).

- Likewise, a majority of fathers of non-science students appeared to be from non-science fields of study, standing at 35.5%, while science students saw 37.4% of their fathers hailing from non-science fields. To a certain degree, this shows an association between father's field of study and the stream of students. Meanwhile, a majority of students' mothers were not from science backgrounds regardless of the streams of study (Table 3.2).

- It is important to highlight that a large proportion of non-science students were not aware of their parents' fields of study. About 31.4% of the students were not aware of their fathers' fields of study, and 26.2% were unaware of their mothers' fields of study.

c. *Parents' current work*

- Most parents had never worked in a science-related industry, with parents of non-science students accounting for a higher share than parents of science students. More than half of the parents of non-science students had never worked in the science industry (Table 3.3).

- However, there is a relatively large percentage of science students whose fathers are working in a science industry. About 30% of science students have fathers working in a science industry while non-science students only have 16% of their fathers working in a science-related industry.

- Among those working in a science-related industry, about 93% or 216 respondents' fathers have science-related jobs, such as Engineer, IT Manager, Doctor/Dentist/Pharmacist/Surgeon, System Analyst, and Biochemist, while 80.6% or 83 respondents' mothers are working in science-related jobs such as IT Manager, Quality Controller, System Consultant, and Doctor/Dentist/Pharmacist/Nurse (Table 3.4). A large number of them are parents of science-stream students.

Table 3.2 Percentage share of parents' fields of study (%)

Parents' field of study	Science students		Non-science students	
	Father	Mother	Father	Mother
Science/Engineering/Technology	43.5	20.7	28.1	15.2
Non-science	37.4	54.8	35.5	51.0
Don't know	15.8	16.5	31.4	26.2
Not applicable*	3.4	8.1	5.0	7.7
Total respondents	**596**	**595**	**363**	**363**

*Refers to parents who had attained primary education or never had a formal education.

Table 3.3 Percentage share of parents' current work (%)

Parents' current work	Science students		Non-science students	
	Father	Mother	Father	Mother
He/she currently works in the science industry.	30.2	13.6	16.0	6.1
He/she does not work in the science industry, but used to in the past.	11.9	9.4	8.3	6.1
He/she has never worked in the science industry.	44.5	57.3	52.9	61.4
Others	13.4	19.7	22.9	26.4
Total respondents	**596**	**595**	**363**	**363**

Table 3.4 Percentage share of parents' current job for those who works in science industry (%)

Parents' current job	Science students		Non-science students		Total	
	Father	Mother	Father	Mother	Father	Mother
He/she is currently working in a science-related job.	93.3	84.0	92.6	68.2	93.1	80.6
He/she is currently working in a non-science-related job.	6.7	16.0	7.4	31.8	6.9	19.4
Total respondents	**178**	**81**	**54**	**22**	**232**	**103**

Note: There may be discrepancies in the total number of respondents in Table 3.3 compared with Table 3.4, as students who did not indicate their parents' current jobs are excluded.

3.3 Students' interest in science

This section describes secondary-school students' interest in and perception of science. The elements discuss in this section include:

a. General interest in science
b. Factors that led to their interest in science or lack of interest in science
c. Factors that could increase students' interest in science

Students were first asked about their general interest in science on a five-scale rating where zero meant no interest at all and four meant very interested. Students also responded to questions related to factors leading to their interest in science, as well as factors that could help increase students' level of interest.

a. General interest in science

- Only 14% or 136 respondents reported a relatively low score in their interest in science, with a mean of 2.8, where they claimed *not interested at all* or *rather not interested* in the subject (Table 3.5).
- Out of 602 science students, nearly 85% or 511 respondents indicated a high score for their interest in science. They were *rather interested* or *very interested* in science subjects. The average score for science students was 3.25.
- While a majority of non-science students indicated that they are *rather interested* in science (38.8%, 141 respondents), the mean score was recorded at only 2.06, meaning that non-science students on average were *neither interested nor disinterested* in science.
- No significance differences were found in students' science interest level between genders (Figure 3.5).

Table 3.5 Students' level of interest in science

	Interest level					Total
	0	1	2	3	4	
Number of respondents	68	68	147	385	297	965
% respondents	7.0	7.0	15.2	39.9	30.8	100.0

Note: 0 – Not interested at all; 1 – Rather not interested; 2- Neither interested nor disinterested (includes those who do not know their level of interest); 3 – Rather interested; 4 – Very interested

Table 3.6 Students' level of interest in science by type of school

Science interest level	HPS		CSE		Non-HPS/CSE		Total	
	No.	% share	No.	% share	No.	% share	No.	% share
Very interested	87	41.2	151	31.9	59	21.0	297	30.8
Rather interested	79	37.4	184	38.9	122	43.4	385	39.9
Neither interested nor disinterested	31	14.6	57	12.0	59	20.9	147	15.2
Rather not interested	11	5.2	43	9.1	14	5.0	68	7.0
Not interested at all	3	1.4	38	8.0	27	9.6	68	7.0
Total respondents	**211**	**100**	**473**	**100**	**281**	**100**	**965**	**100**

- Students from HPS and CSE were more likely to be very interested or rather interested in science compared with non-HPS/CSE students. More than 70% of the respondents claimed that they were very interested or rather interested in science compared with 64.4% from non-HPS/CSE (Table 3.6). However, about 17% of CSE students who responded to the survey claimed that they were rather not interested or not interested at all in science, compared with 6.6% and 14.6% from HPS and non-HPS/CSE, respectively. A large proportion of the 17% of CSE students were not from science stream.

- It is important to highlight that the majority of students who attended science classes were very interested in all the science subjects. At least 44% were very interested in the subjects (44.1% or 266 respondents in Add Maths, 45% or 250 respondents in Biology, 44.3% or 266 respondents in Physics, and 44.4% or 266 respondents in Chemistry) (Table 3.7).

- Among those who claimed to be very interested in science, a majority achieved better results in all science subjects except Add Maths. Over half of the respondents (130 respondents) scored a grade "A" (either "A+", "A" or "A-") in Biology, 47.4% or 126 respondents attained a grade "A" in Physics, and 44.7% or 119 respondents achieved an "A" in Chemistry (see Appendix B: Table 2). For Add Maths, out of 266 respondents who claimed to be very interested in science, only slightly more than a third obtained a grade "A" for the subject, and approximately 37% of the 266 respondents either passed or failed the subject. Although a large number of respondents expressed an interest in science, they still scored poorly in Add Maths.

- Students are more likely to have an interest in science if their parents' education level is high. Out of 270 respondents who reported to be *very interested* in science, nearly 70% of the respondents' parents possessed a tertiary education (see Appendix B: Table 3).

- For students with a lower interest in science, a large proportion of their parents, particularly their mothers, had attained secondary education. At least half of the students that stated they were *neither interested nor disinterested*, *rather not interested*, and *not interested at all* in science had mothers who attained a secondary education (see Appendix B: Table 3). This further confirmed that the higher the level of parents' education, the higher the level of students' interest in science.

- However, parents' current jobs are also associated with the students' interest level in science. While some respondents' parents currently have jobs that are related to science, more than half of their parents are working in non-science positions, and this proportion increases as the interest level decreases, particularly with their fathers' occupation (see Appendix B: Table 4).

Figure 3.4 Students' level of interest in science by stream of study

Science students = 602; Non-science students = 363

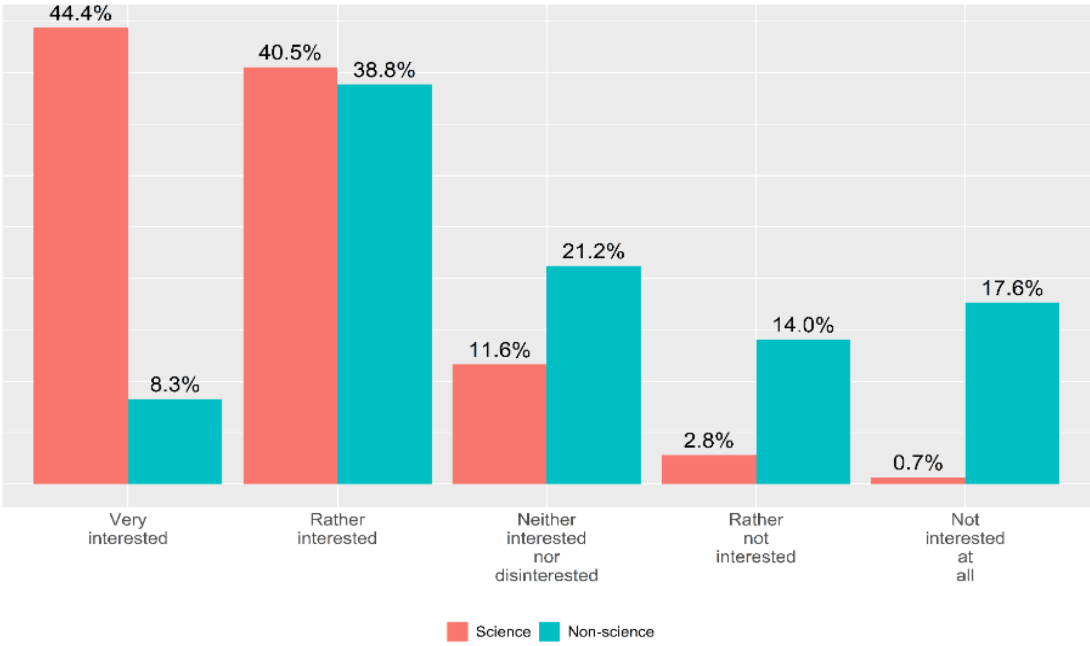


Figure 3.5 Students' level of interest in science by gender

Male students = 395; Female students = 570

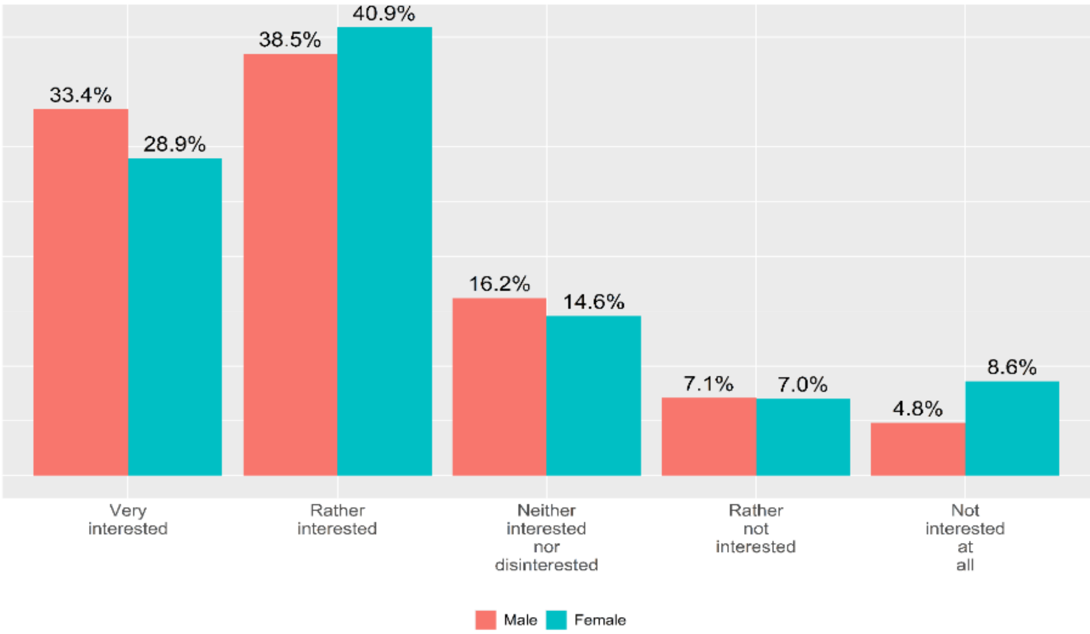


Table 3.7 Students' level of interest in science by science subjects (% of total respondents)

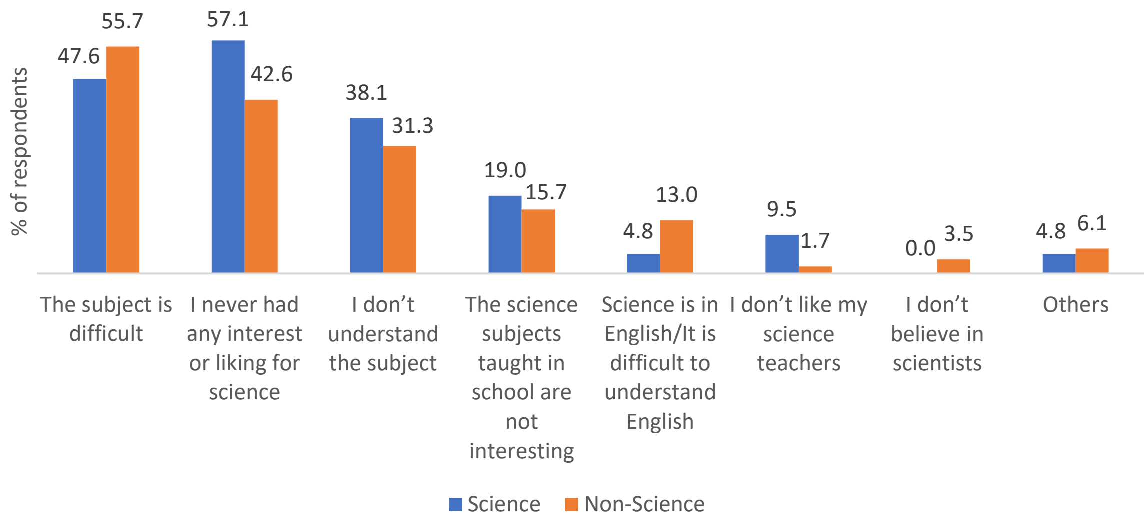
Science interest level	Add Maths	Biology	Physics	Chemistry
Very interested	44.1	45.0	44.3	44.4
Rather interested	40.6	40.3	40.3	40.4
Neither interested nor disinterested	11.7	11.1	11.7	11.5
Rather not interested	2.8	2.7	2.8	2.8
Not interested at all	0.8	0.9	0.8	0.8
Total respondents	**602**	**556**	**600**	**599**

b. *Factors that led to an interest in science or lack of interest in science*

- Out of 965 respondents, only 14% or 136 respondents indicated that they were *not interested* in science. A large proportion of them (84.6% or 115 respondents) were not from the science stream and only 15.4% or 21 respondents were from the science stream (see Appendix B: Table 1). To a certain degree, this result matches the choice of study decision of the majority of science-stream respondents attending science classes.
- Among 136 respondents who were not interested in science, nearly two-thirds were females. The majority of the 136 respondents were also females from non-science classes, constituting about 58% or 79 respondents (see Appendix B: Table 1a). No significant difference was found among science students between males and females.
- When students from non-science classes were asked to indicate the main factors affecting the lack of interest in science, the most common factor was that the subject is difficult (55.7% or 64 respondents) (Figure 3.6). This was then followed by respondents who claimed that they never had any interest in science (42.6% or 49 respondents), and that they do not understand the subject (31.3% or 36 respondents).

Figure 3.6 Main factors for the lack of interest in science

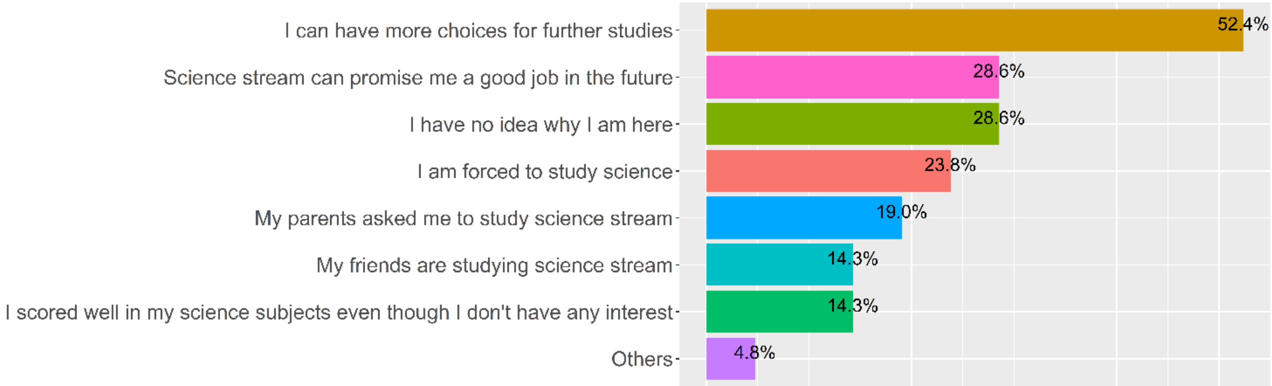
Science students = 21; Non-science students = 115



- Shockingly, for those who were from the science stream, the majority felt that they never had any interest or liking for science (57.1% or 12 respondents), followed by the subject is difficult (47.6% or 10 respondents).
- Students were then asked to elaborate on why they felt that the subject is difficult. They found that the scientific concepts were difficult to understand, and there were too many theories, terms, and formulae that they had to memorise. A majority of these students were from CSE and attended non-science classes.

Figure 3.7 Reasons for science students who claimed disinterest in science but attended science classes

Total respondents = 21



- Although only 21 respondents from the science stream claimed that they were not interested in science, more than half believed that studying science subjects can lead to more choices for further studies, and 28.6% of them felt that the science stream can provide them with a good job in the future (Figure 3.7).
- About 29% of those who were not interested in science had no idea why they were in science stream. Furthermore, about 24% said they were forced into the science stream, and 19% were requested by parents to study science stream. About 14% followed friends who chose to study in the science stream.
- For students who said they were interested in science, we examined the reasons why they were interested in science, as well as the areas of science and science subjects that interest them the most.
- As shown in Table 3.5, out of 965 total respondents, nearly 71% or 682 respondents reported that they were *interested* in science. Approximately three-quarters of them were from the science stream, and the remainder were from the non-science stream.
- When students who reported to be interested in science were asked to state reasons for liking science, 35.2% or 240 respondents said that *science is interesting and amazing*, and nearly three-quarters of these respondents came from the science stream (Figure 3.8). *Science helps me to understand things in everyday life* was the second-most-cited reason (30.9%, 211 respondents), followed by *I like learning new things* (27.6%, 188 respondents), *I can have more*

choices for further studies (21.8%, 149 respondents), and *I enjoy learning science than other subjects* (19.4%, 132 respondents).

- Respondents from all types of schools shared similar reasons except those from non-HPS/CSE. Respondents from non-HPS/CSE did not cite more choices for further studies as one of the top reasons they have an interest in science (Figure 3.9).

Figure 3.8 Top reasons for having an interest in science

Total respondents = 682

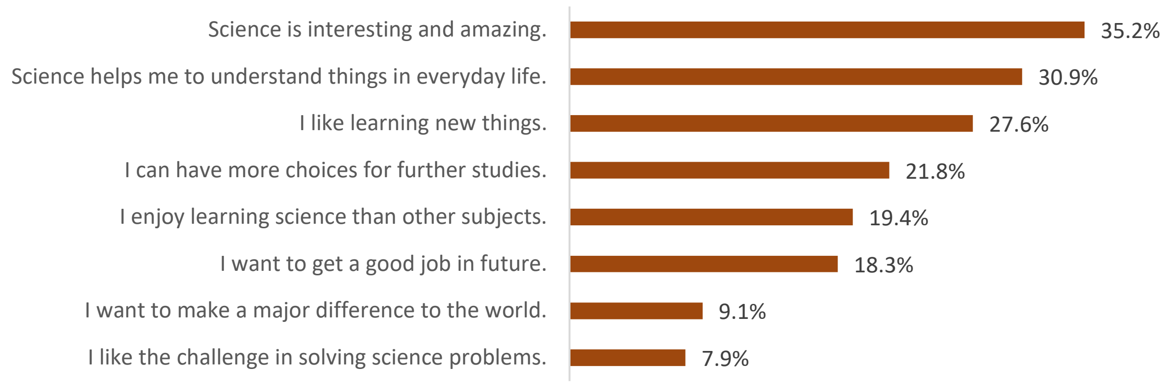
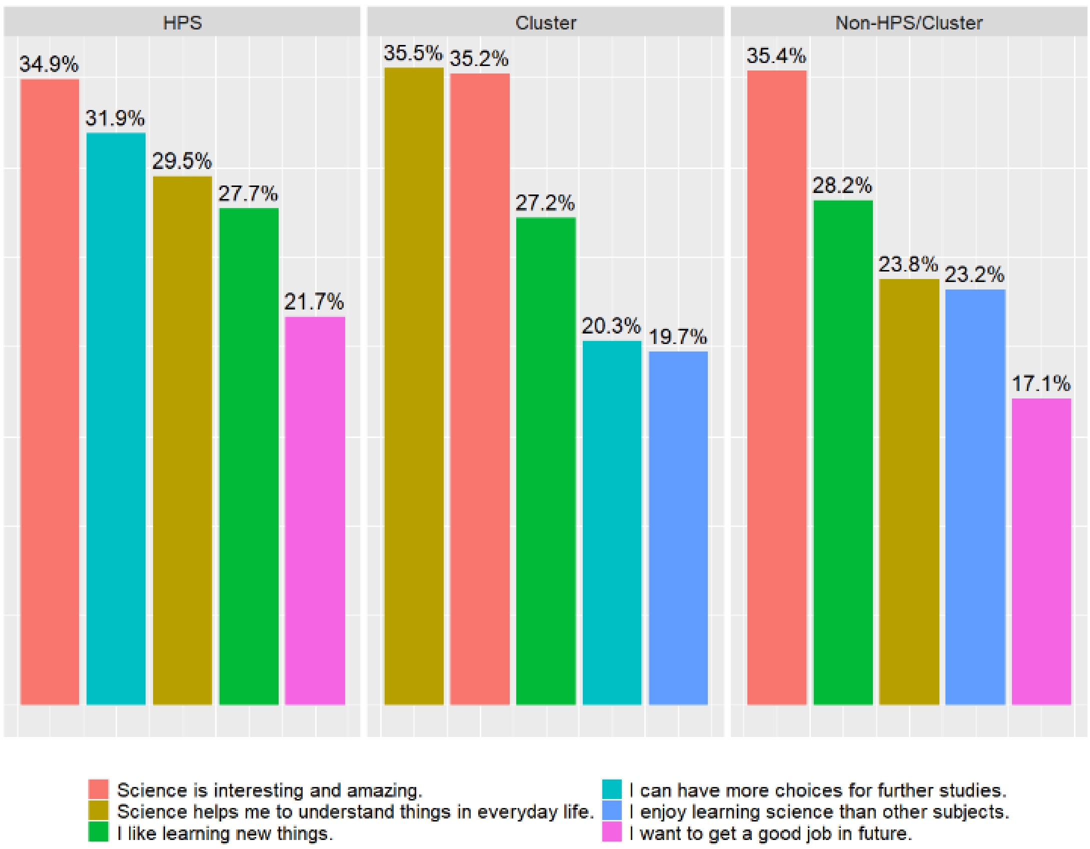


Figure 3.9 Top-five reasons for having interest in science by type of school

HPS students = 166; CSE students = 335; Non-HPS/CSE students = 181



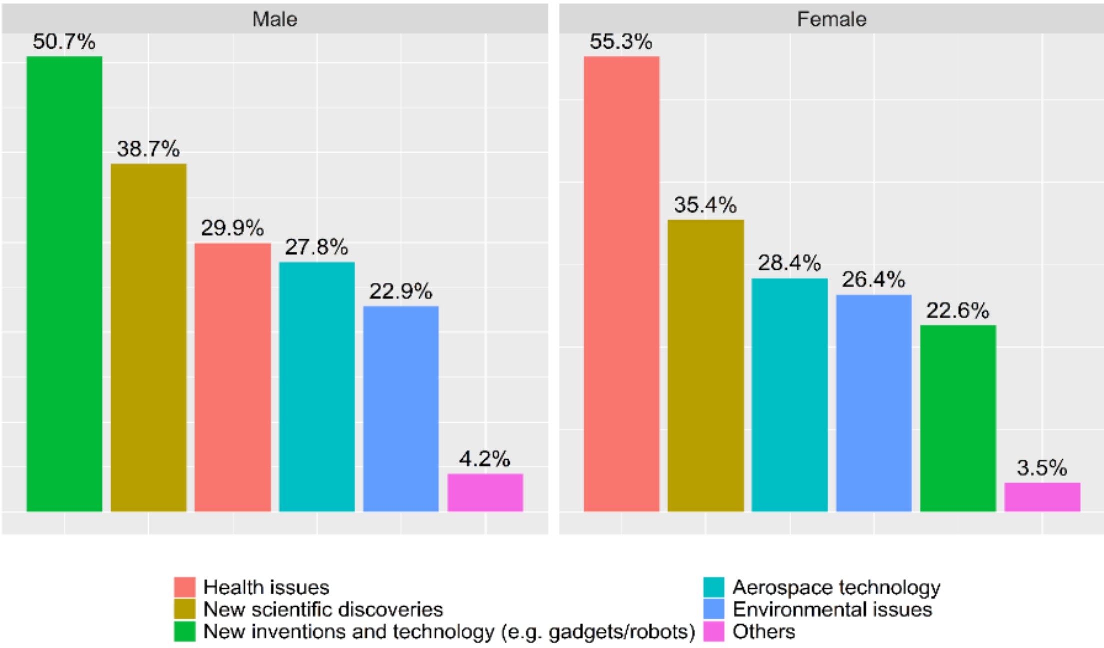
- When students were asked to choose the areas of science that interest them the most, over half of female students had a distinctive preference for *health issues* (55.3% or 220 respondents) while slightly more than half of male students stated their interest in *new inventions and technology* (50.7% or 144 respondents) (Figure 3.10). This is followed by new *scientific discoveries* for both males and females. This finding seems to infer that while both genders have an interest in scientific discoveries, males are particularly more interested in engineering and physical sciences compared with females who are more interested in health and life sciences.

- Respondents from all types of schools had the highest interest in *health issues*, followed by *new scientific discoveries*, with more than 40% of the respondents citing the former and at least 35% citing the latter area of science (Figure 3.11).

- In addition, animal sciences and veterinary medicines, astronomy, psychology, forensics, and quantum physics were specifically mentioned by students when they responded to the areas of science that interest them the most.

Figure 3.10 Students' interest in areas of science by gender

Male students = 284; Female students = 398



- Next, students from the science stream were asked to choose the science subject that interests them the most. This selection is to predict students' decisions in future studies and career plans, and how this will shape the labour supply in the future.

- A large proportion of female students picked Biology (31.5% or 91 respondents), followed by Chemistry (23.9% or 69 respondents), Mathematics (17.6% or 51 respondents), and Physics (13.1% or 38 respondents) (Figure 3.12). Meanwhile, 28.8% or 63 male respondents selected Physics as the science subject they were most interested in, followed by Biology (23.7% or 52 respondents) and Chemistry (19.2% or 42 respondents). This suggests that a majority of science students are likely to engage in non-engineering job functions in the future owing to a large proportion of science students preferring Biology over Physics, given that the majority of science students are females. This finding is consistent across all types of schools (Figure 3.13).

Figure 3.11 Students' interest in areas of science by type of school

HPS students = 166; CSE students = 335; Non-HPS/CSE = 181

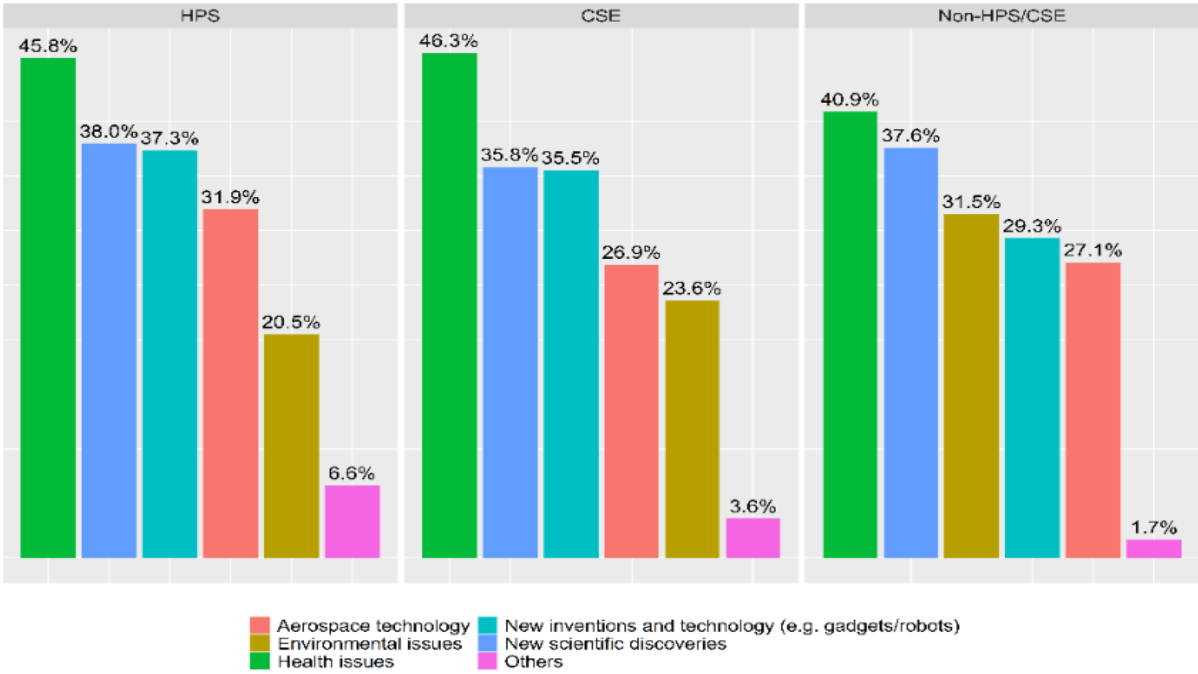


Figure 3.12 Students' interest in science subjects by gender

Male students = 219; Female students = 289

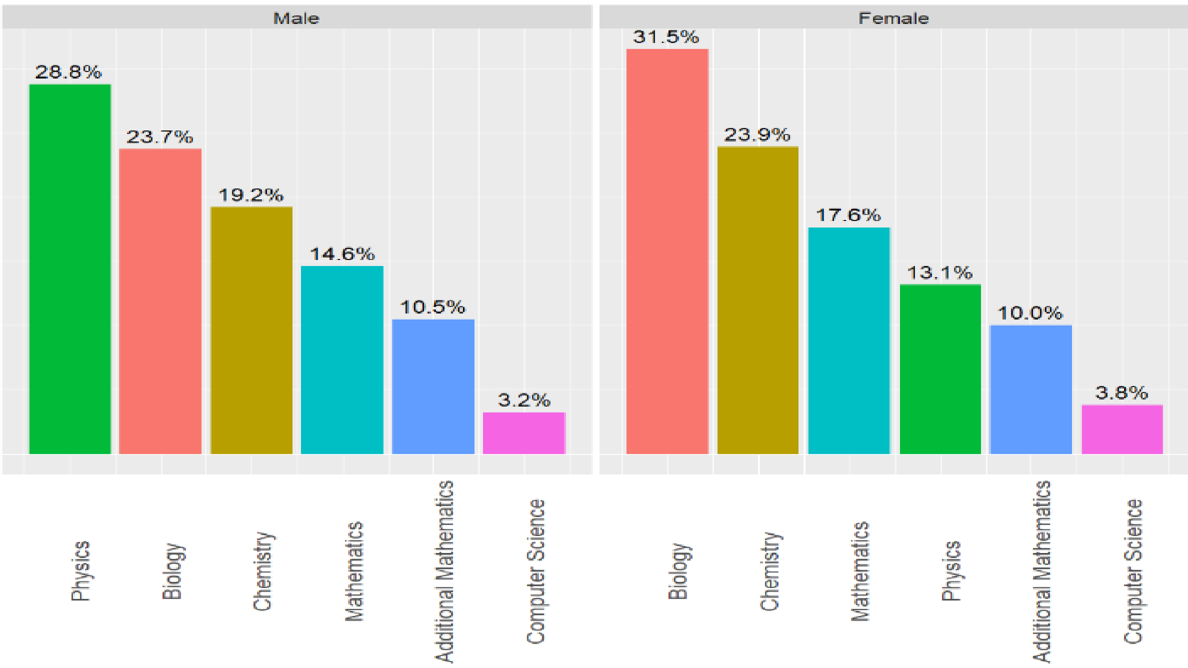
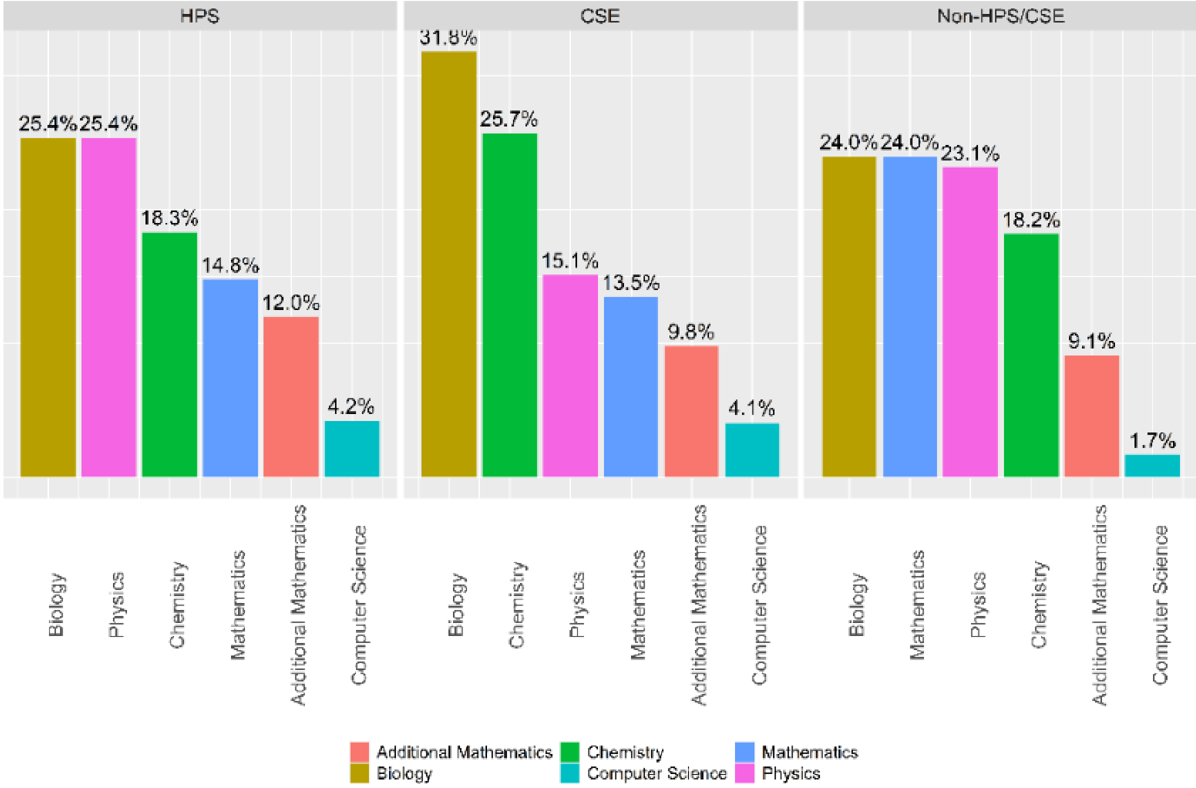


Figure 3.13 Students' interest in science subjects by type of school

HPS students = 142; CSE students = 245; Non-HPS/CSE = 121



- Out of 363 respondents from the non-science stream, about 47% or 171 respondents said that they were interested in science. A majority of them were from CSE (51.5% or 88 respondents), followed by non-HPS/CSE (34.5% or 59 respondents) and HPS (14.0% or 24 respondents).

- These students were asked to state their reasons for not entering the science stream despite having an interest in science. Over half of the respondents stated *arts-stream subjects are easier to understand than the science subjects* as the main reason (Table 3.8). About 40% or 68 respondents claimed that *science is a hobby and studying arts stream is their preferred option for future career*, and 36.3% or 61 respondents said that they scored badly in science subjects and, as a result, explicitly stated that they had no choice but to study in the arts stream.

- About 11% of the respondents gave other reasons for not attending the science stream; parents and teachers have instead played a role in influencing students to enter the non-science stream. For example, two respondents from CSE were advised by teachers to enter the arts stream, and a respondent from non-HPS/CSE was told by parents to enter the arts stream because it would be difficult to score in exams in the science stream.

- It is imperative to note that, while the proportion remains low, a number of respondents from the non-science stream have independently decided on their career direction in upper-secondary school; they stated that they would not be entering science-related careers. A respondent from a non-HPS/CSE school wanted to be a software engineer or pursue an IT-related career, and saw that science-related subjects such as Physics, Chemistry, and Biology would not help him achieve this ambition.

Table 3.8 Reasons for having interest in science despite entering the non-science stream

Reasons	HPS		CSE		Non-HPS/CSE		Total	
	No.	% share	No.	% share	No.	% share	No.	% share
Arts-stream subjects are easier to understand than science subjects	15	62.5	50	56.8	28	50.0	93	55.4
Science is my hobby and I prefer arts stream to be my future career	8	33.3	36	40.9	24	42.9	68	40.5
I scored badly in science subjects	8	33.3	35	39.8	18	32.1	61	36.3
Arts stream can promise me a job in the future	4	16.7	18	20.5	12	21.4	34	20.2
Arts stream can give me quality and/or high-income jobs	5	20.8	6	6.8	10	17.9	21	12.5
Others	3	12.5	13	14.8	2	3.6	18	10.7
Total	**24**	**100**	**88**	**100**	**56**	**100**	**168**	**100**

Note: Three respondents from the non-science stream did not respond to this question.

c. Factors that could increase students' interest in science

- All respondents were asked to state the top-three factors that could help increase their interest in science. Out of 965 respondents, about 84% thought that science subjects should be made more fun and interesting, 67.7% felt that there should be more science-related activities/exhibitions available, and 56.3% proposed that science classes should be taught through a hands-on and interactive approach (Table 3.9).
- These answers remain consistent across all types of schools, genders, and streams of study, indicating the need to innovate science teaching methods by making subjects more engaging through technology-assisted lessons (Appendix B: Table 8 and Table 9).

Table 3.9 Factors to help increase students' interest in science

Factors	Science		Non-science		Total	
	No.	% share	No.	% share	No.	% share
Make science more interesting/fun	488	81.6	315	86.8	803	83.6
More science-related activities/exhibitions	411	68.7	240	66.1	651	67.7
A more hands-on/interactive approach during school lessons	374	62.5	167	46.0	541	56.3
More seminars/opportunities to learn	149	24.9	94	25.9	243	25.3
Introduce new laboratories	123	20.6	107	29.5	230	23.9
More emphasis on computer studies	119	19.9	96	26.4	215	22.4
More emphasis on science in school	113	18.9	63	17.4	176	18.3
Others	9	1.5	4	1.1	13	1.4
Total	**598**	**100.0**	**363**	**100.0**	**961**	**100.0**

Note: Four students from the science stream did not respond to this question.

3.4 Current choice of study

Students' decision to enter either the science or non-science stream is hypothesised to be influenced by a number of external factors. This section explores the influence of parents, friends, teachers, and schools over students' choice of stream.

a. Parental attitude

- Students were asked to indicate whether they were urged by their parents into choosing the science stream at Form 4; 34.7% or 335 respondents said they were urged by their parents. The majority were from CSE (44.8%), followed by non-HPS/CSE (30.1%) and HPS (25.1%).
- Table 3.10 shows a significant difference in parental attitudes towards science when comparing science and non-science students. Overall, the parents of non-science students were much less likely to have urged students to choose the science stream. Only 18.5% of non-science students were asked to study science, compared with 44.5% of science students.
- A large percentage of science students from HPS said they were urged by their parents to study in the science stream (47.5%, 77 respondents). While a large proportion of non-science students said their parents were not involved in the student's choice of study stream, 18.5% of parents urged their children to study in the science stream (Table 3.10).
- Among parents with tertiary education, a larger percentage of them had urged their children to study science (father: 38%, 147 respondents; mother: 38.9%, 146 respondents), despite a majority of parents not being involved in the study stream selection. (Appendix B: Table 10).
- While fathers with jobs related to science made up only a quarter of the sample, a relatively higher percentage of them had urged their children to study in the science stream (41.5%, 95 respondents). Likewise, though only 10% of mothers working in science-related jobs, the survey found that nearly half of these mothers urged their children to take up the sciences (49.5%, 46 respondents) (Appendix B: Table 11). This appears to indicate that mothers may play a central role in encouraging their children to enrol in science studies.
- Out of 335 respondents whose parents urged them to attend science classes, more than half of their parents said that the science stream would be good for their future, with a slightly higher percentage of students from CSE (53.3%) and non-HPS/CSE (53.5%) stating this reason, compared with HPS (51.2%). About one-third of parents told their children that the science stream will provide them with high-income jobs, particularly those from HPS (44%) compared with CSE (36%) and non-HPS/CSE (22.8%).

Table 3.10 Students urged by their parents to study in the science stream

Stream and type of school	Yes		No		Total	
	No.	% share	No.	% share	No.	% share
Science	*268*	*44.5*	*334*	*55.5*	*602*	*62.4*
HPS	77	47.5	85	52.5	162	16.8
CSE	122	43.4	159	56.6	281	29.1
Non-HPS/CSE	69	43.4	90	56.6	159	16.5
Non-science	*67*	*18.5*	*296*	*81.5*	*363*	*37.6*
HPS	7	14.3	42	85.7	49	5.1
CSE	28	14.6	164	85.4	192	19.9
Non-HPS/CSE	32	26.2	90	73.8	122	12.6
Total	**335**	**34.7**	**630**	**65.3**	**965**	**100.0**
HPS	84	39.8	127	60.2	211	21.9
CSE	150	31.7	323	68.3	473	49.0
Non-HPS/CSE	101	35.9	180	64.1	281	29.1

b. *Peer influence*

- All surveyed students were asked to reveal whether they were influenced by friends when selecting the stream of study.
- Table 3.11 shows that nearly 37% of respondents were influenced by friends and 63% were not influenced by friends.
- In essence, science students were more likely to have been influenced by friends when selecting streams of study (44%, 263 respondents) compared with non-science students (25.3%, 92 respondents).
- In terms of gender, males were more likely to be influenced by friends compared with females. Out of 392 male respondents, about 40% were influenced by their peers while 34.8% of female respondents were influenced by their peers (Appendix B: Table 13).

c. *Teacher performance*

- When students were asked to indicate whether their science teachers met their expectations in learning science, more than half reported that science classes conducted by teachers were able to meet their expectation (57.5%, 555 respondents), and only about 17% of the total respondents felt otherwise (Table 3.12).
- A majority of teachers who taught science classes in the science stream were able to meet students' expectations (59.1%, 356 respondents) compared with teachers who taught science in the non-science stream (54.8%, 199 respondents). This is despite the fact that a relatively large percentage of students were uncertain about their teachers' performance (21.3% from science students; 32.8% from non-science students).
- Science students from CSE were more likely to feel that their teachers met their expectations (63.7%, 179 respondents), followed by HPS (59.3%, 96 respondents) and non-HPS/CSE (50.9%, 81 respondents). Meanwhile, 75.5% of non-science students from HPS thought that their

teachers were able to meet their expectations, followed by non-science students from CSE (59.4%, 114 respondents) and non-HPS/CSE (39.3%, 48 respondents).

- About 17% or 163 students said that science classes had not met their expectations, a majority of these students were from the science stream (72.4%, 118 respondents) (Table 3.12). Science classes that were too heavily exam-oriented were the top reason why these classes failed to meet students' expectation; males accounted for nearly 59% or 96 students predominating by males. This is followed by *teachers are not innovative and creative* (41.1%, 67 respondents) and *too textbook-oriented* (39.9%, 65 respondents).

- Figure 3.14 shows that more than half of science students have said that science classes were too exam-oriented; 55.4% or 36 respondents were from CSE (Appendix B: Table 14). Meanwhile, 35.8% or 19 science students from HPS said that science teachers were not innovative or creative compared with non-HPS/CSE (34%, 18 respondents) and CSE (30.2%, 16 respondents) (Appendix B: Table 14). However, CSE was deemed to be more textbook-oriented (48.9%, 22 respondents) compared with HPS (26.7%, 12 respondents) and non-HPS/CSE (24.4%, 11 respondents).

