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Investigating Determinants of STEM Major Choice Among Malaysian Undergraduates

Ghim Hock Ong [1], Saras Krishnan [2]*, Enriqueta Reston [3]

[1] *INTI International University*, MALAYSIA
[2] *Xiamen University Malaysia*, MALAYSIA
[3] *University of San Carlos*, THE PHILIPPINES

*__Corresponding Author:__ saras.krishnan@xmu.edu.my

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ABSTRACT

STEM education plays a significant role in a country's economy growth. Consequently, innovative and advanced careers in STEM domains are fast emerging because more people are employed in STEM related professions. Literature has identified various determinants of STEM career and STEM major choices including gender, self-efficacy, parental influence, outcome expectancy and aptitude towards science and mathematics. While extensive literature exists on STEM major choices, it is predominantly concentrated on Western countries. This study aims to fill the gap by providing empirical evidence of gender, ethnicity, and high school grades as determinants of STEM major choice among undergraduates in a developing country. The results expand the understanding of how demographic factors influence academic choices in non-Western settings. Practically, the findings can inform policy makers on strategies to encourage STEM enrolment among diverse student populations in Malaysia.

Keywords: ethnicity, gender gap, inclusive education, sustainable communities

INTRODUCTION

STEM education is essential to nation development, economic competitiveness and societal wellbeing because the rapidly changing, globally interconnected world demands increased scientific literacy and high-level STEM skills (Freeman et al., 2019). More significantly, STEM contributes to economic growth, industry, innovation, and infrastructure, all of which are key factors in creating sustainable communities. A number of education organizations have established classroom standards and recommendations since the 1990s to help students become better equipped for learning the subjects covered by the STEM disciplines. These include the National Council of Teachers and Mathematics (NCTM) and the National Science Education Standards in the United States. Different nations prioritize STEM differently, based on the cultural norms, economic conditions, and available resources. Australia, for example, has National STEM School Education Strategy, China has Science and Technology Development Goal and Argentina has National Plan of Science, Technology and Innovation (Freeman et al., 2019).

STEM subjects are covered in Malaysian curricula at every educational level. In high school, students can choose to major in arts or STEM. Students that enroll in the STEM stream gain enhanced theoretical understanding as well as practical STEM skills. However, as Evans et al. (2020) correctly pointed out, even non-STEM jobs demand workforces that are proficient with technology and possess the mathematical skills necessary to handle difficult problems. STEM education is a key factor in guiding Malaysia toward IR4.0 and so to effectively advance the

nation, it is crucial to empower a younger generation that appreciates STEM (Abd Manaf, 2018). The young people in the nation can broaden and deepen their knowledge through STEM education, equipping them with skills that will be essential to the demands of the workforce in the future.

Malaysia is strongly focusing on STEM education as the government anticipates that further technological advancements, discoveries, and inventions that will push Malaysia to new heights. To prepare the younger generation with strong foundations in STEM, a number of programs and initiatives have been proposed and implemented. This includes the founding of the National Science Centre (NSC) in 1996 which collaborates with the STEM Learning Centre in the UK to create a comprehensive framework for STEM teachers' continuing professional development. NSC itself is an agenda of The National STEM Action Plan 2018-2025, which was created in collaboration with the Ministry of Science, Technology, and Innovation (MOSTI) and Ministry of Higher Education (MOHE) (MEB, 2013). Of more recent, the National STEM Association (NSA) was established in 2018 with the goal of igniting interest in STEM at all levels.

The STEM education framework in the Malaysia Education Blueprint 2013-2025 focuses on nurturing interest in STEM in early childhood up to developing and enhancing STEM skills at higher education levels in order to produce STEM workforce and STEM literate society (Idris et al., 2023). However, there are many factors influencing graduates choosing STEM careers. According to Bicer et al. (2020), the two main factors influencing STEM career choice are individual characteristics and societal characteristics. Individual characteristics include gender, ethnicity and economic status while societal characteristics are those pertaining to education such as quality of schools and access to resources.

Despite the global acknowledgement of the importance of STEM education, research in STEM education in the developing countries is still less in number, in comparison to the developed nations (Chomphuphra et al., 2019; Vuong et al., 2020). According to Abe and Chikoko (2020), for the past two decades literature on decisions on career in STEM has been focused on Western countries. In fact, Lee et al. (2019) pointed out that Asian countries, Malaysia included, accounted for only 8.5% of the research articles in STEM education. This calls for more research and publications in various areas of STEM education from and involving the developing countries. In the context of this research, Evans et al. (2020) observed that literature on STEM major choice has been limited and narrowly focused thus pointed out a need for more research in this domain.

