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Ethnic Disparities and Socioeconomic Factors in STEM Education in Malaysia: Towards Inclusive Practice

Perbezaan Etnik dan Faktor Sosioekonomi dalam Pendidikan STEM di Malaysia: Ke Arah Amalan Inklusif

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ABSTRACT

The pursuit of Science, Technology, Engineering, and Mathematics (STEM) education has become essential for the economic and social advancement of nations in the modern world. However, in multiracial countries such as Malaysia, the impact of ethnicity on access to, engagement with, and success in STEM fields presents significant challenges. Advancing from a previous study, this paper investigates the relationship between ethnicity and STEM education in Malaysia, with a specific focus on the influence of parents' socio-economic status and its effects on students' performance in STEM subjects. Purposive sampling was used to identify 300 respondents from the higher learning institutions in all the five regions in Malaysia. Data collected through a validated survey questionnaire was analyzed using the Chi Square test to determine if there are significant associations between students' grades in the STEM subjects and the socio-economic factors, for different ethnicities. This study found that students from different ethnic backgrounds are affected by socio-economic factors in different ways, particularly in science and mathematics subjects. In addition to ethnic disparities in parents' socio-economic status, inequalities in access to educational resources, financial support, and school environments also contribute to differences in STEM performance. These findings offer valuable insights into the underlying reasons for such outcomes and highlight potential areas for strategic intervention. To address these issues and to foster a more balanced and fair educational landscape in STEM disciplines across Malaysia, the paper offers strategies for promoting inclusivity and ensuring equitable opportunities for all students, regardless of their ethnic backgrounds.

Keywords: equity; ethnic diversity; holistic education; inclusive education; socio-economic status

ABSTRAK

Pemperolehan ilmu di dalam bidang Sains, Teknologi, Kejuruteraan, dan Matematik (STEM) telah menjadi sangat penting untuk kemajuan ekonomi dan sosial negara-negara di dunia moden. Walau bagaimanapun, di negara berbilang kaum seperti Malaysia, kesan etnik terhadap akses, penglibatan, dan kejayaan dalam bidang STEM memberikan cabaran yang ketara. Lanjutan daripada kajian terdahulu, kertas ini menyiasat hubungan di antara etnik dan pendidikan STEM di Malaysia, dengan tumpuan khusus kepada pengaruh status sosio-ekonomi ibu bapa dan kesannya terhadap pencapaian pelajar dalam subjek STEM. Persampelan bertujuan telah digunakan bagi mengenal pasti 300 responden di institusi-institusi pengajian tinggi daripada lima wilayah utama di Malaysia. Data yang diperoleh melalui soal selidik yang telah disahkan kesahihannya dianalisis menggunakan ujian Chi Square untuk menentukan sama ada terdapat hubungan yang signifikan antara pencapaian pelajar dalam subjek-subjek STEM dengan faktor sosio-ekonomi untuk latar belakang etnik yang berbeza. Kajian ini mendapati bahawa pelajar dari latar belakang etnik yang berbeza dipengaruhi oleh faktor sosio-ekonomi dengan cara yang berbeza, terutamanya dalam subjek seperti sains dan matematik. Selain daripada perbezaan etnik pada status sosio-ekonomi ibu bapa, perbezaan pada akses kepada sumber pendidikan, sokongan kewangan, dan persekitaran sekolah juga menyumbang kepada perbezaan dalam prestasi STEM. Penemuan ini memberikan pandangan yang berharga mengenai sebab-sebab yang mendasari hasil tersebut dan menyerlahkan bahagian-bahagian yang berpotensi untuk campur tangan strategik. Untuk menangani isu perbezaan etnik di dalam pendidikan STEM, kertas ini mencadangkan beberapa strategi yang bertujuan untuk mempromosikan inklusiviti dan memastikan peluang yang saksama untuk semua pelajar, tanpa mengira latar belakang etnik mereka.

