GENDER DIFFERENCES IN CHOOSING STEM SUBJECTS AT SECONDARY SCHOOL AND UNIVERSITY IN HONG KONG

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Final Report

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Standard Abbreviations

HKDSE/DSE – Hong Kong Diploma of Education Examination

ICT – Information and Communication Technology

M1 – Mathematics Extended Part Module 1 (Calculus and Statistics)

M2 – Mathematics Extended Part Module 2 (Algebra and Calculus)

STEM – Science, Technology, Engineering and Mathematics

Executive Summary

The present study adopts the "leaky pipeline" as a conceptual framework to understand not only the under-representation of women in STEM subjects in DSE but also the factors contributing to their dropout from STEM fields at multiple stages. In particular, we examine factors contributing to students' choices of STEM electives in DSE, their intention to drop STEM-related electives, and whether and why they will choose STEM as their preferred choice of university majors and career orientations. This is a mixed-method study which consists of a representative survey of 2807 Form 5 students from 43 schools and 8 focus-group in-depth interviews with 56 students (31 girls and 25 boys) who have chosen different number of STEM electives in DSE.

Our findings indicate that there were gender differences in taking STEM-related electives in DSE. Female students are 28.1% and 41.1% less likely than male students to take at least one STEM elective and to take extended mathematics modules in the DSE curriculum respectively. On closer inspection, the gender differences in taking physics and ICT electives are even larger. Female students are 52.7% and 72.4% less likely than male students to take these two STEM electives.

Furthermore, not only are female students less likely to take STEM-related electives in the DSE curriculum, but they are also more likely to leak out from the STEM pipeline than male students in the later stages. That is, even female students have taken STEM-related electives in DSE, they are less likely to consider STEM majors in higher education and work in the STEM fields. 58.8% and 29.2% of male students who have taken at least one STEM-related elective in the DSE curriculum have the intention to study STEM in university and pursue a STEM career. In comparison, only 26.8% and 10.6% of female students who have taken at least one STEM-related elective have the intention to study STEM in university and pursue a STEM career. Hence, compared with male students, female students are 54.4% and 63.7% less likely to have the intention to study STEM further and work in STEM fields even though they have taken STEM electives in DSE curriculum.

The higher dropout rate for women in the STEM pipeline is not because female students put less effort into studying STEM especially for those who have taken the related subjects in DSE curriculum. On the contrary, female students invested more money and time in the STEM electives and in mathematics than the male students. On average, female students spent 77.1% and 63.3% more money on tutorial classes for the STEM electives and mathematics than male students. However, female students are more likely to feel dissatisfied with their performance in STEM subjects. Generally speaking, female students hold more negative perceptions of their STEM learning domains. Female students are 19.6%, 17.4% and 15.2% less confident than male students in ICT, mathematics and science learning domains respectively. Similarly, female students are less interested in these learning domains than male students. As a result, female students are 11.8% more regretful than male students about their choices in taking STEM-related DSE electives. Likewise, female students are 82.8% more likely than male students to drop Mathematics extended modules (M1 and M2).

Our statistical analyses show that gender differences in the subject perception (self-efficacy, interests, and perceived value), preference on job characteristics, and stereotypical beliefs in STEM all play a substantial role in explaining women's choice and dropout at different stages. First, female students report a more positive perception of the language/humanities domain while male students report a more positive perception of the science-related domains. Additional analysis shows that positive perception of language and humanities learning domains is negatively associated with the students' choice in STEM while the positive perception of science-related learning domains is positively associated with the students' choice in STEM. Consequently, female students are less likely to be retained in the STEM pipeline than male students. Our models show that 38.7% and 38.1% of the gender differences in the intention to study STEM further and pursue STEM careers can be explained by the gender differences in the subject perceptions together.

Secondly, there are gender differences in the preference on job characteristics as well. Female students reported a higher preference towards jobs that are perceived as meaningful whereas male students reported a higher preference towards jobs that are related to technology, machines and other STEM-related characteristics. Meanwhile, female students' preference and aspiration to work for meaningful jobs is negatively associated with their intention to study STEM in university and take up a STEM-related job. On the contrary, male students' preference and aspiration to work in jobs that are related to technology is positively associated with their intention to study STEM in university and take up a STEM-related job. Our models show that 48.9% and 47.6% of the gender differences in the intention to study STEM further and pursue STEM careers are related to the gender differences in the preference on job characteristics.

Furthermore, female students who hold stronger gender stereotypical beliefs in STEM (such as "boys are better than girls in learning science" or "girls are more suitable to study language and humanities") are less likely to take STEM electives and M1/M2, and have a lower intention to study STEM in university and pursue a STEM career. Assuming male and female students do not hold gender stereotypical beliefs, our statistical models predict that the gender differences in pursuing STEM at university and as a career can be significantly reduced by 43% and 23.6% respectively.

Our focus group interviews further substantiated our understanding of students' subject choices/electives in DSE. Instead of choosing subjects/electives as related to their personal interest, students 'choice' of DSE electives has been shaped by school culture and concern with university entrance. As most secondary schools in Hong Kong privilege science over arts or other streams and accord higher status to STEM subjects like M1 and M2, top achieving students, including women, usually choose science subjects out of status and strategic concerns. This may also explain why female students "leak out" in the later stages. Women who choose STEM-related subjects to get admitted into university may, once admitted, take up non-STEM majors that are associated with jobs that are meaningful or helpful to others.

Women's lower intention to take up STEM as DSE electives, in university education, and in their careers can also be attributed to the prevalent gender beliefs associated with math and science-related subjects. Our focus group interviews also find that there are some prominent gendered beliefs prevalent amongst students, for example: "math is a science subject as it requires understanding, whereas biology is a pseudo-science subject as it needs memorization"; "only boys are endowed with math sense – the natural ability to do math"; "boys are able to solve mathematical questions quickly, intuitively, and effortlessly"; "boys are more sensible whereas girls are more sensitive"; "girls only work hard but have no math sense"; and "girls that are good at math are exceptional or abnormal". These masculine - or male-dominated - beliefs are not simply stereotypical but are unhealthy and limiting to female students, as they undermine girls' self-efficacy and learner-identities. In particular, most female interviewees, including those who have chosen M1/M2, have lower self-efficacy in math and science related subjects, and tended to only rate their performance as above average. We believe this probably also explains why more female students dropped M1/M2 in the later stages.

Based on the above findings, we have the following recommendations. First, we do not think making STEM-related electives compulsory is an effective solution to the gender inequality in STEM education because it could not prevent female students from leaking out from the STEM pipeline. Secondly, we believe schools, teachers, and parents should be more vigilant of the specific gender beliefs that deter girls from pursuing STEM at different stages. Thirdly, having access to more ordinary female role models can help counter negative stereotypes. In addition, the images of STEM, be they related to the subjects, the fields, or job nature should be revamped. Female students currently do not find STEM jobs meaningful. Instead, they often describe science as boring, dirty, and detached from daily life. The policy makers and field practitioners should actively promote a more "humane" image of STEM to attract more young women to join. In particular, educators, schools and teachers should consider making math or science-related subjects more relevant to students' real life. Similarly, more efforts are needed to enhance the status and significance of ICT.

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1. Background

In the past two decades, women's access to education has been significantly improved in many countries; however, the gender skew in STEM subjects – the underrepresentation of female students in Science, Technology, Engineering and Mathematics – persists. According to UNESCO (2017, pp. 18-20), between 2014 and 2016, the global average enrollment figures of university students in the fields of "education" and "health and welfare" fields were female-dominant, with 71% and 68% respectively. In contrast, the situations in the fields of "information and communication technologies" and "engineering, manufacturing and construction" were male dominated, as female students only constituted 28% and 27% respectively.

We may gain a fuller picture by looking at the development in America. In 2012, there were about the same numbers of female and male students in mathematics and science subjects in US primary and secondary schools, where female also outperformed male in the overall scores. Nevertheless, at the university level, female's participation in mathematics and science subjects significantly dropped to 20% and 36% of total bachelor degree awardees, and to 23% and 31% at the master and doctorate levels (Wang & Degol, 2013, p. 305).

The underrepresentation of females in STEM fields has several negative consequences. First, society will be worse-off when it fails to recruit and fully engage the most qualified pool of talents, viz. women, into a rising field. Secondly, women as a group will suffer when they fail to gain access to "highly valued occupations". Currently female STEM workers earn about 33% more than women who work in other fields, and the gender wage gap in STEM fields is lower than those in non-STEM fields – 14% for the former and 21% for the latter. Thirdly, a vicious circle will set in, as women's under-representation in STEM may further discourage young female students from pursuing education or career development in these related fields (Diekman, Steinberg, Brown, Belanger, & Clark, 2017, pp. 146-147).

There is a similar situation in Asia-Pacific countries. According to a survey entitled "Girls in Tech" (MasterCard, 2018), 21% of female respondents, aged 12 to 19, in Australia, China, India, Indonesia, Malaysia and Singapore, chose not to pursue STEM career due to "perception of gender bias". Family members are identified as the primary factor in shaping respondents' STEM choice. An overwhelming proportion of respondents (68%) rated parents as the "most influential" factor in their decision to study or work in STEM fields. Similarly, among women who are currently STEM students, 63% of them have parents and/or elder siblings in STEM-related fields.

Hong Kong's situation is similar to that of Asia-Pacific countries and the U.S. An analysis of the 2017 Hong Kong Diploma of Secondary Education Examination (HKDSE) shows that gender skew exists. For example, 27.6% of male students (8,599 out of a total of 31,123) and 10.4% of female students (3,046 out of 29,226) took physics. In the subject of ICT, the percentages were 14.8% and 4.8% of male and female students respectively. In mathematics, although the percentages of male and female students were almost the same, 94.7% and 95% respectively, it became skewed again, as 18.1% of male students (5637) and 8.6% female students (2534) took part in Extended Math (both M1 and M2) respectively. At the tertiary education level, although female students share a slight majority of first-year intake (around 52% to 54%) from 2011 to 2017, they have been minorities in programmes of "Sciences" and "Engineering and Technology", standing at around 35% to 39% and 29% to 33% respectively (UGC, 2018). Such a gender bias obviously will limit not only the labour supply but also upward mobility of female workers, since the salary and career prospect in STEM industries is generally better than others (Chiu, Ip, & Li, 2016).

The problem of gender bias in STEM fields has attracted concern from enterprises and industries. To encourage more female university students to pursue a career in I.T. industries, some transnational I.T. enterprises launched training camps. For example, Microsoft Hong Kong's GirlSpark camp aims at recruiting non-STEM major female university students to cultivate their interest in STEM fields (Microsoft Hong Kong, 2016).

As far as the government is concerned, in its 2015 Policy Address the Hong Kong Government (2015, p. 46) pledged to promote and strengthen STEM education. In particular, it proposed to "renew and enrich the curricula and learning activities" and "enhance the training of teachers". The promotion of STEM was subsequently "a key emphasis under the ongoing renewal of the school curriculum [Learn 2.0]" (Curriculum Development Council, 2015, p. 2). Since 2016, the Education Bureau has taken various measures to facilitate the development of STEM education, including renewing key learning areas, assisting teaching and learning for teachers and students, and strengthening relationships with other stakeholders (Education Bureau, 2016, p. i).

Nevertheless, the Government has done relatively little to minimize the gender gap in STEM fields. In its reply to legislators in 2014, the government believed that the current principles upheld by the Education Bureau, viz. Principle of Equal Opportunities and the Sex Discrimination Ordinance, have already protected female students from being unfairly treated in their access to education. Therefore, it preferred to promote STEM subjects to both male and female students without taking gender as a consideration. (Legislative Council, 2014). This "gender-neutral" stance was problematic as it failed to recognise that students, females in particular, can be affected by "traditional" values, and consider STEM as "male subjects". (Yeung and Liong, 2016)

The Women's Foundation, which aims to promote the full and equal participation of women and girls in all aspects of Hong Kong society, believes that the gender imbalance in STEM subjects deserves closer examination. In November 2016, it commissioned the authors of this report to conduct an independent study to investigate Hong Kong secondary school students' choices in STEM-related DSE subjects and their intention to apply for STEM-related programmes in university. This research aims to achieve the following objectives:

1. Exploring students' reasons in choosing STEM/non-STEM subjects at school and their concerns in choosing university majors;
2. Allowing young girls and boys to elaborate their views regarding their subject choice, their aspirations and gender beliefs;
3. Generating statistical data in order to explain the gender differences (including self-assessment of mathematics and language efficacy, career aspiration, gender beliefs, parental involvement, teacher advice, and school selection);
4. Collecting views and experiences that cannot be adequately covered by the survey, especially students' gendered understanding of various subjects.

In the following, we will outside the research design, then report the key findings that have been obtained from the quantitative survey and the focus group interviews.

2. Research Design

This is a mixed-method study which consists of a representative student survey (Student N=2807 from 43 schools) and 8 focus-group interviews (N=56). Figure 1 presents the guiding conceptual framework in this study. The horizontal sex segregation of occupations can be traced back to the sex segregation by field of study in tertiary education, which is also a result of sex segregation by elective choices in secondary education. The metaphor of "leaky pipeline" – an approach in understanding the underrepresentation of women in the science fields- suggests that women drop out from STEM fields at multiple stages. In this study, we examine students' choices of DSE electives, their intention to drop some of the DSE electives, their preferred choice of university majors and their career-orientation.

2.1 Quantitative Data: Student Survey

The target population of this study are Form 5 students from government, subsidized, or direct-subsidy scheme secondary schools who are enrolled in the HKDSE curriculum. Private and international school students are not included in this study. In order to obtain a representative sample, a multi-stage stratified probability sampling strategy was adopted in this survey. At the first stage, a stratified sampling method is used to select schools from three strata: girls' schools, co-ed schools and boys' schools. The sampling frame was the official school list obtained from the Education Bureau. Since single-sex schooling may have an effect on the students' strategy and preferences in choosing subjects, an adequate sample size from each type of school is required. Stratified sampling was used to ensure an adequate number of schools and students are recruited from each type of school.

At the second stage, cluster sampling was used to select Form 5 students within the selected schools. In most cases, two classes were randomly selected to participate in the survey. If the selected school has an art-science streaming policy, then one science class and one non-science class were randomly selected. To gather more information from each type of school, we sampled more than two Form 5 classes in a few selected schools. For all the selected classes, all students were invited to complete a self-administered questionnaire in class. The number of schools in the sampling frame and our sample are shown in Table 2.1.