- Science students also said that teachers did not explain the material well even though technology-assisted teaching approaches were used in science classes. One science student said that teachers would rush their classes in order to finish chapters in textbooks, which led to a large amount of homework.

Table 3.11 Students influenced by peers in stream of study selection by type of school

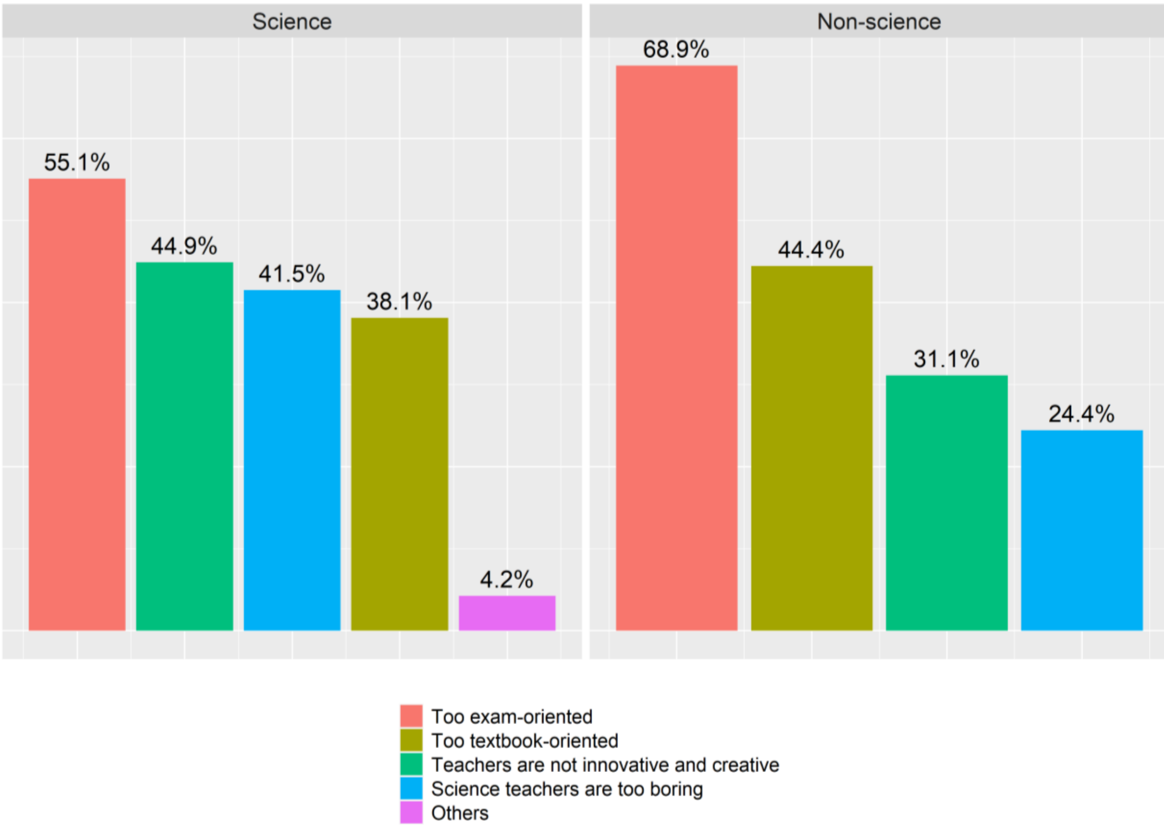
Stream and type of school	Yes		No		Total	
	No.	% share	No.	% share	No.	% share
Science	*263*	*44.0*	*335*	*56.0*	*598*	*62.2*
HPS	73	46.2	85	53.8	158	16.4
CSE	124	44.1	157	55.9	281	29.2
Non-HPS/CSE	66	41.5	93	58.5	159	16.5
Non-science	*92*	*25.3*	*271*	*74.7*	*363*	*37.8*
HPS	9	18.4	40	81.6	49	5.1
CSE	44	22.9	148	77.1	192	20.0
Non-HPS/CSE	39	32.0	83	68.0	122	12.7
Total	**355**	**36.9**	**606**	**63.1**	**961**	**100.0**
HPS	82	39.6	125	60.4	207	21.5
CSE	168	35.5	305	64.5	473	49.2
Non-HPS/CSE	105	37.4	176	62.6	281	29.2

Table 3.12 Ability of teachers to meet students' expectation to learn science by type of schools

Stream and type of school	Yes		No		Don't know		Total	
	No.	% share	No.	% share	No.	% share	No.	% share
Science	*356*	*59.1*	*118*	*19.6*	*128*	*21.3*	*602*	*62.4*
HPS	96	59.3	31	19.1	35	21.6	162	16.8
CSE	179	63.7	52	18.5	50	17.8	281	29.1
Non-HPS/CSE	81	50.9	35	22.0	43	27.0	159	16.5
Non-science	*199*	*54.8*	*45*	*12.4*	*119*	*32.8*	*363*	*37.6*
HPS	37	75.5	2	4.1	10	20.4	49	5.1
CSE	114	59.4	24	12.5	54	28.1	192	19.9
Non-HPS/CSE	48	39.3	19	15.6	55	45.1	122	12.6
Total	**555**	**57.5**	**163**	**16.9**	**247**	**25.6**	**965**	**100.0**
HPS	133	63.0	33	15.6	45	21.3	211	21.9
CSE	293	61.9	76	16.1	104	22.0	473	49.0
Non-HPS/CSE	129	45.9	54	19.2	98	34.9	281	29.1

Figure 3.14 Areas of science classes that did not meet students' expectation

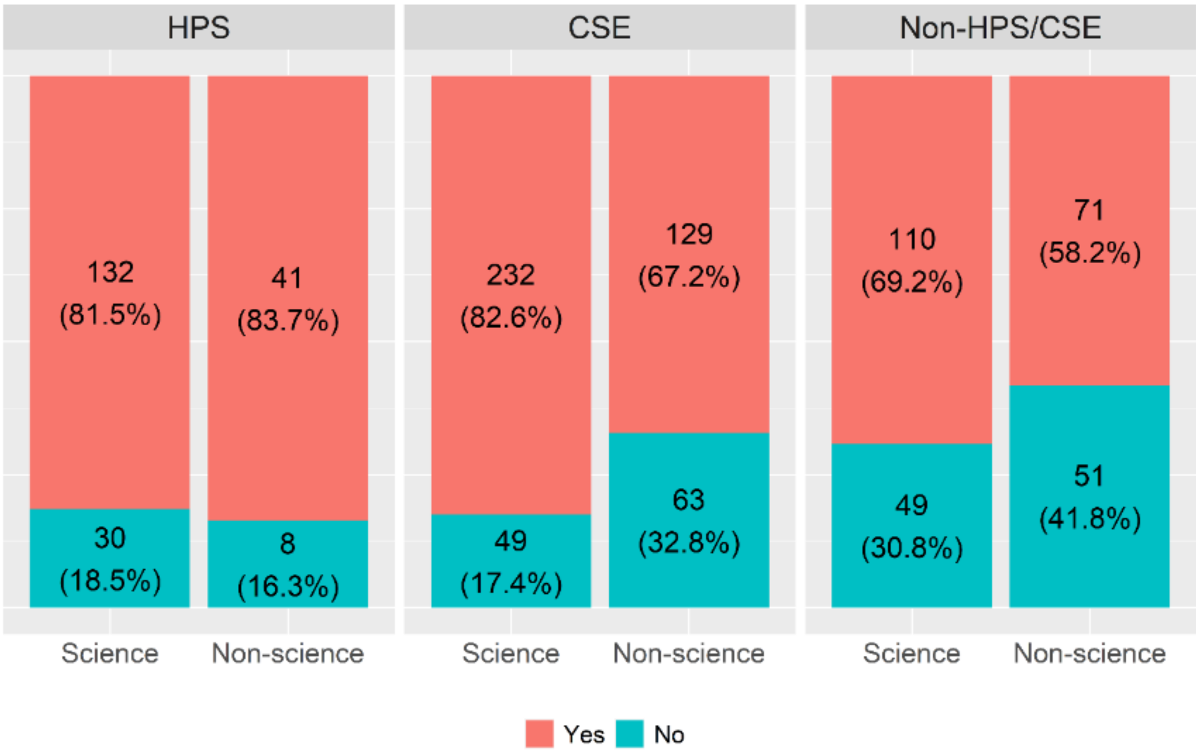
Science students= 118; non-science students = 45



d. School motivation

- Out of 965 respondents, about 74% or 715 indicated that they were motivated by their schools to learn science. Females made up about 58% while the remaining 42% comprised males (Appendix B: Table 16).
- About two-thirds of these students were from the science stream, and one-third came from the non-science stream.
- Half of these respondents were from CSE (50.5%, 361 respondents) followed by non-HPS/CSE (25.3%, 181 respondents) and HPS (24.2%, 173 respondents).
- As can be seen in Figure 3.15, a larger proportion of science students from CSE and non-HPS/CSE appeared to agree on the role of the school in motivating students to learn science compared with those from the non-science stream. No significant difference between responses from science and non-science streams were found in HPS.

Figure 3.15 Students' responses to schools motivating them to learn science
Science students in HPS = 162; CSE = 281; Non-HPS/CSE = 159
Non-science students in HPS = 49; CSE = 192; Non-HPS/CSE = 122



- Respondents who agreed that the school should play a motivating role were then directed to questions pertaining to the nature of motivation offered by schools. A total of 13 statements were presented to students regarding the pedagogical strategies and school environment.
- On a Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree), the overall mean score for pedagogical strategies (mean = 3.64)—associated with general instructional approaches for student learning—was higher than the mean score perceived by students on

school environment in learning science—science learning activity and science facility (mean = 3.51) (Table 3.13).

- Within pedagogical strategies, the mean score perceived by students in when teachers use real-life examples in science classes was the highest at 3.84, followed by teachers who provided assistance to understand science concepts (mean = 3.82) and encouragement by teachers to participate in science subjects (mean = 3.76).
- On average, science students rated pedagogical strategies (mean = 3.71) higher than their students in the non-science stream (mean = 3.51). All eight statements under pedagogical strategies were statistically significant between science and non-science streams, except *science classes are exciting* and *teachers regularly update us with the latest developments in science and technology*, which were rated the lowest at 3.48 and 3.37, respectively. All respondents from science students tended to rate these statements higher than those from non-science classes.
- For school environment, five statements were categorised into this factor, and science students again rated a higher mean score (mean = 3.55) compared with non-science students (mean = 3.43), with only two statements being significantly different between science and non-science students (Table 3.13). These two statements were *school creates a cooperative environment among students towards learning science subjects* (p = 0) and *a variety of internal science-related activities and clubs* (p = 0.02).

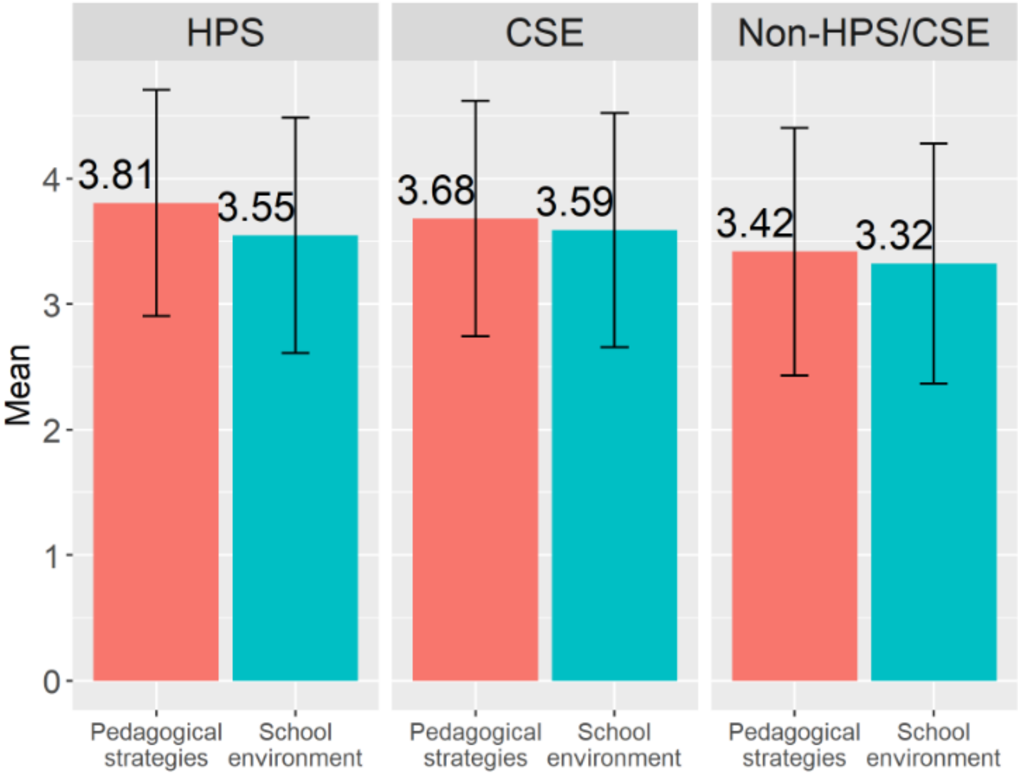
Table 3.13 Mean score and U-value of students' perceptions of factors motivating science learning in schools by stream of study

Statements	Mean			Mann-Whitney U-value^
	Total	Science	Non-Science	
Factor 1: Pedagogical strategies	3.64	3.71	3.51	-
Teachers use real-life examples in science classes.	3.84	3.93	3.68	65,861**
Teachers assist us to understand science concepts.	3.82	3.91	3.63	66,879**
Teachers encourage us to participate in learning science subjects.	3.76	3.85	3.57	67,114**
Highly inspiring and enthusiastic science teachers	3.64	3.71	3.52	63,416**
Teachers identify students' learning needs and difficulties in science subjects.	3.63	3.70	3.47	65,401**
I am motivated to conduct experiments independently.	3.62	3.72	3.44	67,185**
Science classes are exciting.	3.48	3.53	3.40	60,545
Teachers regularly update us with the latest developments in science and technology.	3.37	3.35	3.39	56,049
Factor 2: School environment	3.51	3.55	3.43	-
Highly supportive science environment with complete laboratories and science tools	3.57	3.61	3.48	61,568
Various external science programmes such as visiting National Science Centre, Tech Dome, Penang Science Cluster, etc.	3.56	3.59	3.48	60,746
School creates cooperative environment among students towards learning science subjects.	3.55	3.63	3.39	64,785**
A variety of internal science-related activities and clubs	3.50	3.54	3.41	62,660*
Science activities held in school are sufficient to encourage science learning.	3.39	3.39	3.40	56,454

^ Mann-Whitney U test is used to compare the differences between two categorical groups, i.e. science and non-science streams, that are independent and not normally distributed.
*$p<0.05$; **$p<0.01$

- Furthermore, Figure 3.16 depicts that the mean value for pedagogical strategies was rated the highest in HPS (3.81), followed by CSE (3.68) and non-HPS/CSE (3.42). Meanwhile, the mean value for the school environment factor was at almost the same rate at HPS (3.55) and CSE (3.59), but the lowest mean value was found in non-HPS/CSE schools (3.32). This suggests that CSE and non-HPS/CSE have to improve instructional methods for science learning, while non-HPS/CSE should be given more support to provide a conducive learning environment for students to love science.

Figure 3.16 Mean score of students' perceptions for factors motivating science learning by type of school



Note:

1. Likert-type scale:1=Strongly disagree; 2=Disagree; 3=Neutral; 4=Agree; 5=Strongly agree
2. The error bars represent one standard deviation from the mean values.

- Out of 965 respondents, students who did not think that school had motivated them into learning science made up about 26% or 250 respondents. Of these, 61.2% were females and 38.8% were males. More than half of the female respondents were from the non-science stream (55.6%, 85 respondents) compared with those from the science stream (44.4%, 68 respondents) (Appendix B: Table 16).

- Non-HPS/CSE had the highest percentage of students claiming that school had demotivated them from learning science—both science (30.8%, 49 respondents) and non-science streams (41.8%, 51 respondents) (Figure 3.15).

- CSE had more non-science students indicating that their schools had not motivated them to learn science (32.8%, 63 respondents) compared with science students (17.4%, 49 respondents). This is in contrast with responses from HPS, where only 16.3% or 8 non-science students disagreed that their schools motivated them in their science studies, while 18.5% or 30 respondents from the science stream disagreed.

- When students were asked to rate factors demotivating them from learning science, *too exam-oriented science classes* gained the highest score, with a mean score of 3.54 (agree), followed by *science teachers are too boring* (mean = 3.35) and *inadequate teaching time to conduct experiments in laboratories* (mean = 3.31) (Table 3.14).

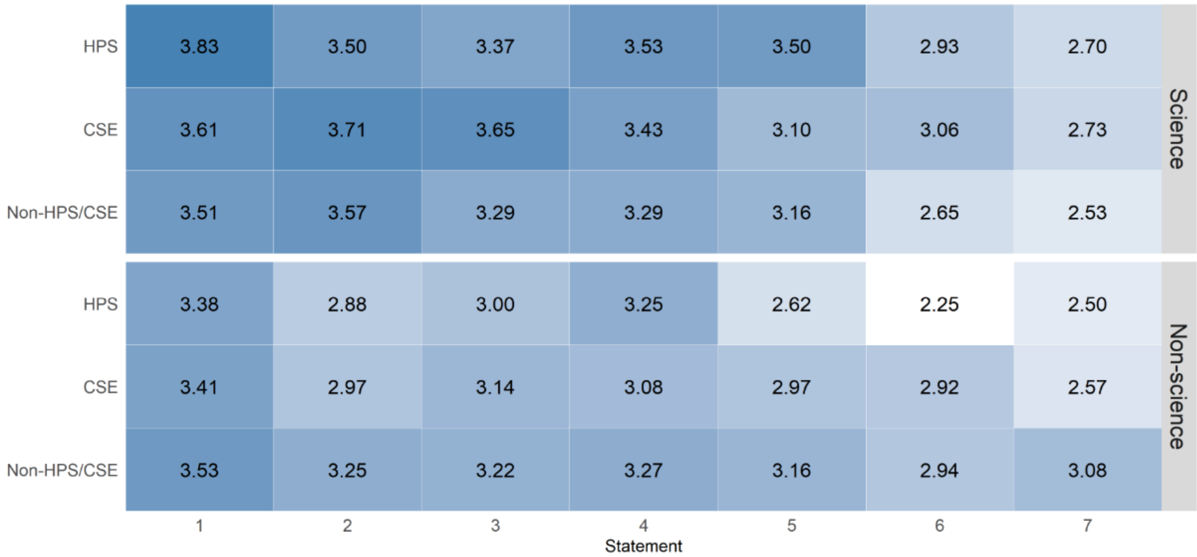
- Science students had a higher mean value for all demotivating factors except *large number of students in the class and laboratories* and *lack of laboratories*.
- Among seven demotivating factors, only *science teachers are too boring* and *inadequate teaching time to conduct experiment in laboratories* were statistically significantly different between science and non-science streams (p = 0). The former is consistent with the earlier finding where *exciting science classes* was the second-lowest mean score rated by students across all types of school.
- Regardless of stream of study, students from all types of schools perceived that science classes are too exam-oriented, with students from HPS scoring the highest mean at 3.83 (compared with CSE = 3.61 and non-HPS/CSE = 3.51), despite pedagogical strategies being perceived as the most effective science learning methods among all types of school (Figure 3.17).
- Meanwhile, students from CSE and non-HPS/CSE rated *science teachers are too boring* as the top reason demotivating them from learning science. Students from CSE also perceived that teaching time was inadequate when experiments were conducted in laboratories with a mean score of 3.65, which was the highest mean recorded across all school types of science classes.
- For policy interventions, concerted efforts are necessary to reduce exam-oriented science studies in all types of schools. Special attention is needed to focus on pedagogical strategies in CSE and non-HPS/CSE owing to the highest mean scores given for *science teachers were too boring* by students in both types of schools (CSE = 3.71; non-HPS/CSE = 3.57).

Table 3.14 Mean score and t-statistics of students' perceptions of factors demotivating science learning in schools by stream of study

Statements	Total	Science	Non-science	t-statistic
Too exam-oriented science classes	3.54	3.63	3.46	-1.22
Science teachers are too boring	3.35	3.61	3.08	-3.71**
Inadequate teaching time to conduct experiments in laboratories	3.31	3.45	3.16	-2.53**
Lack of teaching and learning materials such as chemicals	3.29	3.40	3.17	-1.89
Inadequate number of science teachers	3.12	3.22	3.02	-1.73
Large number of students in the class and laboratories	2.88	2.88	2.89	0.08
Lack of laboratories	2.71	2.65	2.78	1.07

Note: Kaiser-Myer-Olkin measure shows that all statements were independent and cannot be grouped together in any form. Therefore, factor analysis is not appropriate for this set of data.
**p<=0.01

Figure 3.17 Heat map for mean score on demotivating factors by type of school and stream



References for statements:

1	Too exam-oriented science classes
2	Science teachers are too boring
3	Inadequate teaching time to conduct experiments in laboratories
4	Lack of teaching and learning materials such as chemicals
5	Inadequate number of science teachers
6	Large number of students in the class and laboratories
7	Lack of laboratories

3.5 Future study plans

Upper-secondary students from all types of schools were requested to indicate their future study plans in tertiary education either to pursue STEM-related courses or non-STEM-related courses. Students then shared the areas of STEM courses that interest them the most. Students who do not intend to pursue STEM courses in tertiary education were requested to state their reasoning.

- Out of 965 respondents, over half or 508 respondents stated that they intended to study STEM courses in tertiary education, and only 16.5% or 159 respondents planned to pursue non-STEM courses.

- A large percentage of students who attended science classes will pursue STEM courses at the tertiary level (72.4%). About 46% of non-science students were uncertain about their future study plans, 34.4% of non-science students were more inclined to pursue non-STEM-related courses, and 19.8% intended to pursue STEM-related courses. This means that the dropout rate of students from their respective stream is not significant.

- Among students expressing an interest in STEM courses at the tertiary level, their intended field of study varied greatly according to gender and stream of current study. Out of 245 female respondents from the science stream, Medicine (52.2%), Biology (48.6%), Pharmacy (30.6%), Physics (22%), and Astronomy (22%) were the most popular courses while Engineering (34.6%), Physics (31.4%), Biology (28.8%), Mathematics & Statistics (25.1%), and Artificial Intelligence (25.1%) were favoured by male respondents from the same stream (Appendix B: Table 21). This again coincides with the earlier finding where females tend to be more interested in health and life sciences and males are interested in engineering and physical sciences (Section 3.3).

- While the number of non-science students who were intended to pursue STEM courses were insignificant, their interest in STEM courses is encouraging. Out of 72 respondents, nearly 42% planned to pursue Mathematics & Statistics, about 32% intended to pursue Astronomy, and 25% were inclined to study Computer Science. It is surprising to discover that only non-science students were interested in Computer Science (25%), Information Technology (12.5%), and Machine Learning-related courses (12.5%), which were not chosen by science students.
- About 31% or 298 respondents were unable to decide on their study plans during the survey. This is largely seen in the non-science stream in each type of school. Non-HPS/CSE had a particularly large share of science respondents who did not have enough information to decide on studying science during Form 4. These students need more information regarding their future study choices in the science stream when they choose their stream of study.

Figure 3.18 Science students' interest level in STEM courses

Total respondents = 436

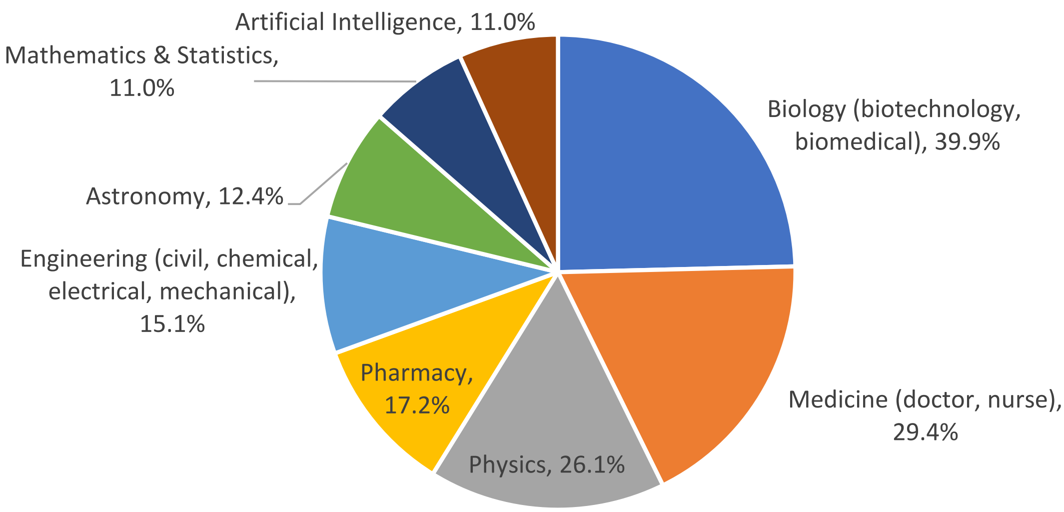
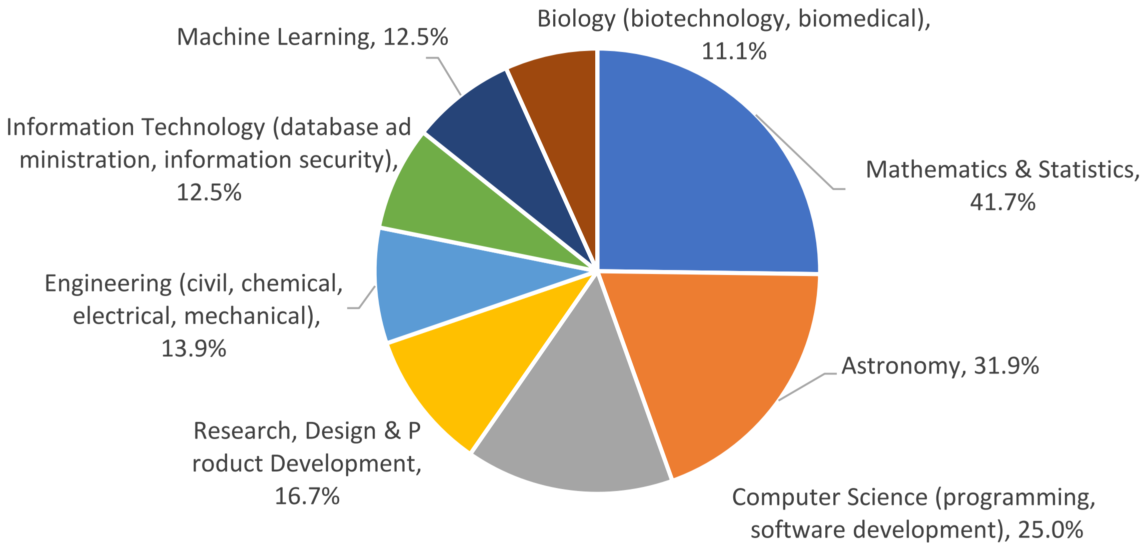


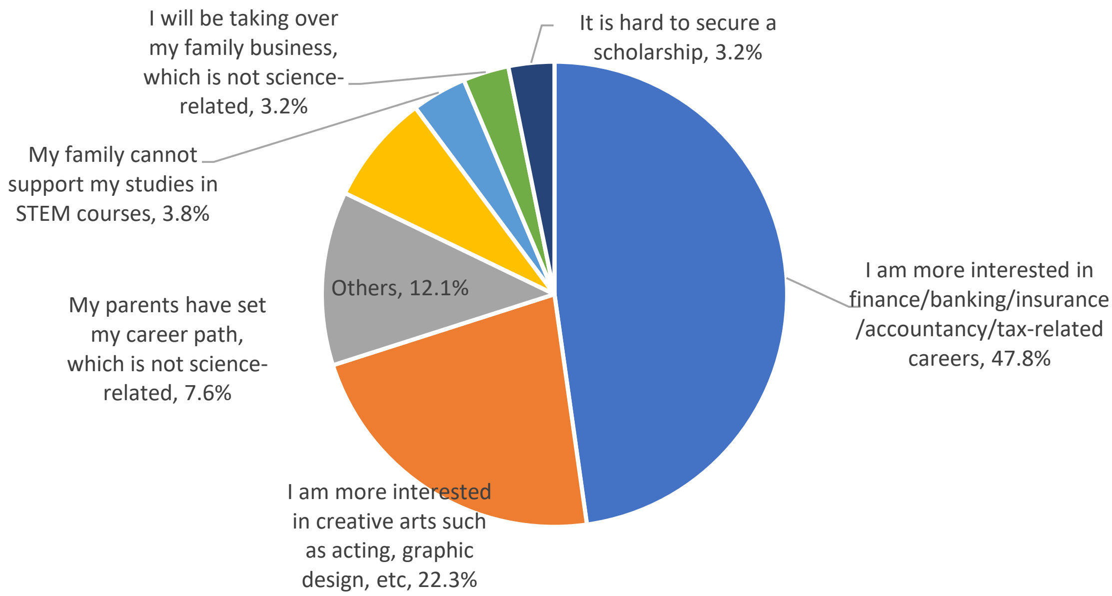
Figure 3.19 Non-science students' interest level in STEM courses
Total respondents = 72



- Out of 157 respondents who did not intend to pursue STEM courses at the tertiary level, nearly 48% said that they were more interested in finance/banking/insurance-related careers (Figure 3.20); a majority of these were from the non-science stream (Appendix B: Table 22). Out of 34 science students, only 9 respondents planned to work in this area, and about 22 were more interested in creative arts, law, politics, and hospitality-related careers.
- In general, non-science students face relatively more challenges compared with science students; about 9% have stated that their career paths had already been set by their parents compared with 3% for science students, while 5% indicated that their families could not support their STEM education, whereas no science student have indicated this.

Figure 3.20 Reasons for not pursuing STEM courses at the tertiary level

Total respondents = 157



3.6 STEM career plan

After assessing plans for future studies, students were asked about plans for their careers. While results showed that there was a large proportion of students who were unsure about their future studies, this uncertainty lessened significantly when it came to future careers. Similar to tertiary education choices, most students planned to opt for career choices consistent with their streams.

- On a whole, out of 595 respondents, three-quarters of science students will consider STEM-related careers. The remaining one-quarter planned to either work in non-STEM-related careers, work in a family business that is not related to STEM, depend on parents' wishes, or were unable to decide (Appendix B: Table 24).

- Approximately 70% of non-science students would look for careers that are not related to STEM, be it in the finance or banking industries (50%) or others (18.9%) such as creative arts, hospitality, mass communication, law, and literature.

- Based on Figure 3.21, non-science students tended to see themselves working in the finance sector or other non-science careers (68.9%), while roughly 10% were considering STEM careers. This was the inverse for science students; the vast majority of science students expressed an intention to work in STEM industries (76%), while 10% thought they would go into non-science careers.

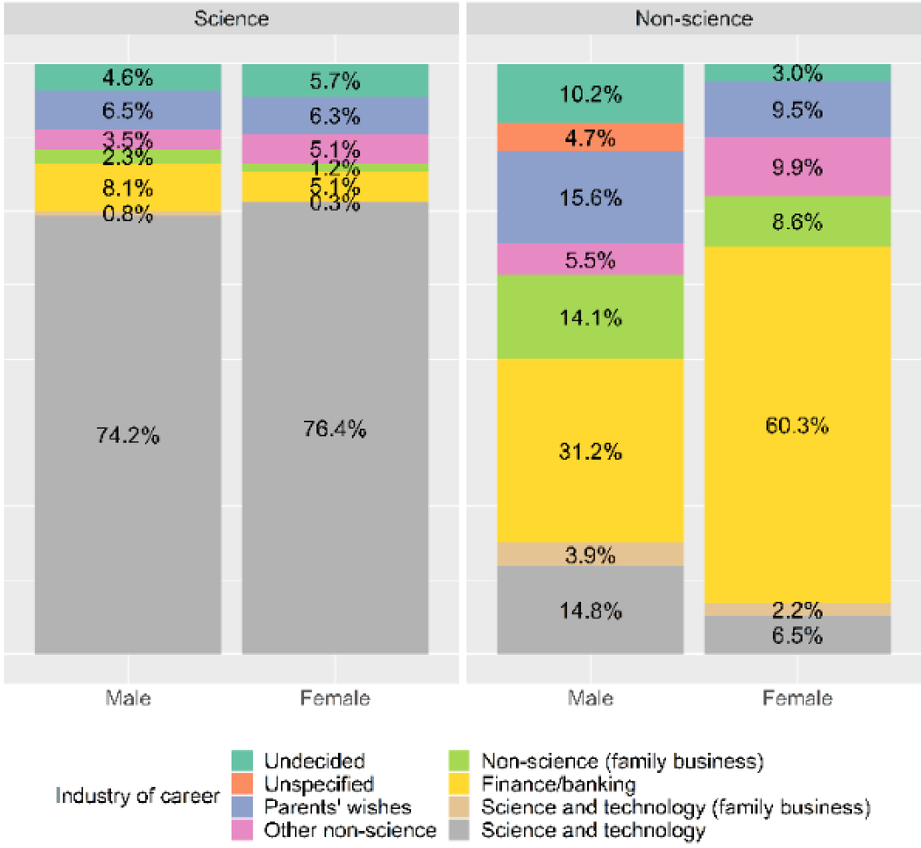
- It is interesting to note that some students are committed to entering the family business after graduation. This is more prevalent among non-science students where the family businesses are not in STEM-related fields (14.1% for male and 8.6% for female).

- In terms of school type, non-HPS/CSE had a lower percentage of science students planned to engage in STEM-related careers compared with those in HPS and CSE. HPS on the other hand had the largest percentage of science students intended to enroll in careers unrelated to STEM such as finance and banking (7.6%) and others (e.g. political analyst, creative arts, mass communication, and business) (3.8%) (Figure 3.22).

Figure 3.21 Future career plans for secondary students by gender and stream of study

Male science students = 260; female science students = 335

Male non-science students = 128; female non-science students = 232

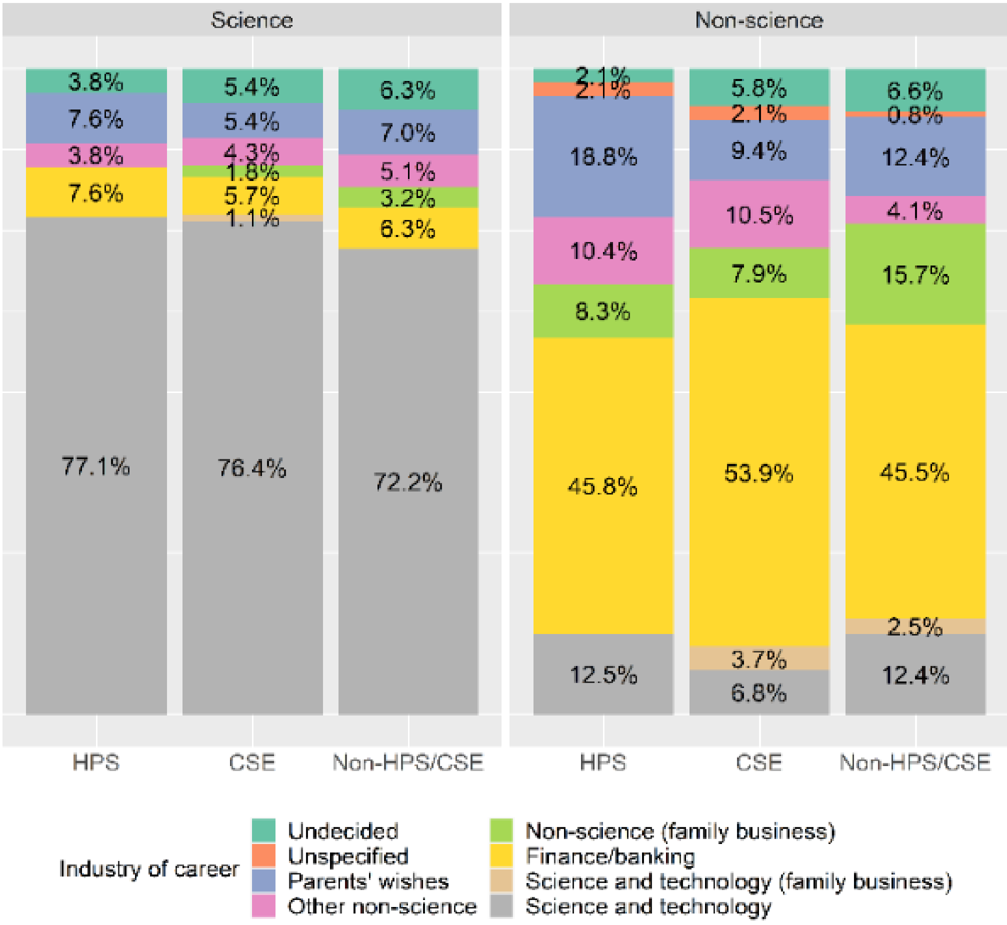


Note: Ten respondents provided inconclusive responses, which cannot be included in this analysis.

Figure 3.22 Future career plans for secondary students by school type and stream of study

Science students: HPS = 157; CSE = 280; Non-HPS/CSE = 158

Non-science students: HPS = 48; CSE = 191; Non-HPS/CSE = 121



Note: Ten respondents provided inconclusive responses, which cannot be included in this analysis.

4 Survey results: Tertiary education

This chapter examines the surveyed students' academic achievements and parental characteristics in persuading students to pursue the STEM field during tertiary education. In addition, this chapter explores factors influencing students' science interest level, current choice of study, and career plans.

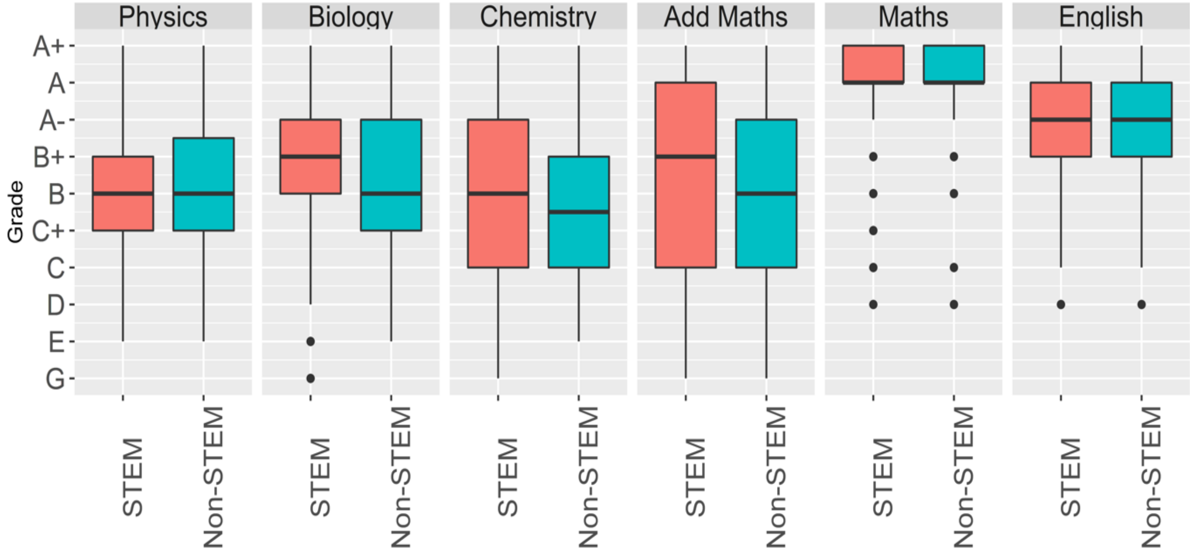
4.1 Academic achievement of respondents

In private higher education institutions, 197 students who graduated from the science stream in secondary education were asked to indicate their SPM exam results for the following subjects: Mathematics, Additional Mathematics (Add Maths), Physics, Biology, Chemistry, and English (Figure 4.1). The academic examination results of science students are summarised as follows:

- Among the four core science-related subjects, namely Biology, Chemistry, Physics and Add Maths, Add Maths had the highest proportion of students scoring "A+", "A", and "A-" in their SPM results (34.2%), followed by Physics (29.9%), Chemistry (24.5%), and Biology (20.1%).
- Add Maths is a subject with the highest share of students failing the subject among both STEM and non-STEM students. Non-STEM had the highest failure rate at about 6.6% compared with 3.2% of STEM students. However, only 1.6% and 1.1% of students (all STEM students) failed Chemistry and Physics, respectively. Add Maths may be relatively more difficult, especially for non-STEM students compared with other science subjects.
- SPM results indicate that STEM and non-STEM students performed almost the same in English and Mathematics. However, STEM students performed slightly better in all main science-related subjects compared with non-STEM students.

Figure 4.1 Whisker box plot of science students' SPM exam results by current field of study

STEM students = 93; Non-STEM students = 91



Note:

1. Out of 197 respondents who graduated from the science stream in secondary education, 13 respondents who did not answer this question were excluded from the results.
2. In the boxplot, the central line represents the median marks, the lower and upper ends of the boxplot represent the 25th (Q1) and 75th (Q3) percentile of the distribution of marks, and the two ends of whiskers extend to ±1.5*IQR from Q1 and Q3, respectively (IQR stand for interquartile range which equals to Q3 minus Q1). The dots represent the outliers.

4.2 Parental characteristics

Students were asked to indicate their parents' highest education level, field of study, and occupational field. While the majority of students could reveal their parents' characteristics, some students said they did not know their parents' jobs and education particulars, with STEM students having the most number of students being unaware[8]. The characteristics of parents of STEM and non-STEM students are presented below.

a. Parents' highest level of education

- In general, the majority of parents have at least secondary education (Table 4.1).
- For STEM students, about 35% of fathers and nearly 29% of mothers had attained tertiary education with the majority of them holding a bachelor's degree, whereas 36% of the parents of non-science students were tertiary-educated.
- For non-STEM students, nearly 50% of their parents attained secondary education versus approximately 45% of parents of STEM students. In general, the level of paternal education was relatively higher than maternal education for both STEM and non-STEM students. This was most pronounced among STEM students.

[8] This may have affected the distribution of parental education and occupation and therefore the analysis.

Table 4.1 Percentage share of parents' highest level of education (%)

Parents' highest education level	STEM students		Non-STEM students	
	Father	Mother	Father	Mother
Higher education	35.1	28.6	36.0	36.0
Ph.D	*1.6*	*0.5*	*0.4*	*0.4*
Masters	*2.2*	*1.1*	*4.0*	*2.8*
Postgraduate Diploma	*0.5*	*0.0*	*0.4*	*1.2*
Bachelor/Degree	*11.9*	*9.2*	*12.1*	*8.1*
Diploma	*8.1*	*5.9*	*8.5*	*8.5*
Certificate	*5.4*	*5.4*	*4.0*	*6.1*
Professional (ACCA, CFA)	*0.5*	*1.1*	*1.6*	*1.6*
Post-secondary (Form 6, Pre-U, A-level)	*4.9*	*5.4*	*4.9*	*7.3*
Secondary level	44.3	46.5	49.8	49.4
Primary level	4.9	6.5	6.5	6.5
No formal education	0.0	0.5	0.0	0.0
Don't know	14.6	16.2	6.5	6.5
Others	1.0	1.6	1.2	1.6
Total responses	**185**	**185**	**247**	**247**

b. Parents' fields of study

- STEM students tended to come from families where their fathers had science backgrounds—approximately 28% of STEM students compared with about 17% of non-STEM students (Table 4.2).
- Similarly, a majority of non-STEM students' parents appeared to be from non-science fields, particularly their mothers, standing at 43.3% compared with 35.1% of STEM students. This indicates an association between parents' field of study and students' choice of study.
- It should be noted that the majority of students, especially STEM students, did not know their parents' field of study. About 35% of STEM students were not aware of their fathers' fields of study, and nearly 40% were unaware of their mothers' fields of study.

Table 4.2 Percentage share of parents' fields of study (%)

Parents' field of study	STEM students		Non-STEM students	
	Father	Mother	Father	Mother
Science/Engineering/Technology	27.6	7.6	17.4	10.1
Non-science	24.3	35.1	36.8	43.3
Don't know	35.1	39.5	33.2	31.2
Not applicable*	13.0	17.8	12.6	15.4
Total responses	**185**	**185**	**247**	**247**

Note: *Refers to parents who had attained primary education or never had a formal education.

c. Parents' current work

- In general, the majority of parents are working in non-science-related occupational fields.
- Disaggregation by stream shows that STEM students were more likely to have parents who are in science-related occupations, especially their fathers (Table 4.3).