Kata kunci: ekuiti; kepelbagaian etnik; pendidikan holistik; pendidikan inklusif; status sosio-ekonomi

INTRODUCTION

Cultural diversity is the umbrella term for racial diversity, ethnic diversity, diversity in language and diversity in religion, among others. Cultural diversity or multiculturalism includes differences in beliefs, ideals, values, morals, behaviours, principles and traditions. Meanwhile, ethnic diversity refers to different ethnic groups within a population. Simply put, cultural diversity refers to the differences in the ways of life while ethnic diversity refers to the group of people whose different ways of life create cultural diversity. Cultural diversity is the existence of different cultures and perspectives in a society or organization while ethnic diversity refers to the representation of different ethnic groups within a population. In educational settings, cultural diversity is important and is an advantage because it makes learning environment more colorful and dynamic. The exchange of learners' ideas, thoughts and perspectives in culturally diverse classrooms allows them to have an enriching experience and to receive valuable knowledge. Having a diversified curriculum is one way to support cultural diversity in education. This includes discussing examples and case studies from different parts of the world and analysing or understanding them from different cultural perspectives and constraints. In addition, educational contents must be inclusive and sensitive to the different cultures to reduce educational disparities (Alam & Mohanty, 2023).

Cultural diversities studies in education are aplenty (e.g., Alam & Mohanty, 2023; Din et al., 2021; Sari & Talib, 2024). Alam and Mohanty (2023) quoted countries like Finland and Japan that promotes comprehensive and holistic education while the education system in countries such as India and Bangladesh recognize learners' talents and efforts instead of having a preconceived notion about the learners' abilities. For instance, Finland which practices progressive education that promotes inclusive learning and equal opportunities in a heterogeneous environment, leverages student diversity to attain holistic education by using the students' individual strengths as an asset. Cultural values and societal attitudes play a significant role in shaping the way different ethnic groups perceive STEM education. Some ethnic groups may have a cultural bias that prioritizes careers in arts, humanities, or business and STEM careers may be seen as deviated from local traditions or cultural expectations, creating an additional barrier to participation. Racial stereotypes can also influence students' self-concept and their willingness to pursue STEM education. Stereotypes, such as the model minority myth applied to Asian students can perpetuate negative expectations and impact students' STEM identity (Kuo et. al., 2024). These stereotypes pressure students from underrepresented ethnic groups to conform to societal stereotypes about their abilities, leading to anxiety and reduced performance. Fostering an inclusive and supportive environment is crucial for ensuring all students, regardless of ethnicity, feel accepted and encouraged in STEM classrooms.

Historically, STEM fields have been dominated by particular ethnic groups, often reflecting broader societal power dynamics and socio-economic stratification. In the United States, for example, the dominance of White and Asian students in STEM disciplines contrasts with the underrepresentation of African American, Hispanic, and Native American students. Similarly, in the United Kingdom, there are significant differences in STEM participation between ethnic groups, in particular among the Black students (Greaves et al., 2021). A number of studies have found that racial and ethnic disparities continue to be a challenge in STEM education (e.g., Costello et al., 2023; Greaves et al., 2021; Santana et al., 2024). By creating inclusive environments, providing mentorship, reforming curricula, and implementing supportive policies, educational systems can foster greater diversity in STEM fields. Ultimately, addressing ethnic disparities in

STEM education will not only promote social equity but also drive innovation and growth by tapping into the full potential of a diverse talent pool.

Equity in education happens when the education system provides each student with what is needed for the student to perform at an adequate level. Conversely, unequal distribution of educational resources and opportunities is a serious issue of educational inequity (Alam & Mohanty, 2023). Although STEM education is pivotal in preparing the workforce for the demands of a rapidly advancing technological society, studies show that participation from certain ethnic groups continues to lag behind. The underrepresentation of ethnic minorities in STEM fields remains a persistent issue worldwide. Ethnic disparities in STEM education are often shaped by complex factors, including systemic barriers, socio-economic inequalities, and cultural attitudes toward STEM. As countries strive to build more inclusive and diverse educational systems, understanding the impact of ethnicity on STEM education is critical in addressing these disparities and creating pathways that lead to greater equity in the STEM workforce. For the past three decades, Malaysia has been striving towards universal primary education and the democratization of secondary education (Lee, 2021). The 1980s witnessed a rapid expansion of higher education with the proliferation of higher education institutions, especially the privatized ones (Lee, 2021). Initially, the upper secondary syllabus was divided into two streams, the science stream and the arts stream but with the advent of technology, the former was renamed as science and technology.