Table 2.1. Sample size and sampling strata

	Girls Schools	Co-ed Schools	Boys Schools	Total
Sampling Frame				
Number of Schools	41	393	29	463
Sampled School				
Number of Schools	14	20	9	43
Number of Students	1057	1279	471	2807

Sampling weights are calculated for students in each school to adjust for the unequal probability of selection due to the complex sample design. All inferential statistics calculated in this survey report have taken the design effects into consideration.

Table 2.2 shows the items used in calculating the school response rate for the student survey. Between January and June 2017, we successfully contacted and reached the principals or teachers-in-charge of 95 secondary schools in total. 43 schools agreed to participate and 52 schools declined. The school response rate is 45%. With the help from the teachers, the average student completion rate is around 92% among those participating schools. The overall response rate is about 42%.

Table 2.2. School response rate

School contacted	95
School participated	43
School declined	52
School response rate	45.3%

2.2 Qualitative Data: Focus Group Interviews

In August 2017, eight focus group interviews were conducted to further study students' perspectives and experiences in making subject choices and their aspirations. Following the principle of the stratified sampling as mentioned above, students were recruited from three types of schools (i.e. Boy's schools, Girl's schools and Co-ed schools).

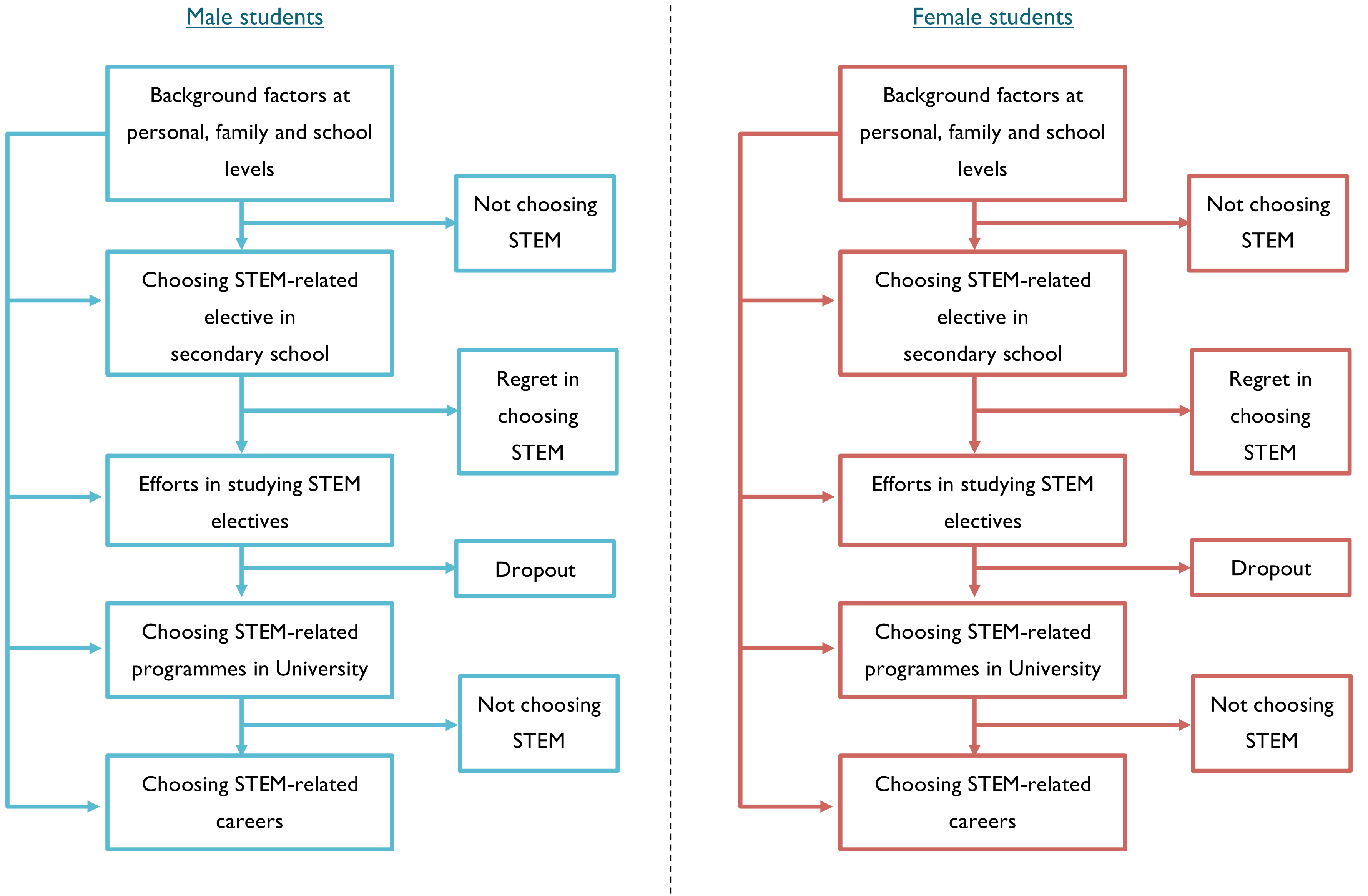
For each type of single-sex school, 2 group interviews were conducted with students who have chosen More or Less STEM subjects in the DSE curriculum. For co-ed schools, 2 group interviews were conducted with male students who have chosen more or fewer STEM subjects while another 2 group interviews were conducted with female students who have chosen more or less STEM subjects. In total, eight focus group interviews were conducted with 56 students. The details about the sample size for the focus group interviews are listed in Table 2.3.

Table 2.3. Sample size for the focus group interviews

	Girls' Schools	Boys' Schools	Co-ed Schools
More STEM subjects	1 Group (6 students)	1 Group (8 students)	2 Groups (10 students)
Less STEM subjects	1 Group (10 students)	1 Group (7 students)	2 Groups (15 students)
Total	2 Groups (16 students)	2 Groups (15 students)	4 Groups (25 students)

The focus group interviews lasted for about 1 hour and were conducted in schools and community centers. The focus group interviews were audio-taped. Transcripts of the interviews were then prepared for analysis.

Figure 1. Conceptual framework in understanding the gender difference in STEM related choices in this study



3. Respondents' Profile of the Student Survey

A summary of the survey respondents' profile is presented in the Table 3.1. Concerning the demographic background of our sample, there are slightly more female students (53.6%) than male students (46.4%) in our sample. Most of the student respondents were at around 16 years old (59.3%). As Hong Kong is an immigrant city, there is a significant proportion of students with an immigrant background. About one-quarter of the students were born elsewhere (25.1%) while three-quarters of the students were born in Hong Kong (75%). Regarding the parents' birthplace, only around 35.4% of the students have two local parents, and 35.1% of the students have two non-local parents. 29.5% of the students have one local and one non-local parent. The study also includes single-parent families. While 77.9% of the sampled students are from two-parent families; 19.6% of the sampled students are from single-parent families. 72.3% of the sampled students have siblings at home.

Turning to indicators on socioeconomic background, most of the students are from dual-earner families (58.6%) while less than two-fifths of the sampled students' families are sole-earner families (38.3%), with around 3.1% of the families with both parents not working. The median income level for the sampled students were at around $20,000-$29,999. The median educational attainment levels for their fathers and mothers are both high school level. While 18.6% of the fathers received post-secondary education or more, 14.5% of the mothers received post-secondary education or more. 26.3% of the sampled students' fathers were reported as working for a professional or managerial position while only about 13.2% of the students' mothers were working for a professional or managerial position. 26.1% of the sampled students' fathers were working for a position with technical work or operating machines while only 1.6% of the students' mothers were working in a similar position.

The students were also asked if there are any members in the family working for a STEM-related job. 11.8% of the students reported that they have a family member working in STEM-related fields. The typical examples of STEM-related jobs given by the students include engineers, programmers, technicians, and science teachers.

Table 3.1. Respondents' background characteristics

Variables	%	Variable	%
Gender		Father's education	
Female	53.6	Junior Secondary or below	40.1
Male	46.4	High School	41.3
		Post-secondary	12.7
Age		Postgraduate	5.9
16 or Below	59.3		
17	30.7	Mother's education	
18 or Above	10.0	Junior Secondary or below	42.3
		High School	43.3
Students' Birthplace		Post-secondary	10.4
Hong Kong	74.9	Postgraduate	4.1
Outside Hong Kong	25.1		
		Father's occupation	
Parents' birthplace		Professional/Managerial	26.3
No parent born in HK	35.1	Clerical/Office Work	7.2
One parent born in HK	29.5	Service/Salesperson	15.1
Both parents born in HK	35.4	Machine-operators/Technical Work	26.1
		Non-skilled worker	16.7
Parental work status		Not employed	8.6
Both not working	3.1		
Sole-earner	38.3	Mother's occupation	
Dual-earner	58.6	Professional/Managerial	13.2
		Clerical/Office Work	17.2
Household Structure		Service/Salesperson	21.7
Two-parent family	77.9	Machine-operators/Technical Work	1.6
Single-father family	5.0	Non-skilled worker	10.0
Single-mother family	14.6	Not employed	36.3
Other	2.4		
		Family income	
Sibling		Less than $10,000	7.8
Has sibling	72.3	$10,000-$19,999	27.8
No sibling	27.7	$20,000-$29,999	23.8
		$30,000-$39,999	17.1
Family members in STEM-related fields		$40,000-$49,999	8.9
No	88.2	$50,000-$59,999	5.5
Yes	11.8	$60,000 or more	9.1

4. Quantitative Results

4.1 Gender Differences in Choosing STEM at Various Levels

Table 4.1 shows the figures concerning male and female students' choices in studying STEM-related electives in the DSE curriculum and their intentions to apply for STEM-related programmes in university and aspiration to choose STEM-related careers.

Table 4.1. STEM-related elective choices and intention to study/work in STEM fields

	Girls	Boys	Sig. Level
M1/M2 Module (%)			
No	82.2	69.8	***
Yes	17.8	30.2	
STEM elective subjects			
0	48.2	31.9	***
1	23.1	29.5	
2	23.9	29.0	
3	4.8	9.7	
STEM-electives proportion (%)	36.9	51.3	***
STEM elective subjects (excluding biology)			
0	59.5	39.1	***
1	29.1	33.1	
2	11.2	24.9	
3	0.2	3.0	
STEM-electives proportion (%) (excluding biology)	22.1	40.4	***
STEM College Majors (%)			
No	84.1	54.3	***
Yes	15.9	45.7	

STEM Careers* (%)			
No	94.3	78.6	***
Yes	5.7	21.4	

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

In our sample, 30.2% of the male students took DSE mathematics extended modules (M1 or M2) while only 17.8% of the female students took these modules. **The gender difference in taking DSE mathematics extended modules (M1 or M2) is 12.4% points.** For DSE electives, male students are also more likely to take STEM-related electives than female students[1]. For male students, 51.3% of their elective subjects are STEM-related while the respective proportion for female students is only 36.9%. **The gender difference in the proportion of STEM-related electives in all electives is 14.4% points.**

The top five DSE electives in our sample for male and female students are listed in Table 4.2. Male and female students have different priorities in taking DSE electives. In our sample, the five most popular DSE electives for female students are Biology, Chemistry, Economics, BAFS (business, accounting and financial studies) and Geography. For male students, the five most popular DSE electives are Physics, Chemistry, Economics, Biology, and ICT. Girls are less likely to choose physics (16.5% as compared with 34.9% among male students) and ICT (5.6% as compared with 20.3% among male students). **The gender differences in taking these two STEM electives – physics and ICT – are 18.5% points and**

[1] In this study, the list of STEM-related DSE electives includes chemistry, biology, physics, integrated science, combined science, information and communication technology, design and applied technology, and technology and living.

[2] In this study, STEM-related university programmes refer to programmes offered by departments of mathematics, engineering departments, computing departments and other science departments. However, programmes of social sciences and medicine are not considered as STEM-related programmes.

14.8% points respectively. This pattern is similar to the overall gender differences in physics and ICT in the DSE examination in 2017.

Table 4.2. Top five DSE electives in our sample by gender

	Girls	Boys
Rank		
1	Biology	Physics
2	Chemistry	Chemistry
3	Economics	Economics
4	BAFS	Biology
5	Geography	ICT

Excluding biology, the gender difference in the proportion of STEM-related elective in all electives increases to 18.3% points. 40.4% of all electives taken by male students are STEM-related (excluding biology) while the proportion for female students is 22.1%. [We believe students' subject choice deserves closer examination. In analyzing focus group interviews, we have identified some subtle influences of students' subject choice and their (gendered) views about various science subjects. For more details, please go to Section 5 Qualitative Analysis.]

The differences between the two genders are even more substantial in the college and career plans students have for the future While 45.7% of male students expressed their interest in applying for STEM-related university programmes[2], only 15.9% of female students have the intention to apply for STEM-related programmes. **The gender differences in the**

[2] In this study, STEM-related university programmes refer to programmes offered by departments of mathematics, engineering departments, computing departments and other science departments. However, programmes of social sciences and medicine are not considered as STEM-related programmes.

intention to study STEM-related university programmes is 29.8% points. Similarly, female students (5.7%) are less likely than male students (21.4%) to consider a STEM-related career[3]. **The gender differences in the intention to choose STEM-related careers is 15.7% points.**

Table 4.3 shows the three-way cross-tabulation of taking DSE STEM electives and their intention to study STEM in university and pursue a STEM career. 46.5% of female students did not take any DSE STEM-related electives and have no intention to study STEM in university or take a STEM-related career. The same figure for the male students is 25.7% only.