LITERATURE REVIEW

Literature identifies some of the factors for choosing STEM oriented careers as societal conditioning, outcome expectancy, self-efficacy, parental, teacher and friends' influence, and exposure to job prospects in STEM fields (Abd Rahman and Halim, 2022; Abe and Chikoko, 2020; Bicer et al., 2020; Tey et al., 2020). In addition, factors such as gender, financial resources, aptitude towards science and mathematics, and demographic variables have been identified as determinants of students' choice of STEM majors (Evans et al., 2020; Jeffries et al., 2020; Kaleva et al., 2019). Past studies have also identified socio-economic status and immigrant status as factors that contribute towards students' major choices whereby students from low socio-economic backgrounds and with immigrant status are less likely to choose STEM courses (Jeffries et al., 2020).

Gender is the most extensively studied demographic character and the most robust predictor in relation to STEM major choices and thus have been of much interest to researchers and practitioners (Evans et al., 2020; Jeffries et al., 2020). Studies largely found that female students are less interested in STEM majors and are underrepresented in STEM (e.g., Delaney and Devereux, 2019; Idris et al., 2023; Jeffries et al., 2020; Kaleva et al., 2019). In addition, women mostly choose health-related fields compared to computing and engineering fields (Fry et al., 2021). Fry et al. (2021) also revealed that there is a tendency for women to earn less than their male counterparts in the STEM field. The study by Fauzi et al. (2024) found that gender inequality also exists in leadership at higher education institutions and thus a change of mind set is much needed for institutional transformation.

Cultural diversity is a challenge in achieving effective inclusive education systems all over the world (Semião et al., 2023). The report by Fry et al. (2021) revealed that ethnicity is a contributing factor towards the STEM workforce in the United States where Asians, Blacks and Hispanics occupy less than 50% of STEM jobs compared to the white people. Moreover, diversity in the job sectors have remained over the years regardless of the notable increase in the number of graduates in the STEM fields. More seriously, the gaps in the ethnic earnings among the STEM employees also increased in recent times. Immigrant status was also found to be a significant predictor whereby native students are less likely to choose STEM courses compared to students from the migrant families (Jeffries et al., 2020).

A number of studies on STEM education has involved high school students and high school variables (e.g., Evans et al., 2020; Jeffries et al., 2020; Sasson, 2021). The study by Sasson (2021) found a statistically significant correlation between high school majors and graduates' career choice whereby those who graduated from STEM

courses have taken STEM subjects in high school, some with combination of social science subjects. Interestingly, a very small number who did not study STEM in high school still chose to have a career in STEM fields. In their study, Sahin and Waxman (2021) also found that courses taken in high school is one of the three main factors influencing graduates to choose STEM career, the other two factors being parental influence and teacher influence. The study by Evans et al. (2020) found that students' self-efficacy in high school has significant association with their choice of STEM majors. In addition, the study by Jeffries et al. (2020) found that demographic background is a determining factor of high school students' enrolment into STEM courses while personal value, attitude and achievement are the mediating factors.

RESEARCH DESIGN

Research Objective

The objective of this study is to determine if gender, ethnicity and high school grades are determining factors in students' choice of STEM majors. These predictors are recognized as determinants of students' STEM major choices in existing literature (e.g., Evans et al., 2020; Jeffries et al., 2020). In the framework of this study, these predictors are selected to investigate their significance in the Malaysian context, where the cultural and educational dynamics differ from the Western countries.

Research Questions

This study investigates a possible association between gender, ethnicity and high school grades with choice of STEM majors among Malaysian undergraduates. Therefore, the research questions are:

(1) Is there an association between student's gender and choice of STEM majors?
(2) Is there an association between student's ethnicity and choice of STEM majors?
(3) Is there an association between student's high school grades and choice of STEM majors?

Research Sample

The population of interest for this research is students from the higher education institutions in Malaysia including the government owned institutions and private institutions. This study uses purposive sampling to gather responses from students in all the main regions of the country that is the northern, central, southern, east coast and west coast regions. In specific, the research sample consists of 278 undergraduates from one institution in the northern region, three institutions in the central region, two institutions in the southern region, three institutions in the east coast region and one institution in the west coast region.

Instrumentation

This study employs the cross-sectional survey method to collect data of students' responses to a questionnaire designed for the purpose of this research. The questionnaire gathers information about respondents' gender, ethnicity, academic qualification and field of study at the universities. The reliability of the questionnaire was established with a Cronbach's alpha that met the standard threshold of 0.70.