The aftermath of the devastating 13 May 1969 tragedy in Malaysia due to ethnic clashes saw the implementation of the New Economic Policy (NEP) to restructure society by diminishing ethnic based occupations and economic classifications (Ravallion, 2020). However, the policy has received criticism and backlashes because it is seen as favouring certain ethnicity and disadvantaging others in the pursuit to upgrade the economically substandard ethnic group. Similarly, although in writings it is stated that the aim of Malaysian education system is to equalize education in order to promote unity among the different ethnic groups, Nasir et al. (2021) boldly pointed out that Malaysian education is highly politicised and ethnic-biased as it openly favours certain ethnic groups only. For instance, the matriculation programs in the public universities are only offered to the Bumiputera students. In fact, Ravallion (2020) argued that despite the various efforts to reduce ethnic inequalities in Malaysia, the country's absolute disparities are comparatively larger than before.

This paper investigates the impact of ethnicity on the relationship between parents' socio-economic status and students' performance in STEM subjects. By considering opportunities that arise from ethnic diversity, Malaysia can establish a more inclusive and equitable STEM education system as stated in UNESCO's (United Nations Educational, Scientific and Cultural Organization) fourth sustainable development goals. This study adds to the existing literature in STEM education research in Malaysia by investigating impact of ethnic diversities, a crucial element in educational policy in a multi-racial country. This sudy builds upon a prior cross-sectional explanatory study that examined the correlation between students' performance in STEM subjects and their parents' socio-economic status.

LITERATURE REVIEW

Although the majority of scholars over the years have defined STEM education as consisting of the four core areas of science, technology, engineering, and mathematics (e.g., Toma et al., 2024), definitions of STEM education have also evolved in recent years to become more logical and holistic. Especially as STEM education moves forward from a silo approach to an integrated approach, any other subjects or courses related to the four main subjects and is a division of these main areas such as chemistry, computer science and biochemistry, are also considered as STEM education (e.g., Roehrig et al., 2021). While the agenda of STEM in the technologically advanced countries have been guided by political and economic motives, strengthening STEM education has been the main focus in the developing nations (Krishnan et. al., 2023). The bibliometric analysis conducted by Zhan et al. (2022) revealed that the initial stage of STEM education research, that is between 2004 and 2007, focused solely on the education aspects. Moving on, in the second and third stages, that is between 2008 and 2017, interdisciplinary and multidisciplinary integration was the focus. From 2018 onwards, STEM education research has been focused on technological integration rather than disciplinary integration.

Be it in the Western countries or the Asian countries, STEM education is evolving rapidly including research and publication in this field (Zhan et al., 2022). Research was initially prominent in the United States, United Kingdom, Australia and Germany but in just a few years, that is by 2013, the Asian countries including Malaysia and China actively produced journal articles in STEM education. Further, Zhan et al. (2022) found that the top four most popular themes in STEM education research are educational equity, pedagogy, empirical effects and career development. In particular, educational equity included keywords such as gender, race and diversity. Research concerning gender and racial equality are especially important to address the social issues in STEM education (Zhan et al., 2022). In their study, Costello et al. (2023) found that gender disparities and ethnic disparities led to disparities in aspiration and attrition in STEM education respectively. While gender disparity resulted in fewer females compared to males pursuing STEM studies and careers, ethnic disparity caused lower percentage of STEM graduates from certain ethnic groups due to various challenges including limited academic opportunities (Costello et al., 2023).

The report by Fry et al. (2021) revealed that certain ethnic groups in the United States continue to be underrepresented in STEM workforce. A major contributing factor is the lesser number of graduates in STEM fields among these ethnic groups. While Montalvo and Reynal-Querol (2021) stated that the relationship between ethnic heterogeneity and a country's economic growth has been found to be statistically insignificant, they maintained that the case is different at city levels. One of the key factors influencing ethnic disparities in STEM education is socio-economic status. Ethnic minority groups, particularly those from lower-income backgrounds, often face financial barriers that limit their access to advance STEM resources, such as extracurricular activities, tutoring, and technology. The lack of exposure to STEM fields during formative years often results in reduced confidence and interest in pursuing STEM careers later in life. Additionally, ethnic minorities may also experience a lack of familial or community support in STEM fields due to historical underrepresentation of role models in STEM professions. Ethnic disparities in STEM education poses significant challenge that requires concerted efforts from educational systems, communities, and policymakers. While the barriers to participation are substantial, there are also many opportunities to encourage and promote inclusivity.