Table 4.3. STEM-related elective choices and intention to study/work in STEM fields

Girls

	No DSE STEM subjects		With DSE STEM subjects	
	Not choosing STEM college major	Choosing STEM college major	Not choosing STEM college major	Choosing STEM college major
Not choosing STEM career	46.1%	1.9%	36.5%	9.7%
Choosing STEM career	0.1%	0.2%	1.4%	4.1%

Boys

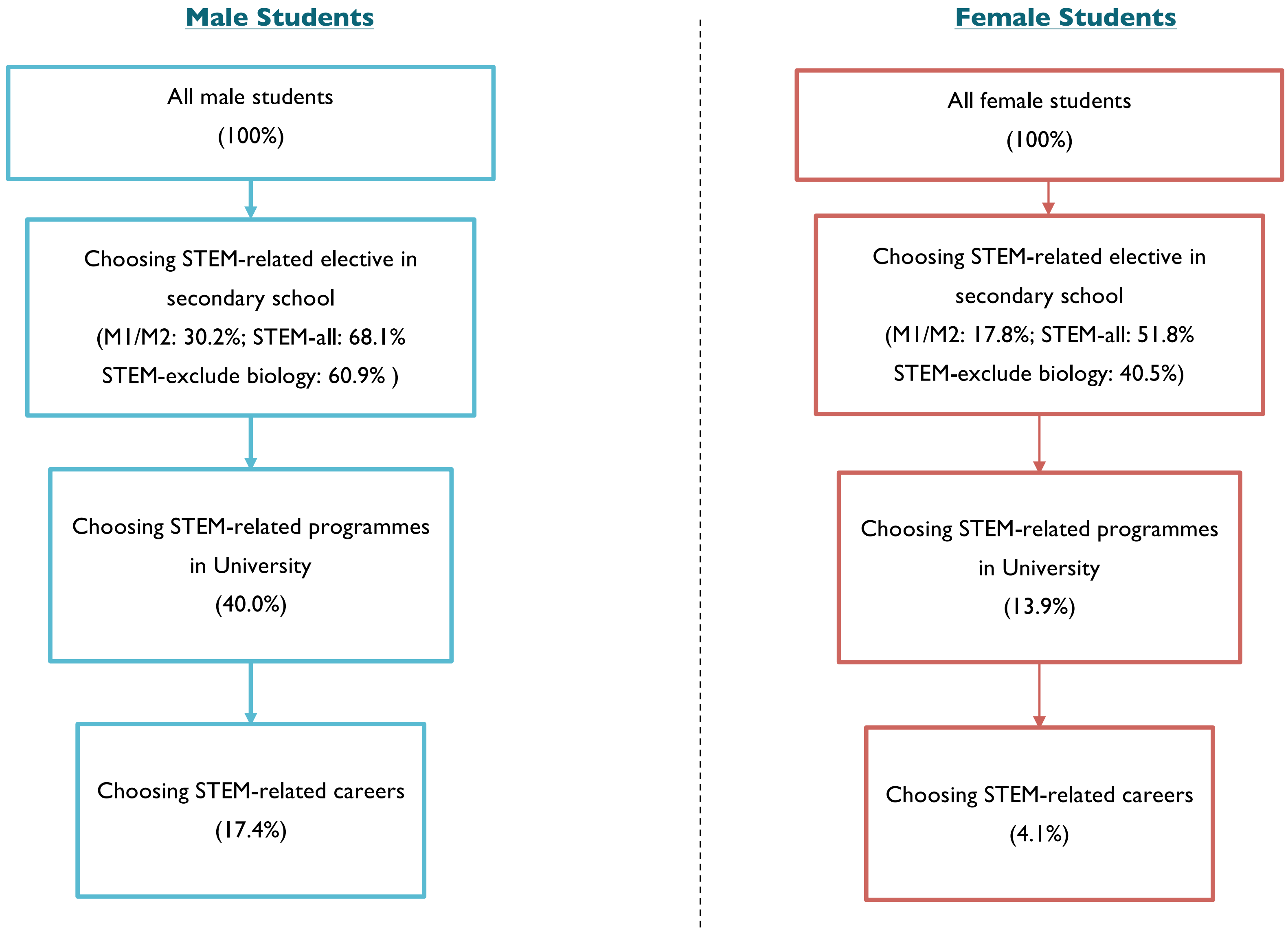
	No DSE STEM subjects		With DSE STEM subjects	
	Not choosing STEM college major	Choosing STEM college major	Not choosing STEM college major	Choosing STEM college major
Not choosing STEM career	25.7%	4.7%	25.6%	22.6%

[3] In this study, STEM-related careers refer to jobs related to science, scientific-research, computers, and information and communication technology.

Choosing STEM career	0.5%	1.0%	2.4%	17.4%

Female students not only start with a lower proportion of STEM-related electives in the DSE curriculum, they are more likely to leak out from the STEM pipeline than male students in the later stages. The gender differences in the intention to take STEM as a major in higher education and choose to enter STEM fields for their careers are wider. 36.5% of the female students took at least one STEM-related elective but have no intention to study STEM in university or work in a STEM-related job. The same figure for the male students is only 25.6%. That is, even female students who took STEM-related electives in DSE are less likely to remain in STEM areas in higher education and work in STEM fields. The proportion of female students who took at least one DSE STEM-related elective and who intended to apply for STEM-related programmes in university and work is only 4.1%. To compare, the same figure for male students is 17.4%. Figure 2 visualizes the proportions of male and female students' remaining in the STEM pipeline.

Figure 2. DSE electives, Intention to study/work in STEM-related fields



4.2 Efforts in studying DSE subjects and dropout before attending DSE

Table 4.4 shows the amount of time the students spent on studying on their own, the time and expenditure on tutorial, and their levels of satisfaction with their performance on the DSE subjects that they have taken.

In general, **there is no significant gender differences in the time spent studying outside the classroom.** Both male and female students spent significantly more time studying mathematics and STEM electives compared to other subjects. Both male and female students tend to spend a similar amount of time in tutoring as well. Yet, **female students spent slightly more time on Mathematics tutoring than male students.** Consequentially, **female students spent more money on tutoring for mathematics and STEM electives than male students.**

Even though female students tend to give similar efforts, if not more, on studying STEM-related subjects, male students are more satisfied with their performance in STEM electives than the female students.

Table 4.4. Interest, time and money investment among DSE subjects

	Girls	Boys	Sig. Level
Own study time (in hour)			
Chinese language	0.86	0.90	NS
English language	0.89	0.94	NS
Mathematics	1.21	1.11	NS
Liberal Studies	0.54	0.55	NS
STEM electives#	1.20	1.32	NS
Non-STEM electives#	1.14	1.19	NS
Time spent for tutorial (in hour)			
Chinese language	0.36	0.38	NS
English language	0.60	0.53	NS
Mathematics	0.53	0.40	***
Liberal Studies	0.09	0.10	NS
STEM electives#	0.30	0.26	NS
Non-STEM electives#	0.13	0.12	NS

Table 4.4. Interest, time and money investment among DSE subjects (Con't)

	Girls	Boys	Sig. Level
Money spent for tutorial (in $)			
Chinese language	146	145	NS
English language	262	214	NS
Mathematics	227	139	**
Liberal Studies	36	22	NS
STEM electives#	124	70	***
Non-STEM electives#	41	42	NS
Satisfied with own performance (1-5)			
Chinese language	2.72	2.66	NS
English language	2.53	2.58	NS
Mathematics	2.67	2.78	NS
Liberal Studies	2.74	2.71	NS
STEM electives#	2.65	2.80	*
Non-STEM electives#	2.93	2.85	NS

Note: # only for students who is currently taking at least one STEM/ Non-STEM elective subject.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Students were also asked if they regretted their DSE elective subject choice. Some students expressed their regrets in choosing their DSE elective subjects. In a scale from 1 to 5 (1 = not regretful; 5 = very regretful) that indicated their level of regret in choosing their DSE elective subjects, students rated around 2 for their DSE elective subjects. **Female students who have taken STEM electives reported a slightly higher level of feeling regretful (mean = 2.18) in choosing STEM electives than male students (mean = 1.95). Despite this, female students do not have a higher intention to drop or be more likely to have dropped STEM subjects.** About

15.5% of the female students who have taken STEM electives intended or have dropped the STEM electives. The same figure for male students is about 15.7%. The difference is non-significant. **However, there is a higher percent of female students (5.3%) who intended or have dropped the extended mathematics modules M1 and M2 as compared to male students (2.9%).**

Table 4.5a. Intention/decision to drop and regret in the choices of DSE electives

	Girls	Boys	Sig. Level
Regret of Elective Choice (STEM) (1-5)#	2.18	1.95	*
Regret of Elective Choice (Non-STEM) (1-5)#	1.97	2.00	NS
Dropped/ Intention to drop			
No	68.5	72.3	NS
Yes	31.5	27.7	
Dropped/ Intention to drop (M1/M2 module)			
No	94.7	97.1	*
Yes	5.3	2.9	
Dropped/ Intention to drop (STEM)			
No	89.7	87.0	NS
Yes	10.3	13.0	
Dropped/ Intention to drop (Non-STEM)			
No	83.5	88.0	NS
Yes	16.5	12.0	

Note: # Only for students who were taking STEM/ Non-STEM DSE electives
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Students who reported feeling regretful about their DSE elective choices were asked for the reasons behind their regret. **Most of them reported that the elective subjects were more difficult or were more boring than they expected. Females were more likely than males to report that they found the subjects as being more difficult than expected.** In contrast, a similar proportion of male and female students reported that they found the subjects more boring than expected. Some students also reported that they were regretful because they had not thought through their decisions clearly, or they mainly followed their parents' or teachers' advice. However, there were no gender differences in these reasons for feeling regretful.

Table 4.5b. Reasons of feeling regretful in choosing the subjects - % of Yes

(Multiple answers allowed)

	Girls	Boys	Sig. Level
More difficult than expected	71.0	63.5	*
More boring than expected	41.2	48.4	NS
Have not thought clearly for the decisions	20.6	19.6	NS
I was mainly following parents' advice	6.1	6.5	NS
I was mainly following teachers' advice	2.7	3.8	NS

Note: For multiple allowed answers, the percentages added up do not equal to 100%. Only for students who feel regretful in choosing the elective subjects.

To summarize this section, female students are less likely to take mathematics extended modules as well as STEM electives in DSE. However, this only partly explains the under-representation of women in STEM in higher education and in occupations. Female students have significantly lower intention to study STEM at the university level and/or choose a STEM career even though they took mathematics extended modules and STEM-related DSE electives. The higher dropout rate for women in the STEM pipeline is not because female students put less effort into studying STEM, especially for those who have taken the related subjects in DSE curriculum. On the contrary, female students invest much more time than male students who study STEM. However, female students are more likely to be dissatisfied with their performance in STEM subjects and more deeply regret in taking STEM. Female students are also more likely to drop Mathematics extended modules. Yet, they do not show a higher dropout rate of other STEM electives in the DSE curriculum.

4.3 Factors in explaining these gender differences

To understand the factors contributing to this pattern about STEM-related choices made by the male and female students, this section presents the distribution of some relevant factors among the male and female students, and how these factors are associated with the DSE elective choices and their intention to study STEM in higher education and to choose a STEM career.

4.3.1 Self-assessed importance of several factors about their DSE subject choices

To start with, we analyzed and compared the subjective perceptions of the male and female students on what factors contributed to their choices in DSE electives. The students were asked to rate the importance of different factors in choosing the DSE electives. Table 4.6 shows the students' rating on the importance of several factors in choosing DSE electives. In general, **both male and female students rate their own interest and abilities as the most important factors in choosing the DSE elective subjects. Male students gave a higher rating on the importance of their interest in the subjects**, as compared with the female students. In contrast, **female students gave a higher rating on the importance of their ability in choosing electives**, as compared to male students. **University admission conditions and career orientation were also important factors. Relatively speaking, female students gave a higher rating on the importance of the university admission requirement than the male students.**

Teachers' and parents' advice are the next most important factors. **The female students rated the importance of advice from the teachers and parents and family members higher, as compared to the male students.** In comparison to the aforementioned factors, the choices made by the students' closest friends and their classmates are of lesser concern. **The male students rated the importance of the choices made by their closest friends and their classmates higher than the female students.**

Table 4.6. Self-assessed importance of the criteria in choosing DSE electives

	Girls	Boys	Sig. Level
Importance of criteria to choose electives (1-5)			
Own interest	4.15	4.22	*
Own abilities	4.07	3.94	***
Career orientation	3.70	3.57	NS
University admission conditions	3.57	3.37	*
Teachers' advice	3.19	2.99	**
Advices from parents and family members	3.01	2.79	**
Close friends' choice	2.25	2.47	***
Other classmates' choice	2.04	2.23	***

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

To sum, the students' interests and abilities and their perceived importance of the subjects in the university admission are the most important self-assessed factors in choosing STEM in education.

4.3.2 Gender differences in the subject perceptions

Since the students highly rated the importance of their abilities and interests in making subject choices, the gender differences in their self-perceived abilities and interests in various learning domains may explain the gender differences in the STEM choices at various stages. We analyze and compare the students' perceptions on various learning domains. The students were asked to rate their interests, abilities and their perceived values of each learning domain they study. The results are shown in Table 4.7.

Among language/humanities, mathematics, sciences and ICT learning domains, females have a relative edge over male students on language/humanities subjects. **Girls reported a higher level of self-reported efficacy over the male students and they**

tended to think language/humanities were more important for their future studies and careers compared to the male students. In contrast, **male students have reported a higher self-efficacy, interest and perceived instrumental value of learning mathematics, sciences and ICT than the female students.**

Table 4.7. Self-reported efficacy, interest and perceived values in various disciplines

	Girls	Boys	Sig. Level
Language/humanities perception			
Self-efficacy	3.24	3.06	**
Interest	3.50	3.40	NS
Perceived values	3.76	3.50	**
Mathematics perception			
Self-efficacy	3.03	3.67	***
Interest	3.21	3.78	***
Perceived values	3.43	3.80	***
Sciences perception			
Self-efficacy	2.85	3.36	***
Interest	3.42	3.81	***
Perceived values	3.33	3.68	**
ICT perception			
Self-efficacy	2.71	3.37	***
Interest	2.66	3.53	***
Perceived values	2.61	3.27	***

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

The scores for each subdomain (self-efficacy, interest and perceived values) were then added into an overall perception scale indicating the students' positive feeling towards the subjects. Female students are more positive towards language and humanities domains over

STEM-related domains. Male students are more positive towards STEM-related domains over language and humanities domains. We conducted regression analysis to examine the association between these scales and the students' choice in DSE curriculum and their intention to study STEM and choose a STEM career[4]. The results of the regression models are shown in Table 4.8a.