- About 21% of STEM students have fathers working in a science industry, while less than 10% of non-STEM students' fathers are working in a science-related industry.

Table 4.3 Percentage share of parents' current work by occupational field (%)

Parents' occupational field	STEM students		Non-STEM students	
	Father	Mother	Father	Mother
Science-related	20.7	6.3	9.6	3.9
Non-science-related	62.6	42.0	72.4	40.3
Unspecified field[a]	9.8	3.4	10.5	6.9
Housewife/Unemployed/Retired	5.2	47.7	5.0	48.5
Not applicable[b]	1.7	0.6	2.5	0.4
Total responses	**174**	**176**	**239**	**233**

Note:

1. A total of 20 and 22 from STEM and non-STEM responses are excluded due to non-responses.
2. [a] Refers to generic responses that did not indicate field. For example, "manager", "businessman", "teacher", "officer", etc.

   [b] Deceased parents

4.3 Students' interest in science

This section describes students' interest and perception in STEM studies in tertiary education. The elements discussed in this section include:

a. General interest in science;
b. Factors that led to an interest in STEM, or lack thereof;
c. Areas of STEM found to be the most interesting; and
d. Factors that could increase students' interest in STEM.

Students were asked about their general interest in science on a five-scale rating where zero meant no interest at all and four meant very interested. Students also responded to questions related to factors leading to their interest in STEM, as well as factors that could help increase students' level of interest.

a. General interest in science

- Out of 432 college students, approximately 29% or 124 students reported a low score, which means they were rather not interested or not interested at all in science subjects. More than half (53%, 229 respondents) indicated a high score for their interest in science. They were *very interested or rather interested*. The average score obtained by the whole sample was about 2.2, which corresponds to *neither interested nor disinterested* (Table 4.4).
- Results indicate that students studying STEM courses were more interested in science compared with their non-STEM peers (Figure 4.2).
- Among STEM students, 67% or 124 respondents were *rather interested* or *very interested* in science. The average score for STEM students was 2.6.

- Interestingly, the majority of non-STEM students indicated that they are *very interested* or *rather interested* in science (42.5%, 105 respondents) and only 37.2% were rather not interested or not interested at all. However, the average score was only 1.9.
- In general, male students were more interested in science than female students (Figure 4.3). About 20.3% of male respondents were very interested in science compared with 9.7% of females.

Table 4.4 Students' level of interest in STEM subjects

	Interest level					Total
	0	1	2	3	4	
Number of respondents	74	50	79	162	67	432
% respondents	17.1	11.6	18.3	37.5	15.5	100

Note: 0 – Not interested at all; 1 – Rather not interested; 2- Neither interested nor disinterested; 3 – Rather interested; 4 – Very interested

Figure 4.2 Students' level of interest in science by field of study

STEM students = 185; Non-STEM students = 247

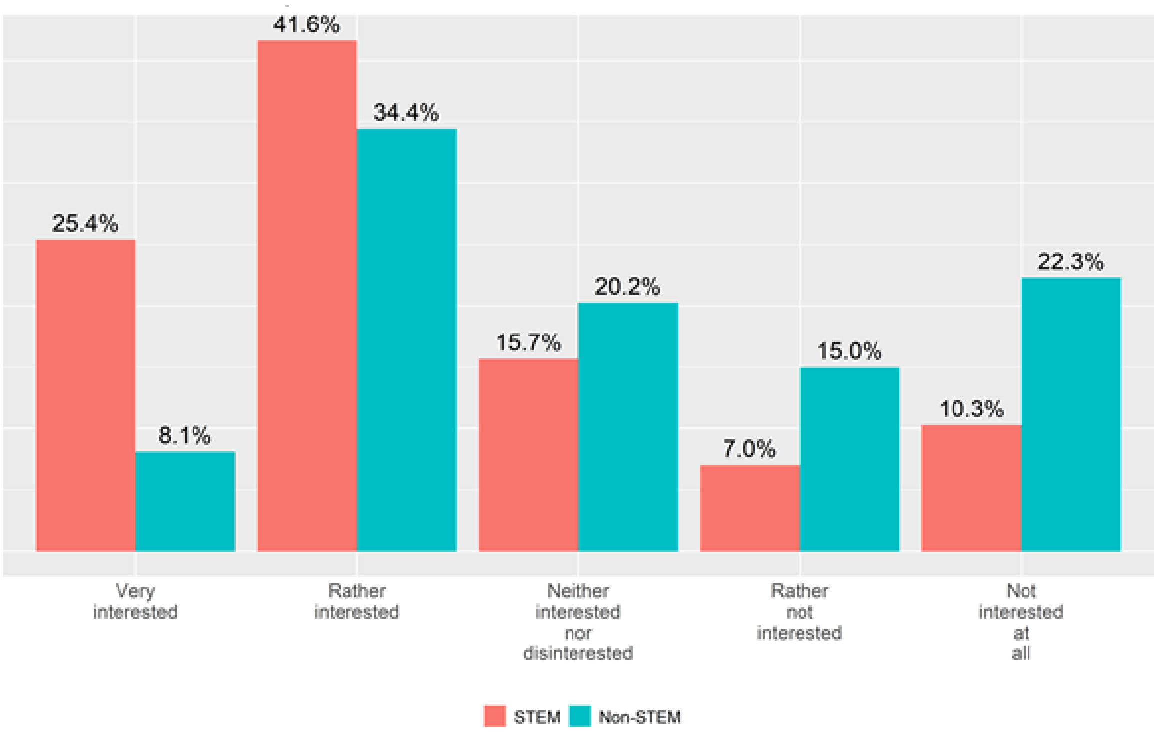
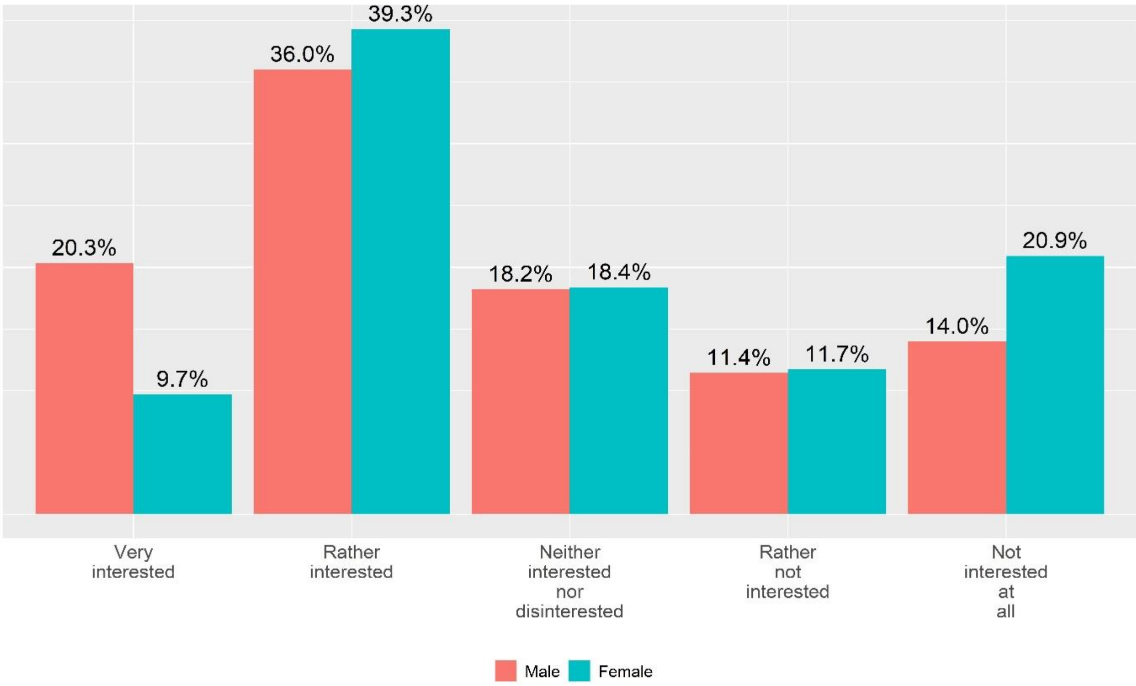


Figure 4.3 Students' level of interest in science by gender

Male students = 236; Female students = 196



b. Factors that led to an interest in science or lack thereof

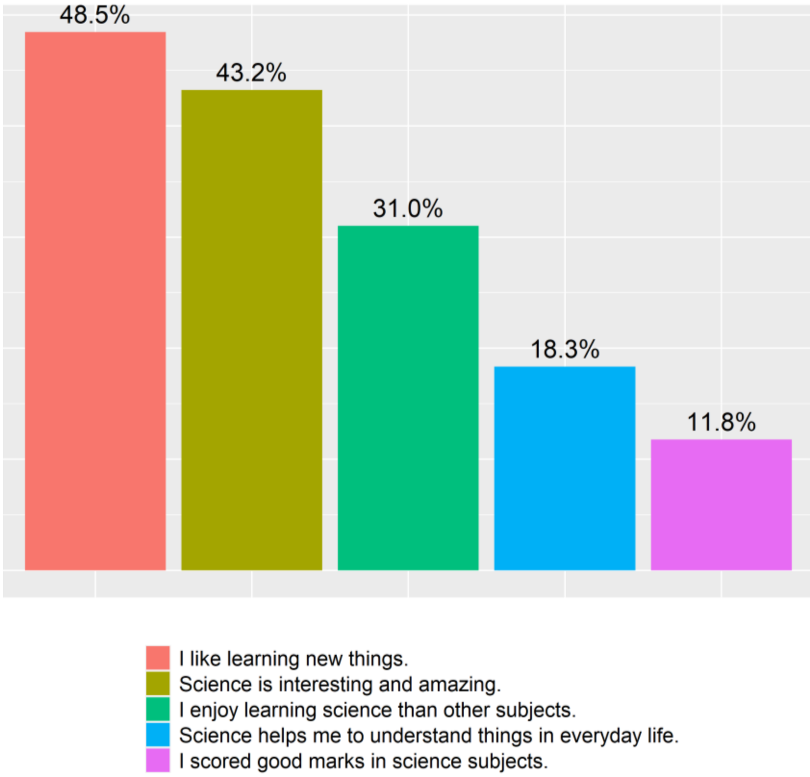
- Results show that the science interest level of tertiary students was highly linked to their secondary stream of study, current field of study, and science class satisfaction. The model estimates are summarized in Appendix C: Table 1.

- For students who were interested in science, the major reasons for liking science were *learning new things* (48.5% or 111 respondents) and *science being an interesting and amazing* subject (43.2% or 99 respondents) (Figure 4.4). This result is the same for both STEM and non-STEM students.

- Similarly, the majority of males (48.9%, or 65 respondents) like science because they are *learning new things*, while nearly half of female respondents (49%, or 47 respondents) like science mostly because they think *science is interesting and amazing* (Appendix C: Table 2).

Figure 4.4 Percentage share of students by reasons for liking science

Students interested in science = 229



- Respondents who claimed that they were not interested in science were asked to identify the main factors that have affected their lack of interest in STEM. Half of them (62 respondents) never had any interest or liking for science. Nearly 48% or 59 respondents said that science subjects are difficult (Figure 4.5). Main difficulties that students faced when studying STEM subjects included *understanding science concepts* (32.3%, 21 respondents) and *memorising science theories, terms, and formulae* (23.1%, 15 respondents) (Appendix C: Table 3).

- Main factors affecting STEM and non-STEM students' lack of interest in STEM were that they found the STEM subjects difficult (59.4%) and never had interest or liking for science (51.1%). Similarly, male and female students' lack of interest in STEM are mainly attributed to difficulty of science subjects and never having any interest or liking for science (Appendix C: Table 4).

- STEM students were asked why they are studying STEM courses despite being not interested. The majority (93.8%) stated that they chose STEM because of the future job opportunities (Figure 4.6).

Figure 4.5 Reasons for lack of interest in science

Students not interested in science = 124

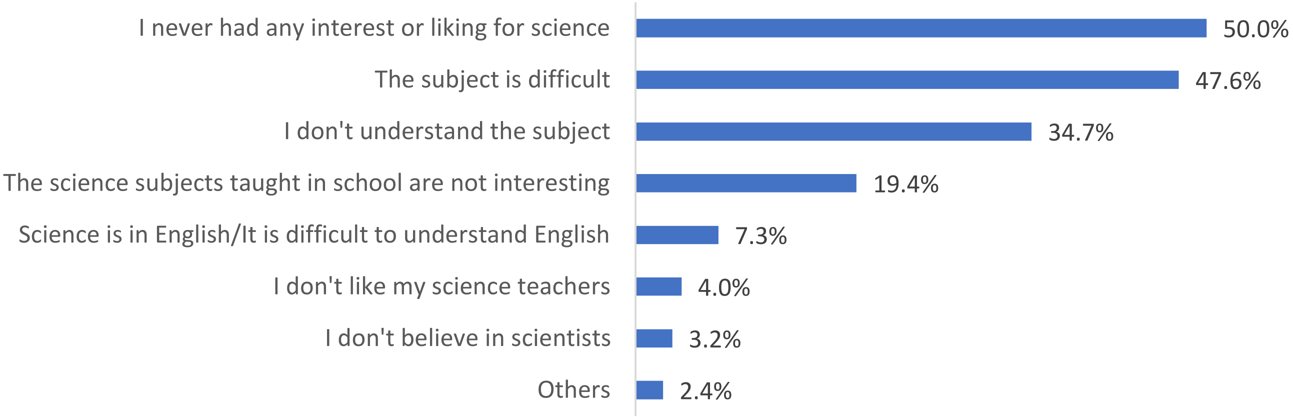
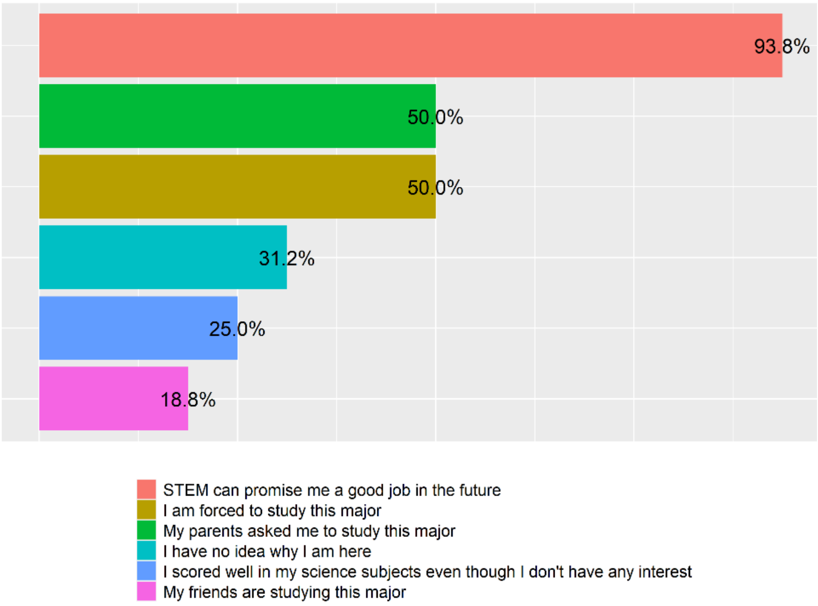


Figure 4.6 Reasons why students pursue a STEM education despite disinterest in STEM

STEM students not interested in science = 16



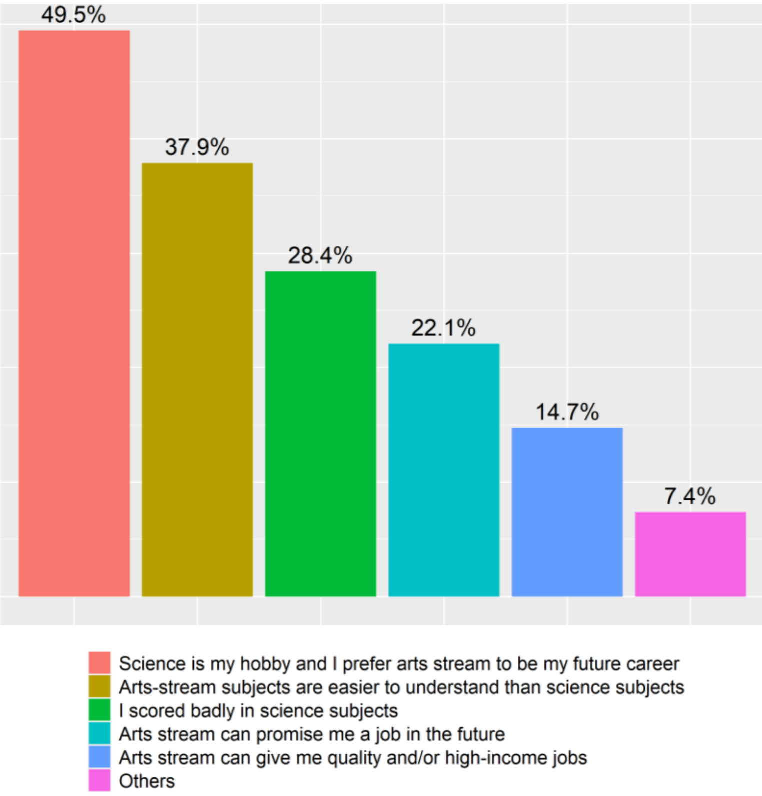
Note: Sixteen students who were in the STEM field thought that they were enrolled in a non-STEM field and did not answer this question.

- Non-STEM students who were interested in science were asked why they are currently in the arts stream. Nearly half of them (49.5%, or 47 respondents) stated that science is their hobby and they prefer the arts stream to be the basis for their future careers. About 38% or 36 respondents mentioned that arts-stream subjects are easier to understand, while more than 28% or 27 respondents opted for non-STEM subjects because they performed badly in science subjects in secondary school (Figure 4.7).

- Out of 95 non-STEM students who are interested in science, 45 students were previously in the science stream in their secondary school. Similarly, 48.9% said that science is their hobby and preferred the arts stream to be the basis for their future careers. About 35.6% chose the arts because they scored badly in science subjects (Appendix C: Figure 1).

Figure 4.7 Reasons for not enrolling in STEM despite having interest in science

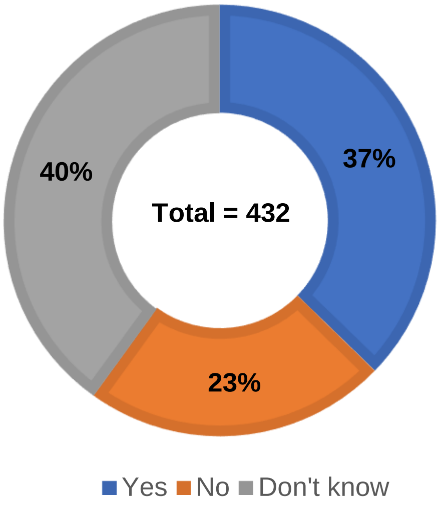
Non-STEM students interested in science = 95



Note: Ten students who did not answer this question were excluded.

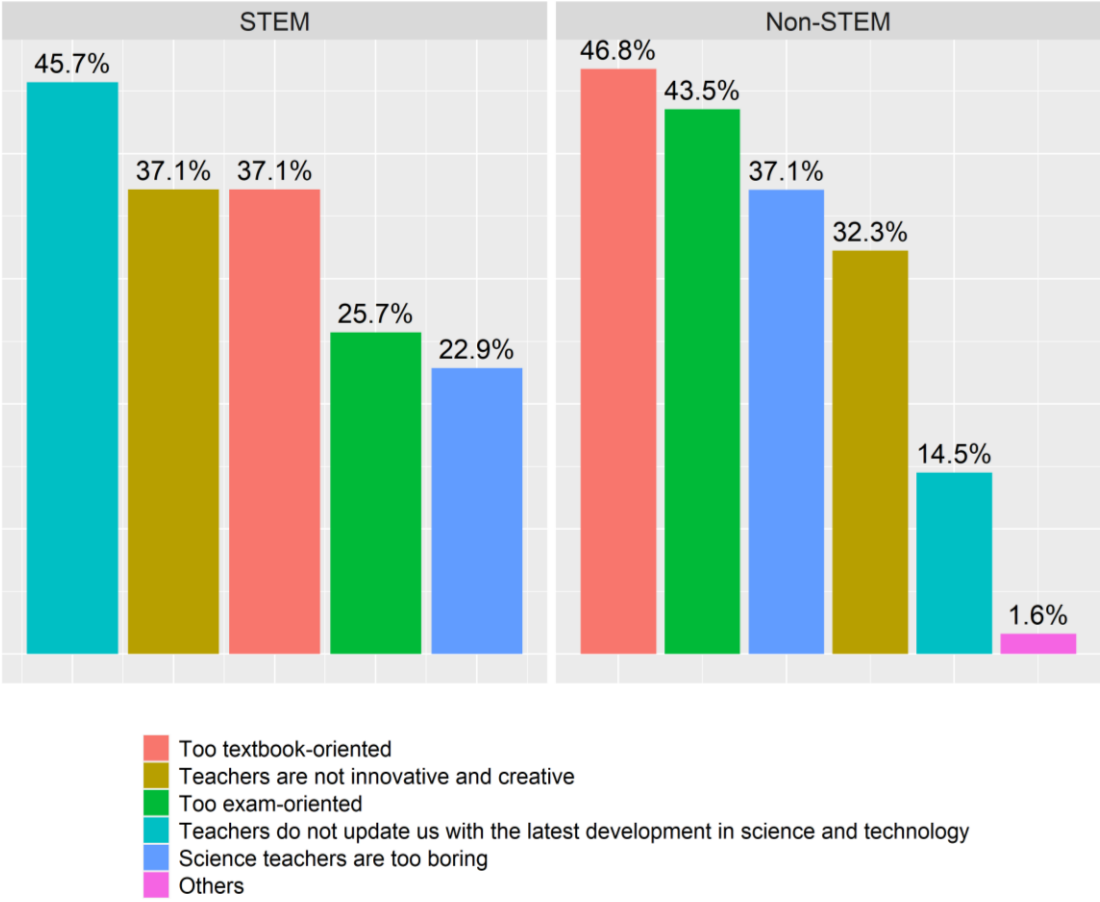
- Students were asked if their teachers/lecturers met their expectations in learning STEM. About 37% or 161 respondents were satisfied with classes and 23% or 98 respondents said that classes have not met their expectations (Figure 4.8).

Figure 4.8 Students' satisfaction with science classes



- Those who expressed dissatisfaction with their science classes were asked to indicate their areas of dissatisfaction. Overall, too textbook- and/or exam-oriented science lessons as well as uncreative teachers were the main causes of dissatisfaction. Disaggregating by field of study shows that about 46% or 16 STEM students stated that teachers did not update them with the latest development in science and technology. However, non-STEM students (46.8%, or 29 respondents) were more dissatisfied by the teaching methods, which were textbook- and/or exam-oriented (Figure 4.9).

Figure 4.9 Share of students by areas in which science classes failed to meet their expectations
STEM students = 35, non-STEM = 62



Note: One student who gave an invalid answer has been excluded.

c. *Areas of STEM which are found to be most interesting*

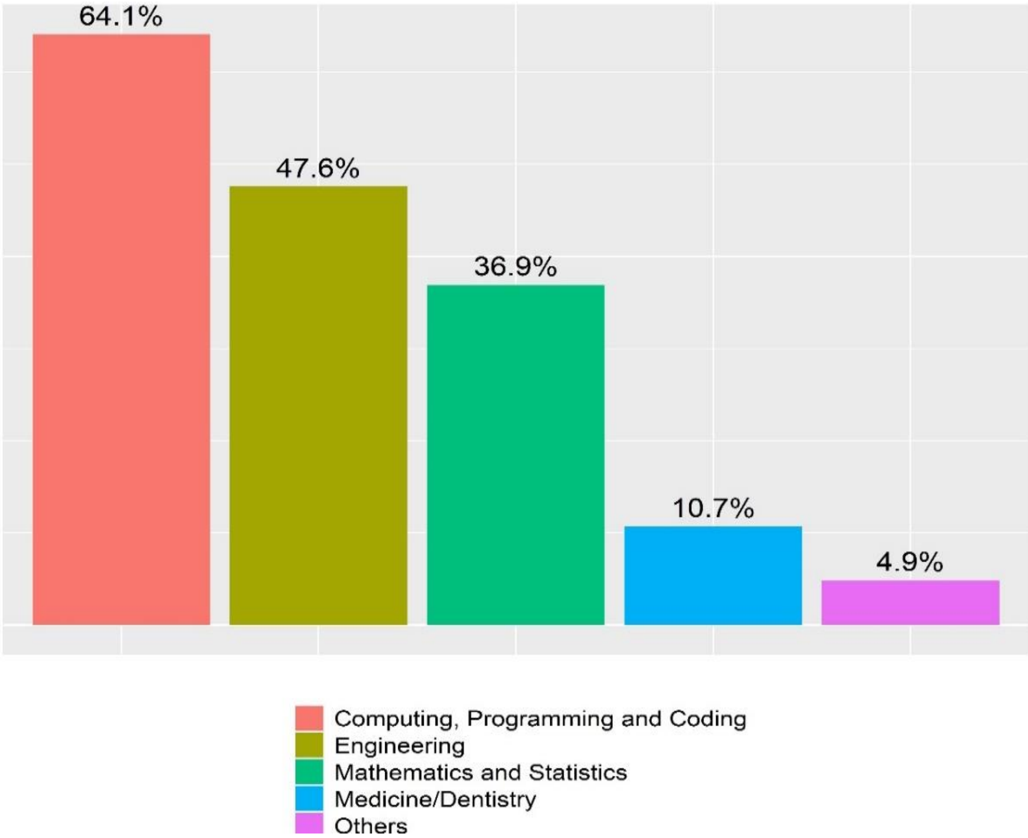
- Among those who claimed to be *very interested or rather interested in science,* a majority were more interested in the Computer, Programming and Coding subject (64.1% or 66 respondents), followed by Engineering (47.6%, 49 respondents) (Figure 4.10).

- Male respondents were more interested in Computer, Programming and Coding (69.2%, 54 respondents) while female respondents showed more interest in Mathematics and Statistics (64%, 16 respondents) (Figure 4.11).

- STEM students of both genders were more interested in areas of science related to new inventions and technology (62.6%, 77 respondents). Among non-STEM students, male respondents were more interested in new inventions and technology (58.3%, 21 respondents), whereas female respondents expressed more interest in health issues (52.2%, 36 respondents) (Figure 4.12).

Figure 4.10 STEM subjects that interest students the most

STEM students = 103

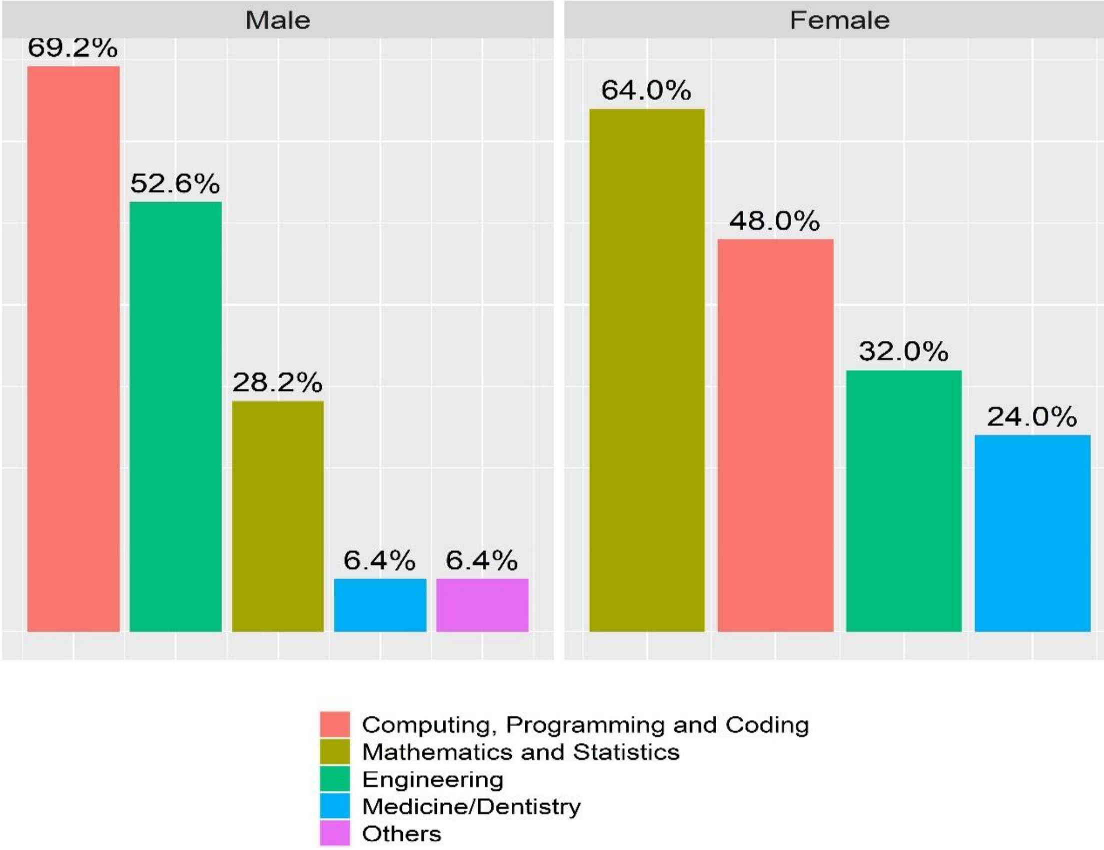


Note:

1. Only STEM students answered this question.
2. Twenty-one students who did not answer this question were excluded.

Figure 4.11 Subjects of science that interest students the most by gender

Male students = 78, Female students = 25

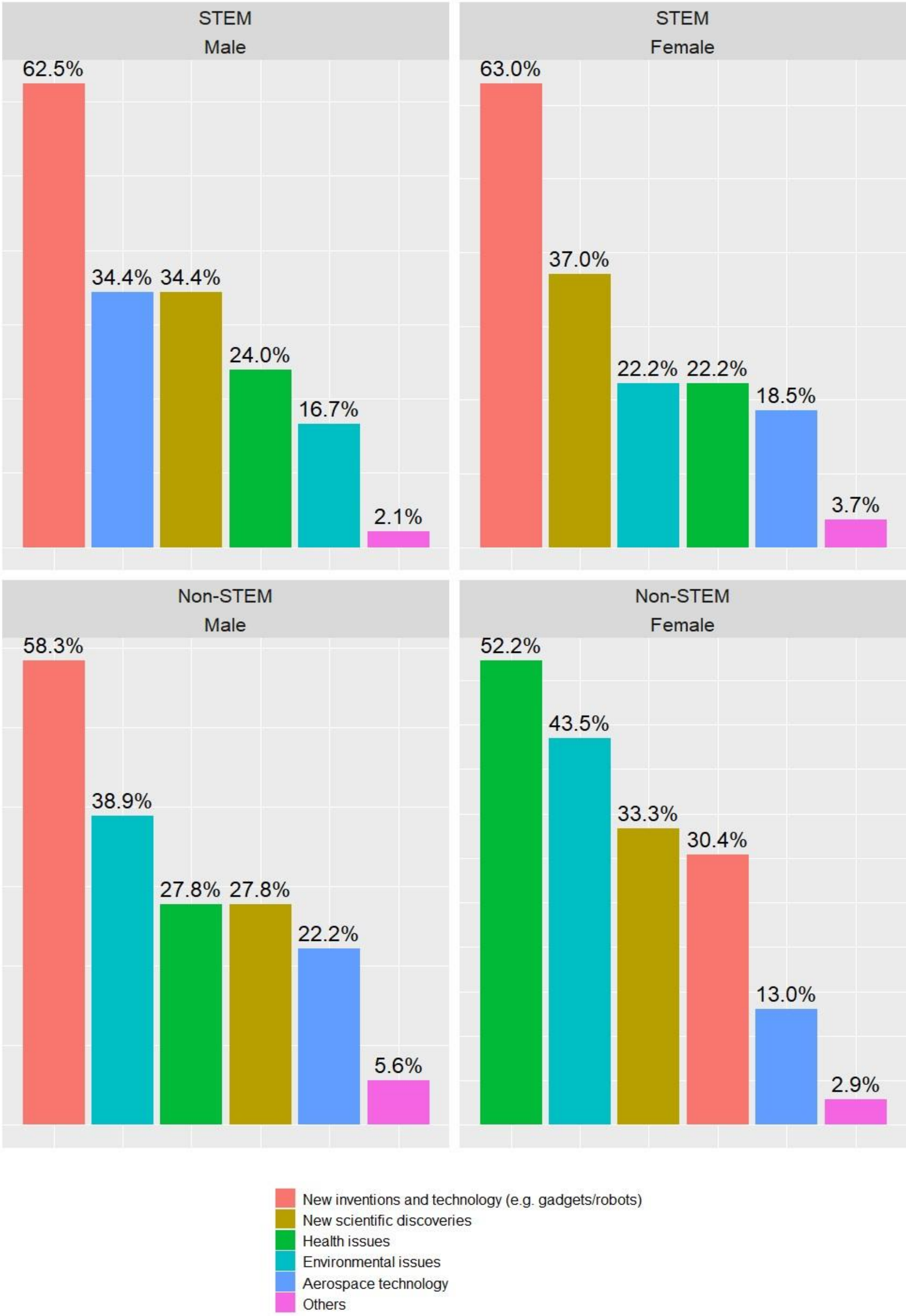


Note: Twenty-one students who did not answer this question were excluded.

Figure 4.12 Areas of science that interest students the most by stream and gender

Male STEM students = 96; Female STEM students = 27

Male non-STEM students = 36; Female non-STEM students = 69



Note: One student was excluded due to invalid answer.

d. Factors that could increase students' interest in STEM

- Respondents believe that making science more interesting or fun (78.7% or 340 respondents), a more hands-on and interactive approach during school lessons (56.7% or 245 respondents), and more science-related activities or exhibitions (52.3% or 226 respondents) are the top-three factors that would help students foster an interest in science (Table 4.5). This result is same for both genders and both STEM and non-STEM students.

Table 4.5 Factors to help increase interest in science (%)

Factors	STEM	Non-STEM	Male	Female	Total
Make science more interesting/fun	75.1	81.4	73.7	84.7	78.7
A more hands-on/interactive approach during school lessons	53.0	59.5	53.0	61.2	56.7
More science-related activities/exhibitions	48.1	55.5	50.4	54.6	52.3
Introduce new laboratories	31.4	32.4	33.1	30.6	31.9
More emphasis on computer studies	37.8	21.1	32.2	23.5	28.2
More seminars/opportunities to learn	28.1	23.9	26.7	24.5	25.7
More emphasis on science in school	24.3	24.3	28.0	19.9	24.3
Others	1.6	1.6	2.5	0.5	1.6
Total number of students	**185**	**247**	**236**	**196**	**432**

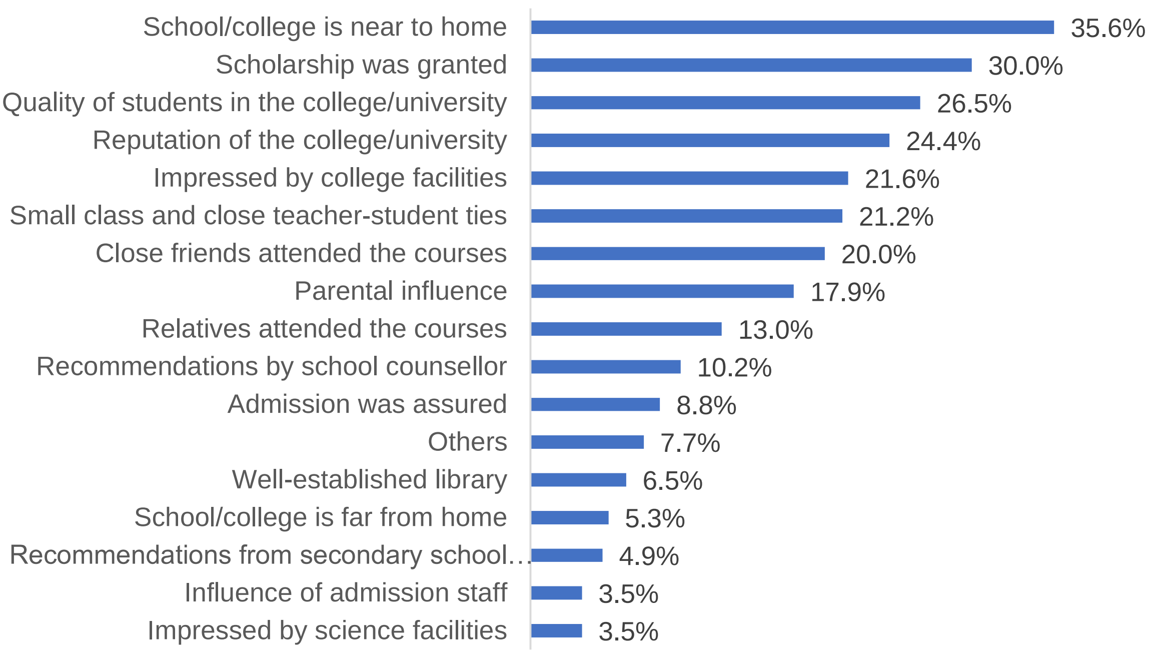
4.4 Current choice of study

This section investigates the external and internal factors influencing students' current choice of study at the tertiary level. External factors included location, college/university reputation, facilities, and scholarships, whereas internal factors comprised students' perception, teachers' advice, friends, parents, and other factors.

a) External factors

- As presented in Figure 4.13, campus proximity (35.6%, or 153 respondents) was the top consideration of students when selecting their current major, while 30% or 129 students chose their current major because they were granted scholarships. This is more pronounced among STEM students (Appendix C: Table 5). Other important considerations were related to the quality of the institution, either in terms of students' performance (26.5%, or 114 respondents), reputation of the college (24.4%, or 105 respondents), or college facilities (21.6%, or 93 respondents).

Figure 4.13 Factors considered when selecting current major (%)
Total students = 430



Note: Two students who answered "Don't know" were excluded. The sum of percentages exceeds 100% because students are allowed to choose up to three answers.

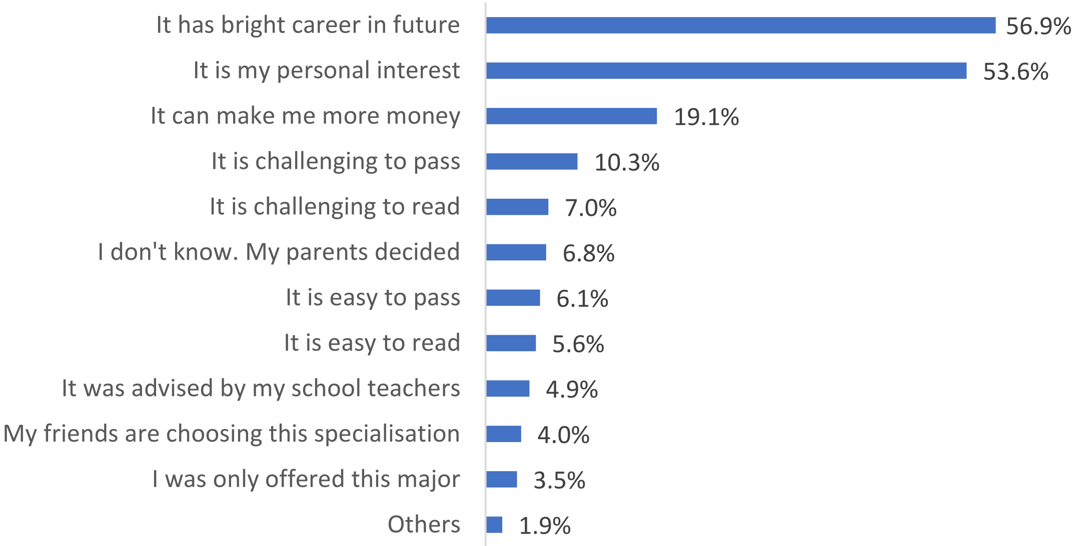
b) Internal factors

- Students were requested to identify the main reasons for choosing their current major. More than half (56.9% or 244 respondents) chose their current major because they believe it would provide them with better career opportunities. About 53.6% or 230 students said that they have a personal interest[9] in the subject, while less than 20% or 82 respondents believed that it could help them make more money. This result is the same for both genders.
- More than half of STEM students (63.6% or 117 respondents) chose this major owing to better career opportunities, whereas about half of non-STEM students (54.3% or 133 respondents) are in their current major because of personal interests (Appendix C: Table 6).
- Course difficulty was another important factor, though STEM and non-STEM students had different preferences. STEM students tended to choose academically challenging courses, while non-STEM students preferred courses that are easier to read or pass.

[9] Personal interest refers to the intrinsic desire to understand a specific topic that persists over time.

Figure 4.14 Reasons for choosing current major (%)

Total students = 429



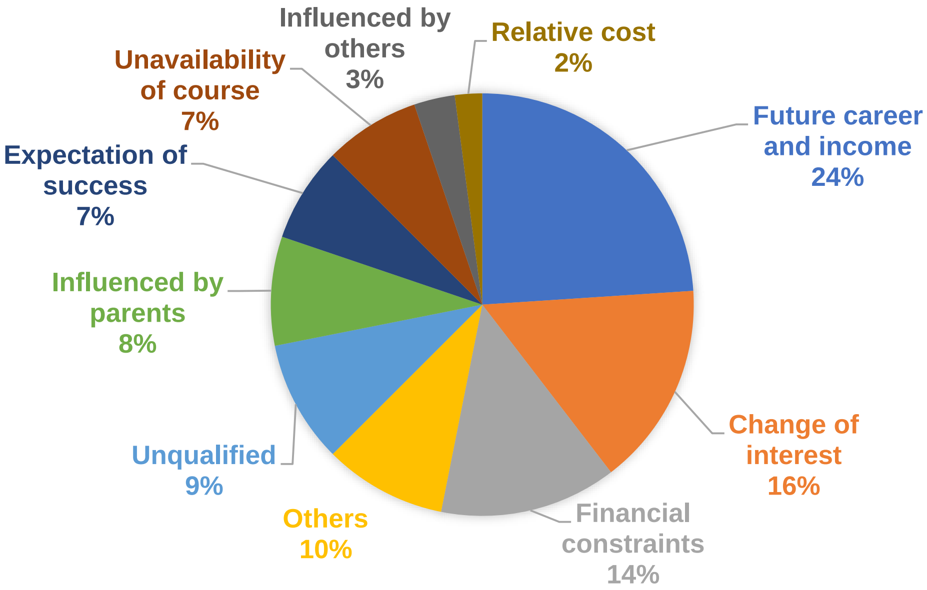
Note: Three students who answered “Don’t know” are excluded.

- About 26.4% or 114 students said their current field of study was not their first choice. About 61% [10] or 64 students changed their majors to Accounting, Business, Finance, or and Management, and 33.3% (35 respondents) changed their majors to STEM courses including Engineering, IT, and Computer Science. However, only 32 out of 105 (30.5%) students changed their stream of study; 23 students changed from STEM to non-STEM and 9 students changed from non-STEM to STEM (Appendix C: Figure 2 - 5).
- The majority of students said they changed their majors because they thought they would gain better career prospects and allow them to earn higher incomes (24%), or because of a change in their interests (15.6%) (Figure 4.15). This result is same for both STEM and non-STEM majors.

[10] Nine students who did not mention their first chosen major are excluded.

Figure 4.15 Reasons for changing majors

Total students = 96



Note: Nine students who did not answer this question are excluded.

- Around 22.2% or 96 respondents said they were influenced by their parents when choosing their major.
- As presented in Table 4.6, the parents of non-STEM students were much less likely to urge them to choose STEM courses. Only 14.2% of non-STEM students were asked to study STEM courses, compared with 33% of STEM students. The majority of their parents told the students that STEM courses would lead them to a brighter future (41%) and will provide them with high-income jobs (33%) (Appendix C: Figure 6).
- In general, parents with tertiary education are more likely to have urged their children to choose STEM courses (father: 28.6%; mother: 35.2%). Interestingly, higher percentages are seen in primary-educated parents (father: 24%; mother: 21.4%) compared with parents with secondary education (father: 16.1%; mother: 13.5%) (Appendix C: Table 7).
- Parents who are working in science-related jobs are more likely to urge their children to enroll in STEM courses (father: 33.9%; mother: 40%) (Appendix C: Table 8).