In the earnest pursuit of the status of a developed nation, Malaysia strives towards a STEM-driven economy. Education being the ultimate transformation tool, the Malaysia Education Blueprint 2013–2025 provides the guiding principles in fostering STEM culture at different levels from pre-school to graduate schools and the introduction of a new secondary school science curriculum in 2017. However, the 2020 Organization for Economic Cooperation and Development (OECD) report notes that inequality and disparities issues in educational outcomes in Malaysia requires a great deal of attention (Idris & Bacotang, 2023). Research and writings on racial disparities in Malaysia have involved economic issues including income inequalities and poverty dynamics (e.g., Rongen et al., 2024), political studies (e.g., Mohiuddin, 2024), financial aspects (e.g., Wee & Goy, 2022) and health related studies (e.g., Muhammad Azami et al., 2023). Moreover, despite the country's many initiatives and efforts to improve its' STEM education such as the National Science Centre, The National STEM Action Plan and the National Science, Technology and Innovation Policy, the number of students choosing to pursue STEM related studies has been declining due to various problems including limited resources and gender gaps (Idris et. al., 2023).

Challenges of STEM education in Malaysia mentioned by past research are lack of qualified STEM teachers, limited facilities and infrastructure, and low and ineffective usage of technology in STEM classrooms. In addition, lack of awareness and understanding of STEM education and the challenges of integrating STEM into other subjects are also obstacles of STEM education (e.g., Hoon et al, 2022; Ramli et al., 2022). The review of STEM education research in Malaysia from year 1999 to year 2013 by Jayarajah et. al. (2014) identified ten research areas which are: (1) use of ICT as teaching tool, (2) teaching and learning, (3) learning strategies, (4) gender, (5) interest and motivation, (6) innovation, (7) assessment, (8) problem solving, (9) TIMSS, and (10) other issues. The bibliometric analysis from year 2004 to year 2021 by Zhan et al. (2022) shows that Malaysia is at the eighth place in the list of countries with the highest number of publications in STEM education. In accordance to the research trend shows that global concern for inclusivity and the need for studies on ethnicities, this issue must be given importance by Malaysian STEM education researchers especially since ethnic issues are predominantly discussed in the Western countries (Zhan et al., 2022). This is important because countries such as Korea, Japan and Finland that prioritizes inclusive education have continuously excelled in international educational assessments such as PISA and TIMMS (Alam & Mohanty, 2023) whereas Malaysia's position in these international assessments have been declining.

Being a pluralistic nation, Malaysia's heterogeneous population presents a challenge in achieving sustainable development (Patras et al., 2022). In order to overcome the challenges due to multiculturalism, Patras et al. (2022) recommended strategies including consistency in policies and practices, practice of multiculturalism in its true sense, embedding universal values into societal culture and implementing multiculturalism in education. Malaysia's poor performance in international rankings is a concern because a substantial amount from the national budget has been allocated for tertiary education. Higher education institutions in Malaysia should consider amending their strategic planning to leverage on the strength of the different ethnic groups in different aspects of STEM education (Adnan et al., 2024).

RESEARCH DESIGN

RESEARCH OBJECTIVE

This study is a furtherance of a previous cross-sectional explanatory study by Krishnan et al. (2023) that investigated the relationship between students' performance in STEM subjects and the parents' socio-economic status. Using Chi-Square analysis, the previous study found significant associations between: (i) students' performance in science and their mothers' education level, (ii) students' performance in science and their parents' income, (iii) students' performance in engineering and their fathers' education levels, (iv) students' performance in mathematics and their fathers' education levels, (v) students' performance in mathematics and their mothers' education levels, (vi) students' performance in mathematics and their fathers' occupations, (vii) students' performance in mathematics and their mothers' occupations, and (viii) students' performance in mathematics and their parents' income. In short, the parents' socio-economic status influenced students' performance in mathematics mostly. In this study, these associations are further investigated for the main ethnic groups in Malaysia.