Table 4.8a Regression analysis: Perceptions over the learning domains and choices in STEM

	Currently taking		Intention to take	
	M1M2	% STEM electives	STEM college majors	STEM career
Gender difference				
Female students	-0.18	-0.05*	-0.95***	-0.88***
Subject perceptions				
Language/humanities perception	-0.28**	-0.06***	-0.49***	-0.24**
Mathematics perception	1.00***	0.01	0.27*	-0.07
Sciences perception	0.43**	0.17***	-0.01	0.14
ICT perception	-0.10	0.02	0.61***	0.68***
Controlled for DSE electives	-	-	Yes	Yes
Sample	2,604	2,604	2,604	2,604

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Having a positive perception of the language and humanities learning domain is significantly and negatively associated with the students' choice in STEM. Students who feel more positively towards this domain are less likely to take mathematics extended modules and STEM electives, and

[4] Three logistic regression models were estimated to examine the associations between the independent variables and three dependent variables (taking M1/M2 modules in DSE, intended to study STEM in university and intended to choose a STEM career). Whether the students took M1/M2 modules and the proportion of STEM electives in all electives the students took were controlled in the models for the intention to study and work in STEM field. Linear regression was estimated to examine the associations between the independent variables and proportion of STEM in all DSE electives the students took.

also have a lower intention to study STEM in university and to pursue STEM careers. Having a positive perception about mathematics is significantly and positively associated with the students' choice in taking mathematics extended modules and their intention to study STEM in university. Having a positive perception about science learning domain is significantly and positively associated with the students' choice in taking mathematics extended modules and STEM electives in DSE. However, it is not significantly related to the students' intention to study STEM in university and to pursue STEM careers. Positive perception over ICT is not significantly related to the students' choice of study in DSE curriculum but is associated with their intention to study STEM in university and to pursue STEM careers.

Table 4.8b Average marginal effects of gender in the choosing STEM: Adjusted for subject perceptions

	Currently taking		Intention to take	
	M1M2	% STEM electives	STEM college majors	STEM career
Gender difference – Baseline	-12.3%p	-14.3%p	-21.7%p	-12.6%p
Gender difference – Controlled for subject perceptions	-2.4%p	-5.0%p	-13.3%p	-7.8%p
Controlled for DSE electives	-	-	Yes	Yes

As previously mentioned, students rated "ability" and "interest" as highly important factors when choosing DSE electives. On top of the self-assessed importance of these factors, **our**

analysis also provides evidence that the gender differences in the subject perceptions (self-efficacy, interests, and perceived values) substantially explain the gender differences in the DSE subject choices. Without considering the students' subject perception, the gender differences in taking mathematics extended modules and the proportion of STEM electives are 12.3% points and 14.3% points respectively. Female are less likely to study STEM-related subjects in DSE. After controlling for the subject perception with the regression models, the gender differences in taking mathematics extended modules and the proportion of STEM electives shrink substantially to 2.4% points and 5% points and become non-significant. In addition, **our analysis further suggests that the gender differences in the subject perceptions also substantially explains the gender differences in the intention to study STEM further and choose STEM careers.** After controlling for the subject perception, the gender differences in the intention to study STEM in university and choose STEM careers shrink substantially to 13.3% points from 21.7% points and to 5% points from 12.6% points. Yet, even controlling for the subject perceptions, the remaining gender differences in their intention are still statistically significant, hinting that other important factors are accountable for these gender differences.

4.3.3 Career orientation: Preferred job characteristics

As mentioned in Table 4.6, career orientation was highly rated by students as an important factor when making their DSE subject choices. Gender differences in the students' preferences in the nature of their future jobs could also explain the gender differences in their subject choices and their intention to study and work in STEM fields. Here we compare the male and female students' preference about their future jobs. They were asked to rate their preferences with a 5-point scale (1= Not important at all and 5 = Very important) on a series of characteristics for their future job.

In general, both male and female students rated the characteristics, "work is meaningful" and "work is at a considerable income level" as the most preferred characteristics. The list of job characteristics included items that are related to STEM (working for jobs that are related to maintenance or construction, operating machinery or mechanical tools, and jobs relating to technology, computing or the internet). **Both male and female students have a lower preference for jobs with these STEM-related characteristics**. In addition, there are also gender differences in the preferred job characteristics between male and female students. **Female students have a higher preference to work for jobs that can help other people and jobs they think are meaningful, as compared to the male students. Male students have a higher preference than female students to work for jobs with a higher social status and at a managerial position. Relatively speaking, male students also have a higher preference than female students to work for jobs with STEM-related characteristics.** The scores for each work characteristic rated by male and female students are listed in Table 4.9.

Table 4.9. Preferred characteristics for their future jobs

	Girls	Boys	Sig. Level
Preferred Job Characteristics (1-5)			
<u>High social status</u>			
Can manage/order other people	2.95	3.07	**
Considerable income level	4.10	4.11	NS
Respectable/high social status	3.32	3.41	*
<u>*Meaningfulness*</u>			
Can help other people	3.64	3.37	***
The work is meaningful	4.14	3.98	***
<u>*STEM-related characteristics*</u>			
Related to technology, computing or internet	2.38	3.09	***

Maintenance or construction related	*2.02*	*2.58*	***
Operating machinery or mechanical tools	*2.11*	*2.74*	***

*Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.*

The scores for the preferred job characteristics were then added into three overall job characteristics scales (High social status, meaningfulness, STEM-related) indicating the students' preference for their future jobs. We conducted regression analysis to examine the association between the students' job preference and their STEM choices. The results are shown in Table 4.10a.

None of the job preferences (prefer having a high social status job, meaningful job and job with STEM-related characteristics in the future) are significantly associated with the students' choice in taking mathematics extended module in DSE curriculum. However, preferred job characteristics are related to students' choice in taking STEM electives. The students who prefer having a higher social status job take less STEM electives in DSE curriculum. In contrast, students who prefer having a job with STEM-related characteristics take more STEM electives in DSE curriculum. In addition, the preferred job characteristics are also significantly associated with the students' intention to study STEM in university and pursue STEM careers. The students who expressed a preference in having a meaningful job (or a job that can help others) have a lower intention to study STEM in university and choose a STEM career. In contrast, students who expressed a preference in having a job with STEM characteristics (a job that is related to technology, computing,

internet, or machinery, or construction) have a much higher intention to study STEM in university and choose a STEM career.

Table 4.10a. Regression analysis: Preferred job characteristics and choices in STEM

	Currently taking		Intention to take	
	M1M2	% STEM electives	STEM college majors	STEM career
<u>Gender difference</u>				
Female students	-0.59**	-0.09**	-0.81***	-0.74***
<u>Preferred job characteristics</u>				
High social status	-0.03	-0.04***	-0.08	-0.15
Meaningfulness	0.04	0.02	-0.49***	-0.27*
STEM-related characteristics	0.18	0.10***	1.04***	0.88***
Controlled for DSE electives	-	-	Yes	Yes
Sample	2,804	2,804	2,804	2,804

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

To combine the findings from Table 4.9 and 4.10a, we found that **female students prefer having a meaningful job, and those who prefer having a meaningful job have less intention to study STEM in university and work a STEM-related job. In contrast, male students prefer having a job with STEM-related characteristics, and those who prefer having a job with STEM-related characteristics have a higher intention to study STEM in university and work in a STEM-related job.**

Our analysis provides evidence that the gender differences in the preferences on job characteristics partly explain the gender differences in the DSE subject choices. Our data suggest that the gender differences in taking mathematics extended modules could not be explained by the job

preference but could explain the proportion of STEM in the elective choices. After controlling for the students' preferences on job characteristics with the regression models, the gender differences in the proportion of STEM in the chosen electives shrink substantially to 8.7% points from 14.3% points. In addition, **our analysis further suggests that the gender differences in the preference on job characteristics substantially explain the gender differences in the intention to study STEM further and choose STEM careers.** After controlling for the preference, the gender differences in the intention to study STEM in university and choose STEM careers shrink substantially to 11.1% points from 21.7% points and to 6.6% points from 12.6% points.

Table 4.10b. Average marginal effects of gender in choosing STEM: Adjusted for preferred job characteristics

	Currently taking		Intention to take	
	M1M2	% STEM electives	STEM college majors	STEM career
Gender difference – Baseline	-12.3%p	-14.3%p	-21.7%p	-12.6%p
Gender difference – Controlled for preferred job characteristics	-10.4%p	-8.7%p	-11.1%p	-6.6%p
Controlled for DSE electives	-	-	Yes	Yes

4.3.4 Stereotypical beliefs in learning STEM and about in-born talent

Other than the students' perceptions over the learning domains and their career preferences, the students' beliefs in learning are also related to their choices in STEM. In our survey, the students were asked whether they agree on a list of gender-stereotypical statements about learning STEM. The answers were coded into a gender stereotype scale ranging from 1 to 6, for which a higher score represents a more stereotypical attitude held by a student (for example, “boys are better than girls in learning science”, “girls are more suitable to study language and humanities subjects” etc.). Our data show that male students have more gender stereotypical beliefs about STEM as compared to female students. Similarly, the student respondents were also asked for their level of agreement over a list of statements emphasizing the importance of inborn-talents over their own efforts (for example, “we are born with talent, we can’t make it”, “No matter how much effort you put, it is impossible for you to improve your performance over the subjects you are not good at” etc.). Male students are more likely to perceive the importance of inborn-talents over their efforts, as compared to female students. The mean scores of the two scales for male and female students are shown in Table 4.11.

Table 4.11. Beliefs in learning

	Girls	Boys	Sig. Level
Gender Stereotype in STEM (1-6)	3.09	3.29	***
Beliefs in inborn-talent	2.88	3.02	**

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

We conducted regression analysis to examine the association between the two scales of beliefs in learning and the choices in STEM. The results are shown in Table 4.12a. When we found male students are holding stronger beliefs in inborn-talent, these beliefs in inborn-talent are not significantly associated with any of the STEM choices in this study. In contrast, gender stereotypical beliefs in STEM are associated with the STEM choices, and these associations are different for each gender.

Table 4.12a. Regression analysis: Beliefs in learning and choices in STEM

	Currently taking		Intention to take	
	M1M2	% STEM electives	STEM college majors	STEM career
Gender difference				
Female students	1.92**	0.20	-0.16	0.09
Stereotypical beliefs in STEM				
Gender Stereotype in STEM (Male)	0.34***	0.04*	0.13*	-0.02
Gender Stereotype in STEM (Female)	-0.38***	-0.09***	-0.27*	-0.36*
Beliefs in inborn-talent (Male)	0.02	-0.03	0.15	0.11
Beliefs in inborn-talent (Female)	-0.10	-0.01	0.16	-0.05
Controlled for DSE electives	-	-	Yes	Yes
Sample	2,801	2,801	2,801	2,801

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Male students who hold gender stereotypical beliefs in STEM are more likely to take mathematics extended modules, take more STEM electives in the DSE curriculum, and have a higher intention to study STEM in university. Female students who hold gender stereotypical beliefs in STEM are less likely to take mathematics extended modules, take fewer STEM electives in the DSE curriculum, and have a lower intention to study STEM in university and choose a STEM career. [A more detailed discussion of students' gendered views on mathematics will be provided in Section 5.]

While the gender stereotypical beliefs do not mediate the gender differences in STEM choices, the beliefs are related to the gender differences as a moderator. **In the context where male and female students do not hold gender stereotypical beliefs, the gender differences in STEM choices are largely reduced.** The gender differences in taking mathematics extended modules and the proportion in STEM electives are only 0.6% points and 1.8% points, as compared to the original gender differences at 12.3% points and 14.3% points. The gender differences in the intention to study STEM in university is reduced to 17.3% points from 21.7% points. **If measures are taken to reduce the stereotypical beliefs about learning STEM among female students, we can expect an improvement in the gender equality in STEM.**

Table 4.12b. Average marginal effects of gender in the choosing STEM: Conditioned by gender stereotypical beliefs

	Currently taking		Intention to take	
	M1M2	% STEM electives	STEM college majors	STEM career
Gender difference – Baseline	-12.3%p	-14.3%p	-21.7%p	-12.6%p
Hypothetical scenarios				
Gender Stereotype in STEM (Low)	0.6%p	-1.8%p	-17.3%p	-11.0%p
Gender Stereotype in STEM (Middle)	-12.3%p	-14.9%p	-23.9%p	-13.0%p
Gender Stereotype in STEM (High)	-24.8%p	-28.1%p	-30.0%p	-14.4%p
Controlled for DSE electives	-	-	Yes	Yes

4.3.5 Parents' and teachers' advice

Table 4.13 shows parent-child academic discussion and parents' and teachers' involvement in subject selection. Our data show that **parent-child discussion among female students is slightly more frequent compared to male students in almost all aspects, except for subject choices.** On the other hand, **male students generally reported a higher score for their parents' understanding on the DSE elective choices and university admission requirement, as compared to female students. The male students (35%) also reported a higher**

percentage of parents giving advice in choosing their DSE electives as compared to female students (29%). Similarly, the male students (36%) also reported a higher percentage of teachers giving advice in choosing their DSE electives as compared to female students (26%).

Table 4.13. Parent-child discussion, parental and teachers' involvement in subject selection

	Girls	Boys	Sig. Level
Frequency of discussing with parents about: (1-5)			
Learning progress	3.43	3.20	**
Checking with coursework	2.60	2.47	*
About subject/career choices	2.94	2.87	NS
About school activities	3.13	2.95	*
How well do your parents understand the DSE curriculum structure and university admission requirement? (1-5)	2.67	2.83	**
Parents suggested the electives you chose (%)			
No	70.7	65.6	*
Yes	29.3	34.6	
Parents suggested NOT to choose the electives you chose (%)			
No	87.9	88.7	NS
Yes	12.1	11.3	
Teachers suggested the electives you chose (%)			
No	74.5	64.5	***
Yes	25.5	35.5	
Teachers suggested NOT to choose the electives you chose (%)			
No	91.4	89.4	NS
Yes	8.6	10.6	

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

These patterns may reflect a gendered expectation on the importance of men's career as opposed to women's careers. Therefore, there is more active involvement of parents and teachers in male students' subject choices. A small proportion of students were suggested by their parents and teachers not to take the elective subjects that they are currently taking. Nevertheless, there is no significant gender differences in receiving these suggestions.

We conducted regression analysis to examine the association between the parent's and teachers' involvement and the choices in STEM. The results are shown in Table 4.14a.