Table 4.6 Parents' influence on choice of STEM courses

Stream	Yes		No		Total	
	No.	% share	No.	% share	No.	% share
STEM	61	*33.0*	124	*67.0*	185	*42.8*
Non-STEM	35	*14.2*	212	*85.8*	247	*57.2*
Total	**96**	***22.2***	**336**	***77.8***	**432**	***100.0***

- All surveyed students were asked to reveal if they were influenced by friends when selecting their current major. As presented in Table 4.7, the majority of them said they were not influenced by friends (77%, 332 respondents) and only 23% or 100 respondents were influenced by friends when choosing their major.
- STEM students were more likely to be influenced by friends when selecting their major (25.9%) compared with non-science students (21.1%).
- In terms of gender, no significant different is seen in this sample. Males were slightly more likely to be affected by friends compared with females. Out of 236 male respondents, about 23.3% were influenced by their peers while 23% of female respondents were influenced by their peers when choosing their current major.

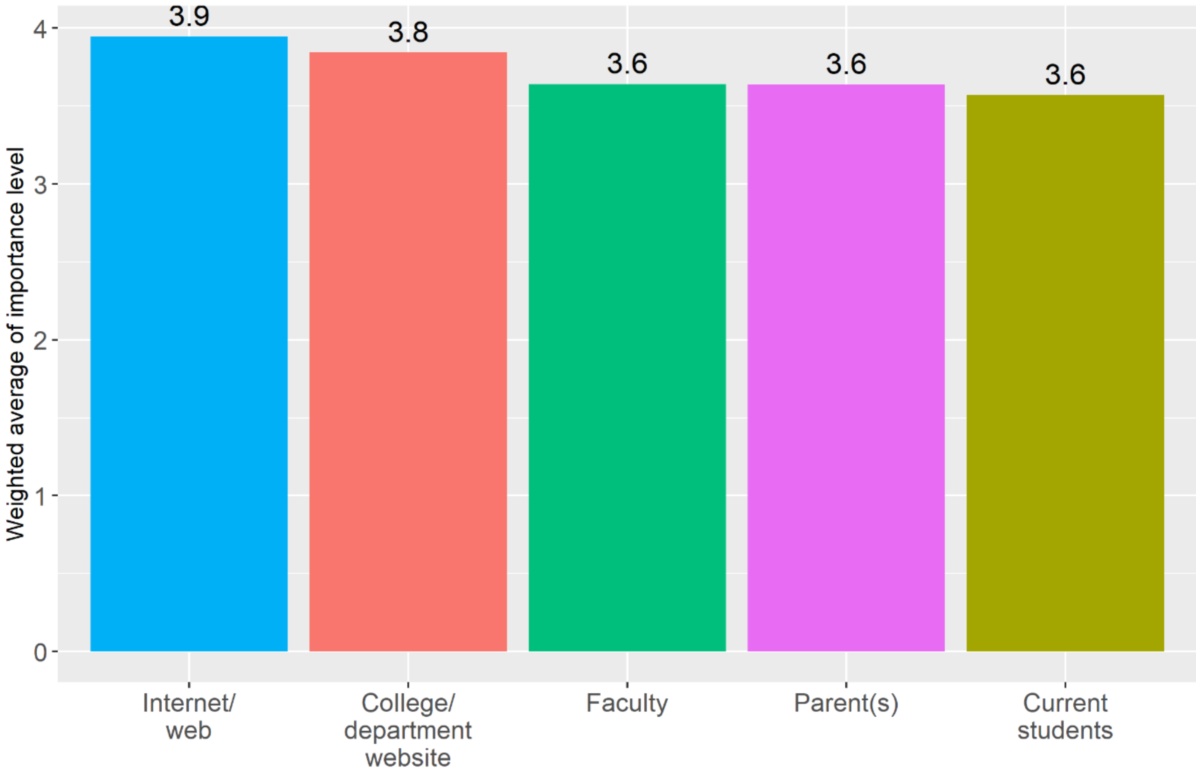
Table 4.7 Students influenced by peers in major selection by gender and field of study

Major	**Yes**		**No**		**Total**	
	No.	**% share**	**No.**	**% share**	**No.**	**% share**
STEM	*48*	*25.9*	*137*	*74.1*	*185*	***42.8***
Male	39	*26.2*	110	*73.8*	149	***34.5***
Female	9	*25.0*	27	*75.0*	36	***8.3***
Non-STEM	*52*	*21.1*	*195*	*78.9*	*247*	***57.2***
Male	16	*18.4*	71	*81.6*	87	***20.1***
Female	36	*22.5*	124	*77.5*	160	***37.0***
Total	**100**	*23.1*	**332**	*76.9*	**432**	***100.0***
Male	55	*23.3*	181	*76.7*	236	***54.6***
Female	45	*23.0*	151	*77.0*	196	***45.4***

- Top sources for information before choosing study majors were the internet and websites of HEIs. The majority of students gave these sources a ranking of around 4, or Important (Figure 4.16). This result is same for both STEM and non-STEM students as well as both genders (Appendix C: Figure 7 and 8).

Figure 4.16 Top-five important sources of information when choosing major of study

Number of students = 432



Note:

1. The levels of importance are assigned values: Very important = 5, Important = 4, Neutral = 3, Not important = 2, Not important at all = 1, Not applicable 0.
2. The weighted average of importance level is calculated by taking the average of percentage multiplied by the importance level.

- The top-three sources of information or news that students use to learn about science and/or technology are the internet (70.2% or 302 respondents), school (54.4% or 234 respondents), and TV programmes, documentaries, and news (41.2% or 177 respondents). This result is the same for both STEM and non-STEM students (Table 4.8). It shows the importance of the internet and school in learning science as well as obtaining information about science and technology, which in turn could help students make their choice of study.
- Among different internet sources, YouTube is the most widely used by both STEM (79.3%) and non-STEM (84.6%) students to obtain information related to science and/or technology (Table 4.9).

Table 4.8 Sources of information about science used by students

Information sources	STEM		Non-STEM		Total	
	No.	% share	No.	% share	No.	% share
Internet	134	*73.2*	168	*68.0*	302	*70.2*
School	105	*57.4*	129	*52.2*	234	*54.4*
TV programme/documentaries/news	71	*38.8*	106	*42.9*	177	*41.2*
Other people (family and friends)	59	*32.2*	52	*21.1*	111	*25.8*
Newspapers	38	*20.8*	53	*21.5*	91	*21.2*
Textbooks	19	*10.4*	47	*19.0*	66	*15.3*
Advertisements	20	*10.9*	45	*18.2*	65	*15.1*
Science magazines	25	*13.7*	28	*11.3*	53	*12.3*
Radio	12	*6.6*	34	*13.8*	46	*10.7*
Public forums	22	*12.0*	16	*6.5*	38	*8.8*
Total number of students	**183**	***100.0***	**247**	***100.0***	**430**	***100.0***

Note: Two students who answered “Don’t know” are excluded.

Table 4.9 Internet sources used by students to obtain information related to science

Internet Sources	STEM		Non-STEM		Total	
	No.	% share	No.	% share	No.	% share
YouTube	146	*79.3*	209	*84.6*	355	*82.4*
Facebook	100	*54.3*	157	*63.6*	257	*59.6*
Search engine (e.g. Google, Yahoo!)	111	*60.3*	125	*50.6*	236	*54.8*
Wikipedia	43	*23.4*	58	*23.5*	101	*23.4*
General websites	31	*16.8*	43	*17.4*	74	*17.2*
Science websites	25	*13.6*	24	*9.7*	49	*11.4*
Academic websites	11	*6.0*	24	*9.7*	35	*8.1*
News websites	15	*8.2*	18	*7.3*	33	*7.7*
Twitter	10	*5.4*	17	*6.9*	27	*6.3*
Blog written by scientists	8	*4.3*	9	*3.6*	17	*3.9*
Others	3	*1.6*	2	*0.8*	5	*1.2*
Total number of students	**184**	***100.0***	**247**	***100.0***	**431**	***100.0***

Note: One student who answered “Don’t know” is excluded.

- Students were asked whether they would remain in the same major if given the choice again. Only 25.5% of them said that they would change their major if given a second chance; the majority of these students (42.7%) said that they would change their major because they are not interested in their current major.

Table 4.10 Choosing the same major if given a second chance

	STEM		Non-STEM		Total	
	No.	**% share**	**No.**	**% share**	**No.**	**% share**
Yes	138	*74.6*	184	*74.5*	322	*74.5*
No	47	*25.4*	63	*25.5*	110	*25.5*
Total	**185**	***100.0***	**247**	***100.0***	**432**	***100.0***

4.5 STEM career plan

This section aims to explore students' future career choices and factors driving STEM career plans. As expected, most students intended to enter careers related to their current studies—study choice and career decisions are interrelated.

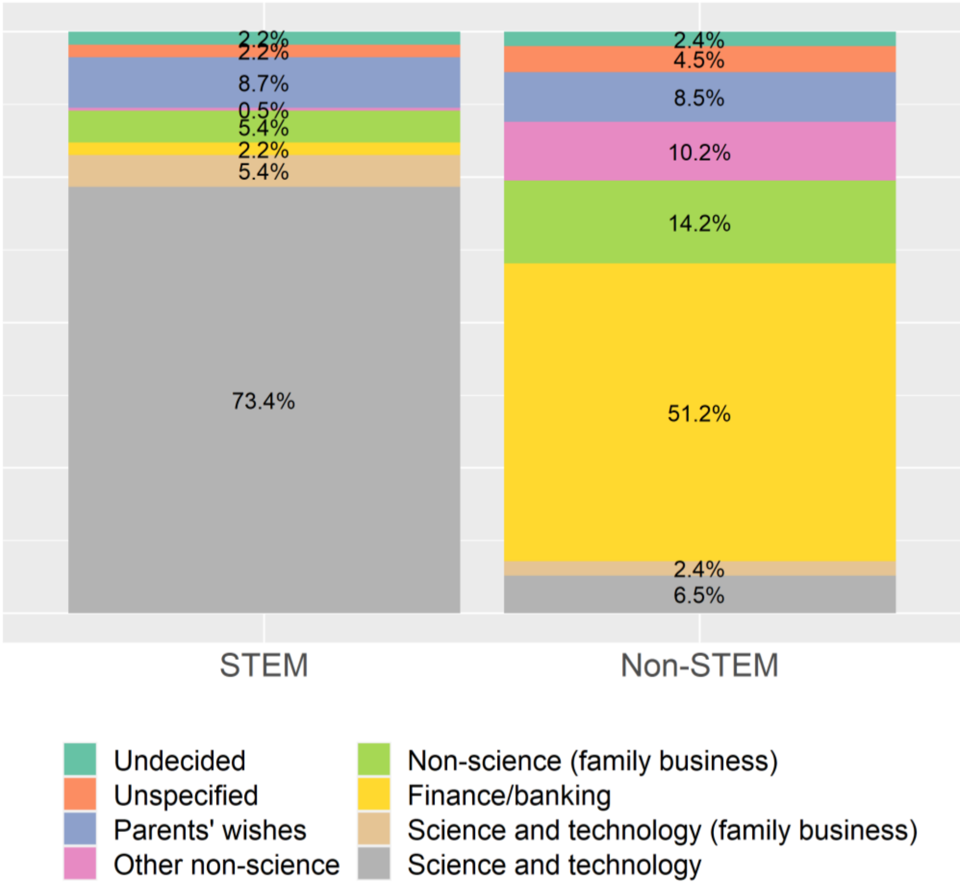
a. Future career plan

- Out of 430[11] respondents, almost half would consider non-science-related careers (46.7%, 201 respondents), while 38.8% or 167 respondents plan to work in science-related industries.
- For STEM students, 78.8% planned to pursue a career in a science and technology industry, including family-owned businesses. Only 8.2% or 15 STEM students would consider working in non-science-related industries. Out of these 15 students, 10 (67%) of them, or 5.4% of STEM students, plan to work in a family-owned business in a non-science industry and the rest would consider working in finance/banking and other non-science-related industries (Figure 4.17).
- About 76.4% or 113 male STEM students[12] and 89% or 32 female STEM students intend to pursue a career in science and technology. Male STEM students are more likely to work in non-science-related industries, especially in family-owned businesses compared with female STEM students (Appendix C, Figure 9).
- For non-STEM students, 75.6% or 186 respondents planned to pursue a career in a non-science-related industry. Finance and banking (67.7% or 126 out of 186 respondents) was the most preferred industry among all non-science careers. Nearly 9% (22 respondents) of non-STEM students intend to pursue a career in a science and technology industry, while 27.3% plan to work in a family-owned business.
- About 78% of female and 71.3% of male non-STEM students plan to work in non-science-related industries. Male non-STEM students are more likely to go for science-related careers than their female counterparts.

[11] Two invalid answers were excluded.
[12] About 8.8% will work in family-owned businesses in science-related industries.

Figure 4.17 Future career plan for college/university students

STEM students = 184; Non-STEM students = 246



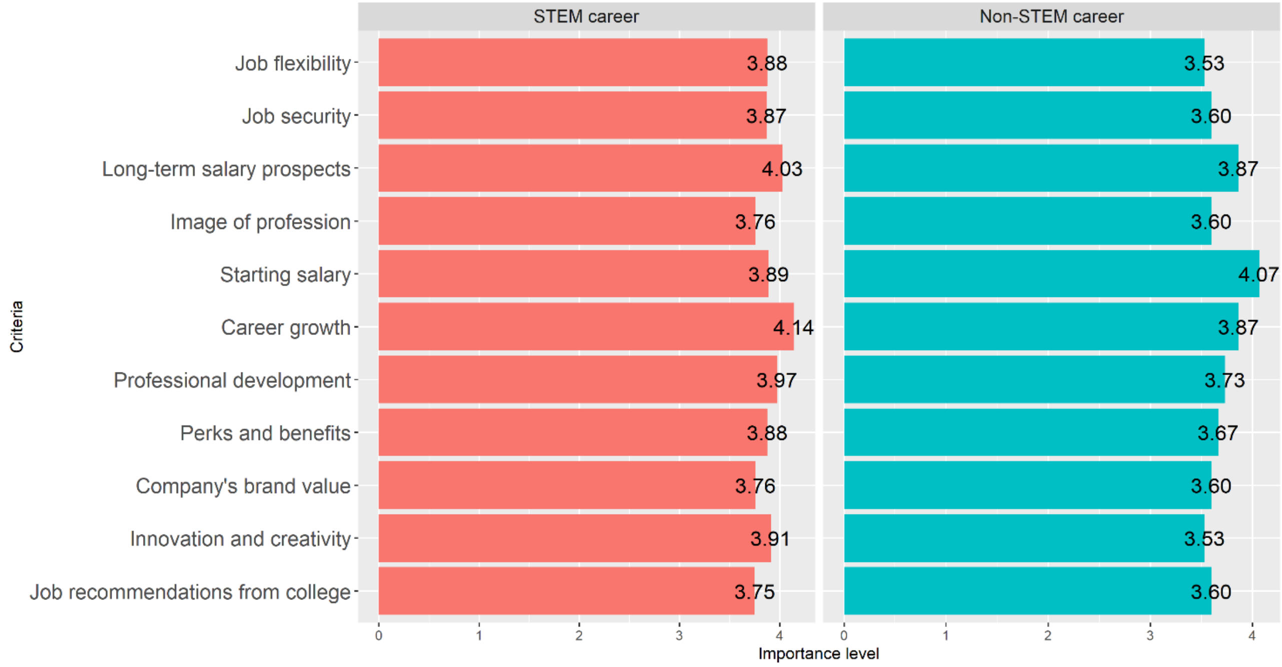
Note: Two invalid answers were excluded.

b. Factors affecting students' career decisions

- Overall, the most important job criteria for STEM students is career growth, followed by long-term salary prospects, professional development, and starting salary.
- Main factors causing STEM students to be more interested to work in a non-STEM industry are starting salary and long-term salary prospects. For STEM students who decide to work in a science-related industry, career growth and long-term salary prospects are the most important factors (Figure 4.18).
- For non-STEM students, job security and long-term salary prospects are important factors in choosing a STEM-related career. However, career growth is seen as main reason for non-STEM students to enter non-STEM careers (Figure 4.19).
- The career decision of STEM students who choose to work in science industries is mostly based on their skills and abilities, followed by their own decision. However, for STEM students who decide to work in non-science industries, it is mainly their own decision, followed by their parent's advice and the market trend (Figure 4.20).

Figure 4.18 Factors affecting career decisions of STEM students

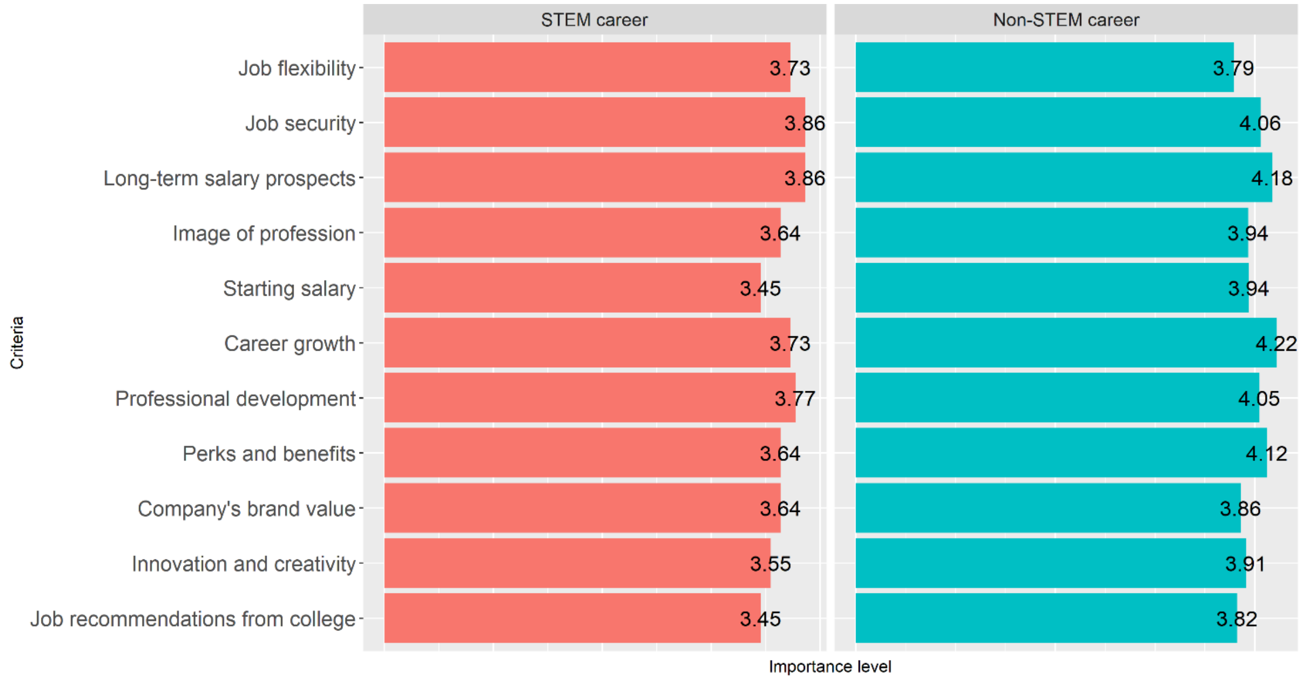
STEM students opted for STEM career = 145, Non-STEM career =15



Note: Students who answered career fields other than "STEM" and "Non-STEM" (e.g. depends on parents' wishes, don't know, unspecified jobs) were excluded.

Figure 4.19 Factors affecting career decisions of non-STEM students

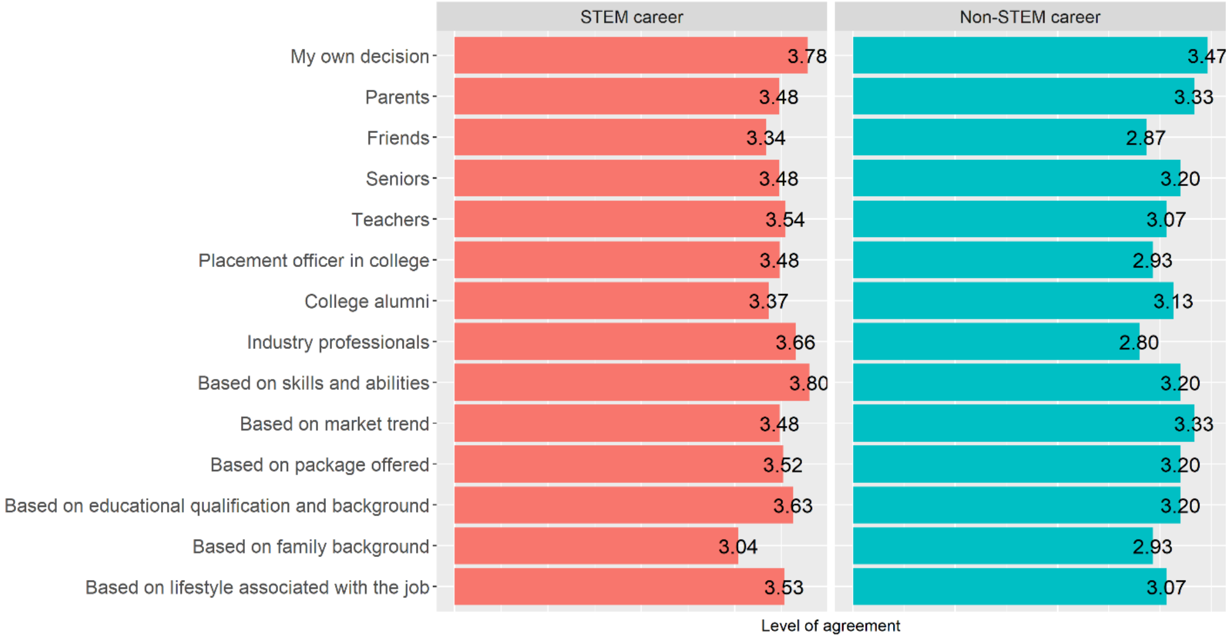
Non-STEM students opted for STEM career = 22, Non-STEM career = 186



Note: Students who answered career fields other than "STEM" and "Non-STEM" (e.g. depends on parents' wishes, don't know, unspecified jobs) were excluded.

Figure 4.20 Factors affecting STEM students' perception of career decision

STEM students opted for STEM career = 145, Non-STEM career = 15



Note: Students who answered career fields other than "STEM" and "Non-STEM" (e.g. depends on parents' wishes, don't know, unspecified jobs) were excluded.

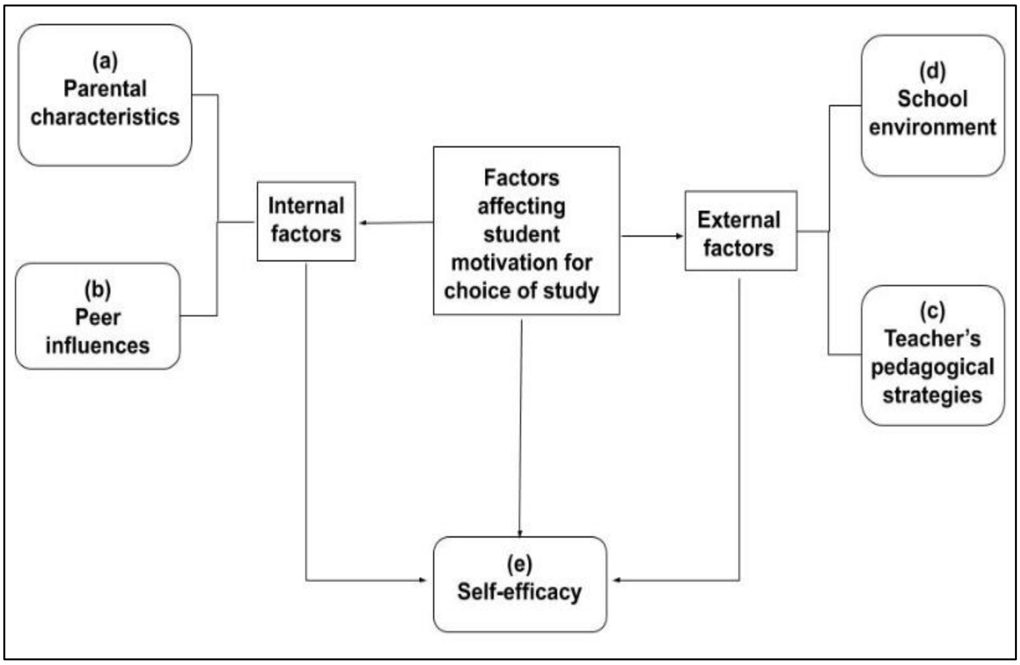
5 Determinants of students' choice of STEM studies and careers

This chapter looks into factors that may affect students' future studies and career selection based on students' perspectives. This takes into account students' and teachers' perspectives from secondary schools, as well as responses from students and heads of schools in institutes of higher learning in Penang. Their responses enable us to discuss factors motivating (or demotivating) students into entering the science stream (for secondary schools) and STEM courses (for institutes of higher learning), and more importantly, why top-performing students drop out of STEM studies. Additionally, the information collected from secondary and tertiary students also reveals the potential characteristics of labour supply in the future.

5.1 Factors affecting student motivation for STEM studies

To determine the factors affecting student motivation in STEM studies, a set of demographic variables such as gender, family background, and type of schools, school motivation and self-interest level are examined. Students who were motivated in science learning would have a higher chance of pursuing STEM majors in tertiary education compared with those who were less motivated in science learning. This can be attributed to a number of factors in the learning environment and the orientation of students as described in Figure 5.1. These include parental characteristics, peer influences, teachers' pedagogical strategies, school environment, and self-efficacy.

Figure 5.1 Factors affecting choice of study



a. Parental characteristics

Parents' attitudes play a central role in determining students' choice of study. According to logistic regression results, upper-secondary and tertiary students were both found to be positively influenced by their parents' attitudes in making science/STEM education decisions. Children whose parents urged them to choose the science stream were about three times more likely to attend science classes at Form 4 or STEM majors in university compared with parents who did not (Appendix D: Table 1). These findings indicate that when parents urge their children to pursue science, there is a high likelihood of their children choosing science or STEM over the non-science stream. When parents are supportive and present positive attitudes and expectations on academic decisions, children's interest in learning science can be improved (Urdan et al., 2007)

Parental occupation could also determine students' academic decisions. If parents' current jobs were related to science, tertiary students were about 2.5 times more likely to study STEM fields while upper-secondary students were only 1.5 times more likely to choose the science stream compared with parents whose current jobs are not related to science (Appendix D: Table 1). In the upper-secondary level, although only 30.5% and 13.6% science-stream students have fathers and mothers, respectively, working in a science industry, 93.3% and 84% of these parents held science-related jobs, as presented in Section 3.2. This suggests that the parents' occupations could have a positive effect on their children's decision to enroll in the science stream. Parents from science fields may be more prone to engage in conversation pertaining to the advantages of studying science with their children compared with parents whose backgrounds or occupations were not science-related.

Parents' highest level of education attainment can also be associated with their children's decision for to enroll in STEM-related fields. At the upper-secondary level, students with tertiary-educated fathers were about 1.4 times more likely to enroll in the science stream. This also implies that if the father is tertiary-educated, the odds of being enrolled in the science stream is expected to increase by about 43%. Maternal education level on the other hand did not appear to have any effect.

As for students at the institutes of higher learning, their fathers' education level did not determine their decision to pursue STEM majors. In contrast, STEM students whose mothers have higher education would be less likely to choose STEM courses at the tertiary level. Students were about 1.72 times more likely (=1/0.581) to choose non-STEM fields if their mothers had tertiary education (Appendix D: Table 2). This may be attributed to the fact that the majority of mothers with children in the science stream had pursed non-STEM-related courses during higher education. Therefore, students were more likely to follow in the footsteps of their mothers and take up non-STEM-related courses during tertiary education, regardless of their previous stream of study during secondary education.

b. Peer influences

Peers were particularly influential among upper-secondary students; students were 1.7 times more likely to select the science stream if their peers were involved in the selection process. This result is in contrast with the sample of tertiary students where their choice of study was not influenced by their peers. This implies that tertiary students are more mature in making educational decisions than their upper-secondary cohorts, although parents' attitudes remain a crucial factor in affecting children's choice of study at both levels of education.

While parents have a role in determining upper-secondary students' choice of study, peer influence is also found to positively contribute to the likelihood of students choosing the science stream. Different characteristics of peers would impact students' education decisions. Students can be prone to conform to their peers on which pathway to choose (Rosenqvist, 2017). High-performing peers may have the tendency to motivate their peers who would otherwise be unmotivated to pursue the science stream. Therefore, aggregating high-performing and non-high-performing students in lower-secondary classes or encouraging more activities between these groups of pupils would provide a positive effect on increasing the uptake for the science stream at the upper-secondary level. Male students were more likely to be influenced by friends compared with female students, as shown in Section 3.4.

c. Teachers' pedagogical strategies

The results revealed that *teachers' pedagogical strategies* in students' science learning could motivate students into choosing the science stream at the upper-secondary level, which could add to their perspectives on tertiary-level STEM education and STEM career pathways. Using real-life examples in science teaching was rated the highest by science and non-science students, signifying the need for an effective science learning approach to improve student's interest. HPS rated the interest level the highest against CSE and non-HPS/CSE (Appendix B: Table 19). Greater positive encouragement and involvement from teachers are necessary to motivate students to take up science courses in college.

Cultivating highly inspiring and enthusiastic science teachers and identifying students' needs and difficulties, especially in science subjects, are urgently needed. Given the difficulties of the subjects, science teachers should be encouraged to adjust the lesson content based on the learning ability of students by improving the lesson process (Tomlinson, 2001). More importantly, the results of this study showed that students' lack of interest in science was primarily due to the difficulty of the science subjects, as described in Section 3.3.

d. School environment

Students' perceptions towards *school environment* could influence their tendency to pursue science stream. School environment includes STEM engagement activities and classroom activities. In comparison with pedagogical strategies, it has less influence over science learning, as shown in Section 3.4. STEM engagement activities were lowly rated by upper-secondary students, whether they were conducted within the schools or outside the schools. In light of the low interest in science subjects and the poor academic performance, internal science activities in non-HPS/CSE need to be expanded further to strengthen the science learning environment. The top-three science-and-technology-related activities that need to be organised are more interactive science activities, more school involvement in science activities, and more hands-on science activities for children.

HPS and non-HPS/CSE on the other hand have to increase their participation in various external STEM-engagement programmes. Our survey results show that over half of the respondents from HPS and non-HPS/CSE have not heard of or visited Penang Science Café (PSC, Appendix D: Figure 1). Regarding the Penang International Science Fair (PISF) organised by the Penang Science Cluster, even though there was a larger percentage of respondents who said they have heard about the science event, at least 40% have yet to visit the fair. Only about 8% of HPS students had visited PSC. However, Penang Tech Dome (PTD) was particularly popular among non-HPS/CSE students, with over half of the respondents having visited the PTD.

In addition, a majority these student visits were initiated by schools, with Penang STEM Programmes (PSP) attracting the highest number of respondents across all types of schools. Exposure of PISF and PTD to non-HPS/CSE students appear to be more prevalent compared with HPS and CSE students. Meanwhile, PSC gained the most exposure among HPS students, followed by CSE and non-HPS/CSE. For students who took the initiative to visit these science events/centres, PISF attracted the highest percentage of students from HPS and CSE. Out of 54 HPS respondents and 193 CSE respondents, 48.3% of HPS students visited PISF on their own initiative while 46% were from CSE (Appendix D: Figure 1). More promotional strategies are necessary to increase the visibility of the science events/centres among students and the public. Table 5.1 summarises the responses on students' participation in Penang's science programmes.

Despite the fact that secondary students were satisfied with classroom facilities such as the availability of fully equipped laboratories and science tools, the teachers' focus group revealed that science laboratories are in urgent need of upgrades and maintenance to continuously provide a conducive learning environment. For tertiary students, science class satisfaction significantly affected their science interest level. The results of our study show that teachers' performance and teaching methods are the key factors influencing students' satisfaction with science classes. Hence, highly qualified and more innovative and creative teachers are needed. To instill an interest in learning science, fun and lively lessons can be held through technology-assisted learning or multimedia-assisted learning to facilitate STEM-content knowledge transfers. With the presence of an interactive learning environment, students' learning is enhanced, and this helps students cultivate additional skills such as learning autonomy and computer literacy (Cerezo et al., 2014; Rivera & Li, 2020).

Table 5.1 Main highlights of students' participations in Penang's science programmes/initiatives

Indicators	Penang Science Café (PSC)	Penang International Science Fair (PISF)	Penang Tech Dome (PTD)	Penang STEM Programmes (PSP)
Awareness/knowledge of Penang's science initiatives (see Appendix D: Figure 1, Figure 2 and Table 3)	Over half of the science and non-science students were not aware of the existence of PSC, with HPS being at the top on the list. Only about 12% of science students and 9% of non-science students have visited the café. 12.1% of non-HPS/CSE students have visited the café, followed by CSE (11%) and HPS (8.1%).	While only 15% of 602 science students had not heard of PISF at the time of survey, 46% had heard of it but have not gone to the PISF. Nearly 39% of science students have attended the event. Among CSE students, 37.2% had attended the event.	A large proportion of students have visited PTD before—42.5% from the science stream and 37.2% from the non-science stream. Non-HPS/CSE students were most likely to visit (53.7%), followed by CSE (41.9%) and HPS (19.9%).	Nearly 43% of science students have attended the programmes; a majority were from CSE (37.2%). However, 41% of science students have heard of PSP but have yet to participate; most were from non-HPS/CSE.
Self-initiative or school-motivated (see Appendix D: Table 4)	Out of 103 students, 65% visited because of activities organised by their schools. HPS students were more likely than others to do so. Meanwhile, students from non-HPS/CSE schools are more likely to self-initiate visits.	Out of 338 students, nearly 63% attended because of school activities, with non-HPS/CSE having a larger percentage, followed by CSE and HPS. There is weak self-initiated participation in non-HPS/CSE.	391 students said they have visited PTD; nearly 75% said the visits were organised by their schools. Non-HPS/CSE students have the greatest tendency to visit due to school events. Self-initiated participation is more prevalent among students from HPS.	Compared to other bodies, PSP saw the highest percentage of students who attended their programmes because of school activities. Out of 332 students, nearly 88% were motivated by their schools. Only 14% of all students who visited PSP were self-motivated. HPS students were most likely to attend PSP owing to school events.
Frequency of visit (see Appendix D: Figure 3)	CSE students were most likely to visit PSC more than once, and 29% of them visited three times or more. However, PSC attracted more than half of CSE students who visited twice or more times (52%).	Non-HPS/CSE students had the highest tendency to visit three times or more (14.6%), followed by CSE (5.1%) and HPS (3.4%).	A large proportion of students across all types of schools attended PTD only once, with HPS having the largest percentage of single visits (70.7%), followed by non-HPS/CSE (63.6%) and CSE (54%). PTD was more popular among CSE students as 46% of them visited twice or more.	A majority of students who had visited PSP were from non-HPS/CSE, with over half of them saying they have visited twice or more times, while CSE had the highest percentage of students who visited once only.

e. Students' self-efficacy

Students' *self-efficacy* in learning science is a crucial determinant for STEM uptake. Students' interest in science can increase the likelihood of upper-secondary students to remain engaged in the STEM field in both tertiary education and their future careers. In upper-secondary school, students who have an interest in science were about 2.9 times more likely to enter the science stream compared with those who did not have interest in science (Appendix D: Table 1).

This likelihood is moderated during tertiary education, where students were only 1.4 times more likely to study STEM fields if they have an interest in science. These students were 1.6 times more likely to enter STEM fields if they had enrolled in the science stream during upper-secondary school (Appendix D: Table 2). This indicates that students with a strong interest in science would have higher self-efficacy to persist in science-related fields.

While a majority of science students perceived learning science to be interesting and amazing and could also help them understand daily life, some had even greater goal commitments. They believed that learning science would give them more choices in tertiary education and secure a good job in the future. Having said that, some students were inclined to switch streams if given a second chance; about 15% or 54 non-science students from the survey wished to change streams. Of this, 44.4% of them regretted not choosing the science stream. Some form of advisory channels should be made available in schools to help students who are considering switching streams after a certain period of time.

Self-efficacy could also be manifested in science students who are uninterested in science but continue to attend science classes. From our survey, students with higher self-efficacy valued the benefits of studying science more than those who study out of self-interest. As discussed in Section 3.3, greater goal commitments in further studies and in future jobs were the top reasons for attending science classes among upper-secondary students. Students with low efficacy on the other hand still attended science classes owing to the influence of parents and friends, as well as other factors including historically scoring well in science subjects. Improving the positivity of these influences on students' choice of study is essential.

Furthermore, science students from upper-secondary schools who have an interest in science claimed that parents played a critical role in influencing students' science-learning experience; about 24% of science students said parents were the most influential actors in cultivating their science interest, followed by the internet (13.9%) and teachers (11.9%).[13] This seems to suggest that learning science in early childhood education—with the joint effort played parents, the internet, and teachers—would be important to raise children's interest in science from a very early age. This was also supported by the responses of Science and Mathematics teachers from Penang's secondary schools in a focus group discussion. They highlighted that the root cause of the lack of students' interest in science could have originated in primary school, where a rigorous and practical environment for science learning is absent.

By imparting an interest in science through discovery and inquiry learning, children's cognitive potential can be broadened and deepened to enhance the building of foundational experiences in science learning (Guccione, 2011; Worth, 2019). Parents and teachers are encouraged to assist

[13] Meanwhile, 24% of non-science student were influenced by their teachers in learning science, followed by 21.6% from internet and 12.3% from movies.

students with setting goals for students in science learning to build up their self-esteem towards pursuing STEM education. Besides, the Ministry of Education should consider introducing science experiments and establishing a practical science learning atmosphere in primary school. Students' physical and psychosocial learning environments are essential in shaping their beliefs and behaviours in STEM learning, which can improve students' self-efficacy. This would help enhance their persistence in STEM education enrollments and career endeavours (Rivera & Li, 2020).

The internet is the most popular avenue used by students to search for science and technology information. Out of 602 science students, 83.4% used internet to search for information related to science, followed by TV programmes/documentaries/news (59.8%) and school (45.7%) (Appendix D: Figure 4). YouTube, search engines (e.g. Google, Yahoo!, etc.), Wikipedia, Facebook, and science websites were the top-five most popular internet platforms for this purpose. This indicates that internet usage holds tremendous attraction for students. To increase their effectiveness in science teaching, science teachers should consider integrating internet resources into science classrooms to enhance the experiences of students' science learning while supporting teachers in explaining science concepts.

While science students searched information related to science and technology more frequently than non-science students, a majority looked for science information due to personal interest, despite over 40% of science students accessing this information only occasionally. CSE and HPS science students were more likely to search for science information online out of personal interest compared with non-HPS/CSE students. About two-thirds of science students reported that the information gathered was sometimes difficult to understand, particularly in the fields of Additional Mathematics, Chemistry, and Physics. More importantly, concern arises when students found information in the internet that was inconsistent with their textbooks, leading to further confusion during exams.

5.2 Factors for top performers dropping out of STEM education and career

To examine what causes high-performing science students to drop out of STEM education, we delve deeper into the survey responses from tertiary students who previously scored in the top-25th percentile for science subjects in SPM[14], but are currently enrolled in non-STEM courses. While a majority of high-performing science students still remain in courses related to science (persisters), out of 52 high-performing students, 40.4% or 21 switched to non-STEM courses at the tertiary level (leavers)—14 females and seven males (Appendix D: Table 8a). The perspectives of top performers from upper-secondary schools have also been scrutinised to give an indication of their preference changes over time. This section looks at factors that cause high-performing science students to switch to a non-STEM education and, subsequently, change their future career plans.

[14] Students who scored in the top-25th percentile in science exams (i.e. Biology, Chemistry, Physics, and Additional Mathematics) were classified as high performers. In this study, high-performing students refer to those with average Science grades of B+ and above for tertiary students (based on SPM results) and A- and above for secondary science students (based on school exam).

5.2.1 Preferences over non-STEM education and career

At the tertiary level, non-STEM students were seen performing relatively well in science subjects in SPM. Although the number was insignificant, students appear to prefer courses that are not consistent with their interest. Out of 21 leavers, two-thirds said they have an interest in science, and a majority claimed that science is their hobby, and they prefer careers in non-STEM fields. This is followed by *arts stream can promise them a high-income job in the future* and *arts stream subjects are easier to understand than science subjects*. Therefore, job security, income, and ease of study were the main reasons for dropping out of the science stream.

Parents' current jobs are also found to have a linkage with the top performers' study decisions. Top performers whose fathers worked in non-science related jobs were more likely to drop out of STEM compared with those whose fathers worked in science related jobs. No significant difference has been found in parents' educational level and top performers who switched to non-STEM paths.

Upper-secondary students who had scored a distinction in science exams were less decisive regarding their tertiary education path, and were more likely to divert from science to non-science disciplines. This may be due to two reasons. First, students may not be exposed to sufficient information about the possible future study and career paths entailing from science education at the first year of upper-secondary school. Second, it could be too early for students to plan for their future studies and career orientations—which could also be true for other students.

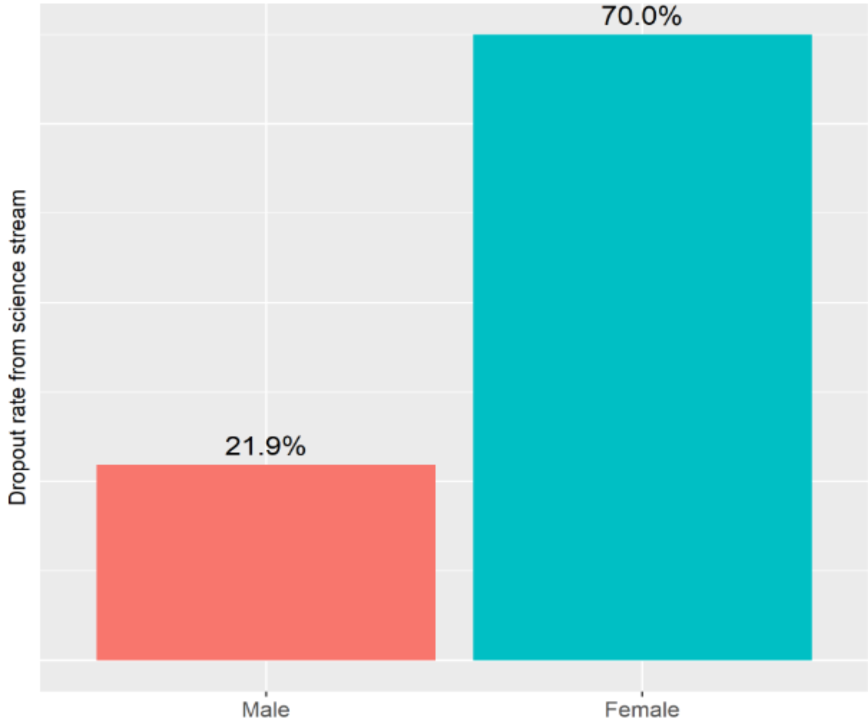
While a majority of the top performers plan to remain in courses related to science in their tertiary studies, 23.4% (41 out of 175) were undecided on their future paths (Appendix D: Table 7a). A majority (24 out of 41) were from CSE. Only five top performers plan to switch to non-STEM courses, with the careers interesting them the most being finance and banking, creative arts, business, law, and politics.

Despite an insignificant number of top performers planning to drop out of STEM in their future studies, more upper-secondary students who performed extraordinarily well in science exams appear certain about their choice of future career. Out of 15 top performers who were certain about their career plans in non-STEM, seven were unsure of their future studies, and only four intended to study non-STEM courses at the tertiary level. In sum, top performers can orientate themselves more easily towards labour market opportunities than their future study plans.

5.2.2 Gender differences in STEM dropouts among high performers

Gender differences are also widespread among top-performing science students; high-performing females were more likely to drop out of the science stream compared with high-performing males. At the tertiary level, where students are currently studying non-STEM courses, the female dropout rate was 70% compared with about 22% for males (Figure 5.2).

Figure 5.2 Dropout rates for high-performing students at the tertiary level
Dropout rate for male students: 7 out of 32; female students: 14 out of 20



The high dropout rate among females in STEM counteracts efforts to increase STEM participation among female students. Females only outperformed in Biology for the top-25th percentile of tertiary students while males did better in Physics, Chemistry, and Additional Mathematics (Appendix D: Figure 6). This suggests that females tended to drop out of STEM fields because they did not perform as well as their male counterparts in physical sciences. Females appear to have a lower persistence compared with males. Additionally, there are gender differences in the willingness to compete, evidenced by previous literature showing that women are more likely to avoid competition and have personal traits that are risk- and feedback-aversive, which arise very early in life (Niederle & Vesterlund, 2007; Sutter & Glätzle-Rützler, 2015).