Data Collection

Data was collected over two months period in the physical and online mode that lasted for about fifteen minutes each session. In both modes, respondents were firstly required to consent to the researchers using their information for the purpose of the research. It was beneficial to have the physical data collection prior to the virtual data collection because immediate feedback from the respondents was obtained during physical data collection. It also allowed the researcher to read the non-verbal cues of the respondents and listen to the discussions of the respondents with regards to the items in the questionnaire. In the online mode, information was gathered using Google forms.

FINDINGS AND DISCUSSION

This study conceptualizes gender, ethnicity, and high school grades as categorical variables. Hence, the chi-square test was chosen for analysis due to its suitability for examining relationships between categorical variables.

Table 1. Distribution of respondents' gender

Gender	Number (n)	Percentages (%)
Male	96	34.5
Female	182	65.5

Table 2. Association between gender and major choice

	Pearson Chi-square	df	p-value
Gender	28.049	7	0.000

Table 3. Cross-tabulation between gender and major choice

Gender		Science	Technology	Engineering	Mathematics
Male	Percentage (%) within gender	57.3	10.4	16.7	14.6
	Percentage (%) within subject	33.1	55.6	69.6	29.2
Female	Percentage (%) within gender	61.0	4.4	3.8	18.7
	Percentage (%) within subject	66.9	44.4	30.4	70.8

Table 4. Distribution of ethnicity

Ethnicity	Number (n)	Percentages (%)
Malay	215	77.3
Chinese	25	9.0
Indian	23	8.3
Other ethnicity	15	5.4

Table 5. Association between ethnicity and major choice

	Pearson Chi-square	df	p-value
Ethnicity	75.101	21	0.000

Gender and Choice of Major

The 278 respondents in this study consists of 96 (34.5%) males and 182 (65.5%) females as shown in **Table 1**.

Table 2 shows that there is a statistically significant association between gender and respondents' choice of STEM major [χ^2 (7, 278) = 28.05, p = 0.000].

Table 3 shows that 57.3% of the male students chose Science, 10.4% of the male students chose Technology, 16.7% of the male students chose Engineering and 14.6% of the male students chose Mathematics. Further, 61.0% of the female students chose Science, 4.4% of the female students chose Technology, 3.8% of the female students chose Engineering and 18.7% of the female students chose Mathematics. The results reveal that more male undergraduates chose Engineering and Technology while more female undergraduates chose Science and Mathematics.

Likewise, 55.6% of the respondents who chose Technology are males compared to 44.4% females while 69.6% of the respondents who chose Engineering are males compared to 30.4% females. Further, 66.9% of the respondents who chose Science are females compared to 33.1% males and 70.8% of the respondents who chose Mathematics are females compared to 29.2% males. The results reveal that the male undergraduates prefer Engineering and Technology while the female undergraduates prefer Science and Mathematics.

Ethnicity and Choice of Major

Table 4 shows the distribution of ethnicity whereby the largest ethnic group in this sample is Malays (77.3%) followed by the Chinese (9.0%), Indians (8.3%) and other ethnic groups (5.4%). The distribution is reflective of the demographic of Malaysia's population whereby as of July 2022, the Statista Research Department (2023) classified 69.9% of the Malaysian population as Bumiputera, 22.8% as Chinese and 6.6% as Indians.

Table 5 shows a statistically significant association between ethnicity and respondents' major choice [χ^2 (21, 278) = 75.10, p = 0.000].

Table 6 shows that among the Malay students, 63.3% chose Science, 6.5% chose Technology, 1.9% chose Engineering and 17.7% chose Mathematics. This suggests that Malay students prefer Science as a major. This observation is supported by 81.9% of those who chose Science are Malay students.

Further, among the Chinese students, 32.0% chose Science, 4.0% chose Technology, 40.0% chose Engineering and 24.0% chose Mathematics. This suggests that Chinese students prefer Engineering courses and this observation is supported by 43.5% of those who chose Engineering majors are Chinese students. Among the

Table 6. Cross-tabulation between ethnicity and major choice

Gender		Science	Technology	Engineering	Mathematics
Malay	Percentage (%) within gender	63.3	6.5	1.9	17.7
	Percentage (%) within subject	81.9	77.8	17.4	79.2
Chinese	Percentage (%) within gender	32.0	4.0	40.0	24.0
	Percentage (%) within subject	4.8	5.6	43.5	12.5
Indian	Percentage (%) within gender	65.2	0.0	30.4	4.3
	Percentage (%) within subject	9.0	0.0	30.4	2.1
Others	Percentage (%) within gender	46.7	20.0	13.3	20.0
	Percentage (%) within subject	4.2	16.7	8.7	6.3