Table 4.14a. Regression analysis: parental and teachers' involvement in subject selection And students' choices in STEM

	Currently taking		Intention to take	
	M1M2	% STEM electives	STEM college majors	STEM career
Gender difference				
Female students	-0.71***	-0.14***	-1.38***	-1.29***
Parental and teacher involvement				
Parent-child discussion	0.13	-0.00	-0.06	-0.09
Parent's knowledge on DSE curriculum and university admission system	-0.01	-0.01	0.03	0.08
Parents suggested the electives	0.50**	0.09**	-0.27	-0.30
Parents suggested not to choose the electives	-0.28	-0.02	0.01	0.01
Teachers suggested the electives	-0.05	0.03	0.08	-0.10
Teachers suggested not to choose the electives	-0.24	-0.07	-0.09	-0.01

Controlled for DSE electives	-	-	Yes	Yes
Sample	2,779	2,779	2,779	2,779

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

While female students have more parent-child academic discussion than male students, this is not significantly associated with any of the STEM choices. Parents' knowledge on DSE curriculum and university admission conditions are also not associated with the students' choices in STEM. Parents' advice on the elective choices is the only significant factor. **Students whose parents gave advice in DSE elective choices are more likely to take mathematics extended modules and STEM electives. However, the parents' advice is not associated with the students' intention to study STEM further or to choose a STEM career. This may reflect that parents' suggestions on STEM-related subjects in DSE are based on the practical concerns over DSE performance and university admission requirements.**

Our data suggest that the gender differences in taking mathematics extended modules and the proportion of STEM electives are not well explained by the gender differences in the parents' and teachers' advice. This finding is consistent with the aforementioned research that found students did not prioritise parental advice when choosing STEM subjects.

Table 4.14b. Average marginal effects of gender in the choosing STEM: Adjusted for parental and teachers' involvement in subject selection

	Currently taking		Intention to take	
	M1M2	% STEM electives	STEM college majors	STEM career
Gender difference – Baseline	-12.3%p	-14.3%p	-21.7%p	-12.6%p
Gender difference – Controlled for parental and teacher involvement	-12.3%p	-13.6%p	-21.5%p	-12.2%p
Controlled for DSE electives	-	-	Yes	Yes

4.3.6 Closest friends' DSE subject choices

The sampled students were also asked to report some of the characteristics of their closest friends whom they studied with in Form 3. **Due to the principle of homophily, peer network is clearly gendered.** Female students tend to have fewer close friends who are male (8%) while male students mainly had close male friends (88%). **Since there is a gendered pattern in taking up STEM-related electives and their peer network is also gendered, male students tend to have more close friends studying the extended mathematics modules (52%) and STEM-electives (51%) as compared to female students (M1/M2: 32%; STEM-electives: 38%). Male students are also more likely to have close friends who are good at STEM-related subjects (59%) compared to female students (41%).**

Table 4.15. STEM-related characteristics of their closest friends

	Girls	Boys	Sig. Level
Proportion of males among their closest friends (%)	7.6	87.8	***
Proportion of their closest friends taken M1/M2 (%)	31.8	51.7	*
Proportion of STEM electives taken by their closest friends (Average %)	38.4	51.1	***
Proportion of these close	41.0	59.1	***

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

We conducted regression analysis to examine the students' closest friends' characteristics and STEM choices and the students' intention to study STEM in university-level and choose STEM career. **The proportion of STEM electives taken by the students' closest friends is not significantly related to the students' intention to study STEM in university and choose a STEM career. However, if the students' closest friends are good at STEM, then these students have a higher intention to take STEM college majors and pursue a STEM career.**

Our data also suggests that the proportion of the students' closest friends taking extended mathematics modules is negatively associated with the students' intention to take STEM college majors. That is, the more close friends take M1/M2 modules, the lower a student's intention to take STEM at university. This may reflect the fact that taking extended mathematics modules indicates the students' academic performance in general and the best performing students have lower intention to study STEM majors in university.

Table 4.16a. Regression analysis: STEM-related characteristics of their closest friends and the students' choices in STEM

	Intention to take	
	STEM college majors	STEM career
Gender difference		
Female students	-1.44***	-1.41**
Closest friends' STEM choices		
Proportion of males among their closest friends (%)	-0.01	-0.09
Proportion of their closest friends taken M1/M2 (%)	-0.63***	-0.48
Proportion of STEM electives taken by their closest friends (Average %)	-0.46	-0.63
Proportion of these close friends are good at STEM subjects as reported by the respondents (%)	0.52**	0.81**
Controlled for DSE electives	Yes	Yes
Sample	2,619	2,619

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Our data suggest that the gender differences in taking mathematics extended modules and the proportion of STEM electives are not well explained by the gender differences in the students' closest friends' characteristics and STEM choices. This finding is consistent with the aforementioned research that found student did not prioritize friends' choices when choosing STEM subjects.

Table 4.16b. Average marginal effects of gender in the choosing STEM: Adjusted for friends' choice in STEM

	Intention to take	
	STEM college majors	STEM career
Gender difference – Baseline	-21.3%p	-13.0%p
Gender difference – Controlled for close friends' STEM choices	-22.1%p	-13.4%p
Controlled for DSE electives	Yes	Yes

To summarize this section, we found that students' self-perception about their abilities and interest in various learning domains are mainly responsible for the gender differences in the STEM choices in the DSE curriculum. Relatively speaking, female students are more positive towards language and humanities domains and male students are more positive towards STEM-related domains (Mathematics, ICT and Science subjects). These perceptions are significantly associated with the subject choices in DSE curriculum. Once the differences in their self-perceptions are considered, there is no substantial difference in the DSE elective choices between male and female students. Also, the gender difference in perceptions can partially explain gender differences in the intention to study STEM in university and in their career aspirations.

The dropout of females in the STEM pipeline is also caused by other factors. In addition to self-concepts about the various learning domains, several other factors are found to be responsible for the gender difference in the intention to study in university and choose a STEM career. Female students have a higher aspiration to work for jobs that are considered meaningful and can help other people. Male students have a higher aspiration to work for jobs that are related to technology, machinery, tools and construction. These differences in preference explain the gender differences in the intention to study STEM in university and take a STEM career.

We also found that the gender differences in the STEM choices and intentions are partly explained by the gender stereotypical belief held by the students. Female students who held a stereotypical belief in STEM education are reluctant to pursue STEM in university education and choose a STEM career, even when they had already taken STEM-related subjects in the DSE curriculum.

Comparatively speaking, the advice given by the teachers and parents, as well as the students' friends' choices in DSE curriculum have a less direct influence on the students' STEM choice and cannot adequately explain the gender differences in STEM education.

5. Qualitative Results

5.1 Focus groups interviews

As mentioned in Session 2.2, eight focus group interviews were conducted to further gauge students' views and experiences in choosing and studying STEM-related subjects. In this section, we want to further address three issues: a) students' subject choice; b) students' (gendered) understanding of STEM-related subjects; and c) students' self-efficacy and learner-identities.

To facilitate the discussion, we have assigned codes to different groups as follow:

Types of Schools	Codes
Girls' school; more STEM subjects	GGMS
Girls' school; less STEM subjects	GGLS
Boys' school; more STEM subjects	BBMS
Boys' school; less STEM subjects	BBLS
Co-ed school (girls' group); more STEM subjects	COGMS
Co-ed school (girls' group); less STEM subjects	COGLS
Co-ed school (boys' group); more STEM subjects	COBMS
Co-ed school (boys' group); less STEM subjects	COBLS

To protect the identity of the participants, student participants are given a number, e.g. 1, 2, and so forth. For instance, a citation from a girl in Co-ed school with "Less STEM" subjects will be cited as either Student 3 of COGLS or COGLS-3.

5.2 Students' Subject Choice: Subtle Factors

In the previous section (4.3), the survey results show that students reported to have chosen DSE elective subjects by considering their own interest and abilities and their preferred job characteristics. In the focus group interviews, we find that students' choice of STEM-related subjects at the senior secondary level is also subtly shaped by school culture and mechanisms, and university admission.

5.2.1 Achieving students could choose science subjects (stream) first

To start with, it seems that the science stream has been privileged over other streams in Hong Kong schools. For example, Student 5 of CoBMS said that his school was famous for science, so more than 3/4 of students take up science subjects while few students study the arts and/or business streams. Similarly, Student 3 of CoGLS also stated that her school seemed to privilege the science stream, because out of the 5 classes, three were assigned for students who studied science as elective subjects.

> I think my school prefers science subjects more, because there are 5 classes, 3 are science classes, so apparently the school focuses more on science subjects (C0GLS-3)

More importantly, all of the students interviewed, whether from single-sex or co-ed schools, said that their schools gave achieving or top students—defined as students with better academic results or higher ranking in overall results in Form 3—the priority to choose science stream/class/subjects as electives in DSE.

For example, Student 3 of GGMS said that only the top 70 students in Form 3 in her school can enter the two science classes, while Student 1 of CoGMS also said that almost all top or achieving students chose sciences subjects.

Boys in "Less STEM" schools had similar observation, and some were very aware of the hierarchy created among different school subjects/streams:

> Usually those students whose scores are above average take Science, and those who are below average take Arts. (…..) Those above average students take Physics, Chemistry, and Biology, while those below average have to take Econ. [Laughs] (*BBLS-2)*

Girls in the "Less STEM" groups found subjects like Physics, Chemistry and Biology were reserved for those that achieved good grades:

> CoGLS-3: In our school, students with good grades, usually the top 30%, chose Physics, Chemistry and Biology. But there were also students with good grades who chose arts subjects.

> GGLS-4: Subject choice is definitely grade-driven. If you are the top 50%, you can definitely study Physics, Chemistry and Biology. Our teachers didn't explicitly say that we couldn't choose those subjects, but we all knew that choices were determined by our grades. You didn't pick the subject, but the subject picked you.

> GGLS-8: After all, grade matters. Teachers won't tell us what subject we should or should not study, as it all depends on our grade. Normally popular subjects like Physics, Chemistry and Biology will all be taken by those top achievers.

As schools prioritise the subject choice of achieving students, students thought that 'free choice' did not really exist. Some of the students admitted that they did not choose their current electives voluntarily. For example, Student 3 of CoBLS explained why he took the arts class:

> In my junior secondary years I didn't study at all, so my examination performance was extremely bad. My overall ranking was very low so I could only choose those subjects that had quotas left.

5.2.2 The best students can study M1/M2 subjects

Aside from privileging science stream, another hierarchy also exists among science subjects. **Some schools only allow the top or best students to choose M1/M2 – mathematics extended subjects, or STEM-related subjects.** For example, Student 1 of GGLS mentioned that only students in EMI class—using English as medium of instruction—were allowed to take M1:

> In my school students from Class C & D studied Commerce or Sciences subjects, whereas Class A and B students studied ICT or Home Economics. (…) However, only students from Class D were allowed to take M1, because it is an EMI class.

Similarly, Student 7 of BBLS also said that in his school only the English class could study the subjects of Physics, Chemistry and Economics. If students wanted to study these three subjects, they had to have good grades in English:

> In my school, if students want to study Physics, Chemistry, and Economics [the most popular subject choice], they have to have good grade in English.

Student 3 of BBMS said that only the top students in his school would be 'invited' to study M1 and M2, and students not invited were not allowed to study the two subjects:

> For M1 and M2, only when your Mathematics scores are higher than 80% of the total marks in several internal examinations, then you will be invited to study these two subjects.

This also happened to Student 2 of GGLS:

> At the end of F3, only 32 students with the best Math grade were selected to study M2, i.e., they were promoted to Class 4D to study M2.

Furthermore, students also remarked that better teachers were assigned to teach science classes:

> Some senior girls told us that teachers who teach well will be assigned to teach the class with science electives. (GGLS-5)

5.2.3 Achieving students avoiding Arts & Business classes

Probably because of the school culture and subject choice mechanisms, which privilege the science stream and encourage top students to study STEM-related subjects, interviewed students told us that the learning atmosphere of arts and business classes was not good. Some boys, in particular, found students in the arts class were not as diligent and passionate about their studies as the science students, which also discouraged them from choosing the arts stream:

> All students with good grades chose the Science class. Although some good students also liked Arts subjects, they still also chose Science class. We heard many bad comments about students in the Arts class; they do not study and simply play sports. Isn't it discouraging if you really liked Arts subjects but had to study with classmates like this? (BBMS-4)

Interestingly, two students in the less STEM group also described themselves as more 'laid back' whereas science students as aggressive and hard-working:

> BBLS- 3: Yeah, Arts' students are relatively laid back and not as aggressive as Sciences students.

> BBLS-6: In my year, those students in Sciences subjects do better. For Arts students, the learning atmosphere is rather laid back.

5.2.4 Low status of ICT

Among STEM-related subjects, most of the students said that t**he subject ICT had a relatively low status**. Only one student, BBMS-8, told us that ICT was the second competitive subject after Physics, Chemistry and Biology:

> If there is no more vacancy in the Science subject like Physics, Chemistry and Biology, we will choose ICT, Economics and VA. These subjects are still very competitive.

On the contrary, some students told us that they were forced to choose ICT as an elective subject:

> CoBMS-2*:* Yeah…not many people like ICT. My school doesn't have much feeling towards ICT. ICT in our school is like a lifesaving subject. Only when your desired subjects are not available, then you'd choose it.
>
> *Moderator: Do you mean students were forced to choose?*
>
> CoBMS-2*:* Yeah. So many people dropped ICT in the second year, because they were not interested, and didn't want to take it.
>
> *Moderator: Were most of them girls?*
>
> *CoBMS-2:* They were boys. Girls? I seldom see girls taking ICT.

Student GGLS-5 took ICT as one of her electives, but was not interested in the subject and did not plan to work in the ICT industry. She explained that she did not voluntarily select the subject. She chose ICT in order to enter the elite class.

> I am not interested in ICT. The reason I studied ICT was because I didn't want to study Geography and History; I was forced to pick ICT if I wanted to enter the elite class.