However, high-performing female students were also less likely to be influenced by their parents and peers. High-performing females can be more determined and have higher self-efficacy in pursuing their education and career paths. Therefore, they dropped out of STEM studies because they are firm in their goals.

5.2.3 Low self-efficacy in STEM careers

As discussed in Section 5.1, student's self-efficacy in learning science is an important determinant for STEM uptake. Students' self-efficacy in science can increase the likelihood of persisting in the STEM field in tertiary education and pursuing a STEM career in the future. In other words, students' reduced interest in STEM careers may be a result of their lower self-efficacy for STEM careers, which could reduce their confidence in persisting in a STEM education.

Self-efficacy in STEM careers may be influenced by STEM career knowledge. The results of this study show that high performers who switched to non-STEM courses in their tertiary education had limited STEM career knowledge. The majority of leavers (62%) had little information on potential STEM career paths compared with non-STEM career paths. In contrast, about 42% of persisters had more information of STEM than non-STEM careers and nearly 23% had the same level of knowledge of both STEM and non-STEM career paths. The level of students' STEM career knowledge will directly affect their intention to pursue a STEM career in the future (Nugent et al., 2015). Previous research has shown that the lack of information on STEM careers would affect students' perception of their capability and the likelihood of their achieving success in STEM fields (Blotnicky et al., 2018). Therefore, despite being high performers in science, their interest in STEM education and careers might decrease. Teachers, parents, and peers can influence students' STEM career knowledge as well as their career interest.

For instance, parents' positive attitude towards science and STEM careers can play an important role in students' self-efficacy in STEM careers. The study found that there is a linkage between parents' current occupation, especially fathers, and top performers' future career plans. Among those who are planning for a non-STEM career, 80% of their fathers are working in jobs that are not related to STEM, compared with 60.9% of those who are planning for a STEM career. This indicates that parents play a significant role in shaping the career aspirations of their children. Involving parents in STEM programmes might help increase students' STEM knowledge and provide better educational and career guidance.

Table 5.2 Profiles summaries of selected leavers of STEM education in upper-secondary and tertiary levels among the high-performing students

Student	**1**	**2**	**3**	**4**	**5**
Future plans	Taking over family business (non-science)	Finance and banking	Finance and banking	Creative arts	Politics
School/ college name	INTI International College Penang	INTI International College Penang	SMK Bukit Jambul	SMK Chung Ling	SMK Jit Sin
Type of school	-	-	HPS	CSE	CSE
Academic performance	Maths A+ Add Maths A Physics A Chemistry A- Biology B+ English B+	Maths A+ Add Maths A+ Physics A+ Chemistry A+ Biology A English A+	Maths A Add Maths A- Physics A- Chemistry B+ Biology A+ English A+	Maths A Add Maths A- Physics A- Chemistry A- Biology A- English A	Maths A Add Maths A- Physics A- Chemistry A- Biology A- English A
Family background	• Non-STEM family background • Urged to study STEM because it is deemed to be good for their future.	• Non-STEM family background • Not urged to study STEM	• STEM family background • Not urged to study STEM	• STEM family background • Not urged to study STEM	• Non-STEM family background • Not urged to study STEM
Motivations for studying science	• Parental influence	• Bright future career • Personal interest	• Wants to make an impact • Interested in science	• Peer influence • More study options	• Curious • Relevance to daily life
Motivations for choosing non-STEM careers	• Not interested in STEM—subject difficulty • Family obligations	• Wants to work as an actuarist in the finance and banking sector • Higher salary	• Personal interest • Brighter future • Higher salary	• Personal interest • Brighter future	• Personal interest

5.3 Challenges of science teaching and implications on science education

As discussed in Section 5.1, teachers play a central role in the attitudes of students towards science. A successful lesson depends on the ability of teachers to impart quality educational knowledge, and this must be supported by a conducive schooling environment. The challenges that science teachers face have an impact on teaching quality, which affects STEM uptake at the tertiary level, as well as their career aspirations. Ultimately, the classroom and how it is conducted can have a significant impact on the future workforce of Malaysia.

This section examines the limitations that science teachers face in teaching science by analysing responses gathered in a focus group discussion, which was attended by school assistant principals and science and mathematics senior teachers from public secondary schools in Penang.

5.3.1 Pedagogical strategies

Science teachers have concerns over their teaching methods. According to the focus group discussion, some teachers revealed difficulties in finding suitable *classroom methods* to hold students' interest. Teachers are aware that science classes need to be conducted in a more innovative and creative manner to hold their students' interest. For example, conventional teaching methods are not welcomed by students. Traditional class activities, especially in a science class, are deemed boring and "a waste of time". Instead, students prefer modern tools and fun class activities. Thoughtful use of state-of-the-art teaching aids such as videos or interactive digital quizzes would improve student understanding of lessons while holding their interest.[15] Therefore, *21st Century Learning*[16] need to be used by teachers to enhance the learning environment.

To generate and sustain interest, teachers have taken the initiative to use different platforms to teach science concepts using real-life examples, and used student presentations as a way of encouraging class participation. These tools were found to be generally helpful to increase students' understanding. While group discussions, lab activity, and oral presentations were used by a majority of teachers to conduct science classes, there are a small number of teachers who have never or rarely used such methods. Likewise, most teachers rarely or never had any project-based learning and journal article writing in science classes.

More crucially, *inadequate teaching time* was the major hurdle that prevented teachers from investing more time into designing more engaging lessons, impacting teaching effectiveness. Heavy non-academic-related workload have often derailed lesson preparations. With only 2.5 hours per week allocated for a science lesson, teachers have struggled to complete the required syllabus and have limited time to use out-of-classroom settings to teach their students. Hence, teachers proposed that science teaching hours should be lengthened to reflect the 60:40 Policy.

[15] According to the teachers' focus group discussion, their teaching materials include: textbook, reference book, Google search, YouTube video, visualizer, LCD, and CD provided for teaching and learning of science and mathematics in English (or *Pengajaran dan Pembelajaran Sains dan Matematik Dalam Inggeris [PPSMI]*).

[16] The 21st Century Learning (or *Pembelajaran Abad ke-21 [PAK21]*) is MOE's initiative that focuses on a student-centric learning process which consists of five main elements: communication, collaboration, critical thinking, creativity, and values and ethics (4C1V) (Julaihi & Hamdan, 2020).

When asked for their opinions about student-centred versus teacher-centred teaching approaches, most of the teachers said they are aware of the long-term ill-effects of entirely using *teacher-centred teaching methods*, where students mainly act as listeners while the teacher lectures. A significant proportion of them agreed that "spoon-feeding" students with facts without allowing them opportunities to apply the knowledge impedes the development of critical-thinking skills and science interest. These teachers would like to plan more student-centred lessons, where students actively participate in their own learning. Unfortunately, because of time considerations, the teachers opted for teacher-centred approaches because these required less preparation time.

5.3.2 Curriculum content and class structure

Despite an intensive science curriculum, there was *insufficient time allocated* for teachers to complete the assigned syllabus. Teachers suggested that the teaching time for science curriculum should be lengthened if the STEM industry is to be the main focus. This is also in line with earlier findings where science subjects are often seen as difficult-to-understand and hard-to-score subjects by students, which most of the secondary teachers also agreed. It is imperative for curriculum curators to consider allocating increased teaching hours for science subjects and/or reducing curriculum content in the syllabus.

Besides having insufficient time in science teaching, *too many subjects* to study is also a factor that can diminish students' interest in science subjects. For example, primary students from vernacular schools are required to sit for eight exam papers during UPSR; only two of these papers are mathematics and science. Teachers suggested that the policy of having 60% of students enrolled in STEM should be reflected in the curriculum and timetable as well.

The medium of instruction also plays a large role in teaching science effectively. Teachers said that students experienced *different languages in science subjects* as they progressed from primary school to tertiary education. It should be noted that mastering English can help improve the understanding of science concepts by using online resources. However, concerns were raised over students from national and vernacular schools, where their learning habits could be affected by the abrupt change in education policy[17].

A large classroom size or *high student-teacher ratio* limits teachers' abilities to deliver effective lessons. Both teachers and pupils agree that science subjects are relatively difficult and hard-to-score compared with non-science subjects. With a large number of students in a class, teachers would have to spend more time to give students real-life examples to ensure a complete understanding of the science concept being taught. In addition, large classes are especially a problem when science experiments are being carried out because of the greater amount of attention and guidance that students would need. At times, not all students were able to conduct the experiment individually. Most teachers felt that a class of 40, the usual size in Malaysian classrooms, is too large, whereas 30

[17] PPSMI is an education policy aimed to improve the command of the English language among pupils at primary and secondary schools in Malaysia. This policy was introduced in 2003 by Mahathir Mohamad, the prime minister at the time. However, this policy had been reversed in 2012 by the current prime minister, Muhyiddin Yassin.

would be reasonable. Therefore, cutting down the number of students, particularly for science classes, is necessary to increase teachers' attention on students' learning abilities.

Outdated textbook content is a stumbling block for teachers and students. Teachers and students found inconsistent science information being conveyed in the textbook content and online resources. As an example, teacher pointed out that the hazard symbols in science textbooks are not up to date. To mitigate this problem, teachers suggested creating digital formats of textbooks as these can be adapted and updated relatively quickly.

5.3.3 Academic-based assessments

While critical-thinking and problem-solving skills are often required in high-qualified positions (Ong, 2017), measuring these skills through exams hampers the effectiveness of *teaching and learning behaviour*. Coupled with pressure from parents, teachers tend to weigh more heavily skills that are tested[18] in Malaysian exams than those that are not[19]. This has caused some teachers to give tips to students when answering exam questions instead of getting students to understand the concepts. As such, students are more interested in memorising exam answers only without understanding the concepts and theories.

Teachers agree that this learning process would demotivate students from developing critical-thinking skills. However, they are also concerned about the *rigid marking scheme* provided for national exams, as this does not require creative problem-solving skills. This demotivates students from exploring new things. According to one teacher, "students are required to think out of the box. However, the answer is already in the box." Therefore, teachers should be given more flexibility and authority in marking exam papers.

A number of teachers highlighted that, while classroom practices would generate students' interest in science, the decision to enroll into the science stream is primarily *examination-based*. Students with good results in science and mathematics subjects are encouraged to enter the science stream. This is partly to ensure that students are able to follow the lessons and have enough basic knowledge to study the sciences. Moreover, additional pressure also comes from parents who place heavy emphasis on exam grades.

The *mindset of students* in making the decision to enter the science stream needs to be more guided. Teachers and students tend to perceive that only students with good results in science and mathematics subjects at Form 3 can enter the science stream, while students with poor science and mathematics results could only enter the arts stream. This arrangement has been practised in most national schools. Nevertheless, the potential ability of non-science students to study STEM subjects should not be neglected. Teachers also concurred that some students with good results prefer to study computer science and accountancy rather than enter the science stream. This social norm should be changed in accordance with the aspiration to increase STEM uptake.

[18] These are "understand science concepts, principles, and strategies", "think in a sequential and procedural manner", and "remember formulas and procedures".
[19] These are "be able to provide reasons to support their conclusions", "understand how science is used in the real world", and "be able to think creatively".

Apart from science teaching, *exam-oriented science activities* are also concerning. For example, approval is only granted if science activities could result in academic-exam-related outcomes. This restricts the scope of activities that can be planned for students. While science activities should always contribute to students' understanding of the syllabus, the parameters for them should be widened so that teachers have more flexibility and are not deterred from planning activities. Exam and non-exam-based learning methods should be balanced in science teaching.

Teachers also said that students did not take content seriously unless it is related to exams. Since the abolishment of *practical exams* in SPM science subjects in 1999, students are not required to conduct invigilated science experiments. Reduced hands-on experience have caused students to perform experiments apathetically, which affected students' interest and understanding of science concepts. Teachers found that students prefer to learn practical science than science theory. Hence, teachers recommended reintroducing practical exams to ensure students conduct science experiments seriously.[20]

Lastly, by measuring outcomes solely through exam grades, *time constraints* arose because parents, students, and schools expect teachers to cover all textbook chapters to prepare students for exams within a certain period of time. An exam-based approach to science education narrows students' learning experience considerably.

5.3.4 The supply of well-qualified science teachers

Science subjects at the secondary school level are highly technical, often requiring trained teachers in relevant fields. Yet teachers note that schools often have a *lack of qualified science and mathematics teachers*. One reason is that it is takes longer for university graduates to receive their postings. Some graduates have no choice but to work in international schools while waiting, depriving public schools of talent. Moreover, retired science teachers are often not replaced immediately. To accelerate the hiring process, it is recommended the relevant authority or school be given the autonomy to recruit and retain qualified teachers.

The shortage of subject specialists has serious implications for science teaching. Empirical evidence strongly suggests that unqualified science teachers fail to elicit science interest among students because they lack subject-matter knowledge and information of current scientific developments. As a result, they are too reliant on textbooks, impeding their ability to create interesting and insightful lessons that stimulate creativity and critical-thinking abilities. To ensure teaching quality, most schools have inexperienced teachers attached to teaching mentors as a way to improve their teaching skills.

Shortages have caused schools to assign non-qualified teachers to STEM subjects. This has resulted in students becoming gradually disinterested in science and missing opportunities to explore science more widely and contextualise the information they receive. This shortage is worsened when *untrained teachers* such as a doctors-to-be are assigned as temporary teachers to temporarily resolve

[20] According to the Malaysia Education Blueprint 2013-2025, the Ministry had planned to reintroduce practical testing elements in national examinations in 2015. However, teachers' focus group emphasised the importance of restoring practical examinations.

the shortage issue. Not only is teaching quality affected, students would become uninterested to the untrained teachers' lack of teaching skills.

Teachers also play a role in influencing students' future education choices by providing them with *information about STEM careers*. Our survey results found that students who possess more information about STEM careers relative to non-STEM ones prior to selecting tertiary courses are 4.4 times more likely to opt for STEM courses (Appendix D: Table 2). Teachers who are subject specialists not only deliver more effective lessons, they are also more confident in providing education and career guidance (Fuller et al., 2014). To encourage more students to enroll in science subjects, some teachers have taken the initiative to provide career information to their students. For students who have yet to decide their future education and career paths, teachers tell their students to consider the science stream in Form 4 and 5 for a more flexible education path for the future.

5.3.5 Professional training and development

Continued training and development throughout a science teacher's career is essential to regularly impart the latest subject-matter knowledge to students. This includes exposure to new teaching tools and advanced pedagogical strategies. Owing to rapid scientific and technological developments, teachers without professional backgrounds can find it challenging to deliver *up-to-date science knowledge* to students. The quality of science teaching may be impacted if teachers refrained from referring to information online and relied entirely on textbook content.

Out of 21 teachers, more than two-thirds participated in courses/workshops that related to subject-matter training and had joined a network teacher group specifically for professional development over the last 18 months. While teachers' training programmes were not regularly held, teachers who had attended found that workshops for curriculum preparation and marking exam papers were helpful, especially where students can be guided to answer exam questions. Through formal or informal exchanges, teachers are exposed to tried-and-true practices, as well as information about STEM education pathways and careers. With this, they would be more equipped to help students make informed decisions on their future studies and career. This is not trivial, given how teachers play a central role in shaping students' perceptions of school science.

However, a *shortage of relevant courses* is another concern. For instance, with different levels of critical-thinking skills possessed by Malaysian students, teachers should be exposed to techniques that can be used to cultivate skills in the Malaysian context, and these techniques should not blindly mirror the teaching methods used in developed countries. *Short duration of training* is also a factor diminishing the quality of teaching. Based on focus group responses, the number of days allocated for yearly professional development ranged between 5 and 10, with an average of 7 days a year. In comparison, the average in OECD countries in 2007 was 15 days (OECD, 2009).

In the areas that require professional development, teachers highlighted the need to improve their ICT skills, elevate their efficiency level in school management and administration, improve subject-matter knowledge, and strengthen their skills in student counselling. However, teachers *lack the time* to improve their teaching skills and subject-matter knowledge due to *heavy workload* or paperwork. This can be remedied by digitising/computerising admin paperwork and/or hiring teaching assistants to support teachers.

Additionally, alternative teaching platforms should be utilised on a regular basis. The national lockdowns resulting from the coronavirus disease 2019 (COVID-19) pandemic have highlighted a greater need for the relevant authorities to equip teachers with appropriate technologies and the skills to use them. The pandemic is an example of how greatly students, especially those from low-income groups, are impacted when schools and teachers are not able to adapt quickly enough owing to a *lack of digital skills*. Sharpening the ICT skills of teachers should be done regularly.

This pandemic has established a new normal in classroom teaching and learning, and schools should embrace this hybrid learning avenue even when the pandemic subsides. As digital tools and proficiency in handling them vary by school, schools should be given more authority to conduct in-house digital training sessions tailored to the needs of the teachers in each school.

5.3.6 Science laboratories

Learning science through practical teaching tools could increase students' interest in science subjects. While practical teaching tools can be effectively used to assist students in understanding science theories, an *unconducive science laborato***ry** has been identified as a hurdle in learning science. The abolishment of practical exams has further deteriorated students' interest in learning science through experiments. This reinforces the notion in students that succeeding in science only requires theoretical knowledge, and hands-on experience is optional.

Not only do poor science facilities play a role in deteriorating students' science interest, *poor upkeep of laboratory equipment and apparatus* has deterred teachers from handling experiments effectively. Students often had to share limited sets of experiment apparatus among themselves, and sometimes experiments cannot be carried out owing to the *lack of suitable apparatus or chemicals*. This has resulted in more time required for all students to handle science experiments individually, severely curtailing teachers' efforts to facilitate practical sessions.

While the Malaysia Education Blueprint 2013-2025 aimed to ensure sufficient laboratory assistants are recruited and trained to support teachers, the hiring of qualified laboratory assistants remains an issue to be addressed by the Ministry of Education. The *shortage of qualified laboratory assistants* has meant that teachers need to spend extra time to help prepare experiments. This places additional burden on teachers and impact the quality of their teaching.

Most importantly, these shortcomings were compounded by the *limited budget* that schools have to maintain laboratories. According to the focus group, school budget allocation for science facilities are based on Per Capita Grant (PCG) for Mathematics and Sciences. This also means that the budget for laboratories were often allocated based on the number of science students in the school. Teachers suggested that it should be allocated based on the needs of school laboratories instead. School laboratories should receive a budget for periodic upgrades too, as many are reported to be in a poor state.

While teachers were aware of the shortcomings of science facilities at secondary schools, they emphasised that science experiments should be introduced at the primary level instead of upper-secondary. One of the key issues impeding effective science learning was that students did not have a good grasp of science concepts while in primary school, and undoing faulty concepts was difficult for secondary school teachers. Thus, it was suggested to equip primary school teachers with the necessary facilities and knowledge in order to introduce practical science lessons at a younger age.

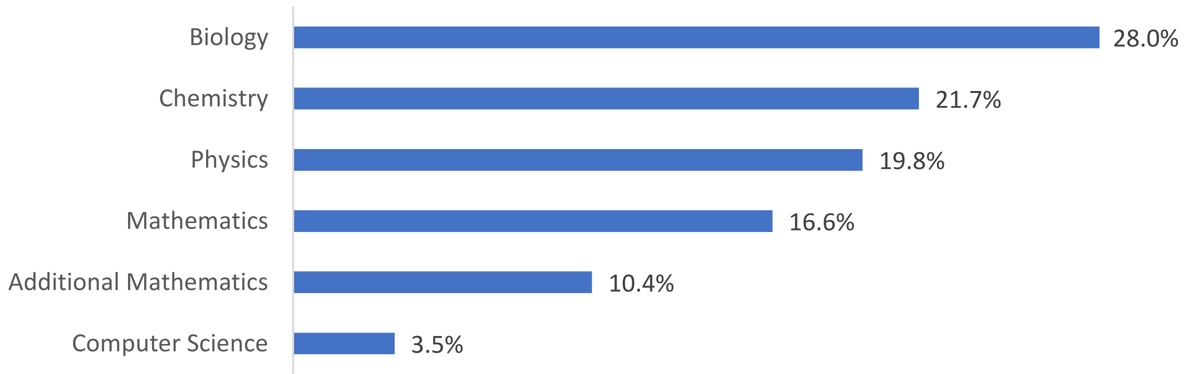
5.4 The potential characteristics of a future STEM workforce

A nation's workforce can be shaped by the current choice of study and interest in STEM fields among upper-secondary students. If enabling Industry 4.0 is the primary focus of the country over the next decade, a workforce with a STEM education would be needed to meet future labour market demand. To achieve this target, education policies should be adjusted accordingly along with labour market policies. Nurturing a large pool of students enrolling in the science stream during the upper-secondary schooling may lead to higher enrollment in tertiary STEM education, thus meeting the needs of the future labour market.

5.4.1 High interest in life-sciences-related jobs

While upper-secondary students may not be aware of the actual requirements in the job market, a set of subjects selected by students were either based on their own interest or on the advice from their parents, peers, and teachers. It is important to note that among the science subjects, a majority of science students chose Biology as their favourite subject (28%) over Chemistry (21.7%), Physics (19.8%), and Mathematics (16.6%) (Figure 5.3).

Figure 5.3 Favourite science subjects among upper-secondary students
Total respondents = 511



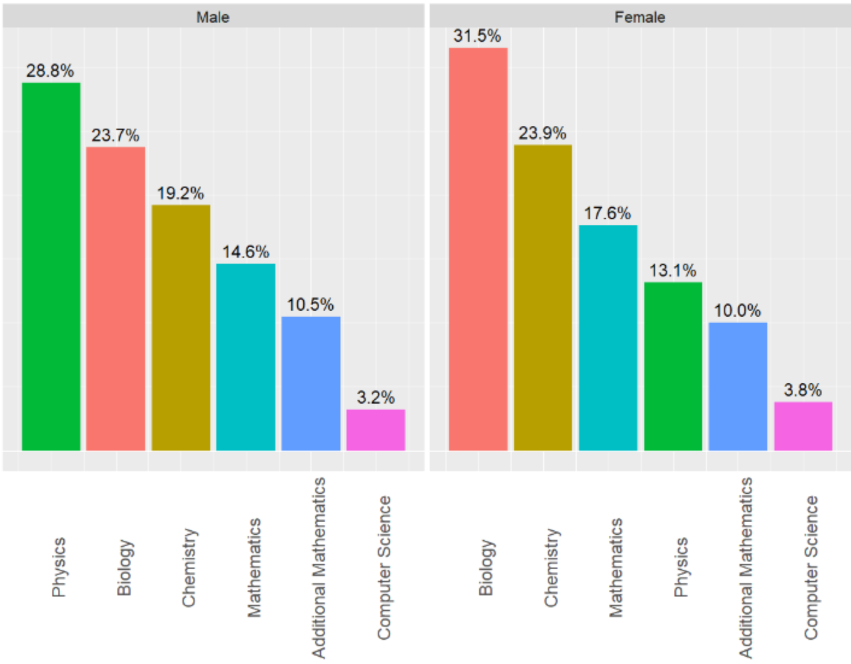
This seems to show that science students generally favour life sciences compared with physical sciences (which include Physics, Chemistry, Astronomy, and Earth Sciences), signifying that these students may have a greater interest in the areas of human biology, zoology, ecology, biochemistry, botany, and genetics, among others. More importantly, this result is consistent with the examination results across all types of schools (Section 3.1: Figure 3.3). This shows that students have a high interest in life-sciences-related jobs. Having more job opportunities in life sciences in Penang is necessary to prevent brain drain. Otherwise, life sciences graduates may enter careers that do not require life sciences qualification or leave the country for better opportunities.

5.4.2 A gender-based education and career

A gender-based academic interest is evident in this study. Female students seemed to gravitate towards Biology over Physics, as seen in Figure 5.4, while male students preferred Physics over Biology. In essence, women study about people and living creatures because they have the tendency to want to make a positive impact in society (Renken, 2016). This means that women can be more interested in pathways that integrates social interactions with cognitive science. This could mean careers in psychology, medicine, and bioscience, among others. Men are more interested in technological developments compared with females, despite both males and females having similar attitudes towards problem solving (Baran, 2016).

Figure 5.4 Favourite science subjects among upper-secondary students by gender

Total male students who were interested in science = 219; female students = 289



Health issues became the top preferred science among female students, while new inventions and technologies were preferred by half of male students. However, upper-secondary students of both genders ranked new scientific discoveries as their second-most-preferred area. Coupled with a fairly sizeable interest among male students in health issues (third-most-preferred science area), efforts to increase the uptake for physics-related subjects can be challenging. Therefore, the lack of enrollment in physics-related fields during tertiary education can be seen.

While a majority of science-stream students intend to remain in STEM fields at the tertiary level, at least a quarter of them said they would be interested in life-sciences-related courses such as Biotechnology, Biomedical, and Medicine. More importantly, over half of females chose to study Medicine (e.g. doctor, nurse), and only 22% of them have an interest in physics-related courses. Biology, Medicine, and Pharmacy were the top-three courses selected by female students.

Male students reacted differently to their future choice of study. While there was still a reasonably large proportion of male students interested in life-sciences-related courses, physical sciences remain the favoured course during tertiary education. Engineering-related courses saw the highest percentage of interest among male students, followed by Physics, Biology, Mathematics & Statistics, and Artificial Intelligence.

In sum, life-science-related careers are expected to be highly in demand in the next 10 years. If these jobs are insufficient, graduates who have a related degree may either pursue higher levels of education, drop out of STEM careers and enter non-STEM careers, or worse, work overseas. Therefore, students should be given more information related to jobs that are of high marketability.

5.4.3 Prioritising the interests of non-science students in computing and digital technology

It is important to note that STEM-courses are not limited to life sciences and physical sciences, and STEM courses should not be restricted to science students only. Opportunities in STEM education should be opened to non-science students who are interested in computing and digital technology developments, as there are not enough science students who are interested in these areas, as discussed in Section 3.5. From our survey, a handful of non-science students indicated their plans to enroll in STEM courses (19.8% out of 363 students); a majority of them expressed an interest in computer science, information technology, research, design and product development, and machine learning—despite the fact that some students chose mathematics and statistics and astronomy as their most-interested courses to study during higher education.

Some non-science students said were aware of the entry requirements for computer-science-related courses as they were rather informed on current job market trends. Entering a non-science stream would lead them to the courses they wish to study; entering the science stream, which was assumed to be more difficult, would be unnecessary. Therefore, even though computer science, information technology, and machine learning were not among the areas of interest indicated by science students, efforts to support non-science students in these areas should not be neglected. In turn, more concerted efforts are needed to enable the digital and inventive abilities of the potential students.

Sharing of information related to future careers is important to both science and non-science students. Although a small percentage of science students intend to drop out of STEM courses during higher education (5.6% out of 602 students), a fairly large proportion of students have yet to decide on their future study plans (22%). This share increases dramatically for non-science students, particularly those from HPS and CSE. This suggests an urgent need to hold workshops on a regular basis to understand students’ interest and provide guidance on the next wave of technological evolution, which would bring in new job opportunities led through either vocational or academic learning pathway.

Disseminating information pertaining to current and potential job market trends is crucial to provide students with more education and career opportunities. Job-seeking challenges occur if there was an oversupply of graduates seeking similar professions. Jobs need to be made available on a timely basis to avoid graduate unemployment, skills mismatch, and underemployment. Schools, teachers, and parents will have to work together to educate students about the challenges of job placements. If left unaddressed, this issue may worsen as we would be left with a high number of graduates with little choice but to accept jobs that only require secondary education, as highlighted in the Penang Skilled Workforce Study (Ong, 2017). Thus, overqualification is another issue to consider in making labour policies.

5.4.4 "Starting salary" a pull factor for non-STEM careers

STEM careers remain attractive for a majority of STEM students at secondary and tertiary levels. Over 70% of higher-education students plan to seek science-and-technology-related careers upon graduation, including those with family-business commitments. Career growth is highly regarded, along with professional development and innovation and creativity. For long-term career development, Monster, an international recruitment agency, has identified the six-fastest-growing science and technology jobs. These include information technology, biotechnology, environmental technology, and engineering technology. Additionally, demand for computing professionals will rise in almost all industries over the next decade (Yate, n.d.).

Among the STEM professions, information technology and engineering industries are expected to grow in the coming years. Despite the fact that long-term salary progression takes into account of years of working experience, fresh graduates with high efficacy are inclined to view the starting salary as a key factor in their career decisions. However, salary differences between information technology and engineering positions are still widespread, where the former would offer highest starting salary with low science importance score[21] compared with the latter. According to Kelly Services' 2019 Malaysia Salary Guide, the monthly salary for a Design Engineer with three-to-four years of experience ranged between RM3,500 and RM5,000 in 2019, while a Java Developer with not more than three years of experience could earn between RM4,500 and RM7,000. Since none of students from the science stream have expressed an interest in information technology courses, more workshops should be made available to educate upper-secondary science and non-science students on the demand for IT professionals (including artificial intelligence and data science) and the associated long-term career prospects.

STEM students who attempt to take up non-STEM careers should be a concern to policymakers. Our survey shows that while less than 8% of STEM students intend to work in non-STEM fields—including family businesses—starting salary was found to be a pull factor for some STEM students who intend to change to non-STEM careers, followed by long-term salary prospects and career growth. Compared with students who intend to stay in STEM fields, this group of students is believed to be more determined in their career decisions and aware of ongoing market trends. In other words, goal-oriented students with high self-efficacy may require greater effort to increase their interest in STEM.

For tertiary students, although the proportion was insignificant, the next-largest group of students say that their career plans are dependent on their parents' wishes (8.7% out of 184 students); this includes both males and females. This means that parents are a major influence in their children's career decisions, even at the tertiary level. This may lead to indecisiveness among these students as their

[21] According to Hoff, Perino, and Smith (2020), the Occupational Information Network (O*NET), a US Department of Labour database ranks the importance of using scientific rules and methods to solve problems in any jobs. This is measured by a score between zero and 100, with science-centric positions such as medical officers and chemists being ranked between 80 and 100, while computer and information systems managers, lawyers, and financial managers scored not more than 20.

choices have been made for them since they were young. The involvement of parents is less prevalent in students who wish to work in non-STEM careers.

Students should be trained to develop decision-making ability in making their own career paths. To build resilience in students, parents can play a vital role to facilitate and assist their children in making suitable career choices based on their children's strengths and weaknesses. Meanwhile, universities' career information centres can play a part to constantly update students about the latest market trends and engage and assist students who are still unable to make career decisions.

6 Proposed measures to increase STEM participation

This chapter proposes measures to increase STEM participation by gathering students' feedback on their perceptions and science-learning experiences at upper-secondary school and private colleges and university. A focus group discussion, with the participation of science and mathematics assistant principals (*Ketua Penolong*) and senior teachers (*Guru Kanan*) as well as a stakeholder engagement with the heads of colleges and universities also contributed to the making of the proposed solutions. Issues and challenges shared during the above-mentioned engagements were also captured. Finally, the proposed solutions to mitigate STEM drop-outs in careers are also discussed in this chapter.

6.1 Proposed measures to increase students' participation in science

To address the lack of interest in the sciences among upper-secondary students, proposed measures have centered around students' perceptions of science, parental influence, peer influence, teacher's pedagogical strategies, and the school environment.

Table 6.1 Proposed measures to increase students' participation in science

Issues	Challenges/observations	Proposed measures	Actors
A. Students' perception			
1. Lack of interest in science	a. The subjects are difficult; overwhelmed by concepts and theories. b. Students who were uncertain and had low self-efficacy were influenced by their parents, teachers, and friends. c. Early childhood science education and practical science-learning experiences in primary school were inadequate. d. Students and teachers are confused by inconsistent information found on the internet and in science textbooks. e. Lack of STEM career information.	i. Science theories should be relevant to real-life context. ii. Pedagogical strategies should improve students' self-efficacy. For example, encourage students to try challenging but attainable tasks; use peer models and capitalise on students' interest. iii. Parents should allow students to make their own choices but provide relevant guidance. iv. Primary schools/preschools should have science experiments to increase students' interest in science. v. Textbooks need to be updated digitally. vi. Industry experts should be invited to conduct workshops/short courses at	i. MOE and teaching colleges ii. Teachers and schools iii. Parents iv. MOE v. PSC and Penang STEM 4.0

		primary and secondary schools.	
2. Secondary-school students unable to reverse stream choices	a. Some students who have an interest in science and regret not choosing the science stream. b. Students were not given sufficient information about science subjects.	i. An academic advisory channel is recommended to be made available in schools to assist students in making their stream decisions. ii. A grace period of three months (maximum) should be given to students who may want to change their minds. iii. A compulsory course with an academic counsellor should be held to increase students' knowledge about subjects and future career plans before entering the upper-secondary level.	i. MOE and schools
B. Parents' attitudes			
1. Lack of positive guidance towards science	a. Statistically, parents' attitudes towards science learning has a significant effect on students' choice of stream. b. A majority of students' parents work in a non-science industry. Owing to the lack of knowledge in science, students were not encouraged to study science. However, parents whose jobs are related to science were more likely to advise their children to enter the science stream. c. Parents are unaware of STEM career pathways.	i. Parents should be involved in science programmes.	i. PSC and schools
2. Insufficient mothers in STEM	a. Fathers with higher education have a higher chance of urging their children to study in the science stream. b. But at tertiary level, mothers had greater involvement in study decisions, where they would encourage their children to study non-STEM courses regardless of the stream of study in upper-secondary school. c. Lack of women in engineering and computer science fields	i. More female STEM role models should be engaged in workshops/seminars for students.	i. PSC and schools

	have contributed to the gender gap in STEM.		
C. Peer influence			
1. Students' educational decision affected by peers	a. Science students are more likely to be influenced by their peers. b. High-performing peers may motivate peers to pursue a science education.	i. High-performing students should be aggregated with the rest at the lower-secondary level. ii. More activities should be encouraged between high-performing students and the rest.	i. Schools
D. Teachers' influence			
1. Ineffective pedagogical strategies	a. Teaching methods are exam-oriented and do not sustain interest in science. b. Conventional teaching methods were not welcomed by students. c. Teachers lack time to prepare and teach owing to heavy workload and syllabus. d. Teachers were unable to update their teaching methods due to lack of professional development.	i. Digital-enabled tools (e.g. smart board) are needed to improve student learning. ii. Teachers should employ a variety of platforms (e.g. YouTube, Netflix) to make science more fun and interesting. iii. Digitisation is required to reduce teachers' heavy workload. iv. More funds should be allocated to upgrade teaching tools and enable teachers' professional development.	i. MOE ii. Schools iii. Teachers iv. PSC
2. Intensive curriculum content and structure	a. Teachers have insufficient time to complete syllabus. b. Students have too many non-science subjects to study. c. Teachers have to switch between mediums of instruction. d. High student-teacher ratio limits teachers' productivity, particularly in science subjects. e. Outdated textbook content confuses teachers and students.	i. Science teaching hours should be lengthened to achieve 60:40 Policy. ii. Teaching assistants should be hired to assist teachers. iii. Subjects taken by students should reflect 60:40 Policy. iv. Science and mathematics is recommended to be taught in one language. v. Institutional reforms are required (refer to F). vi. Digital textbooks are recommended as they can be updated easily.	i. MOE
3. Overemphasis on academic assessment	a. There is a lack of practical examinations in SPM science subjects.	i. Practical examinations in SPM science subjects is highly recommended. ii. A more balanced assessment should be in	i. MOE ii. PSC iii. Teachers iv. Parents

	b. Students do not take study content seriously unless it is part of exams. c. Teachers are restricted to science activities that have exam-related outcomes. d. Teachers are pressured by parents who emphasised heavily on exam grades. e. An exam-based approach to science education narrows students' learning experience considerably.	place based on class participation and practical experiments. iii. Non-exam-oriented science activities should be allowed to cultivate science interest. iv. Parents should be involved in science and non-science activities.	
4. Shortage of well-qualified science teachers	a. There is a shortage of subject specialists in school. b. Non-qualified teachers are assigned to teach STEM subjects. c. Delay in postings for qualified teachers deprive public schools of talent. d. Retired science teachers are often not replaced. e. Teachers have lack of knowledge on market demand/STEM careers.	i. Subject specialists with teaching skills or qualified science and mathematics teachers should be hired. ii. Institutional reforms (refer to F) iii. Ongoing practical training and development should be made available for teachers/subject specialists.	i. MOE ii. JPN iii. PSC
5. Lack of professional training and development	a. Inadequate professional development reduces the effectiveness of science teaching.	i. More funds should be allocated to teachers' professional development. ii. Training in high-need areas such as classroom management skills, IT skills, and pedagogical skills are recommended to be provided to teachers.	i. MOE ii. JPN iii. PSC
E. School environment			
1. Poorly maintained and unconducive school lab facilities	a. Limited science tools are available for science students to conduct experiments. b. Limited funds available to upgrade labs, including equipment and environment. c. Unqualified lab assistants affect teachers' productivity.	i. Digital tools (e.g. smart board) are needed to improve student learning. ii. Funds should be allocated yearly to upgrade and maintain lab facilities based on the needs of school labs. iii. Schools should be more proactive in identifying the shortcomings of science facilities. iv. Qualified lab assistants should be hired and upskilled periodically.	i. MOE ii. Schools iii. Lab assistants

F. Institutional reforms			
1. Over-centralised education system	a. Teachers have limited autonomy over exam marking scheme. b. Schools have no authority in hiring teachers and lab assistants.	i. Teachers should be given flexibility and authority in marking exam papers. ii. Schools should be given more authority over recruitment of teaching staff.	i. MOE
2. Time constraints in teaching	a. Teachers have insufficient time to complete an intensive syllabus. b. Teachers encounter heavy workload.	i. To fulfil 60:40 Policy, science classes should be prioritised. ii. Science topics are recommended to be prioritised in classes.	i. MOE

6.2 Proposed measures to increase STEM workforce

Students' educational and career interests in secondary schools and colleges can provide clues on how the workforce will be shaped in the next five years. While their choice of study and career could be affected by the external influences, lack of education and job opportunities can result in students leaving the state or country, contributing to human capital flight. They would also likely drop out of STEM studies to seek better opportunities despite their interest in science. Table 6.2 summarises the issues and challenges of the future STEM workforce in Penang and measures to address the issues.

Table 6.2 Proposed measures to address future workforce in STEM

Issues	Challenges/observations	Proposed measures	Actors
A. Brain drain			
a. Life-sciences students migrate after graduation	a. Students are more interested in life-sciences-related subjects compared with physical sciences. b. Limited job opportunities for life-sciences students. c. There is a lack of job information for STEM careers in the market. d. Graduate unemployment, underemployment, and skills mismatch will increase if life-sciences-related jobs are not made available.	i. A mandatory short course on STEM market demand should be held at the secondary level. ii. Schools should invite recruitment consultants to explain the current job market. iii. The state government is recommended to develop Penang's life sciences industry. iv. Penang should enhance its R&D facilities in life sciences.	i. JPN ii. Schools iii. PSC iv. Recruitment consultants v. Invest Penang vi. PDC vii. Digital Penang

b. Difficult to retain STEM students	a. A majority of secondary-science students are interested in pursuing STEM courses at the tertiary level. b. Despite this, a shortage of STEM workers remains an issue due to either student studying overseas or changing their minds. c. Parents or students perceive higher education in Malaysian to be of lower quality. d. Remuneration packages for STEM jobs are unattractive.	i. Quality of education at universities should be improved. ii. A larger budget should be allocated for universities to hire highly qualified professors/lecturers (i.e. local and international talent). iii. University facilities should be upgraded to reflect students' needs/wants, with a larger budget. iv. Firms are recommended to offer competitive remuneration packages.	i. Institutes of higher learning ii. MOE iii. Companies
B. Dropping out from STEM courses			
1. Unattractive starting salaries in STEM jobs	a. Students who plan to switch to non-STEM jobs are those who value higher starting salaries. b. Students may have misconceptions about STEM starting salaries given that many are highly remunerated, e.g. IT-related jobs. c. Entry-level pay for STEM jobs are low because candidate quality does not meet firm expectations (lower employability), and graduates need to be retrained. d. According to the Penang Skilled Workforce Study (Ong, 2017), STEM graduates have relatively poor soft skills compared with non-STEM graduates. This may include starting salary negotiation skills.	i. Students should be provided with frequent updates about labour market demand and starting salaries. ii. Penang CAT Centre and university career centres should assist students who require career guidance, including strengths assessment, and interviewing skills iii. Apprenticeships should be made compulsory for STEM students (secondary and tertiary students). iv. Secondary students should be involved in industry-related projects as part of CSR programmes.	i. Penang CAT Centre ii. University career centres iii. Companies iv. Recruitment consultants v. PSC
2. Lack of information on STEM careers	a. Teachers/counsellors lack career-related information. b. Students might be misinformed about long-term career prospects.	i. Industry recruitment experts should be engaged to deliver career-related short courses or workshops for both teachers and students.	i. PSC ii. Recruitment consultants
3. Gender gap in STEM	a. Female students prefer life sciences over physical sciences, leading to a lack	i. Students should be exposed to more female role models in STEM.	i. Schools ii. Teachers iii. PSC

education and workforce	of women pursuing physical sciences. b. Students may feel pressured to conform to gender stereotypes when choosing their education and careers.	ii. Female students should be encouraged by providing them with special incentives (e.g. scholarships, perks, training) to enroll in STEM courses and to remain in the STEM workforce. iii. Firms are recommended to organise females-only apprenticeships in addition to their usual programs for STEM students.	iv. Companies
4. Insufficient interest from science/STEM students for IT-related courses	a. Compared with science students, a relatively large proportion of non-science students indicated an interest in pursuing STEM courses at the tertiary level (i.e. computer science, machine learning, design and product development). b. Parents of non-science students may be unaware of STEM education opportunities in IT-related courses, and are less likely to encourage them to enroll in those courses.	i. Opportunities in STEM education should be opened to non-science/STEM students who are interested in computing and digital technology development. ii. More outreach programmes should be targeted at non-science students who are still uncertain about their future plans.	i. PSC ii. Schools iii. Parents

6.3 Proposed measures to decrease STEM drop-out rates among high performers

The labour shortage in STEM fields is not just because students are not interested in science, leading to fewer students in STEM courses. The previous chapter shows that science students who had performed well in exams also intend to leave science-related fields in their future study and career plans. This would lead to a further tightening of the labour market in STEM fields.

Table 6.3 Proposed measures to reduce STEM drop-out rates among high performers

Issues	Challenges/observations	Proposed measures	Actors
1. High-performing leavers prefer non-STEM education and career over STEM.	a. Two-thirds of leavers were interested in science. b. 58% of leavers dropped out because science is their hobby but they prefer non-STEM careers. c. Job security, income, and easy to study were the main reasons for dropping out of science.	i. Students should be given more information about STEM careers.	i. PSC ii. Schools iii. Parents

2. The gender gap is more prevalent among high performers.	a. High-performing females are more likely to drop out of the science stream compared with high-performing males. b. Almost half of high-performing females who switched streams are interested in science, but switched because of career aspirations. c. Science is often seen as their hobby instead of a future career.	i. Students should be exposed to more female role models in STEM.	i. JPN ii. Schools iii. PSC iv. Parents
3. Low self-efficacy in STEM careers	a. Students lack information related to STEM careers. Therefore, they are less confident in remaining in STEM education and careers. b. Only 7% of leavers have parents in STEM occupations compared with 38% of persisters.	i. Students should be given more information about STEM careers. ii. Parents should be involved in STEM programmes, including external events organised by Penang STEM 4.0.	i. Schools ii. Parents iii. Penang STEM 4.0

6.4 Concluding remarks

The future workforce of a nation is shaped by the fields of study presently pursued by the students in upper-secondary schools and colleges. However, students' choice of study is interrelated to career opportunities. More university courses that are relevant to market needs should be offered to students to ensure that they are employable in the future. In fact, university graduates are supposed to be hired for highly qualified positions that are closely tied to their academic background.

Through this study, it is found that students' choice of study is determined by internal and external factors throughout their education history. Parental characteristics and peer influences are the internal factors influencing students' choice of study while the school environment and teachers' pedagogical strategies are the external factors determining it. These factors play a part in students' self-efficacy in addition to their own interests and goal-oriented characteristics.

Malaysian teachers face substantial hurdles in raising the quality of science-teaching standards, namely those related to pedagogical strategies, curriculum and classroom structure, academic assessment, the supply of qualified teachers, professional development, and the school environment. These can impact student's class satisfaction levels and motivation to study science; both factors are strongly linked to interest and, ultimately, STEM uptake. Finally, the constraints that teachers experience also indirectly diminish STEM graduates' employability and—in the long term—capacity for innovation.