Table 7. Distribution of high school grades

Subjects	Grade A	Grade B	Grade C	Others
Science	118 (42.4%)	102 (36.7%)	25 (9.0%)	33 (11.9%)
Technology	36 (12.9%)	27 (9.7%)	5 (1.8%)	210 (75.6%)
Engineering	17 (6.1%)	21 (7.6%)	9 (3.2%)	231 (83.1%)
Mathematics	207 (74.5%)	35 (12.6%)	18 (6.5%)	18 (6.5%)

Table 8. Association between school grades and major choice

	Pearson Chi-square	df	p-value
Science	69.716	28	0.000
Technology	71.123	35	0.000
Engineering	67.037	35	0.001
Mathematics	68.637	42	0.006

Table 9. Cross-tabulation between science grades and major choice

Gender		Science	Technology	Engineering	Mathematics
Grade A	Percentage (%) within gender	72.9	1.7	5.1	16.1
	Percentage (%) within subject	51.8	11.1	26.1	39.6
Grade B	Percentage (%) within gender	43.1	10.8	6.9	23.5
	Percentage (%) within subject	26.5	61.1	30.4	50.0
Grade C	Percentage (%) within gender	64.0	4.0	24.0	4.0
	Percentage (%) within subject	9.6	5.6	26.1	2.1

Indian students, 65.2% of them chose Science, 30.4% chose Engineering and 4.3% chose Mathematics suggesting that Indian students prefer Science as a major. However, within the Science major only 9.0% are Indian students.

High School Grades and Choice of Major

Table 7 shows the distribution of high school grades for the subjects Science, Technology, Engineering and Mathematics. In this study sample, most of the respondents have good achievement in the STEM subjects. For example, 42.4% of the respondents got grade A in high school Science and 74.5% got grade A in high school Mathematics. Technology and Engineering are not common subjects in Malaysian high schools hence the 75.6% of others category for Technology and 83.1% of others category for Engineering. This includes missing data and the option 'not applicable' when students do not take these subjects in high schools.

Table 8 shows statistically significant associations between high school Science grades and major choice [χ^2 (28, 278) = 69.72, p = 0.000], between high school Technology grades and major choice [χ^2 (35, 278) = 71.12, p = 0.000], between high school Engineering grades and major choice [χ^2 (35, 278) = 67.04, p = 0.001] and between high school Mathematics grades and major choice [χ^2 (42, 278) = 68.64, p = 0.006].

Table 9 shows that of the respondents with grade A in high school Science, 72.9% chose Science, 1.7% chose Technology, 5.1% chose Engineering and 16.1% chose Mathematics. Further, of the respondents with grade B in high school Science, 43.1% chose Science, 10.8% chose Technology, 6.9% chose Engineering and 23.5% chose Mathematics. These suggest that students with good grades in high school Science prefer to choose Science in their undergraduate studies. This observation is supported by 51.8% of respondents who chose to major in Science are those with grade A in high school Science.

Table 10 shows that of the students with grade A in high school Technology, 55.6% chose Science, 13.9% chose Technology and 11.1% chose Mathematics. This suggests that students with grade A in high school Technology prefer to choose Science in their undergraduate studies. Similarly, of the students with grade B in high

Table 10. Cross-tabulation between technology grades and major choice

Gender		Science	Technology	Engineering	Mathematics
Grade A	Percentage (%) within gender	55.6	13.9	0.0	11.1
	Percentage (%) within subject	12.0	27.8	0.0	8.3
Grade B	Percentage (%) within gender	77.8	0.0	14.8	7.4
	Percentage (%) within subject	12.7	0.0	17.4	4.2
Grade C	Percentage (%) within gender	100	0.0	0.0	0.0
	Percentage (%) within subject	3.0	0.0	0.0	0.0

Table 11. Cross-tabulation between engineering grades and major choice

Gender		Science	Technology	Engineering	Mathematics
Grade A	Percentage (%) within gender	82.4	0.0	0.0	17.6
	Percentage (%) within subject	8.4	0.0	0.0	6.3
Grade B	Percentage (%) within gender	76.2	0.0	14.3	4.8
	Percentage (%) within subject	9.6	0.0	13.0	2.1
Grade C	Percentage (%) within gender	77.8	0.0	22.2	0.0
	Percentage (%) within subject	4.2	0.0	8.7	0.0

Table 12. Cross-tabulation between mathematics grades and major choice

Gender		Science	Technology	Engineering	Mathematics
Grade A	Percentage (%) within gender	58.0	5.8	5.8	23.2
	Percentage (%) within subject	72.3	66.7	52.2	100
Grade B	Percentage (%) within gender	57.1	8.6	11.4	0.0
	Percentage (%) within subject	12.0	16.7	17.4	0.0
Grade C	Percentage (%) within gender	55.6	11.1	33.3	0.0
	Percentage (%) within subject	6.0	11.1	26.1	0.0

school Technology, 77.8% chose Science, 14.8% chose Engineering and 7.4% chose Mathematics suggesting that students with grade B in high school Technology chose to major in Science in their undergraduate studies.