5.2.5 Instrumental considerations

Many students admitted that their current subject choice was made out of instrumental concern as they wanted to get higher marks in DSE in order to get into universities:

> If you take Science, and if you go to the University, you can basically choose any major. But if you take Arts, it may not be the case. (CoBMS-3)
>
> I just chose some easier subjects in order to be admitted into the university. My career aspiration is to become a police officer. (BBLS-3)
>
> I want to become a Chinese teacher. My electives now are totally irrelevant to choose…. Whichever are easier for me to get good grade in exam, I chose them. (BBLS-4)

It is possible that students' career aspirations are not necessarily related to STEM fields at all. In fact, for girls in the "More STEM" groups, it is not uncommon to find that their career aspirations are not in the STEM field but in education. Students may have chosen STEM subjects in DSE mainly to enhance their chances to get into universities.

These examples suggest that students' subject choice in DSE is not so much based on one's interest. Because of school culture and practice, top students tend to choose subjects – science in particular – because those subjects carry higher status and enhance their chances of university entrance.

This observation can also help us understand female students' subject choices. Our statistical analysis found that female students, despite spending more time and effort on STEM subjects, have less intention to study STEM in the university and choose a STEM career. Based on our focus group interviews, we notice that most female students who have chosen STEM electives, including M1/M2, are high achieving students or the top student in their schools. Their choice of science stream for DSE may have instrumental concern, i.e. greater chance of getting admitted to university, which can be shaped by the school culture and university admission. As their STEM choice is not so much based on personal interest or preferred job characteristics, once these young women successfully make it into the university, they are more likely to discontinue any STEM-related pursuits.

To summarize this section, the focus group interviews provide a more nuanced understanding of students' subject choices/electives in DSE. Instead of choosing subjects/electives that relate to their personal interest, we find that students 'choice' can be shaped by school culture and the instrumental concern of university entrance. As most secondary schools in Hong Kong privilege science over arts or other streams and accord higher status to STEM subjects like M1 and M2, top achieving students, including female students, usually choose science subjects out of status and pragmatic concerns. This may help explain why there is further 'leakage' at the later stages among female students who have chosen STEM-related subjects. Another interesting finding is that ICT is not a popular or high-status subject in Hong Kong secondary school. Future research may want to explore the reasons for this phenomenon.

5.3 (Gendered) understanding of different subjects

Students' perceptions about a school subject reflect not only their experiences of studying those subjects, but also their gender beliefs and stereotypes. Such understanding can also affect their subject choice, decisions regarding future education or career development in the subject area, as well as their learner identities (eg. sense of competence) and aspirations. In the previous section, our quantitative data showed that there were significant gender differences in taking DSE mathematics extended modules (M1 and M2), physics and ICT; and the gender differences in the intention to study STEM-related university programmes are further widened. In particular, there was a higher percentage of female students who intended to or have dropped M1 and M2 as compared to male students. In this section, by revealing students' understanding of science subjects, especially Math, we gain some insights of why female students may drop these subjects.

5.3.1 Biology as an arts subject for memorization

As mentioned before, in Hong Kong schools, the arts stream is considered less popular and valuable than the science stream. One important reason given by students is the significant amount of rote memorizing that is required in arts subjects.

For example, Student 2 of BBMS explained why he chose science in order to avoid arts subjects and rote memorization:

> I do not like Arts subjects as they need to recite materials. I chose Science subjects as they require understanding and comprehension rather than rote memorisation. Initially I also chose Business subjects, but I dropped them, as they also require reciting a lot of materials.

An interesting discussion that emerged from the focus group interviews is that the subject

Biology also requires memorization, which renders its status as a science subject ambiguous. In the last section, we mentioned that Biology was the most popular DSE electives among the female students whereas it ranked fourth among the male students. When we talked to boys from the More STEM groups, **some actually complained about Biology for violating their understanding of what a science subject should be, as they were required to recite the subject knowledge.** This subject 'nature' has deterred some students from choosing it. Those who have chosen Biology expressed regret or even dropped it:

> I was good at Mathematics and Science, so I chose science streams. I eventually dropped Biology, as there were too many materials to recite. (BBMS-1)

Student CoBMS-5 also explained why he chose Physics, Chemistry, History, but not Biology:

> I didn't choose Biology because I hate memorizing things. Physics doesn't require you to memorize, as you just have to understand how those formula work. Physics is like the application of math to daily life. Most Physics need to apply Math formula. For Chemistry, it is half memorizing and half application, which is acceptable. For history, many people misunderstood that the subject has many facts to memorize, but it is not true… In my opinion, *Biology should be considered as an Arts subjects in Science*. (CoBMS-5)

Student BBMS-4 who scored relatively low marks for Biology felt he had been cheated by Chemistry and Biology:

> BBMS-4: Physics is more fundamental, while Chemistry and Biology are similar with Arts subjects. I don't like Arts subjects… These two subjects were very different from what I expected and I felt very uncomfortable.

A few female students also share the view that Biology is an Arts subject:

> Girls like to choose biology because the subject needs us to memorize the concepts. This seems easier to handle. (CoGLS-1)

> Yes, Biology is an arts subject within the science stream. Although we learn science-related knowledge in Biology, but all we need to do is to memorize them. (CoGLS-7)

Having said so, there is a minority view that Biology also requires logical and 'flexible thinking' on top of memorizing things:

> In the tutorial lesson, he (the instructor) said that Biology is usually taken by Arts student, whereas Chemistry and Physics are usually taken by pure Sciences students. He said Biology requires a lot of memorizing. (……) Yes, when compared to Chemistry, Biology really has more contents to be memorized. But Biology also needs flexible thinking, and we cannot simply memorize facts like a robot. (CoBMS-3)

5.3.2 Math as challenging and rewarding vs Math as abstract and irrelevant

Students' understanding about the subjects of Mathematics, including the Math core, Math Extended Parts, M1 and M2, is another interesting example. A closer examination of students' narratives reveals some contradictory and inconsistent gender beliefs.

To start with, students, both females and males, from the "More STEM" groups, describe Math as a challenging and rewarding subject, which gives them great satisfaction. For example, Student BBMS-3 described how the problem-solving process motivates him to work harder:

> I study core Math and M2. In M2 you cannot always get the answer immediately. When the problem is solved, you can feel a strong sense of achievement. You just have to do it, slowly and step by step, and eventually you will get the perfect answer. The difficult questions only drive me to work harder. It is as if I was an athlete. After practicing for a long time and you win a competition, this is your return. The two activities are similar. When I solve a mathematical problem, I feel like I have won a prize. (BBMS-3)

Student BBMS-1 also shared a similar idea but used a different analogy:

> I only had a little sense of achievement at the junior level. I now study M1. It is more difficult, but I feel so happy when I can answer all the questions of M1. I like to keep doing. (...) It is like winning a video game. You can have a great sense of satisfaction after you clocked the

game. (BBMS-1)

Female students from the "More STEM" groups also found Mathematics difficult but challenging. In the focus group interview, Student GGMS-4 told us that her classmate, GGMS-6, disliked 'easy Math'. She herself also felt happier when dealing with difficult math:

GGMS-4: She (pointing to GGMS-6) doesn't like easy Mathematics.

Moderator: What does it mean?

GGMS-4: She likes difficult Mathematics. (……) I also feel happier to deal with difficult math.

Moderator: Why?

GGMS-6: I found those easy math boring. Our teacher gives us similar questions again and again. As I have seen those questions many times, I did not find them challenging.

Moderator: So actually, you like Mathematics because it challenges you.

GGMS-6: I think so. I feel happier when I get them correctly.

Other female students from the "More STEM" groups like GGMS-1 and GGMS-2, also thought that the sense of achievement has driven them to work continuously on the subject, and they believe their diligence brings them better results.

On the contrary, many "Less STEM" students, both female and male students, have very negative views on Mathematics and described the subject as difficult, tricky, abstract and irrelevant. In the following discussions, boys in the CoBLS group shared their negative views about math. Interestingly Student CoBLS-3 was a student who has M2 as his self-studied elective subject. While he was confident about his performance in the Math subject, he agreed that the math syllabus would not be applied to their daily life.

> CoBLS-2: I don't think the knowledge of Mathematics can be applied to our daily life.
>
> CoBLS-5: You will not use sin/ cos etc. in real life situation
>
> CoBLS-6: In a wet market no one will say the price of a vegetable is "X equals to something".
>
> CoBLS-3: You do not need Algebra in daily life. My friend told me that the Mathematics that he learns in the University cannot be applied to daily life. The Mathematics that we learned from Form1 to Form 3 is good enough for daily life.

Similarly, girls in "Less STEM" groups felt discouraged when tackling difficult math questions:

> I am not good at Math. Math questions are tricky and difficult; they require logic. You need to understand many units of knowledge in order to get the right answers. This is too difficult for me. (CoGLS-4)
>
> Math doesn't have any relation with me. I need to memorize the Math formulas, but I cannot use them in the real life. (CoGLS-6)

Students' frustration with math can be best captured by the following group discussions:

> GGLS-1: I don't understand why math always make simple things complicated. It troubles me, as I cannot get it.
>
> GGLS-9: I wish the syllabus could be closer to daily life…. Like when you are eating a cup noodle, you really don't care about the angle. Please teach us something that we could apply to our daily lives.

> GGLS-1: It is very abstract to us
>
> GGLS-9: The wordings of math questions were so much easier to understand back then. Like Peter has how many candies, and someone took some of his candies…but now, math is about triangle, and you have to add dotted line or cut it, as there are small triangles inside a

big triangle etc.

GGLS-8: It's impossible to visualise that picture.

Aside from irrelevant and abstract subject knowledge, students in the GGLS group also complained that the teaching style used in Math classes made the subject even more difficult. For instance, Student GGLS-10 told us that she could not understand how and why the formulas were developed, and the teacher simply asked them to use rote memory:

GGLS-10: I have no idea why I have to study Math. For Chinese and English, I know they are useful because they can improve my communication skills with others. If you study Accounting or Economics, the knowledge could be useful for your future career. However, *math does not seem to have any value*. You won't need to use log when you go shopping. (…) When I learn math, I want to know how this and this will lead to that, but *my teacher can't explain the logics. The teacher gives us the formulas to memorise but I want to know how and why the formula is formed.*

5.3.3 "Boys are better at math than girls"

In the above discussions, **both female and male students from the "More STEM" groups find math challenging and rewarding whereas both female and male students from the "Less STEM" groups remark math as difficult and abstract**. However, when it comes to the topic of gender and math, the majority of students, whether "More STEM" or "Less STEM" students, females or males, subscribe to the view that 'boys are naturally better than girls at Math and Sciences'. This views, when examined more carefully, contains and is reinforced by three related gendered beliefs, namely:

a) Females and males think differently but the male way of thinking is superior;
b) Math sense is an inborn faculty of male students (and female students can be hardworking but they can never be as good as males);

c) Male high achievers in math are the norm/standard, and female high achievers in math are exceptional/abnormal.

The following sections will show that these beliefs are gendered. They are a reflection of the gender stereotypes held by the students, in particular stereotypes regarding students' understanding of ability, personality, and styles of learning. What worries us most is that the gender differences that students portrayed, i.e. those associated with females, tend to be negative, inferior or exceptional.

5.3.4 Boys: Female way of thinking is slow, rigid, and confused

When some participants mentioned innate differences between boys and girls, their understandings of "gender differences" were more critical and negative. They believed that **boys are better at math than girls because they have different ways of thinking**. More precisely, **they remarked that female students are slower in thinking and always "think too much", or easily got confused when they worked on Mathematics questions**.

For example, the following male students all said that boys were quick learners whereas girls were much slower in understanding and applying math concepts:

> Teaching boys are much easier. For girls, even after million times of repetition, they still could not get it. Furthermore, when you show girls another similar question, they would still not able to get it. Even though you make a little twist, like changing the name or number, they won't be able to handle it. They got confused easily. (CoBMS-1)
>
> When teaching a girl math, I need to repeat many times before she could understand. When teaching a boy, usually mid-way through, he would get it. (CoBMS-2)
>
> For example, female classmates always apply a wrong formula to a question; they always use a complicated method to calculate the answer. We can grasp the main point of mathematics questions quickly and clearly. We can do it by skipping a few steps; but girls won't, they have

to do it step by step. (CoBLS-5)

Some female participants in the focus groups also noted that boys are faster than girls at solving mathematics problem but they have slightly different interpretations:

CoGMS-1: **Girls are more sensitive whereas boys are more sensible**, so most of the time girls can't get it first…If a girl teaching a girl math, it can be more confusing. When a boy teaches a girl math, she is definitely less confused. Boys are more confident at what they said. He usually says, "It's true, trust me", even though he is wrong. [Laughs].

CoGMS-3: I think boys are better at solving math, as girls tend to think too much…

CoGMS-2: Like overthinking.

CoGMS-3: Yes, overthink and then lose sight of what follows.

CoGMS-2: Even though boys don't really understand it, they won't waste time on it and just move on. But girls are more persistent; they struggle and strive to unlock the problem before moving on to something new.

Both female and male students share the stereotypical view that boys are naturally better at math, but there are some subtle differences in their viewpoints. **Male students tend to present girls as less clever students who think more slowly and are more rigid. On the contrary, female students describe differences in terms of personality and confidence.** They agree that girls think too much and more slowly, but they also explain those differences in terms of girls being more sensitive, persistent, and meticulous, whereas boys are more sensible, practical, and confident. In other words, instead of seeing boys are better at math because of their natural ability, female interviewees also point out the possibility of girls having lower self-efficacy in math, or girls' attempt to understand the subject matter more thoroughly.

5.3.5 Boys: Girls only work hard but don't have the 'math sense'

Apart from seeing girls as slower learners, male participants also described girls as lacking the 'math sense'. This refers to the ability to perform well in the Math or Physics subjects. In their descriptions, 'math sense' appears to be an exclusive, inborn talent of men only, who can have good math performance rather effortlessly and intuitively. Girls lack this natural talent; therefore, even though they put in the effort, their results are not as good as the boys who are naturally good in math. A vivid example came from Student CoBMS-5 who was from an elite coeducational school in the New Territories. He expressed the strongest view as follow:

> CoBMS-5: For Math and Physics, as long as you understand the formula, the rests are just variation and application. You don't need to memorize all the variations, but you need to have that sense. This is what I consider girls are not good at.
>
> *Moderator: What do you mean by "math sense"?*
>
> CoBMS-5: You can easily decode a math question. Girls are more focused on the surface.
>
> *Moderator: Surface?*
>
> CoBMS-5: Meaning what to write, how to write, things like that…girls are more concerned about the formality. I think studying math is like playing chess. Boys usually contemplate what happens next when they see a situation, but girls can only think one step at a time. They could not anticipate how this step is going to affect the next one. They are simply bad at grasping the whole situation; they are very bad at this… In my school, girls are doing much worse in math**. There're many boys who don't study. However, even though they didn't do well in other subjects they could still be in the top 10 in math without putting much effort**.