Policy reforms are also said to be the cause of the weak take-up rate in STEM subjects. For example, the target for placing 60% of students in the science stream at the upper-secondary school level (or the 60:40 Policy), set by the MOE since 1970, has not been achieved in 2020. The recent abolishment of class streaming in 2020 would not help achieve this target. As a result, increasing STEM uptake remains a considerable challenge. Students would be more inclined to choose subjects based on their own interests, and science subjects, which are often perceived as difficult, would have fewer students enrolled. Therefore, producing a readily available and highly qualified STEM workforce will continue to pose a critical challenge for institutes of higher learning and for the high-tech sector if mitigation measures are not taken to address the gap in the labour market.

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Appendices

Appendix A: Questionnaires for upper-secondary and tertiary students

Student's Questionnaire

Secondary Students

Penang Institute and Penang Science Cluster

Penang Institute is in collaboration with Penang Science Cluster to undertake a study entitled "Students' Choice of STEM Study in Secondary and Tertiary Education: A Penang Case Study". The objective of this study is to identify factors affecting students' choice of study. It also aims to address the shortage of STEM (Science, Technology, Engineering and Mathematics) supply towards achieving a sustainable growth in STEM industries in Penang. This survey will take 20 minutes of your time. Please be assured that all information provided is treated in the *strictest confidence*.

Name: __________________________

School name: _______________________________ Class name: ____________________

Form of study: ☐ Form 4 ☐ Form 5

Stream: ☐ Science ☐ Non-science

A. Demographics

1. Age: _____ years old
2. Gender: ☐ Male ☐ Female
3. Ethnicity: ☐ Malay ☐ Chinese ☐ Indian ☐ Others (please specify): _______________
4. Are you currently in science or non-science stream?
   ☐ Science (**GO TO Q5**) ☐ Non-science (**GO TO Q6**)
5. Please state your last academic results for the following subjects
   (grade A+, A, A-, B+, B, C+, C, D, E, G, Not applicable):
   Mathematics: ________________ Physics: __________________
   Additional maths: _____________ Chemistry: ________________
   Biology: _____________________ English: __________________

6. Please indicate subjects that you are currently taking. (**CHOOSE ALL THAT APPLY**)

Subject	**Tick**
Physics	☐
Chemistry	☐
Biology	☐
Additional Mathematics	☐
Additional Science	☐
Information and Communication Technology (ICT)	☐
Computer Science (Sains Komputer)	☐
Principles of Accounting (Prinsip Perakaunan)	☐
Economics (Ekonomi)	☐
Commerce (Perniagaan)	☐
Entrepreneurial Studies (Pengajian Keusahawanan)	☐
Geography (Geografi)	☐
Religious Studies (Pendidikan Al-Quran & As-Sunnah/Pendidikan Syariah Islamiah/Tasawwur Islam/Bible Knowledge)	☐
Literature (Malay/Chinese/Tamil/English/etc.)	☐
Arts and Health (Seni Visual/Muzik/Sains Sukan)	☐

7. What are the highest education levels of your parents?

Level of education	**Father**	**Mother**
Doctorate (Ph.D)	☐	☐
Masters	☐	☐
Postgraduate Diploma	☐	☐
Bachelor/Degree	☐	☐
Diploma	☐	☐
Post-secondary (Form 6, Pre-U, A-level)	☐	☐
Certificate	☐	☐
Professional (ACCA, CFA)	☐	☐
Secondary	☐	☐
Primary	☐	☐
Never attended school	☐	☐
Others	☐	☐
Don’t know	☐	☐
Not applicable	☐	☐

8. What are your parents’ current work?

	Father	**Mother**
He/she currently works in the science industry. (**GO TO Q8a**)	☐	☐
He/she doesn’t work in the science industry, but he/she used to in the past. (**GO TO Q9**)	☐	☐
He/she has never worked in the science industry. (**GO TO Q9**)	☐	☐
Others (please specify): ___________________________ (**GO TO Q9**)	☐	☐
Others (please specify): ___________________________ (**GO TO Q9**)	☐	☐

8a. Are they working in science-related jobs?

	Father	Mother
He/she is currently working in a science-related job.	☐	☐
He/she is currently working in a non-science-related job.	☐	☐

9. What were the fields of study of your parents?

Field of study	Father	Mother
Science/Engineering/Technology	☐	☐
Non-science	☐	☐
Don't know	☐	☐
Not applicable	☐	☐

10. What are your parents' current occupations?

Father: _________________

Mother: _________________

11. What are your eldest brother's/sister's highest education level, field of study and occupation? (OPTIONAL)
Education level: _______________ Field of study: _________________ Occupation: ______________

B. Interest and perception in science

1. How interested are you in science?

☐ Not interested at all	**GO TO Q2-Q3**
☐ Rather not interested	
☐ Rather interested	**GO TO Q4-Q8**
☐ Very interested	
☐ Neither interested nor disinterested	**GO TO Q9**
☐ Don't know	

2. What is/are the main factor(s) that has/have affected your lack of interest in science? (**CHOOSE MAX TWO ONLY**)

☐ I never had any interest or liking for science.
☐ I don't understand the subject.
☐ The subject is difficult. (**GO TO Q2a**)
☐ I don't believe in scientist.
☐ Science is in English. /It is difficult to understand English.
☐ The science subjects taught in school are not interesting.
☐ I don't like my science teacher because ____________________________ (please specify)
☐ Others (please specify): ____________________________________

2a. What difficulties did/do you face when you study science subjects?

____

Go to Q3 if you are in SCIENCE stream;
Go to Q10 if you are in NON-SCIENCE stream.

3. Why are you not interested in science but you are currently with science stream? (**CHOOSE MAX TWO ONLY**)
   ☐ I am forced to study science.
   ☐ I scored well in my science subjects even though I don't have any interest.
   ☐ I can have more choices for further studies.
   ☐ My parents asked me to study science stream.
   ☐ My friends are studying science stream.
   ☐ Science stream can promise me a good job in the future.
   ☐ I have no idea why I am here.
   ☐ Others (please specify): ___________

   Skip Q4-Q9, go to Q10.

4. Why do you like science? (**CHOOSE MAX TWO ONLY**)
   ☐ I am sure I can do well in science.
   ☐ I scored good marks in science subjects.
   ☐ I enjoy learning science than other subjects.
   ☐ I want to make a major difference to the world.
   ☐ I like learning new things.
   ☐ Science is interesting and amazing.
   ☐ I like the challenge in solving science problems.
   ☐ Science helps me to understand things in everyday life.
   ☐ Studying science makes me look smart.
   ☐ I want to get a good job in future.
   ☐ I can have more choices for further studies.
   ☐ My science teacher was really good.
   ☐ My parents did science too.
   ☐ I like the science activities at school.
   ☐ Others (please specify): ___________________

5. Which domain has influenced you the MOST in learning science? (**CHOOSE ONE ONLY**)
   ☐ Parents
   ☐ Teachers
   ☐ Documentaries
   ☐ Friends
   ☐ Science books (non-fiction)
   ☐ Science fictions
   ☐ Internet
   ☐ Movies
   ☐ School science activities
   ☐ A role model (besides parents, teachers and friends)
   ☐ Others (please specify): ______________

6. Which area(s) of science interest you the MOST? (**CHOOSE MAX TWO ONLY**)
   ☐ Health issues
   ☐ Environmental issues
   ☐ Aerospace technology
   ☐ New inventions and technology (e.g. gadgets/robots)
   ☐ New scientific discoveries
   ☐ Others (please specify): ______________

Go to Q7 if you are in SCIENCE stream;
Go to Q8 if you are in NON-SCIENCE stream.

7. Which subject of science interest you the most? (**CHOOSE ONE ONLY**)
   - ☐ Mathematics
   - ☐ Biology
   - ☐ Additional Mathematics
   - ☐ Chemistry
   - ☐ Physics
   - ☐ Computer Science

   Skip Q8-Q9, go to Q10.

8. Why are you interested in science, but you are currently with arts stream? (**CHOOSE MAX TWO ONLY**)
   - ☐ I scored badly in science subjects.
   - ☐ Arts-stream subjects are easier to understand than the science subjects.
   - ☐ Science is my hobby and I prefer arts stream to be my future career.
   - ☐ Arts stream can promise me a job in the future.
   - ☐ Arts stream can give me quality and/or high-income jobs.
   - ☐ Others (please specify): __________________

   Skip Q9, go to Q10.

9. What is/are the reason(s) to study science subjects? (**CHOOSE MAX TWO ONLY**)
   - ☐ The subjects are inspiring and eye opening.
   - ☐ I enjoy studying science subjects.
   - ☐ Science is amazing and interesting.
   - ☐ I will be respected at school and in the society.
   - ☐ I want to get a good job in the future.
   - ☐ I will be very rich if I study science.
   - ☐ Most of my friends are studying science stream.
   - ☐ I can have more choices for further studies.
   - ☐ Teachers told me to do so.
   - ☐ I am sure that I can do well in science.
   - ☐ I am forced to study science.
   - ☐ I did well in science subjects' exams.
   - ☐ My parents asked me to study science stream.
   - ☐ My parents did science too.
   - ☐ Studying science will help me in life.
   - ☐ It is easier to do science subjects than other subjects.
   - ☐ I have no idea why I am here.
   - ☐ Others (please specify): ___________________

All

10. Did/do the science classes conducted by teachers meet your expectation in learning science?
    ☐ Yes (**GO TO Q11**) ☐ No (**GO TO Q10a**) ☐ Don't know (**GO TO Q11**)

    10a. What is/are the area(s) that you think your science classes have not met your expectations? (**CHOOSE MAX TWO ONLY**)
    - ☐ Too textbook-oriented
    - ☐ Too exam-oriented
    - ☐ Teachers are not innovative and creative.
    - ☐ Science teachers are too boring.
    - ☐ Others (please specify): ____

11. What do you think are the **TOP THREE** factors that could help increase your interest in science? (**CHOOSE EXACTLY THREE ONLY**)
    - ☐ A more hands-on/interactive approach during school lessons
    - ☐ More emphasis on science in school
    - ☐ Introduce new laboratories
    - ☐ More seminars/opportunities to learn
    - ☐ Make science more interesting/fun
    - ☐ More emphasis on computer studies
    - ☐ More science-related activities/exhibitions
    - ☐ Others (please specify): ____________________________________

12. Did your parents urge you to choose science stream?
    - ☐ Yes **(GO TO Q13)**
    - ☐ No **(GO TO Q14)**

13. What did your parents say?
    - ☐ Science stream is good for my future.
    - ☐ Science stream will give me quality and/or high-income jobs.
    - ☐ No reason was given.
    - ☐ Others (please specify): ___________________________________

    Skip Q14, go to Q15.

14. Why didn't your parents urge you to choose science stream?
    - ☐ I don't know.
    - ☐ They said that science stream cannot promise good future.
    - ☐ They said that science stream cannot promise good income.
    - ☐ They said that arts stream is good for my future.
    - ☐ They said that arts stream will give me quality and/or high-income jobs.
    - ☐ They said that it's all dependent on my interest.
    - ☐ Others (please specify): ___________________________________

15. Did your friends influence you to choose the current stream of your study?
    - ☐ Yes
    - ☐ No

C. Science learning experience

1. Did/Does your school motivate you in learning science?
    - ☐ Yes **(GO TO Q2)**
    - ☐ No **(GO TO Q3)**

2. How did/does your school motivate you in learning science?

		1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
i.	A variety of internal science-related activities and clubs	☐	☐	☐	☐	☐
ii.	Various external science programmes such as visiting National Science Centre, Tech Dome, Penang Science Cluster, etc.	☐	☐	☐	☐	☐
iii.	Highly inspiring and enthusiastic science teachers	☐	☐	☐	☐	☐
iv.	Exciting science classes	☐	☐	☐	☐	☐
v.	Teachers assist us to understand science concepts.	☐	☐	☐	☐	☐
vi.	Teachers use real-life examples in science classes.	☐	☐	☐	☐	☐
vii.	Teachers regularly update us with the latest development in science and technology.	☐	☐	☐	☐	☐
viii.	Science activities held in school are sufficient to encourage science learning.	☐	☐	☐	☐	☐
ix.	Highly supportive science environment with complete laboratories and science tools	☐	☐	☐	☐	☐
x.	Teachers encourage us to participate in learning science subjects.	☐	☐	☐	☐	☐
xi.	Teachers identify student learning needs and difficulties in science subjects.	☐	☐	☐	☐	☐
xii.	School creates cooperative environment among students towards learning science subjects.	☐	☐	☐	☐	☐
xiii.	I am motivated to conduct experiment independently.	☐	☐	☐	☐	☐

Skip Q3, go to Q4.

3. In what areas that you think your school did/does not motivate you in learning science?

		1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
i.	Inadequate number of science teachers	☐	☐	☐	☐	☐
ii.	Large number of students in the class and laboratories	☐	☐	☐	☐	☐
iii.	Inadequate teaching time in conducting experiment in laboratories	☐	☐	☐	☐	☐
iv.	Lack of teaching and learning materials such as chemicals for practical	☐	☐	☐	☐	☐
v.	Lack of laboratories	☐	☐	☐	☐	☐
vi.	Too exam-oriented	☐	☐	☐	☐	☐
vii.	Science teachers are too boring.	☐	☐	☐	☐	☐

4. Do you think that the grades you obtained for science subjects are important to reflect your understanding of the subject?

1 Not important at all	2 Not important	3 Neutral	4 Important	5 Very important
☐	☐	☐	☐	☐

5. Where do you usually come across information or news about science and/or technology? (**CHOOSE MAX THREE ONLY**)

☐ Radio
☐ Newspapers
☐ School
☐ Other people (family and friends)
☐ Textbooks
☐ TV programme/documentaries/news
☐ Science magazines
☐ Public forums
☐ Internet
☐ Advertisements
☐ Others (please specify): ________________

6. How often do you actively search for information related to science and/or technology?

☐ Very frequently
☐ Frequently
☐ Occasionally
☐ Rarely
☐ Never

7. Which internet source(s) do you use? (**CHOOSE MAX THREE ONLY**)

☐ Search engine (e.g. google, yahoo)
☐ YouTube videos
☐ Facebook
☐ Twitter
☐ News websites
☐ General websites
☐ Science websites
☐ Academic websites
☐ Blogs written by scientists or science commentators
☐ Wikipedia
☐ Others (please specify): ________________

8. For what reason(s) did/do you actively search for information about science and/or technology?
   ☐ School projects
   ☐ Personal interest
   ☐ Others (please specify): ______________________

9. Do you generally find what you are looking for?

☐ Always	**GO TO Q10**
☐ Sometimes	
☐ Rarely	**GO TO Q11**
☐ Never	
☐ It depends on the subject.	
☐ Don't know	**GO TO Q12**
☐ Not applicable	

10. Is the information that you find …?
    ☐ Always easy to understand
    ☐ Sometimes difficult to understand
    ☐ Often difficult to understand
    ☐ Never easy to understand
    ☐ It depends on the subject.

    Skip Q11, go to Q12.

11. What subject(s) do you find it difficult to obtain information about?

    ____

12. How often do you …

		1	2	3	4	5
		Never	**Rarely (once a month or less)**	**Occasionally (2-3 times a week)**	**Frequently (1-2 times a day)**	**Very frequently (more than 2 times a day)**
i.	Watch documentaries	☐	☐	☐	☐	☐
ii.	Read about science	☐	☐	☐	☐	☐
iii.	Access the internet on a computer/mobile devices to look for information about science	☐	☐	☐	☐	☐
iv.	Attend a debate or talk on a science-related subject	☐	☐	☐	☐	☐
v.	Attend a science-related public activity (e.g. science fair)	☐	☐	☐	☐	☐

13. Which of these activities or events have you heard of or visited before?

	Heard of	Visit		
		Visited	No. of visit	Self-initiated/school events
Penang Science Café	☐	☐	___ times	☐ Self ☐ School
Penang International Science Fair	☐	☐	___ times	☐ Self ☐ School
Penang Tech Dome	☐	☐	___ times	☐ Self ☐ School
Penang STEM programmes	☐	☐	___ times	☐ Self ☐ School

14. What other science and technology-related activity/activities or event(s) do you think could be organised? (**CHOOSE MAX THREE ONLY**)
    ☐ More hands-on science for children
    ☐ School involvement in events
    ☐ More science competitions should be organised.
    ☐ More inexpensive exhibitions
    ☐ More interactive science activities
    ☐ Others (please specify): ______________________________________

15. If you were given the chance to make a choice again, would you remain in the same stream?
    ☐ Yes, because ______________________________________ (please specify)
    ☐ No, because _______________________________________ (please specify)

D. Further studies and careers in science

1. Will you pursue your study in Science, Technology, Engineering and Mathematics (STEM) courses?
   ☐ Yes **(GO TO Q2)** ☐ No (**GO TO Q3**) ☐ Don't know (**GO TO Q4**)

2. Which subject(s) or course(s) interest you the MOST? (**CHOOSE MAX THREE ONLY**)
   ☐ Data Science
   ☐ Artificial Intelligence
   ☐ Machine Learning
   ☐ Physics
   ☐ Astronomy
   ☐ Biology (biotechnology, biomedical)
   ☐ Computer Science (programming, software development)
   ☐ Mathematics & Statistics
   ☐ Medicine (doctor, nurse)
   ☐ Geology
   ☐ Engineering (civil, chemical, electrical, mechanical)
   ☐ Pharmacy
   ☐ Precision Machining & Engineering
   ☐ Information Technology (database administration, information security)
   ☐ Research, Design and Product Development
   ☐ Others (please specify): ______________________

Skip Q3, go to Q4.

3. Why wouldn't you pursue your study in STEM courses? (**CHOOSE ONE ONLY**)
   ☐ I will be taking over my family business, which is not science-related.
   ☐ My parents have set my career paths, which are not science-related.
   ☐ I am more interested in finance/banking/insurance/accountancy/tax-related careers.
   ☐ I am more interested in creative arts such as acting, graphic design, etc.
   ☐ It is hard to secure scholarship.
   ☐ My family cannot support my study in STEM courses.
   ☐ Others (please specify): ____

4. How do you imagine your future after completing your study? (**CHOOSE ONE ONLY**)
   ☐ I will be working in science and technology industry.
   ☐ I will be working in finance/banking industry.
   ☐ It is likely dependent on my parents' wishes.
   ☐ I will be taking over my family business that is not in science and technology industry.
   ☐ I will be taking over my family business that is in science and technology industry.
   ☐ Others (please specify): ____

5. Do you agree that science courses/subjects suit both men and women equally?

1	**2**	**3**	**4**	**5**
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
☐	☐	☐	☐	☐

6. What do you think about the government funding for science research? (**CHOOSE ONE ONLY**)
   ☐ It should be reduced because the money can be better spent elsewhere.
   ☐ It should be remained as it is.
   ☐ It should be increased as science research is important for the economy.
   ☐ I have no idea/am not aware of current funding.

-THANK YOU FOR YOUR TIME-

We wish you all the best in your SPM examination.

Student's Questionnaire

College and University Students

Penang Institute and Penang Science Cluster

Penang Institute is in collaboration with Penang Science Cluster to undertake a study entitled "Students' Choice of STEM Study in Secondary and Tertiary Education: A Penang Case Study". The objective of this study is to identify factors affecting students' choice of study. It also aims to address the shortage of STEM (Science, Technology, Engineering and Mathematics) supply towards achieving a sustainable growth in STEM industries in Penang. This survey will take 20 minutes of your time. Please be assured that all information provided is treated in the *strictest confidence*.

Name of college/university: ________________________ School/Faculty/Programme: ___________________

Major of study: ____ Year in college: ________

Level of study: Certificate/ Diploma/Advance Diploma/Bachelor Degree/Postgraduate (Please circle)

A. Demographics

1. Age: _____ years old

2. Gender: ☐ Male ☐ Female

3. Ethnicity: ☐ Malay ☐ Chinese ☐ Indian ☐ Others (please specify): _________________

4. Were you in science stream or non-science stream during Form Five?
   ☐ Science (**GO TO Q5**) ☐ Non-science (**GO TO Q6**)

5. Please state your SPM results in following subjects (grade A+, A, A-, B+, B, C+, C, D, E, G, Not applicable):
   Mathematics: ____ Additional maths: ____ Biology: ____
   Physics: ___ Chemistry: ____ English: ____

6. What are the highest education levels of your parents?

Level of education	Father	Mother
Doctorate (Ph.D)	☐	☐
Masters	☐	☐
Postgraduate Diploma	☐	☐
Bachelor/Degree	☐	☐
Diploma	☐	☐
Post-secondary (Form six, Pre-U, A-level)	☐	☐
Certificate	☐	☐
Professional (ACCA, CFA)	☐	☐
Secondary	☐	☐
Primary	☐	☐
Never attended school	☐	☐
Others	☐	☐
Don't know	☐	☐
Not applicable	☐	☐

7. What are your parents' current work?

	Father	Mother
He/she currently works in the science industry. (**GO TO Q7a**)	☐	☐
He/she doesn't work in the science industry, but he/she used to in the past. (**GO TO Q8**)	☐	☐
He/she has never worked in the science industry. (**GO TO Q8**)	☐	☐
Others (please specify): ___________________________ (**GO TO Q8**)	☐	☐
Others (please specify): ___________________________ (**GO TO Q8**)	☐	☐

7a. Are they working in science-related jobs?

	Father	Mother
He/she is currently working in a science-related job.	☐	☐
He/she is currently working in a non-science-related job.	☐	☐

8. What were the fields of study of your parents?

Field of study	Father	Mother
Science/Engineering/Technology	☐	☐
Non-science	☐	☐
Don't know	☐	☐
Not applicable	☐	☐

9. What are your parents' current occupations?

Father: _________________

Mother: _________________

10. What are your eldest brother's/sister's highest education level, field of study and occupation? (OPTIONAL)
Education level: __________ Field of study: __________ Occupation: ______________

B. Choice of study and perception in STEM

1. What was/were your consideration(s) when you decided to study your current major? (**CHOOSE MAX THREE ONLY**)

☐ Small class and close teacher-student ties
☐ Relatives attended the courses.
☐ Close friends attended the courses.
☐ School/college is near to home.
☐ School/college is far from home.
☐ Scholarship was granted.
☐ Admission was assured.
☐ Impressed by college facilities
☐ Impressed by science facilities
☐ Others (please specify): __________
☐ Recommendations by school counsellor
☐ Recommendations from high school teacher
☐ Parental influence
☐ Influence of admission staff
☐ Quality of students in the college/university
☐ Well-established library
☐ Reputation of the college/university

2. Why did you choose this major? (**CHOOSE MAX TWO ONLY)**

☐ It is easy to pass.
☐It can make more money.
☐ It is easy to read.
☐ I don't know. My parents decide.
☐ It is challenging to pass.
☐ My friends are choosing this specialisation.
☐ It is challenging to read.
☐ It was advised by my school teachers.
☐ It has bright career in future.
☐ I was only offered this major.
☐ It is my personal interest.
☐ Others (please specify): ____________

3. Is your current major your first choice of study?

☐ Yes (**GO TO Q6**) ☐ No (**GO TO Q4**)

4. What was your first chosen major?

____

5. Why did you change your major?

____

6. Did your parents urge you to choose STEM courses?

☐ Yes **(GO TO Q7)**
☐ No **(GO TO Q8)**

7. What did your parents say?

☐ STEM are good for my future.
☐ STEM will give me quality and /or high-income jobs.
☐ No reason was given.
☐ Others (please specify): ___________________________________

Skip Q8, go to Q9.

8. Why didn't your parents urge you to choose STEM courses?

☐ I don't know.
☐ They said that STEM cannot promise good future.
☐ They said that STEM cannot promise good income.
☐They said that business/accounting/banking majors are good for my future.
☐ They said that business/accounting/banking majors will give me quality and/or high-income jobs.
☐ They said that it's all dependent on my interest.
☐ Others (please specify): ___________________________________

9. Did your friends influence you to choose your current major?

☐ Yes
☐ No

C. **Perception of chosen study**

1. Please rate the importance of the following factors in selecting your current study.

		1	2	3	4	5	0
		Not important at all	**Not important**	**Neutral**	**Important**	**Very important**	**Not applicable**
i.	Personal interest in subject matter	☐	☐	☐	☐	☐	☐
ii.	Difficulty of subject matter	☐	☐	☐	☐	☐	☐
iii.	Performance in secondary school science courses	☐	☐	☐	☐	☐	☐
iv.	Performance in secondary school math courses	☐	☐	☐	☐	☐	☐
v.	Family member(s)	☐	☐	☐	☐	☐	☐
vi.	Friend(s)	☐	☐	☐	☐	☐	☐
vii.	Secondary school guidance counsellor(s)	☐	☐	☐	☐	☐	☐
viii.	Secondary school teacher(s)	☐	☐	☐	☐	☐	☐
ix.	Secondary school career interest tests	☐	☐	☐	☐	☐	☐
x.	Reputation of the college/university	☐	☐	☐	☐	☐	☐
xi.	Reputation of degree programme at college/university	☐	☐	☐	☐	☐	☐
xii.	Quality of lecturers	☐	☐	☐	☐	☐	☐
xiii.	Opportunity to participate in student organisation	☐	☐	☐	☐	☐	☐
xiv.	Prolong internship period	☐	☐	☐	☐	☐	☐
xv.	Proximity to home	☐	☐	☐	☐	☐	☐
xvi.	Promising career in future	☐	☐	☐	☐	☐	☐
xvii.	Good income	☐	☐	☐	☐	☐	☐

2. How interested are you in science?

☐ Not interested at all	**GO TO Q3-Q4**
☐ Rather not interested	
☐ Rather interested	**GO TO Q5-Q9**
☐ Very interested	
☐ Neither interested nor disinterested	**GO TO Q10**
☐ Don't know	

3. What is/are the main factor(s) that has/have affected your lack of interest in science? (**CHOOSE MAX TWO ONLY**)

☐ I never had any interest or liking for science.
☐ I don't understand the subject.
☐ The subject is difficult. (**GO TO Q3a**)
☐ I don't believe in scientist.
☐ Science is in English. /It is difficult to understand English.
☐ The science subjects taught in school are not interesting.
☐ I don't like my science teacher because ____
☐ Others (please specify): ___________________________________

3a. What difficulties did/do you face when you study science subjects?

____

Go to Q4 if your major of study is in STEM field;
Go to Q10 if your major of study is in NON-STEM field.

4. Why are you not interested in science but you are currently studying STEM major? (**CHOOSE MAX TWO ONLY**)

☐ I am forced to study this major.
☐ I scored well in my science subjects even though I don't have any interest.
☐ My parents asked me to study this major.
☐ My friends are studying this major.
☐ STEM can promise me a good job in the future.
☐ I have no idea why I am here.
☐ Others (please specify): __________________________________

Skip Q5-Q9, go to Q10.

5. Why do you like science? (**CHOOSE MAX TWO ONLY**)

- ☐ I am sure I can do well in science.
- ☐ I scored good marks in science subjects.
- ☐ I enjoy learning science than other subjects.
- ☐ I want to make a major difference to the world.
- ☐ I like learning new things.
- ☐ Science is interesting and amazing.
- ☐ I like the challenge in solving science problems.
- ☐ My parents did science too.
- ☐ Studying science makes me look smart.
- ☐ I want to get a good job in future.
- ☐ My science teacher was really good.
- ☐ I like the science activities at school/college/university.
- ☐ Science helps me to understand things in everyday life.
- ☐ Others (please specify): ______________________________

6. Which domain has influenced you the MOST in learning science? (**CHOOSE ONE ONLY**)

- ☐ Parents
- ☐ Teachers
- ☐ Documentaries
- ☐ Friends
- ☐ Science books (non-fiction)
- ☐ Science fictions
- ☐ Internet
- ☐ Movies
- ☐ School science activities
- ☐ A role model (besides parents, teachers and friends)
- ☐ Others (please specify): __________

7. Which area(s) of science interest you the MOST? (**CHOOSE MAX TWO ONLY**)

- ☐ Health issues
- ☐ Environmental issues
- ☐ Aerospace technology
- ☐ Others (please specify): __________
- ☐ New inventions and technology (e.g. gadgets/robots)
- ☐ New scientific discoveries

Go to Q8 if your major of study is in STEM field;
Go to Q9 if your major of study is in NON-STEM field.

8. Which subject(s) of STEM interest you the MOST? (**CHOOSE MAX TWO ONLY**)

- ☐ Mathematics and Statistics
- ☐ Medicine/Dentistry
- ☐ Engineering (please specify): _______________________________
- ☐ Computing, Programming and Coding
- ☐ Others (please specify): ___________________________________

Skip Q9, go to Q10.

9. Why are you interested in science, but you are currently with arts stream? (**CHOOSE MAX TWO ONLY**)
    ☐ I scored badly in science subjects.
    ☐ Arts-stream subjects are easier to understand than the science subjects.
    ☐ Science is my hobby and I prefer arts stream to be my future career.
    ☐ Arts stream can promise me a job in the future.
    ☐ Arts stream can give me quality and/or high-income jobs.
    ☐ Others (please specify): ____________

All

10. Did/do the classes conducted by teachers/lecturers meet your expectation in learning science?

☐ Yes (**GO TO Q11**) ☐ No (**GO TO Q10a**) ☐ Don't know (**GO TO Q11**)

10a. What is/are the area(s) that you think your science classes have not met your expectations? (**CHOOSE MAX TWO ONLY**)

☐ Too textbook-oriented
☐ Too exam-oriented
☐ Teachers are not innovative and creative.
☐ Science teachers are too boring.
☐ Teachers do not update us with the latest development in science and technology.
☐ Others (please specify): ____

11. What do you think are the **TOP THREE** factors that could help increase your interest in science?

☐ A more hands-on/interactive approach during school lessons
☐ More emphasis on science in school
☐ Introduce new laboratories
☐ More seminars/opportunities to learn
☐ Make science more interesting/fun
☐ More emphasis on computer studies
☐ More science related activities/exhibitions
☐ Others (please specify): _______________

12. To what extent are the following information sources important in choosing your major?

	1	**2**	**3**	**4**	**5**	**0**
	Not important at all	**Not important**	**Neutral**	**Important**	**Very important**	**Not applicable**
i. Internet/web	☐	☐	☐	☐	☐	☐
ii. College/department website	☐	☐	☐	☐	☐	☐
iii. Current students	☐	☐	☐	☐	☐	☐
iv. Faculty	☐	☐	☐	☐	☐	☐
v. Alumni	☐	☐	☐	☐	☐	☐
vi. University admission counsellors	☐	☐	☐	☐	☐	☐
vii. Invited speakers	☐	☐	☐	☐	☐	☐
viii. TV or movie portrayal of the occupation	☐	☐	☐	☐	☐	☐
ix. Newspaper articles	☐	☐	☐	☐	☐	☐
x. Brochures	☐	☐	☐	☐	☐	☐
xi. Online job listing	☐	☐	☐	☐	☐	☐
xii. Parent(s)	☐	☐	☐	☐	☐	☐
xiii. Friend(s)	☐	☐	☐	☐	☐	☐

13. Thinking back to secondary school, were you aware of the possible career paths in each of the following areas when you completed secondary school?

	1	2	0
	I had vast knowledge.	**I was aware of it/had little knowledge.**	**I was not aware at all.**
i. Data Science	☐	☐	☐
ii. Automation Engineering	☐	☐	☐
iii. Integrated Circuit Design	☐	☐	☐
iv. Computer Science	☐	☐	☐
v. Electrical & Electronic Engineering	☐	☐	☐
vi. Information Technology	☐	☐	☐
vii. Mechanical Engineering	☐	☐	☐
viii. Precision Engineering	☐	☐	☐
ix. Biomedicine	☐	☐	☐
x. Medicine/Pharmacy	☐	☐	☐
xi. Software Design	☐	☐	☐
xii. Mathematics & Statistics	☐	☐	☐
xiii. Business	☐	☐	☐
xiv. Accounting	☐	☐	☐
xv. Finance & Banking	☐	☐	☐
xvi. Arts & Humanities	☐	☐	☐
xvii. Social Sciences	☐	☐	☐

14. For career(s) that you had not been informed, please tell us why so.

____

15. Any other major(s) that you have been informed in secondary school, but it is not being listed in Q13?

____

D. Science learning experience

1. Where do you usually come across information or news about science and/or technology? (**CHOOSE MAX THREE ONLY**)
   - ☐ Radio
   - ☐ Newspapers
   - ☐ School
   - ☐ Other people (family and friends)
   - ☐ Textbooks
   - ☐ TV programmes/documentaries/news
   - ☐ Science magazines
   - ☐ Internet
   - ☐ Advertisements
   - ☐ Public forums
   - ☐ Others (please specify): _____________

2. How often do you actively search for information related to science and/or technology?
   - ☐ Very frequently
   - ☐ Frequently
   - ☐ Occasionally
   - ☐ Rarely
   - ☐ Never

3. Which internet source(s) do you use? (**CHOOSE MAX THREE ONLY**)
   - ☐ Search engine (e.g. google, yahoo)
   - ☐ YouTube videos
   - ☐ Facebook
   - ☐ Twitter
   - ☐ News websites
   - ☐ General websites
   - ☐ Science websites
   - ☐ Academic websites
   - ☐ Blogs written by scientists or science commentators
   - ☐ Wikipedia
   - ☐ Others (please specify): _____________

4. For what reason(s) did/do you actively search for information about science and/or technology?
   - ☐ School projects
   - ☐ Personal interest
   - ☐ Others (please specify): ______________________

5. Do you generally find what you are looking for?

☐ Always	**GO TO Q6**
☐ Sometimes	
☐ Rarely	**GO TO Q7**
☐ Never	
☐ It depends on the subject.	
☐ Don't know	**GO TO Q8**
☐ Not applicable	

6. Is the information that you find …?

☐ Always easy to understand
☐ Sometimes difficult to understand
☐ Often difficult to understand
☐ Never easy to understand
☐ It depends on the subject.

Skip Q7, go to Q8.

7. What subject(s) do you find it difficult to obtain information about?

____

8. How often do you …

	1 Never	**2 Rarely (once a month or less)**	**3 Occasionally (2-3 times a week)**	**4 Frequently (1-2 times a day)**	**5 Very frequently (more than 2 times a day)**
i. Watch documentaries	☐	☐	☐	☐	☐
ii. Read about science	☐	☐	☐	☐	☐
iii. Access the internet on a computer/mobile devices to look for information about science	☐	☐	☐	☐	☐
iv. Attend a debate or talk on a science-related subject	☐	☐	☐	☐	☐
v. Attend a science-related public activity (e.g. science fair)	☐	☐	☐	☐	☐

9. Which of these activities or events have you heard of or visited before?

	Heard of	Visit		
		Visited	No. of visit	Self-initiated/school events
Penang Science Café	☐	☐	__	☐ Self ☐ School
Penang International Science Fair	☐	☐	__	☐ Self ☐ School
Penang Tech Dome	☐	☐	__	☐ Self ☐ School
Penang STEM programmes	☐	☐	__	☐ Self ☐ School

10. What other science and technology-related activity/activities or event(s) do you think could be organised? (**CHOOSE THREE ONLY**)
    - ☐ More hands-on science for children
    - ☐ School involvement in events
    - ☐ More science competitions should be organised.
    - ☐ More inexpensive exhibitions
    - ☐ More interactive science activities
    - ☐ Others (please specify): ______________________________________

11. If you were given the chance to make a choice again, would you remain in the same major?
    - ☐ Yes, because ______________________________________ (please specify)
    - ☐ No, because _______________________________________ (please specify)

E. Career choice

1. How do you imagine your future after studying your current major? (**CHOOSE ONE ONLY**)
   - ☐ I will be working in science and technology industry.
   - ☐ I will be working in finance/banking industry.
   - ☐ It is likely dependent on my parents' wishes.
   - ☐ I will be taking over my family business that is not in science and technology industry.
   - ☐ I will be taking over my family business that is in science and technology industry.
   - ☐ Others (please specify): ____

2. Please rate the importance of the following criteria in job searching.

	1 Not important at all	2 Not important	3 Neutral	4 Important	5 Very important
i. Flexibility of work schedule	☐	☐	☐	☐	☐
ii. Job security	☐	☐	☐	☐	☐
iii. Long-term salary prospects	☐	☐	☐	☐	☐
iv. Prestige/image of profession	☐	☐	☐	☐	☐
v. Starting salary	☐	☐	☐	☐	☐
vi. Career growth	☐	☐	☐	☐	☐
vii. Opportunities of ongoing professional development	☐	☐	☐	☐	☐
viii. Perks and benefits	☐	☐	☐	☐	☐
ix. Brand value of the company	☐	☐	☐	☐	☐
x. Innovation and creativity in the job	☐	☐	☐	☐	☐
xi. Job recommendations from college	☐	☐	☐	☐	☐

3. Please rate your agreement in making career decision.

		1	2	3	4	5
		Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
i.	I am capable of making my own career choice.	☐	☐	☐	☐	☐
ii.	I seek my parent's advice for career choice.	☐	☐	☐	☐	☐
iii.	I consult my friends before making any career choice.	☐	☐	☐	☐	☐
iv.	I seek advice from my seniors in making any career choice.	☐	☐	☐	☐	☐
v.	I consult my teachers in making any career choice.	☐	☐	☐	☐	☐
vi.	I consult my placement officer in college in making career choice.	☐	☐	☐	☐	☐
vii.	I consult the alumni of my college in making career choice.	☐	☐	☐	☐	☐
viii.	I consult industry professionals before making career choice.	☐	☐	☐	☐	☐
ix.	I decide my career based on my skills and abilities.	☐	☐	☐	☐	☐
x.	I refer to the market trend in making career decision.	☐	☐	☐	☐	☐
xi.	I decide to accept the job based on the package offered.	☐	☐	☐	☐	☐
xii.	I decide based on my educational qualification and background.	☐	☐	☐	☐	☐
xiii.	I decide based on my family background.	☐	☐	☐	☐	☐
xiv.	I make the decision based on the lifestyle associated with the job.	☐	☐	☐	☐	☐

4. Do you agree that STEM courses suit both men and women equally?

1	2	3	4	5
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
☐	☐	☐	☐	☐

5. What do you think about the government funding for science research? (**CHOOSE ONE ONLY**)

☐ It should be reduced because the money can be better spent elsewhere.

☐ It should be remained as it is.

☐ It should be increased as science research is important for the economy.

☐ I have no idea/am not aware of current funding.

-THANK YOU FOR YOUR TIME-

Appendix B: Survey results for secondary education

a. General interest in science

Table 1 Number of students by science interest level, type of school and stream of study

Interest level	HPS			CSE			Non-HPS/CSE			Science	Non-science	Total
	Science	Non-science	Total	Science	Non-science	Total	Science	Non-science	Total			
Very interested	82	5	87	138	13	151	47	12	59	267	30	297
Rather interested	60	19	79	109	75	184	75	47	122	244	141	385
Neither interested nor disinterested	13	18	31	27	30	57	30	29	59	70	77	147
Rather not interested	7	4	11	6	37	43	4	10	14	17	51	68
Not interested at all	0	3	3	1	37	38	3	24	27	4	64	68
Total	**162**	**49**	**211**	**281**	**192**	**473**	**159**	**122**	**281**	**602**	**363**	**965**

Table 1a Number of students by science interest level, stream and gender

Interest level	Science			Non-science			Total		Total
	Male	Female	Total	Male	Female	Total	Male	Female	
Very interested	119	148	267	13	17	30	132	165	297
Rather interested	103	141	244	49	92	141	152	233	385
Neither interested nor disinterested	31	39	70	33	44	77	64	83	147
Rather not interested	10	7	17	18	33	51	28	40	68
Not interested at all	1	3	4	18	46	64	19	49	68
Total	**264**	**338**	**602**	**131**	**232**	**363**	**395**	**570**	**965**

Table 2 Students' level of interest in science and academic achievement in science subjects (% share of total respondents)

Interest level	Add Maths					Biology				
	A	B	C	D, E & G	Total respondents	A	B	C	D, E & G	Total respondents
Very interested	34.6	13.5	15.0	36.8	266	52.0	22.0	13.2	12.8	250
Rather interested	36.0	13.6	10.7	39.7	242	40.2	22.3	23.7	13.8	224
Neither interested nor disinterested	35.7	11.4	8.6	44.3	70	29.0	22.6	25.8	22.6	62
Rather not interested	47.1	0.0	29.4	23.5	17	26.7	20.0	40.0	13.3	15
Not interested at all	25.0	0.0	50.0	25.0	4	25.0	25.0	25.0	25.0	4
Total	**35.6**	**12.9**	**13.2**	**38.4**	**599**	**43.8**	**22.2**	**19.6**	**14.4**	**555**

Note: A denotes grade A+, A and A-; B denotes grade B+ and B; and C denotes grade C+ and C.

Table 2 (cont'd)

Interest level	Physics					Chemistry				
	A	B	C	D, E & G	Total respondents	A	B	C	D, E & G	Total respondents
Very interested	47.4	20.7	18.0	13.9	266	44.7	23.3	14.3	17.7	266
Rather interested	41.7	25.2	16.5	16.5	242	42.6	17.8	15.7	24.0	242
Neither interested nor disinterested	37.1	20.0	24.3	18.6	70	30.4	21.7	24.6	23.2	69
Rather not interested	35.3	29.4	23.5	11.8	17	35.3	11.8	23.5	29.4	17
Not interested at all	25.0	0.0	25.0	50.0	4	25.0	0.0	25.0	50.0	4
Total	**43.4**	**22.5**	**18.4**	**15.7**	**599**	**41.8**	**20.4**	**16.4**	**21.4**	**598**

Note: A denotes grade A+, A and A-; B denotes grade B+ and B; and C denotes grade C+ and C.

Table 3 Parents' highest education level and students' level of interest in science (% share of total respondents)

Interest level	Father's education				Total respondents	Mother's education				Total respondents
	Tertiary	Secondary	Primary	No formal education		Tertiary	Secondary	Primary	No formal education	
Very interested	69.3	28.9	1.5	0.4	**270**	68.1	31.5	0.4	0.0	**279**
Rather interested	56.9	40.1	2.4	0.6	**327**	57.7	40.0	1.7	0.6	**345**
Neither interested nor disinterested	48.2	43.8	8.0	0.0	**112**	46.7	50.8	2.5	0.0	**120**
Rather not interested	44.8	50.0	5.2	0.0	**58**	39.3	57.4	3.3	0.0	**61**
Not interested at all	50.0	46.6	3.4	0.0	**58**	37.7	54.1	8.2	0.0	**61**
Total share	**58.4**	**38.1**	**3.2**	**0.4**	**-**	**56.8**	**41.0**	**2.0**	**0.2**	**-**
Total respondents	***482***	***314***	***26***	***3***	***825***	***492***	***355***	***17***	***2***	***866***

Note: "Others" and "Not applicable" were excluded.