Table 11 shows that of the students with grade A in high school Engineering, 82.4% chose Science and 17.6% chose Mathematics. Further, 76.2% chose Science suggesting that students with good grades in high school Engineering prefer to major in Science. Also, among those who chose Science majors, 8.4% are those with grade A and 9.6% are those with grade B in high school Engineering.

Table 12 shows that of the students with grade A in high school Mathematics, 58.0% chose Science, 5.8% chose Technology, 5.8% chose Engineering and 23.2% chose Mathematics. Also, of the students with grade B in high school Mathematics. 57.1% chose Science, 8.6% chose Technology and 11.4% chose Engineering. In addition, 72.3% of those who chose Science have grade A in high school Mathematics suggesting that students with good grades in high school Mathematics prefer to choose Science in their undergraduate studies.

CONCLUSION

This study identified gender, ethnicity and high school grades as determinants of STEM major choices among Malaysian undergraduates. The statistically significant association between gender and STEM major choice in this study conforms with previous studies (e.g., Evans et al., 2020; Jeffries et al., 2020). Further, it was found that the male undergraduates chose Engineering and Technology while the female undergraduates chose Science and Mathematics. The male undergraduates' preference for Engineering and Technology is also consistent with previous studies where STEM was found to be a masculine domain (Jeffries et al., 2020). Although contrary to the study by Jeffries et al. (2020) where Science is regarded as a male dominated subject, the female undergraduates' preference for Science in this study is reflective of the observation made by Evans at al. (2020) that the number of female students in the Sciences has increased. In addition, the female undergraduates' choice of Mathematics is in contrast to the study by Kaleva et al. (2019).

The statistically significant association between the core ethnic groups in Malaysia and the undergraduates' choice of STEM majors is consistent with literature (Fry et al., 2021; Jeffries et al., 2020). In specific, this study discovered that undergraduates from the Malay community preferred Science while undergraduates from the Chinese community preferred Engineering. Although this study found that there is an inclination for the undergraduates from the Indian community to choose Science but within the Science major, the percentage of Indian students are low. The fourth sustainable development goal calls for inclusion in quality education and so policy makers need to look into this imbalance among the different ethnic groups. Understanding the factors that

motivate the different groups' tendency to choose different STEM majors is important in achieving a more well distributed ethnics in the different STEM careers. Especially being a multi racial country, equality and inclusion in the education systems are crucial in achieving stability and harmony that can propel the nation's economic growth.

This study also found a statistically significant association between the students' high school grades and STEM major choice. Moreover, the respondents largely chose Science major for their undergraduate studies regardless of their ethnicity and their performance in high school subjects. Both observations are similar to Sasson's (2021) study that showed a positive and significant correlation between students' specialized subjects in high school and their career choice. It is also encouraging to observe the affinity towards Science majors demonstrated by the Malay and Indian undergraduates. As said by Razali et al. (2020), motivation to learn Science is the drive in the development of students' interest in STEM careers. The other way around, the growth of positive attitude towards STEM increases students' interest in Science (Razali et al., 2020).

Implications of Study

The statistically significant associations observed in this study between gender, ethnicity and high school grades with STEM major choice are aligned with the purpose of this study that investigates the chosen variables as determinants of STEM major choice. The results of this study generally agree with literature although some discrepancies were noted as discussed above. Thus, further studies should look into the involvement of mediating factors such as self-efficacy, attitudes and other influences in the effects that the determinants have on STEM major choice. It is also suggested to investigate the relationship between the determinants in influencing undergraduates STEM major choices. For instance, a potential study is to investigate if female students' major choice in all three ethnic groups are the same.

Another limitation of this study is that the analyses were carried out for individual major choices whereas some students have selected more than one major. For instance, some of the respondents' choice showed combination of Science and Technology, combination of Science, Technology and Engineering, and even combination of Science, Technology, Engineering and Mathematics. Further analyses can help to determine if choosing one STEM major or multiple STEM majors will change the results of this study. It is also noted that the different percentages of male and female students in this study could have an effect on the results hence a larger and a more representative sample can be considered in future research.

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