RESEARCH QUESTIONS

This study has three research questions which are:

(1) Are there associations between parents' education levels and students' performance in STEM subjects for the different ethnic groups in Malaysia?
(2) Are there associations between parents' occupations and students' performance in STEM subjects for the different ethnic groups in Malaysia?
(3) Are there associations between parents' income and students' performance in STEM subjects for the different ethnic groups in Malaysia?

RESEARCH VARIABLES

This study used the quantitative non-experimental cross-sectional explanatory design. While the dependent variables and the independent variables are maintained, a moderating variable is introduced in this study. With reference to Figure 1, the independent variable is the parents' socio-economic status comprising of three constructs which are parents' education levels, parents' occupations, and parents' income. The dependent variable is students' performance in STEM subjects which is measured using their grades in subjects' science, technology, engineering and mathematics. In addition to the previous study, this study introduces ethnicity as the moderating variable. The moderating variable ethnicity better explains the relationship between students' performance and parents' socio-economic status and reveals whether the previously established associations remain true across different ethnic groups.

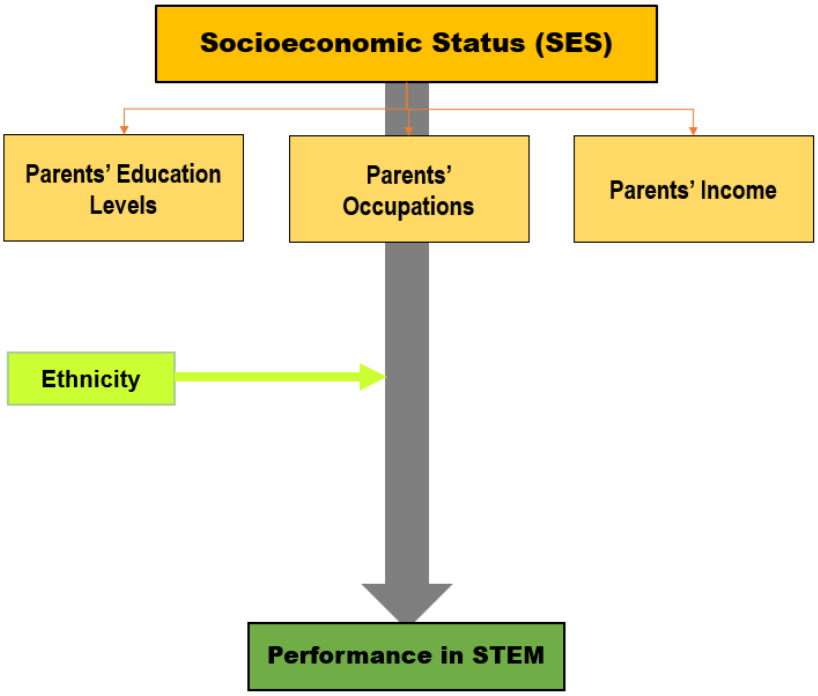

FIGURE 1. Research variables

RESEARCH SAMPLE

This study involved 300 undergraduates from the private and public universities in the main five regions in Malaysia. Table 1 displays the number of respondents from the different regions.

TABLE 1. Number of respondents from the different regions

Regions	States	Number of participants (%)
Central	Selangor, Putrajaya, federal territories of Kuala Lumpur	131 (43.67%)
Southern	Negeri Sembilan, Melaka, Johor	57 (19.00%)
Northern	Perlis, Kedah, Penang, Perak	22 (7.33%)
East Coast	Kelantan, Pahang, Terengganu	83 (27.67%)
West Coast	Sabah, Sarawak	7 (2.33%)
	Total	300