Table 4 Parents' current job and students' level of interest in science (% share of total respondents)

Interest level	Father's current job				Total respondents	Mother's current job			Total respondents
	Science related	Non-science related	Not working	Not specified		Science related	Non-science related	Not working	
Very interested	29.9	51.9	4.8	13.4	**291**	15.5	50.5	34.0	**291**
Rather interested	25.5	59.9	5.7	8.9	**369**	11.1	50.9	37.9	**369**
Neither interested nor disinterested	20.9	61.9	4.3	12.9	**139**	2.8	48.6	48.6	**144**
Rather not interested	18.8	70.3	4.7	6.3	**64**	3.4	60.3	36.2	**58**
Not interested at all	11.5	73.8	8.2	6.6	**61**	1.7	58.3	40.0	**60**
Total	**24.8**	**59.3**	**5.3**	**10.6**	**-**	**10.1**	**51.5**	**38.4**	**-**
Total respondents	***229***	***548***	***49***	***98***	***924***	***93***	***475***	***354***	***922***

Note: "Not applicable" was excluded.

b. Factors that led to interest in science or lack of interest in science

Table 5 Main factors for lack of interest in science

Main factors for lack of interest in science	Science						Non-science					
	Male		Female		Total		Male		Female		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
The subject is difficult	4	36.4	6	60.0	10	47.6	19	52.8	45	57.0	64	55.7
I never had any interest or liking for science	8	72.7	4	40.0	12	57.1	7	19.4	42	53.2	49	42.6
I don't understand the subject	5	45.5	3	30.0	8	38.1	12	33.3	24	30.4	36	31.3
The science subjects taught in school are not interesting	1	9.1	3	30.0	4	19.0	6	16.7	12	15.2	18	15.7
Science is in English /It is difficult to understand English	0	0.0	1	10.0	1	4.8	7	19.4	8	10.1	15	13.0
Others	0	0.0	1	10.0	1	4.8	3	8.3	4	5.1	7	6.1
I don't believe in scientist	0	0.0	0	0.0	0	0.0	4	11.1	0	0.0	4	3.5
I don't like my science teacher	2	18.2	0	0.0	2	9.5	1	2.8	1	1.3	2	1.7
Total	**11**	**100.0**	**10**	**100.0**	**21**	**100.0**	**36**	**100.0**	**79**	**100.0**	**115**	**100.0**

Table 6 Main reasons for having interest in science

Reasons	Science						Non-science					
	Male		Female		Total		Male		Female		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Science is interesting and amazing.	84	37.8	95	32.9	179	35.0	22	35.5	39	35.8	61	35.7
Science helps me to understand things in everyday life.	64	28.8	94	32.5	158	30.9	14	22.6	39	35.8	53	31.0
I like learning new things.	60	27.0	61	21.1	121	23.7	23	37.1	44	40.4	67	39.2
I can have more choices for future studies.	52	23.4	89	30.8	141	27.6	4	6.5	4	3.7	8	4.7
I enjoy learning science than other subjects.	45	20.3	63	21.8	108	21.1	11	17.7	13	11.9	24	14.0
I want to get a good job in future.	33	14.9	83	28.7	116	22.7	3	4.8	6	5.5	9	5.3
I want to make a major difference to the world.	35	15.8	21	7.3	56	11.0	2	3.2	4	3.7	6	3.5
I like the challenge in solving science problem.	22	9.9	24	8.3	46	9.0	4	6.5	4	3.7	8	4.7
I like the science activities at school.	6	2.7	7	2.4	13	2.5	10	16.1	12	11.0	22	12.9
I am sure I can do well in science.	8	3.6	8	2.8	16	3.1	8	12.9	9	8.3	17	9.9
My science teacher is really good.	9	4.1	1	0.3	10	2.0	6	9.7	17	15.6	23	13.5
I scored good marks in science subjects.	4	1.8	8	2.8	12	2.3	6	9.7	12	11.0	18	10.5
Studying science makes me look smart.	6	2.7	7	2.4	13	2.5	3	4.8	6	5.5	9	5.3
Others	5	2.3	3	1.0	8	1.6	1	1.6	0	0.0	1	0.6
My parents did science too.	2	0.9	2	0.7	4	0.8	1	1.6	1	0.9	2	1.2
Total respondents	**222**	**100.0**	**289**	**100.0**	**511**	**100.0**	**62**	**100.0**	**109**	**100.0**	**171**	**100.0**

Table 7 Number of students by reasons for having interest in science but attended non-science stream

Reasons	HPS			CSE			Non-HPS/CSE			Total
	Male	Female	Total	Male	Female	Total	Male	Female	Total	
Arts-stream subjects are easier to understand than science subjects	3	12	15	13	37	50	16	12	28	93
Science is my hobby and I prefer arts stream to be my future career	1	7	8	10	26	36	12	12	24	68
I scored badly in science subjects	3	5	8	7	28	35	12	6	18	61
Arts stream can promise me a job in the future	1	3	4	4	14	18	5	7	12	34
Arts stream can give me quality and/or high-income jobs	3	2	5	2	4	6	6	4	10	21
Others	2	1	3	1	12	13	2	0	2	18
Total	**16**	**8**	**24**	**19**	**69**	**88**	**35**	**21**	**56**	**168**

c. Factors that could increase students' interest in science

Table 8 Factors that could increase students' interest in science by type of school and stream of study (% of total respondents)

Factors	HPS			CSE			Non-HPS/CSE			Total
	Science	Non-science	Total	Science	Non-science	Total	Science	Non-science	Total	
Make science more interesting/fun	82.3	85.7	83.1	81.9	89.1	84.8	80.5	83.6	81.9	83.6
More science-related activities/exhibitions	71.5	73.5	72.0	66.9	66.7	66.8	69.2	62.3	66.2	67.7
A more hands-n/interactive approach during school lessons	57.0	28.6	50.2	68.0	50.0	60.7	58.5	46.7	53.4	56.3
More seminars/opportunities to learn	27.8	34.7	29.5	22.4	26.6	24.1	26.4	21.3	24.2	25.3
Introduce new laboratories	17.1	24.5	18.8	19.9	27.6	23.0	25.2	34.4	29.2	23.9
More emphasis on computer studies	20.9	36.7	24.6	19.2	25.0	21.6	20.1	24.6	22.1	22.4
More emphasis on science in school	19.0	14.3	17.9	19.9	13.0	17.1	17.0	25.4	20.6	18.3
Others	0.0	2.0	0.5	1.8	1.0	1.5	2.5	0.8	1.8	1.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Total respondents	***158***	***49***	***207***	***281***	***192***	***473***	***159***	***122***	***281***	***961***

Note: Four students who didn't answer were excluded.

Table 9 Factors that could increase students' interest in science by stream of study and gender (% of total respondents)

Factors	Science			Non-science			Total
	Male	Female	Total	Male	Female	Total	
Make science more interesting/fun	78.6	83.9	81.6	84.0	88.4	86.8	83.6
More science-related activities/exhibitions	66.0	70.8	68.7	63.4	67.7	66.1	67.7
A more hands-on/interactive approach during school lessons	63.0	62.2	62.5	40.5	49.1	46.0	56.3
More seminars/opportunities to learn	20.6	28.3	24.9	27.5	25.0	25.9	25.3
Introduce new laboratories	22.1	19.3	20.6	32.1	28.0	29.5	23.9
More emphasis on computer studies	25.2	15.8	19.9	32.1	23.3	26.4	22.4
More emphasis on science in school	22.1	16.4	18.9	17.6	17.2	17.4	18.3
Others	1.5	1.5	1.5	1.5	0.9	1.1	1.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Total respondents	***262***	***336***	***598***	***131***	***232***	***363***	***961***

Note: Four students who didn't answer were excluded.

Current choice of study

a. Parental attitude

Table 10 Students urged by their parents to study science stream by parents' highest education level

Education level	Father					Mother				
	Yes		No		Total	Yes		No		Total
	No.	% share	No.	% share		No.	% share	No.	% share	
Primary	7	26.9	19	73.1	26	3	17.6	14	82.4	17
Secondary	128	31.3	281	68.7	409	152	32.2	320	67.8	472
Tertiary	147	38.0	240	62.0	387	146	38.9	229	61.1	375
Others	52	37.1	88	62.9	140	33	33.3	66	66.7	99
Total	**334**	**34.7**	**628**	**65.3**	**962**	**334**	**34.7**	**629**	**65.3**	**963**

Note: Others include no formal education, don't know and not applicable. Three and two non-responses for father's and mother's education level were excluded.

Table 11 Students urged by their parents to study science stream by parents' current job

Current job	Father		Total	Mother		Total
	Yes (%)	No (%)		Yes (%)	No (%)	
Science related	41.5	58.5	229	49.5	50.5	93
Non-science related	30.8	69.2	548	35.6	64.4	475
Not working	53.1	46.9	49	30.8	69.2	354
Not specified	31.6	68.4	98	0.0	0.0	0
Not applicable	25.0	75.0	8	0.0	100.0	1
Total (% of row total)	**34.7**	**65.3**	**932**	**35.1**	**64.9**	**923**
Total respondents	**323**	**609**	**-**	**324**	**599**	**-**

b. *Peer influence*

Table 12 Students influenced by their peer in stream of study selection by type of school

Stream and type of school	Yes		No		Total	
	No.	% share	No.	% share	No.	% share
Science	*263*	*44.0*	*335*	*56.0*	*598*	*62.2*
HPS	73	27.8	85	25.4	158	16.4
CSE	124	47.1	157	46.9	281	29.2
Non-HPS/CSE	66	25.1	93	27.8	159	16.5
Non-science	*92*	*25.3*	*271*	*74.7*	*363*	*37.8*
HPS	9	9.8	40	14.8	49	5.1
CSE	44	47.8	148	54.6	192	20.0
Non-HPS/CSE	39	42.4	83	30.6	122	12.7
Total	**355**	**36.9**	**606**	**63.1**	**961**	**100.0**
HPS	82	39.6	125	60.4	207	21.5
CSE	168	35.5	305	64.5	473	49.2
Non-HPS/CSE	105	37.4	176	62.6	281	29.2

Table 13 Students influenced by their peer in stream of study selection by gender

Stream and gender	Yes		No		Total	
	No.	% share	No.	% share	No.	% share
Science	*263*	*44.0*	*335*	*56.0*	*598*	*62.2*
Male	113	43.3	148	56.7	261	27.2
Female	150	44.5	187	55.5	337	35.1
Non-science	*92*	*25.3*	*271*	*74.7*	*363*	*37.8*
Male	44	33.6	87	66.4	131	13.6
Female	48	20.7	184	79.3	232	24.1
Total	**355**	**36.9**	**606**	**63.1**	**961**	**100.0**
Male	157	40.1	235	59.9	392	40.8
Female	198	34.8	371	65.2	569	59.2

c. *Teacher performance*

Table 14 Areas of science classes that did not meet students' expectation, for science students only

Areas	HPS		CSE		Non-HPS/CSE		Total	
	No.	% share	No.	% share	No.	% share	No.	% share
Too exam-oriented	16	24.6	36	55.4	13	20.0	65	55.1
Teachers are not innovative and creative	19	35.8	16	30.2	18	34.0	53	44.9
Science teachers are too boring	14	28.6	18	36.7	17	34.7	49	41.5
Too textbook-oriented	12	26.7	22	48.9	11	24.4	45	38.1
Others	3	60.0	1	20.0	1	20.0	5	4.2
Total	**31**	**26.3**	**52**	**44.1**	**35**	**29.7**	**118**	**100.0**

Table 15 Areas of science classes that did not meet students' expectation, for science students only

Areas	Male		Female		Total	
	No.	% share	No.	% share	No.	% share
Too exam-oriented	39	61.9	26	47.3	65	55.1
Teachers are not innovative and creative	24	38.1	29	52.7	53	44.9
Science teachers are too boring	23	36.5	26	47.3	49	41.5
Too textbook-oriented	28	44.4	17	30.9	45	38.1
Others	3	4.8	2	3.6	5	4.2
Total	**63**	**100.0**	**55**	**100.0**	**118**	**100.0**

d. School motivation

Table 16 Students' responses to school motivation in learning science by type of school, gender and stream of study

School motivation	HPS			CSE			Non-HPS/CSE			Total		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
Yes (frequency)	*49*	*124*	*173*	*152*	*209*	*361*	*97*	*84*	*181*	*298*	*417*	*715*
Yes (% share of column total)	*75.4*	*84.9*	*82.0*	*81.3*	*73.1*	*76.3*	*67.8*	*60.9*	*64.4*	*75.4*	*73.2*	*74.1*
Yes (% share of row total)	*28.3*	*71.7*	*24.2*	*42.1*	*57.9*	*50.5*	*53.6*	*46.4*	*25.3*	*41.7*	*58.3*	*100.0*
Science (frequency)	38	94	132	114	118	232	52	58	110	204	270	474
Science (% share of column total)	77.6	75.8	76.3	75.0	56.5	64.3	53.6	69.0	60.8	68.5	64.7	66.3
Science (% share of row total)	28.8	71.2	27.8	49.1	50.9	48.9	47.3	52.7	23.2	43.0	57.0	100.0
Non-science (frequency)	11	30	41	38	91	129	45	26	71	94	147	241
Non-science (% share of column total)	22.4	24.2	23.7	25.0	43.5	35.7	46.4	31.0	39.2	31.5	35.3	33.7
Non-science (% share of row total)	26.8	73.2	17.0	29.5	70.5	53.5	63.4	36.6	29.5	39.0	61.0	100.0
No (frequency)	*16*	*22*	*38*	*35*	*77*	*112*	*46*	*54*	*100*	*97*	*153*	*250*
No (% share of column total)	*24.6*	*15.1*	*18.0*	*18.7*	*26.9*	*23.7*	*32.2*	*39.1*	*35.6*	*24.6*	*26.8*	*25.9*
No (% share of row total)	*42.1*	*57.9*	*15.2*	*31.3*	*68.8*	*44.8*	*46.0*	*54.0*	*40.0*	*38.8*	*61.2*	*100.0*
Science (frequency)	12	18	30	22	27	49	26	23	49	60	68	128
Science (% share of column total)	75.0	81.8	78.9	62.9	35.1	43.8	56.5	42.6	49.0	61.9	44.4	51.2
Science (% share of row total)	40.0	60.0	23.4	44.9	55.1	38.3	53.1	46.9	38.3	46.9	53.1	100.0
Non-science (frequency)	4	4	8	13	50	63	20	31	51	37	85	122
Non-science (% share of column total)	25.0	18.2	21.1	37.1	64.9	56.3	43.5	57.4	51.0	38.1	55.6	48.8
Non-science (% share of row total)	50.0	50.0	6.6	20.6	79.4	51.6	39.2	60.8	41.8	30.3	69.7	100.0
Total (frequency)	***65***	***146***	***211***	***187***	***286***	***473***	***143***	***138***	***281***	***395***	***570***	***965***
Total (% share of column total)	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***
Total (% share of row total)	***30.8***	***69.2***	***21.9***	***39.5***	***60.5***	***49.0***	***50.9***	***49.1***	***29.1***	***40.9***	***59.1***	***100.0***

Table 17 Standard deviation for school motivating factors by stream of study

Statements	Total	Science	Non-Science
Pedagogical strategies			
Teachers use real-life examples in science classes.	0.97	0.94	1.01
Teachers assist us to understand science concepts.	0.91	0.89	0.94
Teachers encourage us to participate in learning science subjects.	0.90	0.85	0.95
Highly inspiring and enthusiastic science teachers	0.91	0.90	0.92
Teachers identify student learning needs and difficulties in science subjects.	0.93	0.91	0.95
I am motivated to conduct experiment independently.	1.00	1.01	0.95
Exciting science classes	0.92	0.90	0.96
Teachers regularly update us with the latest development in science and technology.	0.98	1.00	0.94
School environment			
Highly supportive science environment with complete laboratories and science tools	0.97	0.95	0.99
A variety of internal science-related activities and clubs	0.84	0.83	0.84
School creates cooperative environment among students towards learning science subjects.	0.92	0.91	0.93
Science activities held in school are sufficient to encourage science learning.	0.93	0.92	0.95
Various external science programmes such as visiting National Science Centre, Tech Dome, Penang Science Cluster, etc.	1.05	1.03	1.08

Table 18 Mean and standard deviation for school motivating factors by type of school

Statements	Mean			Standard deviation		
	HPS	CSE	Non-HPS/CSE	HPS	CSE	Non-HPS/CSE
Pedagogical strategies	*3.81*	*3.68*	*3.42*	*0.90*	*0.94*	*0.99*
Teachers use real-life examples in science classes.	4.05	3.89	3.55	0.86	0.98	0.99
Teachers assist us to understand science concepts.	3.96	3.84	3.62	0.84	0.91	0.96
Teachers encourage us to participate in learning science subjects.	3.90	3.79	3.56	0.81	0.89	0.96
Highly inspiring and enthusiastic science teachers	3.88	3.66	3.39	0.87	0.91	0.90
Teachers identify student learning needs and difficulties in science subjects.	3.80	3.65	3.40	0.85	0.90	1.00
I am motivated to conduct experiment independently.	3.80	3.63	3.44	0.96	0.96	1.08
Exciting science classes	3.61	3.53	3.27	0.88	0.93	0.91
Teachers regularly update us with the latest development in science and technology.	3.45	3.45	3.12	1.00	0.94	0.98
School environment	*3.55*	*3.59*	*3.32*	*0.94*	*0.93*	*0.96*
Highly supportive science environment with complete laboratories and science tools	3.68	3.63	3.32	0.98	0.94	0.98
School creates cooperative environment among students towards learning science subjects.	3.60	3.63	3.35	0.89	0.91	0.95
A variety of internal science-related activities and clubs	3.57	3.58	3.27	0.81	0.81	0.87
Various external science programmes such as visiting National Science Centre, Tech Dome, Penang Science Cluster, etc.	3.47	3.63	3.48	1.05	1.06	1.02
Science activities held in school are sufficient to encourage science learning.	3.43	3.48	3.19	0.94	0.91	0.94

Table 19 Standard deviation for school demotivating factors by stream of study

Items	Total	Science	Non-science
Too exam-oriented	1.08	1.07	1.08
Science teachers are too boring	1.15	1.14	1.10
Inadequate teaching time in conducting experiment in laboratories	0.89	0.89	0.88
Lack of teaching and learning materials such as chemicals for practical	0.96	1.01	0.89
Inadequate number of science teachers	0.89	0.99	0.78
Large number of students in the class and laboratories	0.99	1.00	1.00
Lack of laboratories	0.98	0.94	1.01

e. Future studies in STEM

Table 20 Future studies in STEM at tertiary education (% share of total respondents) by type of school and stream of study

Future study choice	HPS		CSE		Non-HPS/CSE		Total	
	Science	Non-science	Science	Non-science	Science	Non-science	No.	% share
STEM	76.5	18.4	73.7	16.7	66.0	25.4	508	52.6
Non-STEM	6.2	28.6	5.3	38.0	5.7	31.1	159	16.5
Don't know	17.3	53.1	21.0	45.3	28.3	43.4	298	30.9
Total	**100.0**	**100**	**100.0**	**100.0**	**100.0**	**100.0**	**965**	**100.0**
Total respondents	**162**	**49**	**281**	**192**	**159**	**122**	**-**	**-**

Table 21 Most interested STEM courses (% of respondents)

Most interested STEM courses	Science			Non-Science			Total	
	Male	Female	Total	Male	Female	Total	No.	% share
Biology (biotechnology, biomedical)	28.8	48.6	39.9	0.0	22.2	11.1	182	35.8
Medicine (doctor, nurse)	0.0	52.2	29.4	0.0	0.0	0.0	128	25.2
Physics	31.4	22.0	26.1	0.0	0.0	0.0	114	22.4
Mathematics & Statistics	25.1	0.0	11.0	33.3	50.0	41.7	78	15.4
Astronomy	0.0	22.0	12.4	25.0	38.9	31.9	77	15.2
Engineering (civil, chemical, electrical, mechanical)	34.6	0.0	15.1	27.8	0.0	13.9	76	15.0
Pharmacy	0.0	30.6	17.2	0.0	0.0	0.0	75	14.8
Artificial Intelligence	25.1	0.0	11.0	0.0	0.0	0.0	48	9.4
Computer Science (programming, software development)	0.0	0.0	0.0	33.3	16.7	25.0	18	3.5
Research, Design & Product Development	0.0	0.0	0.0	0.0	33.3	16.7	12	2.4
Information Technology (database administration, information security)	0.0	0.0	0.0	25.0	0.0	12.5	9	1.8
Machine Learning	0.0	0.0	0.0	25.0	0.0	12.5	9	1.8
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**-**	**100.0**
Total respondents	***191***	***245***	***436***	***36***	***36***	***72***	***508***	***-***

Table 22 Number of students by reasons of not intending to pursue STEM in tertiary education

Reasons	Science			Non-science			Total	
	Male	Female	Total	Male	Female	Total	No.	% share
I am more interested in finance/banking/insurance/accountancy/tax-related careers.	6	3	9	15	51	66	75	47.8%
I am more interested in creative arts such as acting, graphic design, etc..	5	7	12	6	17	23	35	22.3%
Others	4	6	10	7	2	9	19	12.1%
My parents have set my career paths, which is not science-related.	1	0	1	5	6	11	12	7.6%
My family cannot support my study in STEM courses.	0	0	0	4	2	6	6	3.8%
I will be taking over my family business, which is not science-related.	0	0	0	2	3	5	5	3.2%
It is hard to secure a scholarship.	2	0	2	2	1	3	5	3.2%
Total respondents	**18**	**16**	**34**	**41**	**82**	**123**	**157**	**100.0%**

Table 23 Percentage of respondents by reasons of not intending to pursue STEM in tertiary education

Reasons	Science			Non-science			Total	
	Male	Female	Total	Male	Female	Total	No.	% share
I am more interested in finance/banking/insurance/accountancy/tax-related careers.	33.3	18.8	26.5	36.6	62.2	53.7	75	47.8%
I am more interested in creative arts such as acting, graphic design, etc.	27.8	43.8	35.3	14.6	20.7	18.7	35	22.3%
Others	22.2	37.5	29.4	17.1	2.4	7.3	19	12.1%
My parents have set my career paths, which is not science-related.	5.6	0.0	2.9	12.2	7.3	8.9	12	7.6%
My family cannot support my study in STEM courses.	0.0	0.0	0.0	9.8	2.4	4.9	6	3.8%
I will be taking over my family business, which is not science-related.	0.0	0.0	0.0	4.9	3.7	4.1	5	3.2%
It is hard to secure a scholarship.	11.1	0.0	5.9	4.9	1.2	2.4	5	3.2%
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**-**	**100.0**
Total respondents	***18***	***16***	***34***	***41***	***82***	***123***	***157***	***-***

f. Future career plan

Table 24 Future career plan for secondary school students by stream of study and gender (% share of total)

Future career plan	Science		Science total		Non-science		Non-science total		Total	
	Male	Female	No.	% share	Male	Female	No.	% share	No.	% share
Science and technology	74.2	76.4	449	75.5	14.8	6.5	34	9.4	483	50.6
Finance/banking	8.1	5.1	38	6.4	31.3	60.3	180	50.0	218	22.8
Parents' wishes	6.5	6.3	38	6.4	15.6	9.5	42	11.7	80	8.4
Other non-science industries	3.5	5.1	26	4.4	5.5	9.9	30	8.3	56	5.9
Undecided	4.6	5.7	31	5.2	10.2	3.0	20	5.6	51	5.3
Non-science and technology (family business)	2.3	1.2	10	1.7	14.1	8.6	38	10.6	48	5.0
Science and technology (family business)	0.8	0.3	3	0.5	3.9	2.2	10	2.8	13	1.4
Not specified	0.0	0.0	0	0.0	4.7	0.0	6	1.7	6	0.6
Total	100.0	100.0	-	100.0	100.0	100.0	-	100.0	-	100.0
Total respondents	***260***	***335***	***595***	-	***128***	***232***	***360***	-	***955***	-

Appendix C: Survey results for tertiary education

Table 1 Regression results for factors influencing the science interest level of tertiary students

Independent variable	**Odds ratio**	**Std. Err.**	**p-value**	**Brant test**	
				Chi-square	**p-value**
Male	0.975	0.206	0.901	3.95	0.27
Tertiary STEM course	2.212	0.223	0.000***	2.49	0.48
Stream of study at upper-secondary level	3.140	0.196	0.000***	3.39	0.34
Father's education	1.090	0.158	0.584	5.65	0.13
Mother's education	0.987	0.164	0.935	2.99	0.39
Parents' current work	0.841	0.255	0.496	8.04	0.05
Students' satisfaction on teachers' performance	2.639	0.198	0.000***	1.33	0.72
Parents' attitude	1.503	0.236	0.085	0.82	0.85
Intercept: NIAA	1.899	0.193	0.001***	-	-
Intercept: RNI	0.868	0.184	0.442	-	-
Intercept: NIND	0.346	0.191	0.000***	-	-
Intercept: RI	0.039	0.250	0.000***	-	-
	Brant test: Chi-square = 28.59, df = 24, p-value = 0.24				

NIAA: Not interested at all, RNI: Rather not interested, NIND: Not interested nor interested, RI: Rather interested

Table 2 Reasons for liking science by gender and stream (% share of total respondents)

Reasons	STEM	Non-STEM	Male	Female	Total
I like learning new things.	46.0	51.4	48.9	47.9	48.5
Science is interesting and amazing.	38.7	48.6	39.1	49.0	43.2
I enjoy learning science than other subjects.	37.9	22.9	32.3	29.2	31.0
Science helps me to understand things in everyday life.	12.9	24.8	17.3	19.8	18.3
I scored good marks in science subjects.	8.9	15.2	10.5	13.5	11.8
I want to get a good job in future.	13.7	3.8	12.0	5.2	9.2
I want to make a major difference to the world.	8.9	5.7	9.0	5.2	7.4
I like the challenge in solving science problems.	8.1	5.7	6.8	7.3	7.0
I am sure I can do well in science.	4.8	4.8	6.0	3.1	4.8
I like the science activities at school/college/university.	4.8	3.8	4.5	4.2	4.4
My science teacher is really good.	3.2	1.9	2.3	3.1	2.6
Studying science makes me look smart.	2.4	1.9	2.3	2.1	2.2
My parents did science too.	2.4	0.0	2.3	0.0	1.3
Total number of respondents	**124**	**105**	**133**	**96**	**229**

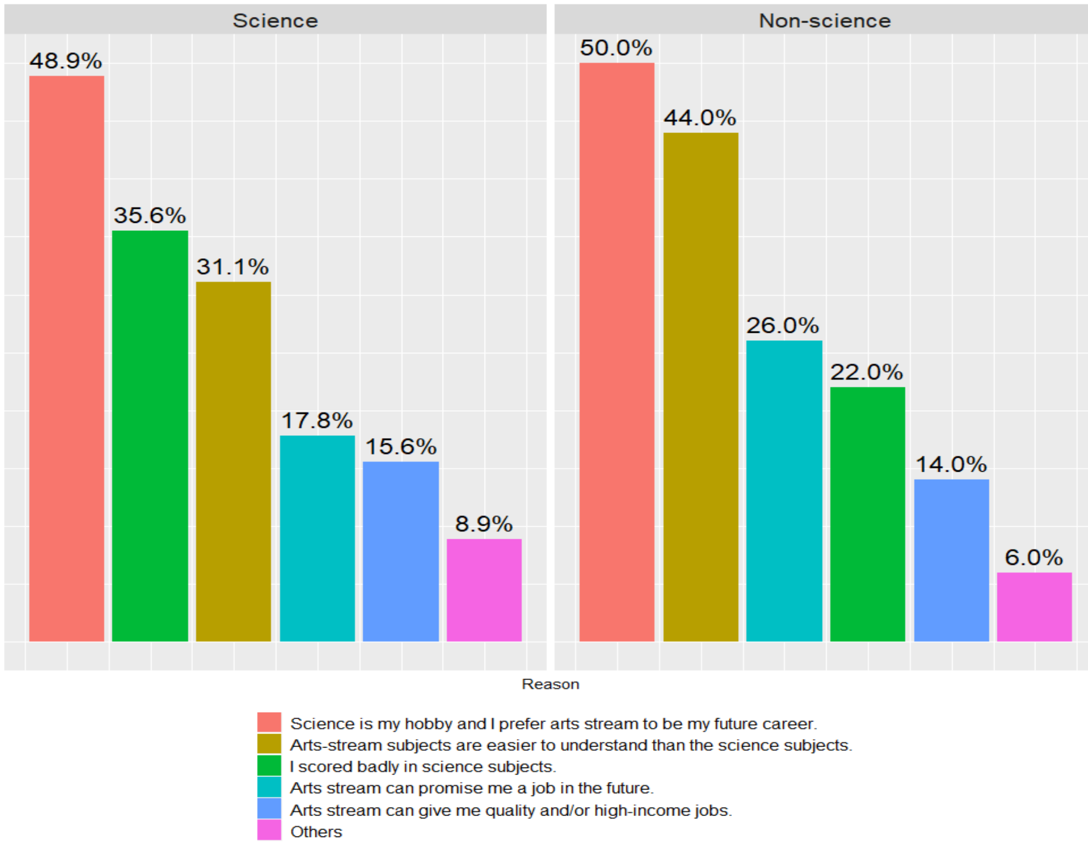
Table 3 Difficulties facing by students studying STEM subjects

Difficulties	Number of responses	%
Can't understand the concept	21	32.3
A lot of theories, terms and formulae to memorise	15	23.1
Others	12	18.5
Difficulty in catching up	7	10.8
Certain subject is difficult	7	10.8
Can't understand the scientific terms	2	3.1
Teacher is boring	1	1.5
Total number of students	**65**	-

Table 4 Factors affected students' lack of interest in STEM (%)

Factors disinterested in science	STEM	Non-STEM	Male	Female	Total
I never had any interest or liking for science.	46.9	51.1	50.0	50.0	50.0
The subject is difficult.	59.4	43.5	51.7	43.8	47.6
I don't understand the subject.	28.1	37.0	25.0	43.8	34.7
The science subjects taught in school are not interesting	9.4	22.8	20.0	18.8	19.4
Science is in English. /It is difficult to understand English.	18.8	3.3	11.7	3.1	7.3
I don't like my science teacher.	6.3	3.3	3.3	4.7	4.0
I don't believe in scientist.	6.3	2.2	3.3	3.1	3.2
Others	0.0	3.3	1.7	3.1	2.4
Total number of students	**32**	**92**	**60**	**64**	**124**

Figure 1 Reasons not choosing STEM courses
Previously science students = 45, Non-science students = 50



Note: Ten students who didn't answer this question were excluded.

Table 5 Factors considered when selecting current major by gender and stream (%)

Factors	STEM	Non-STEM	Male	Female	Total
School/college is near to home.	37.5	34.1	35.3	35.9	35.6
Scholarship was granted.	41.8	21.1	33.2	26.2	30.0
Quality of students in the college/university.	24.5	28.0	26.4	26.7	26.5
Reputation of the college/university.	21.7	26.4	23.0	26.2	24.4
Impressed by college facilities.	19.0	23.6	20.9	22.6	21.6
Small class and close teacher-student ties.	16.3	24.8	18.3	24.6	21.2
Close friends attended the courses.	16.8	22.4	17.4	23.1	20.0
Parental influence	15.8	19.5	17.4	18.5	17.9
Relatives attended the courses.	15.2	11.4	15.7	9.7	13.0
Recommendations by school counsellor	9.2	11.0	9.8	10.8	10.2
Admission was assured.	8.7	8.9	10.2	7.2	8.8
Others	9.2	6.5	8.5	6.7	7.7
Well-established library	3.8	8.5	5.5	7.7	6.5
School/college is far from home.	8.7	2.8	6.4	4.1	5.3
Recommendations from high school teachers	3.3	6.1	4.7	5.1	4.9
Impressed by science facilities	7.1	0.8	4.3	2.6	3.5
Influence of admission staff	3.3	3.7	3.8	3.1	3.5
Total number of students	**184**	**246**	**235**	**195**	**430**

Note: Two students who answered “Don’t know” were excluded.

Table 6 Reasons for choosing current major (%)

Factors	STEM	Non-STEM	Male	Female	Total
It has bright career in future.	63.6	51.8	59.8	53.3	**56.9**
It is my personal interest.	52.7	54.3	54.3	52.8	**53.6**
It can make more money.	16.8	20.8	18.8	19.5	**19.1**
It is challenging to pass.	14.7	6.9	13.2	6.7	**10.3**
It is challenging to read.	8.2	6.1	7.3	6.7	**7.0**
I don't know. My parents decided.	7.1	6.5	4.7	9.2	**6.8**
It is easy to pass.	3.8	7.8	4.7	7.7	**6.1**
It is easy to read.	2.2	8.2	4.7	6.7	**5.6**
It was advised by my school teachers.	4.3	5.3	6.0	3.6	**4.9**
My friends are choosing this specialisation.	3.3	4.5	3.4	4.6	**4.0**
I was only offered this major.	2.2	4.5	3.0	4.1	**3.5**
Others	1.1	2.4	1.7	2.1	**1.9**
Total number of students	**184**	**245**	**234**	**195**	**429**

Note: Three students who answered “Don’t know” were excluded.

Figure 2 Changes in field of study from STEM to STEM
Number of students = 22

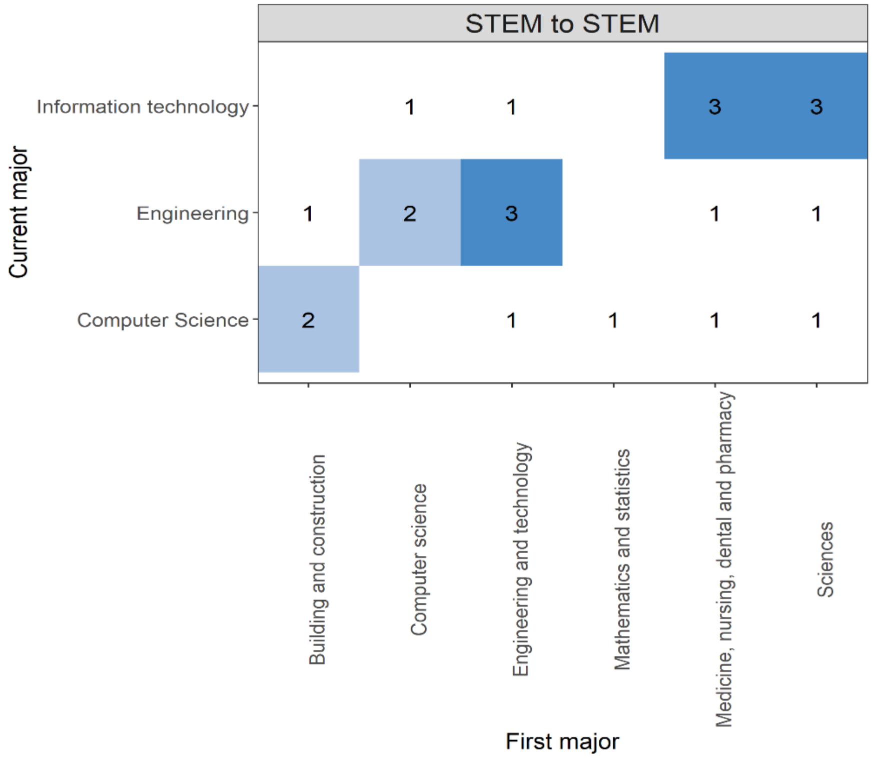


Figure 3 Changes in field of study from STEM to non-STEM
Number of students = 23

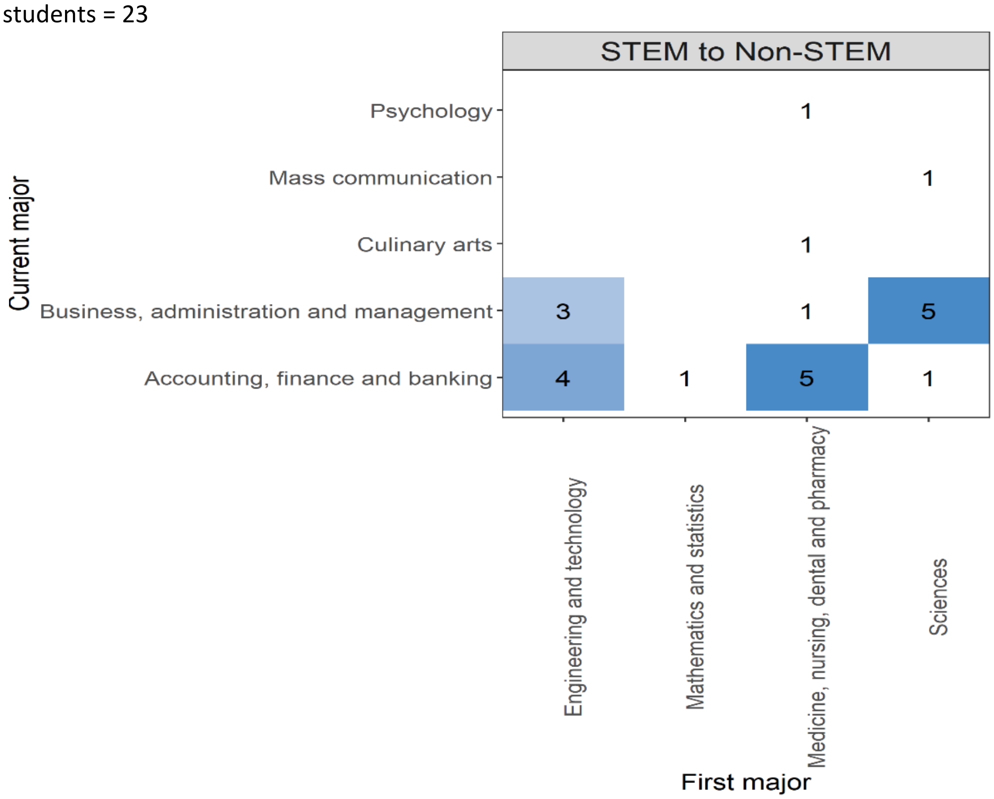


Figure 4 Changes in field of study from non-STEM to STEM
Number of students = 9

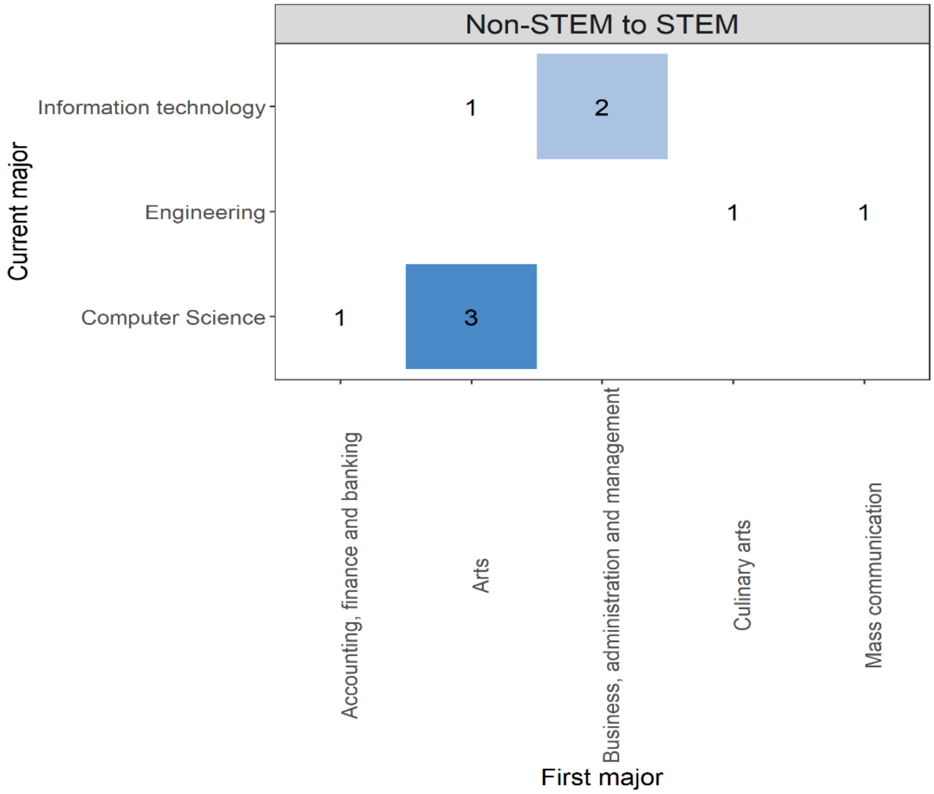


Figure 5 Changes in field of study from non-STEM to non-STEM
Number of students = 51

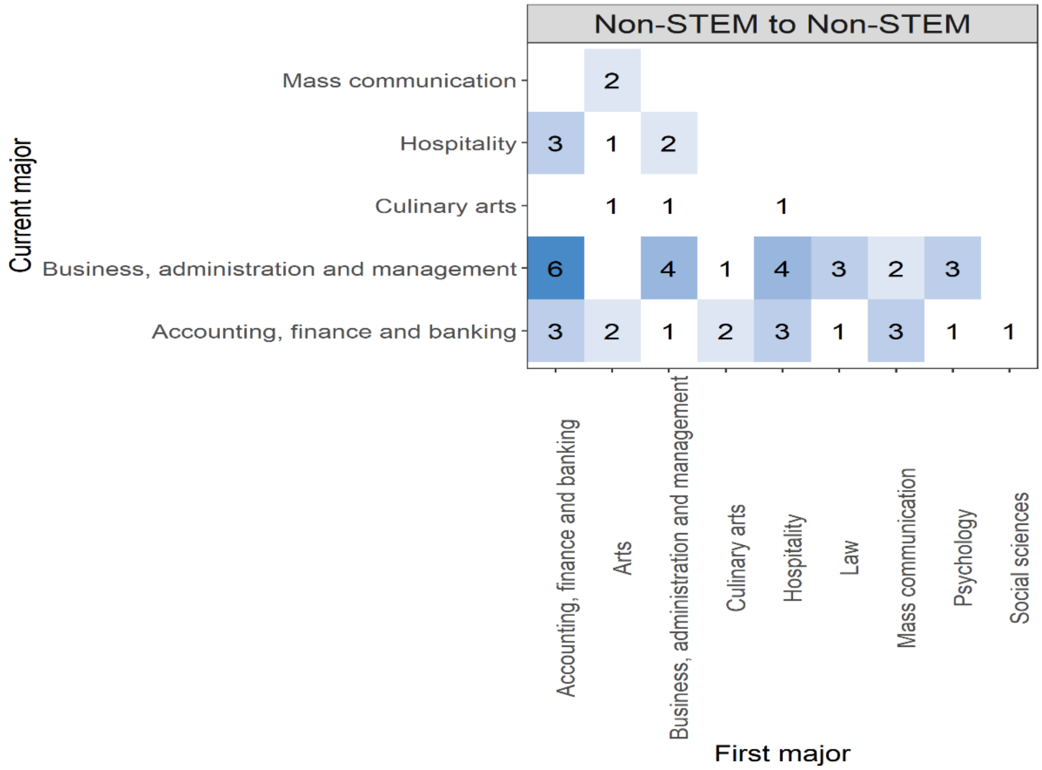
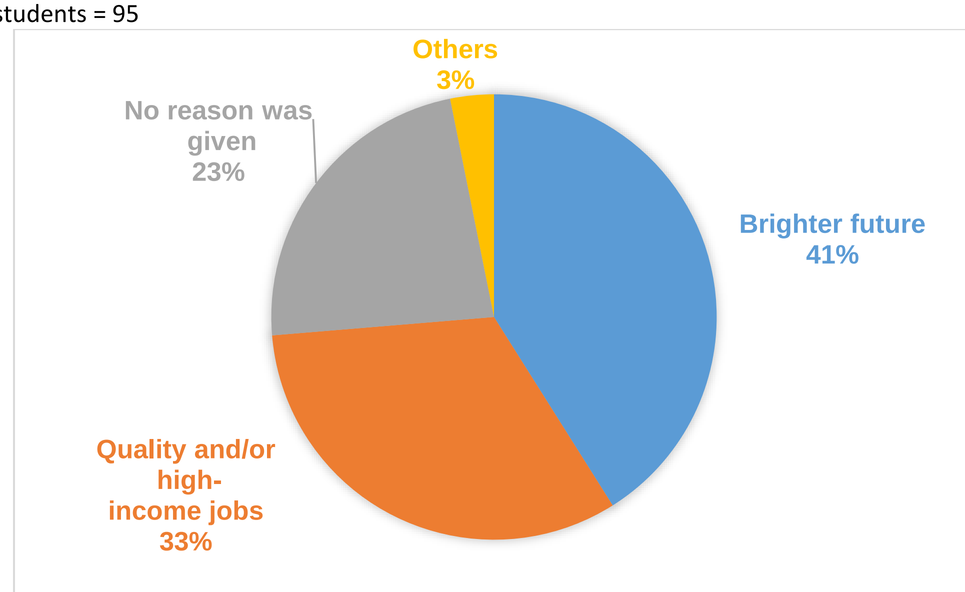


Figure 6 Reasons of parents urging their children to choose STEM courses
Number of students = 95



Note: A student did not answer this question.