In the above discussion, CoBMS-5 obviously subscribes to the view that the **male way of thinking is superior as it is more strategic, foresight, and holistic, whereas the female way of thinking is more superficial, trivial, and sequential**.

Interestingly, in discussing "math sense", he also emphasises the importance of effortlessness – "boys don't put much effort" into math but still get good results. Such emphasis on "effortlessness" is sometimes also used to discredit girls' math performance and ability, as the following comments on the different math performance between boys and girls indicate:

> Most of the subjects that I'm taking now, the top students are girls. Why? Because boys are more laid-back, and are keener to take part in extracurricular activities. Girls also join activities but they pick those easy and quiet types, like gardening or stamp collection, so that they have more time to study…Only in math, there are more boys who get higher grades. Why? Because they **don't need to study for math**. There is no need to memorize things. (CoBMS-2)

Student BBMS-3, from the "More STEM" boys' group, also made a similar comment:

> BBMS-3: The math performance of boys is very extreme. They are either very good or very weak at math. Some boys are very weak at math but some are very good, who **simply get it**.
>
> *Moderator: Boys' results are more extreme, so how about girls?*
>
> BBMS-3: Girls are only average. I rarely come across any girls who are very good at math. Their exam results are just so-so but not very bad. They won't be at the bottom, and are usually in the middle.
>
> *Moderator: How will you make sense of this?*

> BBMS-3: Because girls will drill themselves by doing past papers. I have also done lots of past papers. I guess if you have enough practice, it's not that difficult to get grade 3 in DSE.

Student BBMS-3 observed that the math performance of male students was usually either very good or very weak, while that of female students was usually in the middle. However, he did not think that girls had the math sense as he attributed their average performance to hard work; that is, they practised past papers. It is interesting to note that BBMS-3 also did lots of past papers, but his interpretation on the same behaviour done by girls was different. Furthermore, by resorting to this "explanation", the weak performance of boys was not discussed. It remained unclear if those "weak" boys were not hardworking or lacked the "math sense".

5.3.6 Girls' Hard work – practice – can enhance/compensate 'math sense'

Boys usually discussed 'math sense' as an inborn, natural talent of boys that can achieve good performance effortlessly ("don't put much effort") and intuitively ("simply got it"). On the contrary, **while girls recognise the importance of math sense as an inborn quality, they also stress the importance of training and cultivation, believing hard work can enhance one's ability or 'compensate' one's deficiency/ weak math sense.**

For example, Student GGMS-5, who loved math and believed she had the 'math sense', said that even though math sense was inborn, it had to be sustained through continuous practice:

> Even if you have the math sense, if you don't do Mathematics exercises for a while, it will disappear. But when you practise again, the math sense re-appears.

Several female students also agreed about the importance of practice in enhancing one's math sense. For example, Student GGMS-2 said that having the math sense means she could use the correct solution or formula in resolving a mathematics question quickly, yet that natural 'sense' -- the intuition -- could be developed through practice.

Student GGMS-1 had a similar view:

> Good at math is something inborn, but you also need to cultivate math sense if you want to improve further, or you will be stuck at the preliminary stage. *Math sense requires practices. It only gives you a head start.*

Girls in the "less STEM-oriented" group also recognised the importance of hard work in improving math results.

> CoGLS-1: I am not good at math and science. But my results get better if I work harder. (…) If I did more questions and try different question types, my results were better.
>
> CoGLS-2: I believe I could work harder to improve my math results. When I was F.3, I got 30 marks in the math Exam. After I had worked harder, my scores improved a lot in the end.

Interesting, while female participants in this focus group – CoGLS – who have chosen less STEM subjects believed in the importance of hard work to boost math performance, they still regarded (natural) math sense as more critical:

> CoGLS-1: No matter how hard-working girls are, they cannot compete with boys whose math ability is better. *I don't think girls can overtake boys even though they are hard-working.*
>
> CoGLS-3: In my school boys obviously are a lot better than girls in math and science.
>
> CoGLS-2: Even though we work hard, we still lag behind boys who have a better sense. My class is in arts stream; our average math result is 20 marks less than that of those in the science-stream. The difference is really big.
>
> CoGLS-3: When boys work harder, they will get even better results. Some Form 6 students told us that boys got low marks at the mock exam because they were lazy but girls got good results because they were hard-working. However, they believed that if those boys could work harder, their results would be the same as, if not better than, those hard-working girls.

The above discussions clearly indicate that female students have internalised or are repeatedly exposed to the idea that only boys have math sense and are the "talented" learners. The flip-side of this idea is that no matter how hard girls work, they are unlikely to supersede "the real learners". We cannot help but wonder the effects of this kind of unhealthy gender belief on girls' confidence in studying math and STEM subjects. We will return to this theme in the next section when we discuss self-efficacy and learner-identities.

5.3.7 "The Exceptional Girls"

The notion that only boys have math sense is rather normative, which probably explains why students will describe those girls who are good at math as 'exceptional' or 'individual' cases. This is illustrated in the following discussion with Student CoGMS-4:

> CoGMS-4: I think boys have stronger sense.
>
> *Moderator: You think boys are better in Math and Sciences?*

> CoGMS-4: Yes, that's true, even though there are individual girls, 1 or 2, who are very good. Most of the boys are good at math; they think faster. The top student in my school is a girl. *She is an individual case. She is really exceptional.*

Student CoGLS-3 also described girls who performed well in the science subjects as "exceptional cases":

> Boys are better in science-related subject, but some girls can also handle science-related subject well. There are exceptional cases. (CoGLS-3)

Boys' responses to outstanding female achievers are even more intriguing, as illustrated by the following discussion:

> CoBLS-3: I have an extreme example to share. In my class, there is a girl who got full marks in M2 exam. She is abnormal!
>
> *Moderator: Why can she perform so well in M2 exam?*

> CoBLS-3: I don't know how she got it. If you are familiar with the questions of M2, you should know how hard they are.

Moderator: Do you think she is a genius? Or is she just lucky?

CoBLS-3: You cannot depend on luck to get full marks in M2 tests.

Moderator: So, do you think she is really talented?

CoBLS-3: Yes, she is really talented. Getting full marks in M2 is already extraordinary, and she is a girl! She must be super clever. However, she is an extreme case, a special, exceptional, abnormal case.

Student CoBLS-3 was obviously amazed by the extraordinary performance of his classmates in the M2 exam, as his use of superlatives suggests. However, it is also clear that his astonishment was caused by the gender of the achiever: the superb performance of a female student has contradicted his gendered understanding of a normative talented (male) learner.

Interestingly, boys in the “Less STEM” group also believed that “exceptional girls” could be at an advantage due to their rarity. They argued that that achieving females can be easily identified and therefore privileged. In saying so, *they do not question the normative notion of science as masculine/scientists as men*:

Moderator: Do you see any differences between female and male achievers in math?

CoBLS-5: Oh girls good at math are more likely to surprise you.

CoBLS-3: Because social norm expects boys to be good at math and science.

CoBLS-4: Usually scientists are male, so if there’s a female scientist, she becomes more eye-catching.

5.3.8 Minority views: Not gender stereotypical

In the focus group interviews, there were a few students who did not subscribe to the above gender stereotypical views. Instead, some believed that girls were better learners. Others believed that school success was determined by individual differences rather than gender differences.

Some boys from the "More STEM" groups (CoBMS) did not see boys as naturally better at Science than girls. For example, Students 1 and 2 from CoBMS said that in their schools, female students were usually smarter and were higher achievers than male students. Contrary to some male students who found girls were slower in thinking and confused in teaching math, Student CoBMS-4 held different opinions:

> Girls are more sensitive when they teach you. They are clearer and more detailed in their explanation. Boys are less detailed; they went over the topic very quickly. If you couldn't get it, then they talked again. (CoBMS-4)

A few girls also found girls could be good learners. CoGLS-7, a female student who self-studied Physics as one of her electives, believed that girls and boys could both be good in science. She also remarked that in her school many students who get good grades who chose to study science subjects were girls. Another girl also thought girls have an advantage over boys when studying science and math.

Apart from their own experience, some other students also thought that female students also have an advantage when studying Science and Math:

> We need to be scrupulous in our calculation and avoid making careless mistake. Somebody think girls are better because we are more prudent. I also think girls can have an advantage over boys in this regard. (GGMS-4)

Another minority view is that the ability to study math and science subjects is related to individual talent or personality rather than to gender. For example, Student GGMS-1 and GGMS-2 thought that it was 'the brain' of a person instead of her/his gender that determined whether she/he could study well in science or mathematics. A male participant in the BBLS group also held a similar view.

> It depends on the personality, and not gender. I mean for a lazy and laid back person, you can't do well in studying. You won't say a girl can still do better in a laid back way. (BBLS-4)

This student BBLS-4 is noteworthy as he is one of the few who is critical of stereotypical gender beliefs. He did not believe that boys were better than girls in math and science, and argued that this gender stereotype might have deterred girls from choosing math and science:

> I wonder whether it is because since we were kids, we were told that girls were more suitable for Arts stream, and this caused young girls to avoid studying math and sciences subjects. (BBLS-4)

In this section, we have discussed students' various understandings of two science-related subjects, Biology and Mathematics. Interestingly, these two subjects have been gendered differently. On the one hand, Biology is perceived as an arts subject and is sex-typed as a subject for female students because it requires large amounts of memorization. On the other hand, **math is perceived as a masculine subject, as student participants believed only boys are endowed with the natural ability – math sense – that allows them to solve mathematical questions quickly, intuitively and effortlessly**. Female students, in participants' views, could be diligent and hardworking and some could be exceptional/abnormal, yet they could never be as good as boys, as girls are by nature "slower, easily confused, trivial, and rigid in their thinking". We believe **these gendered beliefs are not simply stereotypical but unhealthy and limiting, and can undermine students' self-efficacy and learner-identities.**

5.4 Students' self-efficacy and learner-identities

In this last section, we will further examine students' self-efficacy in STEM – one's belief about their ability and capacity to study STEM well and their learner's identities – how an individual feels about himself/herself as a learner and how they make sense of their academic performance. The quantitative findings in the previous section show that girls generally have lower self-efficacy (Table 4.7) in learning mathematics, sciences and ICT than boys, as the latter appear to be more confident about their own academic performance. In the focus group interviews, we also noticed significant differences between boys and girls in their self-efficacy. On the whole, **boys in general, whether from "More" or "Less" STEM groups, show more confidence in their learning ability than girls**.

5.4.1 More STEM boys: Confident, uninterested and lazy

In the focus group discussion, when students were asked to evaluate their academic performance, male participants of the More STEM groups (BBMS and CoBMS) explained their dissatisfactory results with reasons, such as lack of interest, content of the subject being boring, unfamiliar with the examination format, or even teachers' unclear teaching. Interestingly, they rarely attributed their poor academic results to their ability.

For example, Student BBMS-7 explained that his bad performance in Math was due to his lack of interest in the subject:

> My Mathematics was not good, as I lost interest in it. I didn't like it, so I couldn't master it. (BBMS-7)

Another Student, BBMS-4, explained his poor results because of laziness:

> I have confidence that my mode of thinking can handle Liberal Studies. My exam results of Science subjects are very fluctuating, coz I am quite lazy now. English is my best subject. Physics is quite good. I don't really understand Biology or Chemistry, as I haven't spent much time on these two subjects. (BBMS-4)

Boys from co-educational school who chose more STEM subjects (CoBMS) also gave similar reasons, such as being 'lazy', not hard-working, do not like reciting, or not spending much time and effort on some subjects. The following two examples are illuminating:

> I am not doing well in my ICT Core, but programming is quite OK. For Math, I am above average in the Core, but my M2 score varies, and it really depends on the topic. In some topics I am really bad, and some topics I am very good and get high marks easily. For Combined Sciences, my Physics is above average, but Chemistry is something that I'm not quite able to handle. …I'm not the hardworking type, so Chemistry is something very difficult for me. (CoBMS-2)
>
> I'm taking Math, Physics, and Chemistry. I'm a lazy person. I don't like studying and daydream a lot in the class, I don't study Physics but my grade is still above average. But for Chemistry, I can understand it, but I never able to get the correct answer**.** I'm not happy with that, I basically understand all the contents but can't get the marks. I feel quite reluctant to continue this subject, but I have no choice but to work hard for it. For Math, I don't really study. As long as I can understand it during the class, I would simply attend the examination without further studying. (CoBMS-5)

Not all male participants were confident about their own performance in STEM. For instance, BBMS-8 considered himself only in the middle in the form for his Math subject but did well in Biology. Students BBMS-5 and BBMS-6 also admitted that their results of all the subjects were not that good. However, even though boys realized that their academic performance was not good, they seldom questioned their ability in STEM. They were still able to have positive learner-identities.

5.4.2 More STEM Girls: "We are not very good"

Among the female participants from the More STEM groups (GGMS and CoGMS), only a couple admitted that they were good in their STEM subjects. As mentioned in the earlier section on subject choice, girls in the "More STEM" groups were usually high achievers in their schools who managed to get into the science stream. However, in the discussion, these young girls all appeared very humble when evaluating their math performance.

For example, even though Student GGMS-5, who was rather good at math, played down her performance and math sense.

> My math results are better than some students, but mine are not really very good. I think I have certain "math sense". However, I very often make a lot of careless mistakes. (GGMS-5)

This also happened to Student CoGMS-2, who rated her math performance as above average in the whole form. However, CoGMS-3, who attends the same school, urged CoGMS-2 not to be too humble in the self-evaluation. CoGMS-2 then explained that she saw herself as not so good as she lacked the 'sense' to achieve her best. Apparently, the notion that "only men have math sense" has undermined her confidence:

> CoGMS-2: I don't have the math sense. Boys are really smarter. They only have one look, and can start working on a question. It usually takes me a while, and sometimes I am still not able to get it. I think I am only good at some topics; but for those boys, they are good at every single topic.