Table 7 Students urged by their parents to choose STEM courses by their parents' highest education level

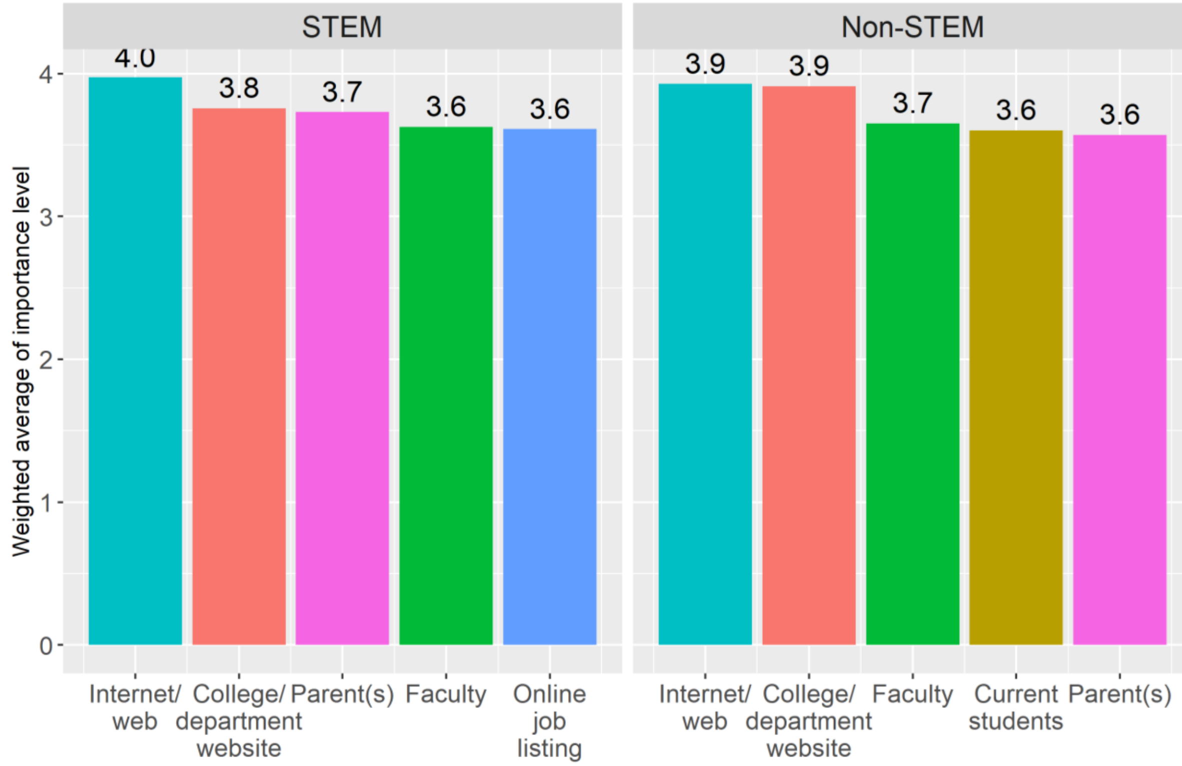
Education level	Father					Mother				
	Yes		No		Total	Yes		No		Total
	No.	% share	No.	% share		No.	% share	No.	% share	
Tertiary	44	28.6%	110	71.4%	154	50	35.2%	92	64.8%	142
Secondary	33	16.1%	172	83.9%	205	28	13.5%	180	86.5%	208
Primary	6	24.0%	19	76.0%	25	6	21.4%	22	78.6%	28
Others	13	27.1%	35	72.9%	48	12	22.2%	42	77.8%	54
Total	**96**	**22.2%**	**336**	**77.8%**	**432**	**96**	**22.2%**	**336**	**77.8%**	**432**

Table 8 Students urged by their parents to study science stream by their parents' occupational field

Parent's occupation	Father					Mother				
	Yes		No		Total	Yes		No		Total
	No.	% share	No.	% share		No.	% share	No.	% share	
Science-related	20	33.9%	39	66.1%	59	8	40.0%	12	60.0%	20
Non-science-related	56	19.9%	226	80.1%	282	35	20.8%	133	79.2%	168
Not applicable	2	22.2%	7	77.8%	9		0.0%	2	100.0%	2
Not working	5	23.8%	16	76.2%	21	42	21.3%	155	78.7%	197
Not specified	10	23.8%	32	76.2%	42	6	27.3%	16	72.7%	22
Don't know	3	15.8%	16	84.2%	19	5	21.7%	18	78.3%	23
Total	**96**	**22.2%**	**336**	**77.8%**	**432**	**96**	**22.2%**	**336**	**77.8%**	**432**

Note: "Not specified" refers to those who mentioned their parents' job, but did not specify whether it is in science or non-science related industry.

Figure 7 Top five important information sources when choosing major of study – by stream



Note:

1. The levels of importance are assigned values: Very important = 5, Important = 4, Neutral = 3, Not important = 2, Not important at all = 1, Not applicable 0.
2. The weighted average of importance level is calculated by taking the average of percentage multiplied by the importance level.

Figure 8 Top five important information sources when choosing major of study – by gender

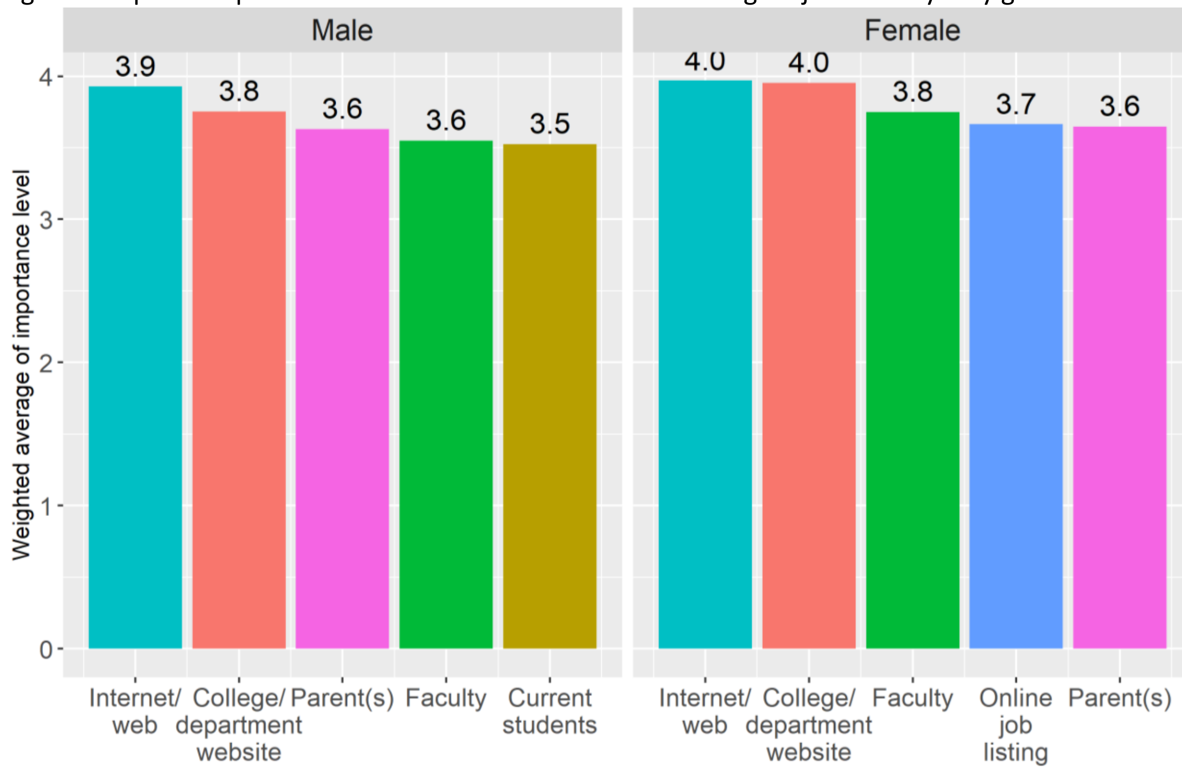
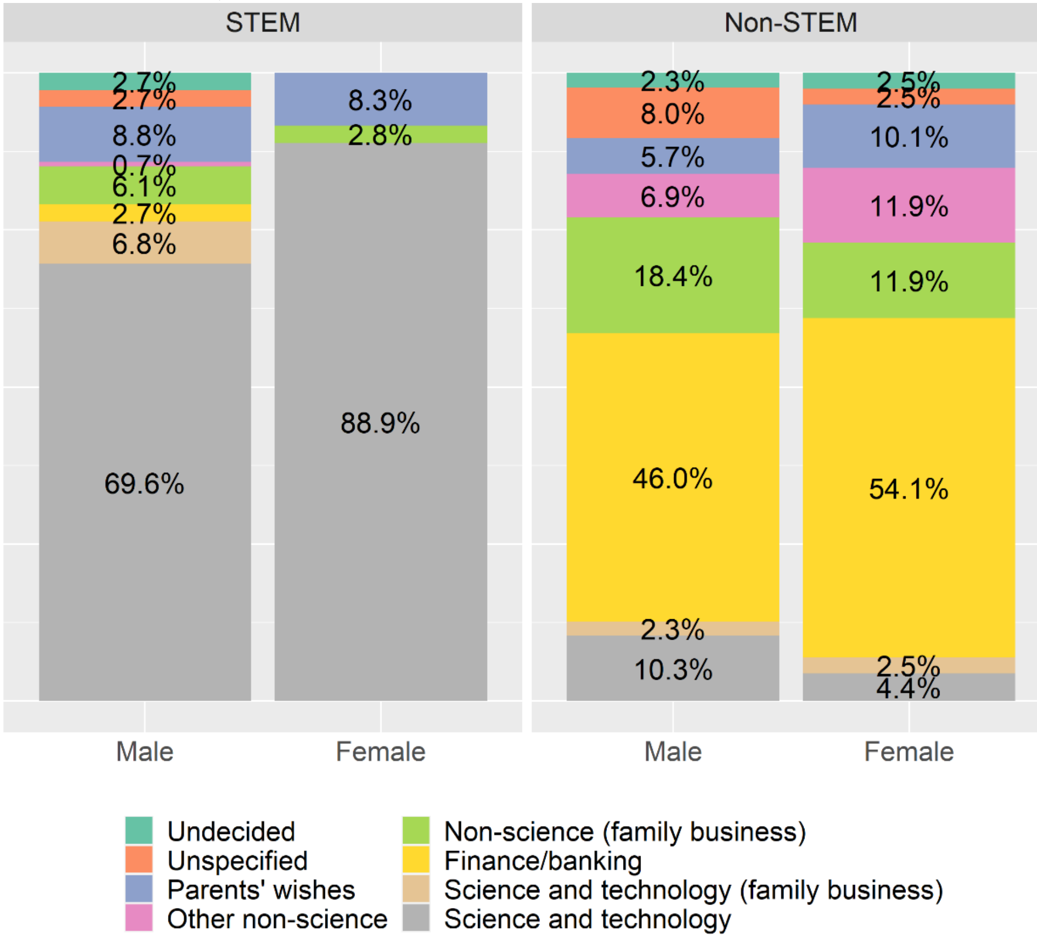


Figure 9 Future career plan of tertiary students by gender and stream
Male STEM students = 148, female STEM students = 36
Male non-STEM students =87, female non-STEM students = 159



Note: Two invalid answers were excluded.

Appendix D: Determinants of student's choice of STEM studies and careers

Table 1 Odds ratio for the regression models of students' choice of science study at upper-secondary schools

Independent variable	Model			Final model
	1	2	3	4
(Intercept)	0.051***	0.042***	0.043***	0.043***
	(0.310)	(0.409)	(0.330)	(0.338)
Male	1.342	1.391	1.374	1.374
	(0.167)	(0.175)	(0.176)	(0.176)
HPS	1.702*	1.507	1.492	1.485
	(0.244)	(0.252)	(0.253)	(0.255)
CSE	0.953	0.896	0.899	0.896
	(0.190)	(0.200)	(0.200)	(0.201)
Father's education	1.555**	1.433*	1.435*	1.436*
	(0.146)	(0.156)	(0.156)	(0.157)
Mother's education	0.959	0.942	0.937	0.938
	(0.146)	(0.153)	(0.153)	(0.153)
Science interest level	2.784***	1.537***	2.858***	2.851***
	(0.088)	(0.094)	(0.094)	(0.095)
Parents' current work	-	2.858*	1.542*	1.542*
	-	(0.201)	(0.201)	(0.201)
School motivation	0.977	1.031	-	1.029
	(0.188)	(0.195)	-	(0.195)
Parents' attitude	2.876***	3.034***	3.062***	3.054***
	(0.186)	(0.195)	(0.196)	(0.196)
Peer influence	1.640**	1.649**	1.657**	1.651**
	(0.178)	(0.187)	(0.185)	(0.187)
Pedagogical strategies	-	-	1.113	1.114
	-	-	(0.232)	(0.232)
School environment	-	-	0.903	0.903
	-	-	(0.235)	(0.235)
Sample size	959	903	903	903
Chi-square statistic	336.656***	321.839***	322.037***	322.058***
Pseudo-R^2 (Cragg-Uhler)	0.4030	0.4105	0.4107	0.4108
Pseudo-R^2 (McFadden)	0.2646	0.2720	0.2721	0.2721

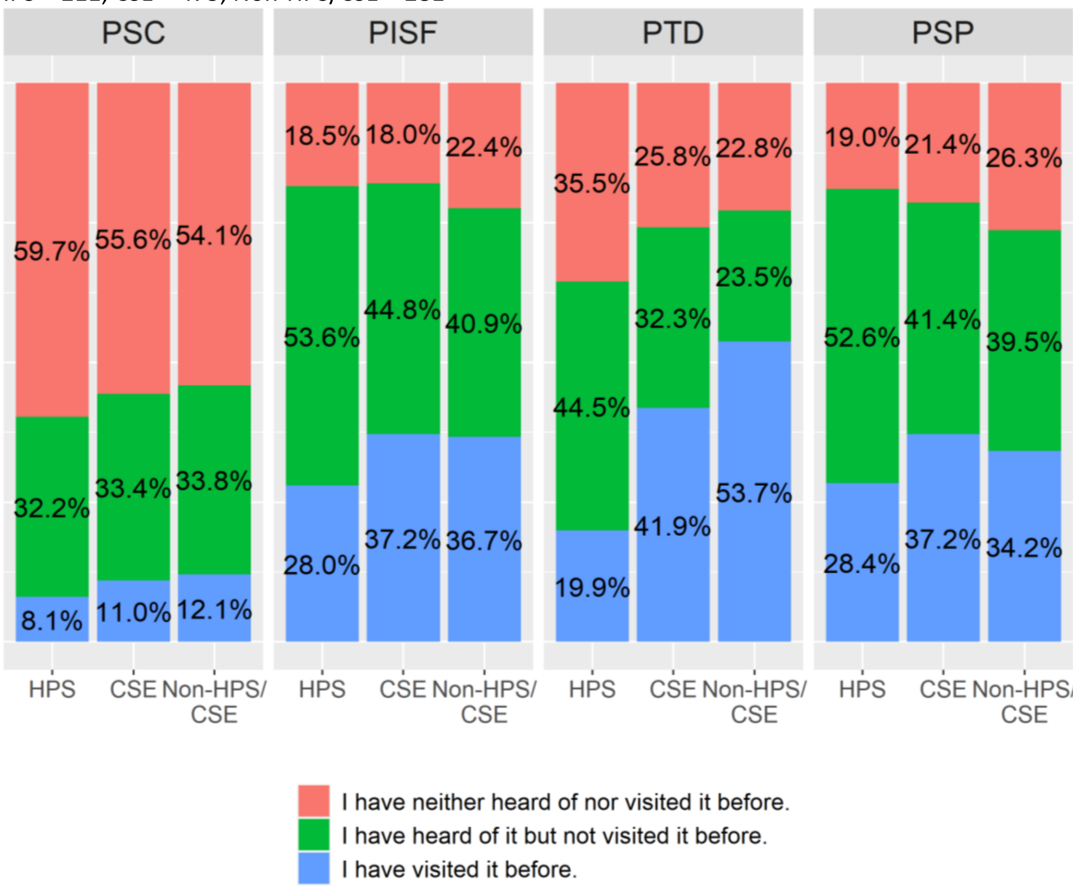
*p<0.10; **p<0.05 and ***p<0.01

Table 2 Regression results for students’ choice of STEM study at tertiary education

Independent variable	Model				Final model
	1	2	3	4	5
(Intercept)	0.011***	0.013***	0.013***	0.013***	0.011***
	(0.479)	(0.463)	(0.466)	(0.466)	(0.479)
Male	6.900***	6.831***	6.699***	6.712***	6.887***
	(0.275)	(0.274)	(0.272)	(0.272)	(0.275)
Stream of study at upper-secondary level	-	-	1.106	-	1.115
	-	-	(0.279)	-	(0.280)
Father's education	1.040	-	1.006	1.011	1.033
	(0.225)	-	(0.223)	(0.222)	(0.226)
Mother's education	0.580*	0.585*	0.587*	0.586*	0.581*
	(0.239)	(0.209)	(0.238)	(0.237)	(0.239)
Parents' current work	2.561**	2.572**	2.545**	2.588**	2.515**
	(0.349)	(0.344)	(0.348)	(0.345)	(0.352)
Science interest level	1.400**	1.372**	1.443**	1.460***	1.383**
	(0.110)	(0.107)	(0.112)	(0.108)	(0.114)
Students’ satisfaction on teachers' performance	1.730*	1.693	-	-	1.732*
	(0.276)	(0.274)	-	-	(0.276)
Parents' attitude	3.181***	3.307***	3.057***	3.052***	3.185***
	(0.327)	(0.324)	(0.324)	(0.324)	(0.327)
Peer influence	1.441	-	1.397	1.387	1.452
	(0.312)	-	(0.310)	(0.309)	(0.313)
Information of STEM career paths before tertiary education	4.533***	4.680***	4.431***	4.513***	4.439***
	(0.297)	(0.299)	(0.297)	(0.294)	(0.301)
Sample size	399	399	399	399	399
Chi-square statistic	178.228***	176.841***	174.378***	174.247***	178.380***
Pseudo-R² (Cragg-Uhler)	0.4873	0.4807	0.4753	0.4751	0.4840
Pseudo-R² (McFadden)	0.3270	0.3245	0.3200	0.3197	0.3273

*p<0.10; **p<0.05 and ***p<0.01

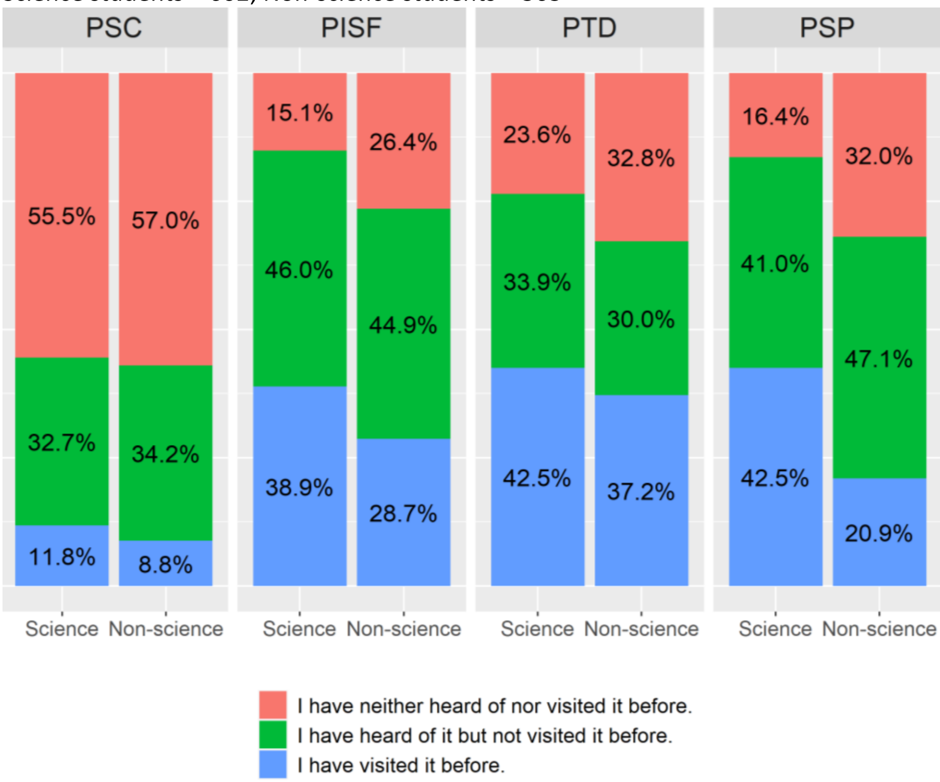
Figure 1 Upper-secondary students' responses on Penang's STEM-engagement programmes
HPS = 211; CSE = 473; Non-HPS/CSE = 281



Note: PSC – Penang Science Café; PISF – Penang International Science Fair; PTD – Penang Tech Dome; and PSP – Penang STEM Programmes organised by Penang STEM 4.0

Figure 2 Upper-secondary students' responses on Penang's STEM-engagement programmes

Science students = 602; Non-science students = 363



Note: PSC – Penang Science Café; PISF – Penang International Science Fair; PTD – Penang Tech Dome; and PSP – Penang STEM Programmes organised by Penang STEM 4.0

Figure 3 Frequency of upper-secondary students' visits for each engagement programme
HPS: PSC = 15, PISF = 58, PTD = 41, PSP = 57
CSE: PSC = 52, PISF = 176, PTD = 198, PSP = 176
Non-HPS/CSE: PSC = 34, PISF = 103, PTD = 151, PSP = 96

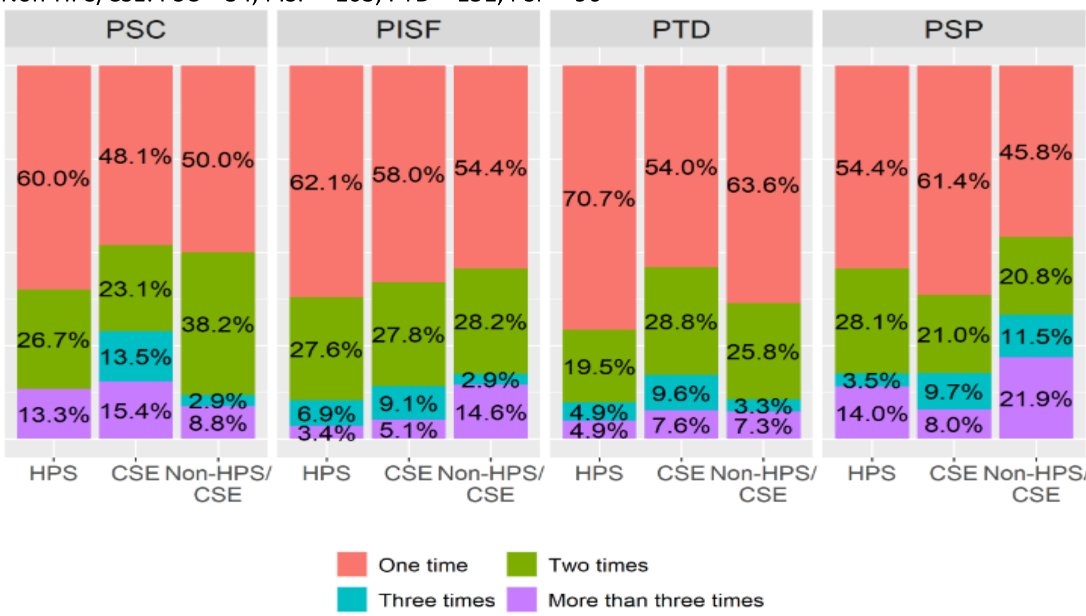


Figure 4 Top five sources of science and technology information
Science students = 602; Non-science students = 363

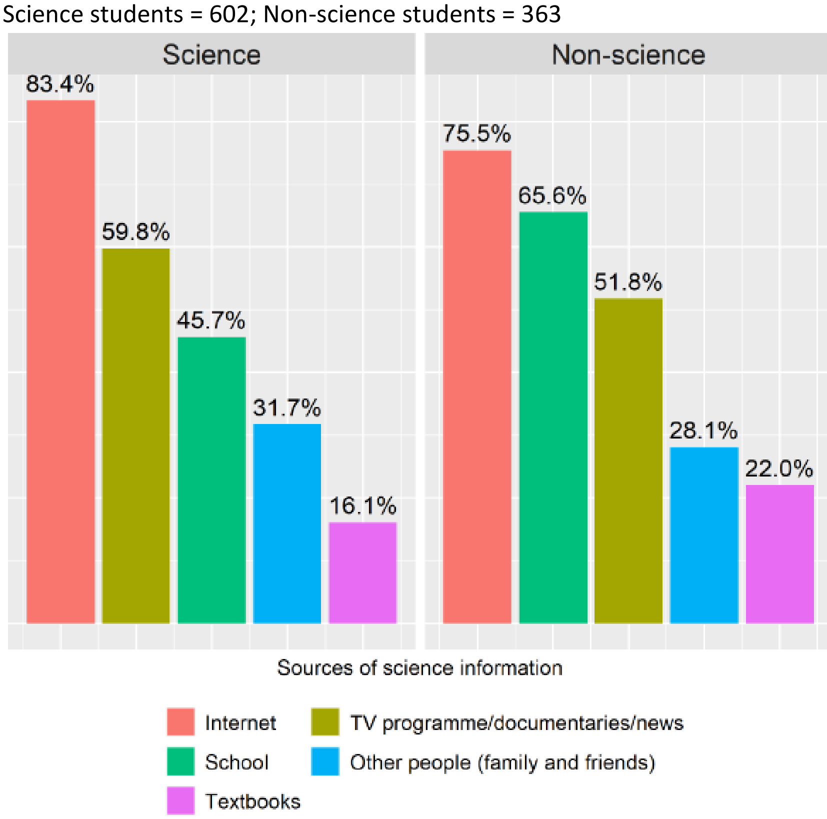


Table 3 Students' participation in Penang's STEM-engagement programmes by stream and types of school

	PSC			Total		PISF			Total		PTD			Total		PSP			Total	
	HPS	CSE	Non-HPS/CSE	No.	%	HPS	CSE	Non-HPS/CSE	No.	%	HPS	CSE	Non-HPS/CSE	No.	%	HPS	CSE	Non-HPS/CSE	No.	%
I have neither heard of nor visited it before.	**59.7**	**55.6**	**54.1**	**541**	**56.1**	**18.5**	**18.0**	**22.4**	**187**	**19.4**	**35.5**	**25.8**	**22.8**	**261**	**27.0**	**19.0**	**21.4**	**26.3**	**215**	**22.3**
Science	59.3	54.8	52.8	334	55.5	16.0	14.2	15.7	91	15.1	36.4	19.2	18.2	142	23.6	16.0	14.6	20.1	99	16.4
Non-science	61.2	56.8	55.7	207	57.0	26.5	23.4	31.1	96	26.4	32.7	35.4	28.7	119	32.8	28.6	31.3	34.4	116	32.0
I have heard of it but not visited it before.	**32.2**	**33.4**	**33.8**	**321**	**33.3**	**53.6**	**44.8**	**40.9**	**440**	**45.6**	**44.5**	**32.3**	**23.5**	**313**	**32.4**	**52.6**	**41.4**	**39.5**	**418**	**43.3**
Science	31.5	32.7	34.0	197	32.7	54.9	44.1	40.3	277	46.0	45.7	35.6	18.9	204	33.9	50.0	37.0	39.0	247	41.0
Non-science	34.7	34.4	33.6	124	34.2	49.0	45.8	41.8	163	44.9	40.8	27.6	29.5	109	30.0	61.2	47.9	40.2	171	47.1
I have visited it before.	**8.1**	**11.0**	**12.1**	**103**	**10.7**	**28.0**	**37.2**	**36.7**	**338**	**35.0**	**19.9**	**41.9**	**53.7**	**391**	**40.5**	**28.4**	**37.2**	**34.2**	**332**	**34.4**
Science	9.3	12.5	13.2	71	11.8	29.0	41.6	44.0	234	38.9	17.9	45.2	62.9	256	42.5	34.0	48.4	40.9	256	42.5
Non-science	4.1	8.9	10.7	32	8.8	24.5	30.7	27.0	104	28.7	26.5	37.0	41.8	135	37.2	10.2	20.8	25.4	76	20.9
Total	***211***	***473***	***281***	***965***	***100.0***	***211***	***473***	***281***	***965***	***100.0***	***211***	***473***	***281***	***965***	***100.0***	***211***	***473***	***281***	***965***	***100.0***
Science	*162*	*281*	*159*	*602*	*62.4*	*162*	*281*	*159*	602	*62.4*	*162*	*281*	*159*	602	*62.4*	*162*	*281*	*159*	602	*62.4*
Non-science	*49*	*192*	*122*	*363*	*37.6*	*49*	*192*	*122*	363	*37.6*	*49*	*192*	*122*	363	*37.6*	*49*	*192*	*122*	363	*37.6*

Table 4 Avenue of students' participating in Penang's STEM-engagement programmes

	PSC		PISF		PTD		PSP	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
HPS	**16**	**15.5**	**58**	**17.2**	**42**	**10.7**	**58**	**17.5**
School events	12	75.0	31	53.4	28	66.7	54	93.1
Self-initiated	6	37.5	28	48.3	16	38.1	4	6.9
CSE	**52**	**50.5**	**176**	**52.1**	**198**	**50.6**	**176**	**53.0**
School events	34	65.4	109	61.9	141	71.2	159	90.3
Self-initiated	18	34.6	81	46.0	73	36.9	21	11.9
Non-HPS/CSE	**34**	**33.0**	**103**	**30.5**	**151**	**38.6**	**96**	**28.9**
School events	21	61.8	72	69.9	124	82.1	80	83.3
Self-initiated	15	44.1	36	35.0	38	25.2	21	21.9
Total	***103***	***100.0***	***338***	***100***	***391***	***100.0***	***332***	***100***
School events	*67*	*65.0*	*212*	*62.7*	*293*	*74.9*	*293*	*88.3*
Self-initiated	*39*	*37.9*	*145*	*42.9*	*127*	*32.5*	*46*	*13.9*

Note: Total percentage does not sum to 100% due to respondents attended the programme by themselves and also through school events.

Figure 5 Most interested areas of science among science students by gender

Male students = 284; Female students = 398

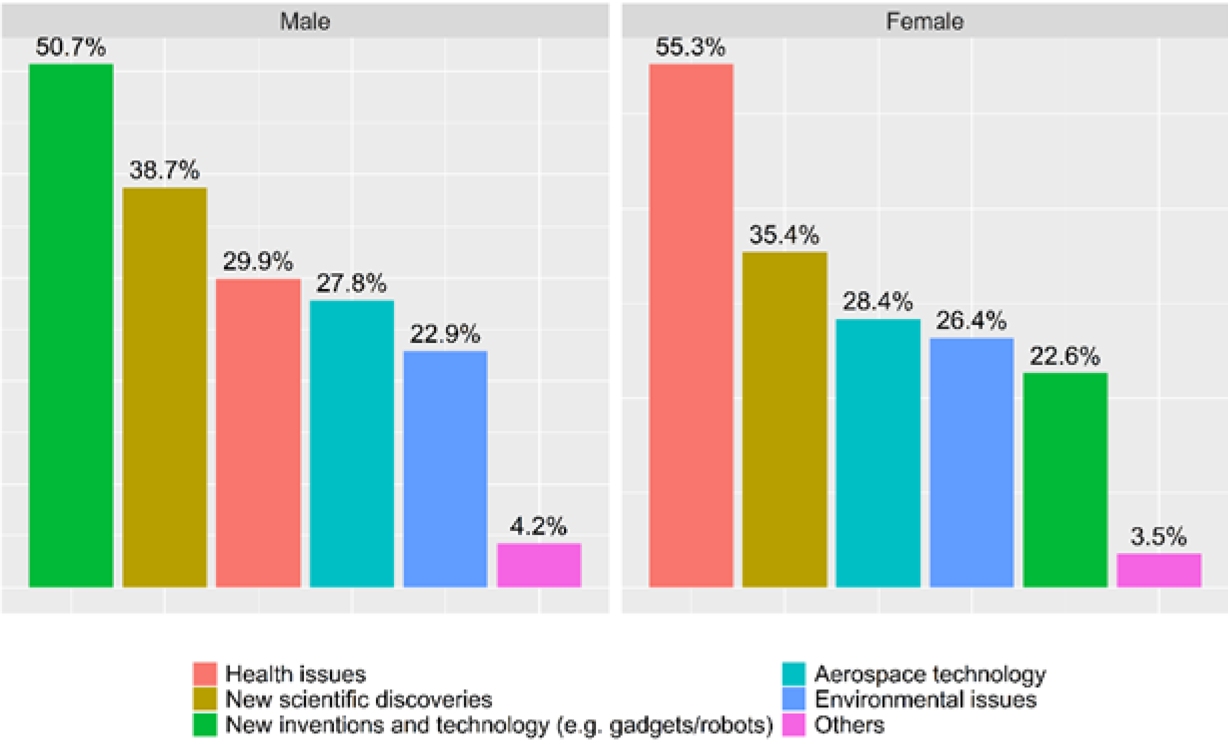


Table 5 Summary statistics for upper-secondary schools among the high performers

Variable	Secondary high performers* who				
	Total	planned to pursue STEM courses	planned to pursue non-STEM courses	planned to pursue STEM careers	planned to pursue non-STEM careers
HPS	10.9%	12.4%	20.0%	11.0%	13.3%
CSE	68.0%	65.1%	60.0%	68.5%	60.0%
Male	39.4%	40.3%	40.0%	41.1%	26.7%
Father's education	61.8%	66.1%	60.0%	63.2%	53.3%
Mother's education	62.4%	69.3%	60.0%	66.0%	53.3%
Parents' current work	35.7%	40.3%	20.0%	37.4%	33.3%
Science interest level	3.34	3.49	3.00	3.41	2.80
School motivation	80.6%	82.2%	60.0%	83.6%	66.7%
Average Science score	8.75	8.85	8.20	8.79	8.51
English score	8.78	8.81	9.00	8.77	9.00
Parents' attitude	41.7%	46.5%	20.0%	41.8%	33.3%
Peer influence	43.4%	44.2%	40.0%	45.2%	40.0%
Future study plan in STEM	73.7%	100.0%	0.0%	82.9%	26.7%
Future study plan in non-STEM	2.9%	0.0%	100.0%	0.7%	26.7%
Future career choice in STEM	83.9%	93.8%	20.0%	100.0%	0.0%
Future career choice in non-STEM	8.6%	3.1%	80.0%	0.0%	100.0%
Sample size^	175	129	5	146	15

Note:

1. High performers are defined as students who scored top 25% in the average Science score for Add Maths, Physics, Biology and Chemistry. The highest score is 10 corresponding to A+ and so on (refer to Section 2.3.1: Table 2.7). The minimum threshold used here is score of 8 (corresponds to A-).
2. All statistics are presented in percentages except for *Science interest level*, *Average Science score* and *English score* which are the mean values (refer to Section 2.3.1: Tables 2.6 and 2.7 for the definition of values).
3. The percentages of students who were unsure about their *Future study plan* (23.4%) and *Future career choice* (7.5%) are not shown in the table above.
4. ^ Sample size may vary for different variables. For those missing values, they are excluded.

Table 6 Summary statistics for tertiary students who were high performers in SPM

Variable	Tertiary high performers* who					Tertiary high performers who are currently in STEM courses and	
	Total	currently in STEM courses	currently in non-STEM courses	planned to pursue STEM careers	planned to pursue non-STEM careers	planned to pursue STEM careers	planned to pursue non-STEM careers
Male	61.5%	80.6%	33.3%	77.8%	38.5%	79.2%	100.0%
Science stream	59.6%	100.0%	0.0%	88.9%	15.4%	100.0%	100.0%
Father's education	53.8%	51.6%	57.1%	48.1%	61.5%	50.0%	100.0%
Mother's education	55.8%	54.8%	57.1%	55.6%	61.5%	58.3%	100.0%
Parents' current work	27.5%	36.7%	14.3%	38.5%	7.7%	43.5%	0.0%
Science interest level	2.79	3.00	2.48	3.15	2.54	3.17	2.00
Students who satisfied with teachers' performance	38.5%	35.5%	42.9%	40.7%	30.8%	33.3%	0.0%
Students who dissatisfied with teachers' performance	28.8%	35.5%	19.0%	37.0%	30.8%	41.7%	50.0%
Average Science score	8.49	8.46	8.52	8.47	8.65	8.48	9.00
English score	8.44	8.06	9.00	8.26	9.15	8.17	8.50
Parents' attitude	34.6%	45.2%	19.0%	40.7%	23.1%	45.8%	50.0%
Peer influence	21.2%	16.1%	28.6%	14.8%	15.4%	12.5%	0.0%
Information of STEM career paths before tertiary education	1.02	1.13	0.86	1.13	0.91	1.18	0.96
Future career choice in STEM	51.9%	77.4%	14.3%	100.0%	0.0%	100.0%	0.0%
Future career choice in non-STEM	25.0%	6.5%	52.4%	0.0%	100.0%	0.0%	100.0%
Sample size^	52	31	21	27	13	24	2

Note:

1. High performers are defined as students who scored top 25% in the average Science score for Add Maths, Physics, Biology and Chemistry. The highest score is 10 corresponding to A+ and so on. The minimum threshold used here is score of 7.5 (corresponds to between B+ and A-).
2. All statistics are presented in percentages except for *Science interest level*, *Average Science score, English score* and *Information of STEM career paths before tertiary education* which are the mean values (refer to Section 2.3.1: Tables 2.6 and 2.7 for the definition of values).
3. The percentages of students who were unsure about their *Satisfaction with teachers' performance* (32.7%) and *Future career choice* (23.1%) are not shown in the table above.
4. ^ Sample size may vary for different variables. For those missing values, they are excluded.

Table 7a Future study choice for high-performing secondary science students by gender

Future study choice	Male		Female		Total	
	No	%	No	%	No	%
STEM	52	75.4	77	72.6	129	73.7
Non-STEM	2	2.9	3	2.8	5	2.9
Don't know	15	21.7	26	24.5	41	23.4
Total	**69**	**100.0**	**106**	**100.0**	**175**	**100.0**

Table 7b Future career choice for high-performing secondary science students by gender

Future career choice	Male		Female		Total	
	No	%	No	%	No	%
STEM career	60	88.3	86	81.1	146	83.9
Non-STEM career	4	5.9	11	10.4	15	8.6
Others	4	5.9	9	8.5	13	7.5
Depends on parents' wishes	*2*	*2.9*	*3*	*2.8*	*5*	*2.9*
Undecided	*2*	*2.9*	*6*	*5.7*	*8*	*4.6*
Total	**68**	**100.0**	**106**	**100.0**	**174**	**100.0**

Note: A student who didn't answer was excluded.

Table 7c Science interest levels for high-performing secondary science students by future study choice and gender

Interest level	STEM						Non-STEM					
	Male		Female		Total		Male		Female		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
Very interested	36	69.2	39	50.7	75	58.1	2	100.0	0	0.0	2	40.0
Rather interested	12	23.1	34	44.7	46	35.7	0	0.0	1	33.3	1	20.0
Neither interested nor disinterested	3	5.8	2	2.6	5	3.9	0	0.0	2	66.7	2	40.0
Rather not interested	1	1.9	1	1.3	2	1.6	0	0.0	0	0.0	0	0.0
Not interested at all	0	0.0	1	1.3	1	0.8	0	0.0	0	0.0	0	0.0
Total	**52**	**100.0**	**77**	**100.0**	**129**	**100.0**	**2**	**100.0**	**3**	**100.0**	**5**	**100.0**

Note: 41 students who selected "Don't know" for future study choice were excluded.

Table 7d Science interest levels for high-performing secondary science students by future career choice and gender

Interest level	STEM career						Non-STEM career					
	Male		Female		Total		Male		Female		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
Very interested	37	61.7	40	46.5	77	52.7	3	75.0	1	9.1	4	26.7
Rather interested	18	30.0	39	45.4	57	39.0	0	0.0	5	45.4	5	33.3
Neither interested nor disinterested	3	5.0	5	5.8	8	5.5	1	25.0	4	36.4	5	33.3
Rather not interested	2	3.3	1	1.2	3	2.1	0	0.0	1	9.1	1	6.7
Not interested at all	0	0.0	1	1.2	1	0.7	0	0.0	0	0.0	0	0.0
Total	**60**	**100.0**	**86**	**100.0**	**146**	**100.0**	**4**	**100.0**	**11**	**100.0**	**15**	**100.0**

Note: 13 students who selected "Others" and 1 student who didn't answer for future career choice were excluded.

Table 7e Parent's occupational field (father and mother) by high-performing secondary science students' future study choice

Parent's occupation	Father						Mother					
	STEM		Non-STEM		Total		STEM		Non-STEM		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
Science-related	44	34.6	1	20.0	45	34.1	16	12.9	0	0.0	16	12.4
Non-science-related	59	46.5	3	60.0	62	47.0	61	49.2	3	60.0	64	49.6
Not specified	16	12.6	1	20.0	17	12.9	0	0.0	0	0.0	0	0.0
Not working	8	6.3	0	0.0	8	6.1	46	37.1	2	40.0	48	37.2
Not applicable	0	0.0	0	0.0	0	0.0	1	0.8	0	0.0	1	0.8
Total	**127**	**100.0**	**4**	**100.0**	**132**	**100.0**	**124**	**100.0**	**5**	**100.0**	**129**	**100.0**

Note: 41 students who were undecided about future studies were excluded. There were 2 non-responses for father's occupation, and 5 for mother's occupation.

Table 8a Study choice for high-performing tertiary students by gender

Study choice	Male		Female		Total	
	No	%	No	%	No	%
STEM	25	78.1	6	30.0	31	59.6
Non-STEM	7	21.9	14	70.0	21	40.4
Total	**32**	**100.0**	**20**	**100.0**	**52**	**100.0**

Table 8b Future career choice for high-performing tertiary students by gender

Future career choice	Male		Female		Total	
	No	%	No	%	No	%
STEM career	21	65.6	6	30.0	27	51.9
Non-STEM career	5	15.6	8	40.0	13	25.0
Others	6	18.8	6	30.0	12	23.1
Parents' wishes	*3*	*9.4*	*3*	*15.0*	*6*	*11.5*
Undecided	*2*	*6.3*	*0*	*0.0*	*2*	*3.9*
Not specified	*1*	*3.1*	*3*	*15.0*	*4*	*7.7*
Total	**32**	**100.0**	**20**	**100.0**	**52**	**100.0**

Table 8c Science interest levels for high-performing tertiary students by study choice and gender

Interest level	STEM						Non-STEM					
	Male		Female		Total		Male		Female		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
Very interested	7	28.0	2	33.3	9	29.0	1	14.3	1	7.1	2	9.5
Rather interested	13	52.0	4	66.7	17	54.8	5	71.4	7	50.0	12	57.1
Neither interested nor disinterested	2	8.0	0	0.0	2	6.5	1	14.3	2	14.3	3	14.3
Rather not interested	2	8.0	0	0.0	2	6.5	0	0.0	2	14.3	2	9.5
Not interested at all	1	4.0	0	0.0	1	3.2	0	0.0	2	14.3	2	9.5
Total	**25**	**100.0**	**6**	**100.0**	**31**	**100.0**	**7**	**100.0**	**14**	**100.0**	**21**	**100.0**

Table 8d Science interest levels for high-performing tertiary students by future career choice and gender

Interest level	STEM career						Non-STEM career					
	Male		Female		Total		Male		Female		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
Very interested	6	28.6	2	33.3	8	29.6	1	20.0	1	12.5	2	15.4
Rather interested	13	61.9	4	66.7	17	63.0	3	60.0	4	50.0	7	53.9
Neither interested nor disinterested	1	4.8	0	0.0	1	3.7	0	0.0	1	12.5	1	7.7
Rather not interested	0	0.0	0	0.0	0	0.0	1	20.0	1	12.5	2	15.4
Not interested at all	1	4.8	0	0.0	1	3.7	0	0.0	1	12.5	1	7.7
Total	**21**	**100.0**	**6**	**100.0**	**27**	**100.0**	**5**	**100.0**	**8**	**100.0**	**13**	**100.0**

Note: 12 students who chose “Others” for career choices were excluded.

Table 8e Parent's occupational field (father and mother) by high-performing tertiary students' study choice

Parent's occupation	Father						Mother					
	STEM		Non-STEM		Total		STEM		Non-STEM		Total	
	No	%	No	%	No	%	No	%	No	%	No	%
Science-related	8	27.6	3	14.3	11	22.0	4	12.9	1	5.0	5	9.8
Non-science-related	17	58.6	14	66.7	31	62.0	11	35.5	8	40.0	19	37.3
Not specified	3	10.3	2	9.5	5	10.0	0	0.0	3	15.0	3	5.9
Not working	1	3.4	1	4.8	2	4.0	16	51.6	8	40.0	24	47.1
Not applicable	0	0.0	1	4.8	1	2.0	0	0.0	0	0.0	0	0.0
Total	**29**	**100.0**	**21**	**100.0**	**45**	**100.0**	**31**	**100.0**	**20**	**100.0**	**48**	**100.0**

Note: The following were excluded - 2 STEM who didn't answer for father's occupation, and 1 non-STEM student who didn't answer for mother's occupation.

Figure 6 SPM results for selected subjects among tertiary students