Similarly, Students CoGMS-4 and 5, who were both in the best math class in the form, emphasised that they were "*among the worst in the best class*". Even though Student CoGMS-4 was already among the top 30 students, she did not feel that her math was good enough and was dissatisfied with her performance.

We are not suggesting that the humble presentation of these young girls means that they necessarily lack confidence. Yet, we did notice that as compared with the "More STEM" boys, these young women seemed to set a higher standard for themselves or always see themselves as "lacking", and thus have lower self-efficacy.

5.4.3 Less STEM Girls: Losing interest and confidence in Math

In the CoGLS group, among nine female participants, six of them considered their math performance was 'not good', and two of them saw their results as 'in the middle'. As we saw in 5.3.7, girls of this focus group have internalised the idea that only boys have math sense and girls can subsequently never be as good as boys. Student CoGLS-7 was the only one in this group who exhibited higher self-efficacy in math and science. She told us she liked math and described herself as performing relatively well in the subject. She also took Physics as her elective subject and was quite conscious that she was different from other girls.

> CoGLS-7: Most (of the girls) are afraid of it [Physics].
>
> *Moderator: Why?*
>
> CoGLS-7: Because they don't want to do calculation again. All of them don't like to calculate. However, I prefer calculation. I try to recommend this subject to them but they just say 'no, no'.

Girls in single-sex schools did not fare much better. For instance, in the GGLS group, most of the students described themselves as not very good in math, and Student GGLS-8 told us that she lost confidence in herself when she did not do well in science subjects.

> GGLS-8: When I was in primary school, I got full marks for my math. I really loved math and science subjects. However, when I started secondary school, I gradually changed from a science person to an Arts person.
>
> *Moderator: Why?*

GGLS-8: Because I gradually scored higher marks in Arts subject, and there's no reason to study subjects [science related] if you could only score lower marks. In fact my math gets worse and worse.

Moderator: Why so?

GGLS-8: I have no idea. I really think my math was quite good in primary school.

We could detect a sense of frustration and even bewilderment in GGLS-8. Instead of attributing the poor results to laziness, GGLS-8 gave up science or math subjects and turned herself to an Arts student.

GGLS-2 was the student who took M2 as her elective. Again she described her math ability as very average:

Moderator: As you take M2, would you consider yourself strong at Math?

GGLS-2: Not that strong actually. I am better than the average*, better than most average girls*.

Interestingly, she sees herself as both "average" and an "above average girl". Her emphasis of "average" twice seems to be an attempt to lower our expectation of her math ability.

On the whole, girls from "Less STEM" groups are similar to girls from "More STEM" groups. Both see themselves as not good at math and both have lower self-efficacy. An obvious reason is that they have internalised the notion that men are better math learners and are born with "math sense".

5.4.4 Less STEM Boys: Lazy but have other talent

If girls from the "Less STEM" groups showed lower self-efficacy and poorer learner-identities, male participants in the "Less STEM" groups (BBLS and CoBLS) did not. While they described themselves as not doing so well in the Math subject (which is the only STEM subject that they have taken), they, similar to boys from "More STEM" groups, attributed their poor performance to laziness.

For example, Student BBLS-6 believed his bad performance in math was not because he lacked 'math sense' but because he did not practice:

> BBLS-6: I never practised math. Whenever I see a math question, I feel headache. I'd rather spend time doing other homework than doing math. I believe if I could practice more before the exam, I would be able to get a much better grade. As I didn't practice, I failed them all.

Although male students of the "Less STEM" group saw themselves performing poorly in STEM-related subjects, they did not see it as a problem. Instead, they valued their ability to study non STEM-related subjects.

For example, all of the students in the CoBLS group said that they did not feel ashamed about not performing well in math, as they considered "learning math" a useless exercise:

> CoBLS-4: It doesn't matter if you fail Mathematics.
>
> CoBLS-3: Yea, we all agree that learning math is useless. After all, it really depends on whether you have the talent.

It is interesting to note that the confidence of male students is not undermined by their poor math results. Instead, they are able to criticise the subject as irrelevant. More importantly, they did not seem to see the lack of 'math sense', the ability most valued by other male participants, as a problem.

When we examined their discussions further, these male students told us that they possessed skills/abilities which are equally good as "math sense". For instance, Student BBLS-4 explained that he was better in subjects that required perception – the ability/ skill to elaborate and interpret. As subjects like Econ and Math did not require such skill, he did not perform well.

Student BBLS-7 also made a similar claim:

> My best subject is Liberal Studies. Liberal Studies does not require you to memorise a lot of facts, but perception. Just like History, you do not simply memorize the facts, you also need perception. But for Math, you just need to keep practicing. If you develop good perception in your study, you will have more time left to do something else. (BBLS-7)

Some male participants in the CoBLS group also emphasised the importance of "feeling" – similar to "intuition" in math sense – to study Arts subjects well.

> CoBLS-4: Liberal Studies needs not recite things
>
> CoBLS-2: Liberal Studies requires critical thinking, and the way you answer the question.
>
> *Moderator: You also mentioned that good Arts subjects' results depend on one's feeling. Can you explain these "feeling"?*
>
> CoBLS-2: For Liberal Studies, I have read a lot of news about current events and have formulated opinions in my mind. When I see a question, I can answer it quickly. This is what I mean the "feeling", or the "intuition" about what a current event should be understood.

By asserting their unusual ability to study Arts subjects, viz. Liberal Studies, well – whether due to perception or "feeling", male participants in the "Less STEM" groups appear to downplay the prestigious status enjoyed by science and math subjects, as well as the feeling of superiority that can be enjoyed by students who possess the "sense".

In this section, we further discussed the gender differences in self-efficacy and learner-identities of boys and girls from the More or Less STEM groups. **On the whole, boys in "More STEM" and "Less STEM" groups show more confidence in their learning ability than girls**. Male participants describe their poor performance as a result of laziness instead of not having the talent. In other words, they exhibited higher confidence of their ability and saw their poor performance not in terms of ability but effort. **On the contrary, most of the female interviewees** (from both the More STEM and Less STEM groups) **seemed to have lower self-efficacy in math and science related subjects.** They tended to downplay their good performance in math by describing themselves as "the worst in the best class" or only above average. Some of them would even say that they did not have the "math sense". Apparently, girls seemed to accept that boys are better learners, as they have the superior "sense".

Interestingly, **the notion of inborn talent – "math sense" – might have undermined girls' confidence but not the confidence of boys from the Less STEM groups**. While those boys admitted they were poor in math and STEM subjects, they saw themselves as equally good, if not better, in studying Arts subjects as they have other skills/abilities: perceptions and feeling.

Discussion and Recommendation

Gender, STEM and the Leaking Pipeline Approach

The pioneering study of Yeung and Liong (2016), funded by The Women's Foundation, has identified factors shaping the inclination of Hong Kong female students at junior secondary level to select STEM subjects. This study aims to further broaden current understanding of gender and STEM in several key ways: First, it examined not only factors contributing to students' choices of STEM electives in DSE, but also **those contributing to their *dropout* from STEM fields at multiple stages**. Secondly, it has **included both female and male students so that a more comprehensive picture of students' perspectives could be gained**. Thirdly, it purposely recruited **female and male students who have chosen more or less STEM electives** so that comparisons across and among boys and girls could be obtained. Conceptually, this study has adopted the "leaky pipeline" as the guiding framework.

Factors Contributing to Females' Dropout from the STEM Pipeline

Similar to many developed countries, fewer female students in Hong Kong chose STEM-related electives in the DSE curriculum than male students. More importantly, for those females who have chosen STEM, despite spending greater efforts, they are still more likely than male students to leak out from the STEM pipeline in the later stages. Our statistical analyses show that gender differences in the subject perception (self-efficacy, interests and perceived value), preference on job characteristics, and stereotypical beliefs in STEM are some key contributing factors to women's dropout. More specifically, female students' positive perception over language and humanities learning domain is negatively associated with their choice in STEM, especially mathematics extended parts (M1 and M2), in DSE. Females' preference and aspiration to work for meaningful jobs is negatively associated with their intention to study STEM in university and take up a STEM-related job. Furthermore, female students who hold stronger gender stereotypical beliefs in STEM (such as "boys are better than girls in learning science" or "girls are more suitable to study language and humanities") are less likely to take STEM and mathematics extended modules and have a lower intention to study STEM in university and choose a STEM career. Our qualitative findings also found that even though female students might have chosen STEM in their DSE, for status and strategic concerns, which could not sustain them to partake STEM as their major in university or as their future career.

Gendered Beliefs Undermining Girls' Self-Efficacy in STEM

Current studies have indicated that gender stereotypical beliefs can affect girls' intention to study, interest, and performance in STEM (Shapiro and Williams, 2011; Yeung and Liong, 2016). This study found that **gender stereotypical beliefs in STEM (in particular students' perceptions about math and science subjects) can also undermine girls' confidence and evaluation of their math performance**. Our statistical analysis found that girls reported to have lower level of self-efficacy in mathematics, sciences and ICT. Our focus group interviews further showed that girls usually saw their math performance as "being average" and "not so good", and was definitely not as good as boys, as they lacked "math sense". Even though among female students who have chosen more STEM electives and/or M1/M2 (who were usually the top or achieving students in their schools), they still regarded their "math sense" as inferior to boys – the normative learners with inborn "math sense". **Their lower self-efficacy in math and science explains why fewer females have chosen STEM-related electives (such as M1, M2, and physics) in DSE examination. More importantly, it also explains why those who have chosen, despite greater effort, will not continue the STEM pursuits in the later stages if they have more options**.

Recommendations

Based on the above findings, we have the following recommendations:

1. We believe **schools, teachers, parents should be more vigilant of the specific gendered beliefs – discipline or subject related – that deter girls from pursuing STEM at different stages**. Despite the rise of women's status, gender stereotypes still exist which prevent young women (and boys) from utilizing their full potentials. In this study, we have identified some prevalent gender beliefs that are associated with science subjects (math in particular), and learning ability/talent among secondary school students. We notice that the gendered beliefs of "boys are better at math than girls", "boys have better math sense than girls", "boys can solve math questions faster, intuitively and effortlessly" have constructed math as a masculine subject that only boys are naturally good at. These gendered notions have negative effects on female learners and have to be countered.
2. **Having access to more ordinary female role models can help counter negative stereotypes**. While we agree with the importance of female role models, those role models should be more and varied. Our focus group interviews clearly indicate that a few successful female models in STEM fields (eg. Sheryl Sandberg) may not really mitigate gender stereotypes, as students are likely to take the "outstanding women" as tokens, exceptional, individual or even abnormal. We need to show girls and boys that there are ordinary women workers in STEM fields.
3. Changing gender stereotypes aside, we believe **the images of STEM, be they related to the subjects, the fields, or job nature should be revamped**. One factor that deters female students from pursuing STEM in university and choose a STEM career is because they prefer jobs that are meaningful and can help other people. Apparently, female participants did not find these characteristics in STEM jobs, which are often described as boring, dirty and detached. Given STEM is going to

revolutionise human living in the years to come, the policy makers and field practitioners should actively promote a more “humane” image, especially its meaningfulness and helpfulness, to attract young women to join.

4. **We do not think making STEM-related subjects compulsory a good idea**. There have been suggestions to make STEM-related subjects (such as physics or ICT) a compulsory subject in the senior secondary curriculum so that more students can be exposed to STEM education. However, in view of students’ negative perceptions of math and STEM-related subjects, and their instrumental consideration of taking DSE electives (who will not continue the STEM subjects after entering university), this suggestion may not really resolve the problem, especially the issue of women leaking out from the STEM pipeline.
5. To promote STEM, we believe **educators, schools and teachers should consider making math or science-related subjects more relevant to students’ real life**. Our research found that most students, both females and males, began to lose interest and confidence in math after promoting to senior secondary school. They complained the subject matters of math have become increasingly abstract, irrelevant and useless. If mathematical thinking is an important cognitive and analytical tool for general life purpose, then we have to rethink the way math, as a core subject, is currently taught in senior secondary school.
6. Similarly, **the status and significance of ICT should be enhanced**. While there were more male students taking ICT as DSE electives than female students, students interviewed, including boys, did not rate the subject highly. This negative evaluation does not facilitate the development of STEM education. We believe students’ earlier exposure to programming and coding, as the Girls Go Tech Programme (organised by TWF) demonstrated, will be more useful to change

students’ negative perception of computing technology and may encourage more females to consider STEM-related fields.

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Appendix 1: List of school participants (in alphabetic order)

We would like to thank the following schools for their participation and for supporting this study.

Baptist Lui Ming Choi Secondary School
Carmel Alison Lam Foundation Secondary School
CCC Kei Long College
Chinese YMCA College
Concordia Lutheran School (North Point)
Diocesan Boys' School
Fung Kai No 1 Secondary School
General Chamber of Commerce & Industry of The Tung Kun District Lau Pak Lok Secondary School
HKTA The Yuen Yuen Institute No. 1 Secondary School
Holy Trinity College
Hong Kong Sea School
Hong Kong Tang King Po College
Hong Kong True Light College
Ju Ching Chu Secondary School (Tuen Mun)
P.H.C. Wing Kwong College
Po Chiu Catholic Secondary School
Po Leung Kuk Wu Chung College
Po Leung Kuk Yao Ling Sun College
Pope Paul VI College
Pui Tak Canossian College
Queen's College
Sacred Heart Canossian College
St. Antonius Girls' College
St. Catharine's School For Girls
St. Francis of Assisi's College
St. Joan of Arc Secondary School
St. Joseph's Anglo-Chinese School
St. Joseph's College
St. Paul's Secondary School
St. Paul's Secondary School (Lam Tin)
Tack Ching Girls' Secondary School
Tak Nga Secondary School

Kiangsu-Chekiang College (Shatin)	Tak Oi Secondary School
Kwun Tong Kung Lok Government	The Hong Kong Management Association K.
Secondary School	S. Lo College
Kwun Tong Lutheran College	True Light Girls' College
Lions College	Tsuen Wan Public Ho Chuen Yiu Memorial
Madam Lau Kam Lung Secondary School Of	College
Miu Fat Buddhist Monastery	TWGHs Chen Zao Men College
Ng Wah Catholic Secondary School	TWGHs Li Ka Shing College
	United Christian College