In this study, the multi-racial population of Malaysian students is segregated into four groups that are the three main groups consisting of the Malay, Chinese and Indian, and other than these three main ethnic groups. As of July 2024, it is reported that 70.4% of the Malaysian population are Bumiputera (that is the Malays and the indigenous people), 22.4% are Chinese, 6.5% are Indians and the rest is classified under other ethnic groups (Siddharta, 2024). It has to be noted that in this study, non-Malay Bumiputera are grouped under the others category. Table 2 shows the distribution of male and female respondents for the different ethnic groups. The total percentage of male respondents and female respondents are 33.67% and 66.33% respectively. The percentages of respondents based on the ethnic groups are 74.0% Malays, 12.0% Chinese, 8.67%

Indians and 5.33% from other ethnic groups. The percentages of respondents from the different ethnic groups are somewhat reflective of the Malaysian population as mentioned above.

TABLE 2. Distribution of sample respondents based on gender and ethnicity

	Malay	Chinese	Indian	Others	Total
Male	65	19	13	4	101
Female	157	17	13	12	199
Total	222	36	26	16	300

INSTRUMENTATION AND DATA COLLECTION

The original instrument is a survey questionnaire consisting of two parts whereby data from the first part is used for this study. Parts of the questionnaire particularly the items relevant to this study are attached in the Appendix. Apart from demographic details such as gender, race and parents' occupations, information about students' grades in the STEM subjects were also obtained. Data was collected: (1) physically through direct contact with the respondents, and (2) virtually through Google forms with links sent out to identified possible respondents. The instrument has a Cronbach's alpha value of 0.78 which is higher than the standard threshold of 0.70. Thus, the instrument is reliable for the purpose of this study.

DATA ANALYSIS AND RESULTS

The Chi-Square test of independence was employed in this study to examine whether statistically significant associations exist between students' academic performance and various parental socioeconomic factors, including academic qualifications, occupations, and income levels. This non-parametric test is appropriate for analyzing categorical data, making it ideal for assessing relationships between students' grades that are categorized into distinct performance levels and parental background variables, whihc are also defined categorically. By evaluating the observed frequencies of grade distributions across different categories for the predictors of the parents' socio-economic status against the expected frequencies under the assumption of independence, the Chi-Square test helps determine whether these variables are associated or independent. A significant result would indicate that students' academic outcomes are not randomly distributed with respect to parental socioeconomic factors, thus providing insights into how family background may influence educational achievement.

Table 3 shows the distribution of parents' education levels for the different ethnic groups, comprising of both father and mother for every participant. Therefore, in total there are 600 parents. The highest qualifications for most of the parents of the different ethnic groups are at school levels (L2) that are 46.40% (206 out of 444) for the Malay students, 48.61% (35 out of 72) for the Chinese students, 42.31% (22 out of 52) for the Indian students and 59.38% (19 out of 32) for students from the Others category. Furthermore, the percentage of postgraduate parents (L4), in ascending order, are 5.77% (3 out of 52) for the Indian students, 8.33% (6 out of 72) for the Chinese students, 9.23% (41 out of 444) for the Malay students and 9.38% (3 out of 32) for students from other ethnic groups.

TABLE 3. Distribution of parents' education levels based on ethnicity

	Malay (n =222)		Chinese (n = 36)		Indian (n = 26)		Others (n = 16)		Total
	Father	*Mother*	*Father*	*Mother*	*Father*	*Mother*	*Father*	*Mother*	
No formal education	1	2	0	1	3	1	0	0	8
School level	100	106	19	16	11	11	9	10	282
Tertiary level	92	91	12	13	10	13	6	4	241
Post graduate	24	17	3	3	2	1	1	2	53
Others	5	6	2	3	0	0	0	0	16

The previous study showed that there are no statistically significant associations between fathers' education levels and students' performance in science or technology but there are statistically significant associations between fathers' education levels and students' performance in engineering and mathematics. More specifically, Table 4 reveals that there is a statistically significant association between fathers' education levels and students' performance in engineering only for the Chinese ethnic group $\chi^2(25, N = 36) = 37.78, p = 0.049$ and there is statistically significant association between fathers' education levels and students' performance in mathematics only for the Malay ethnic group $\chi^2(42, N = 222) = 256.93, p = 0.000$.

TABLE 4. Association between fathers' education and students' performance in STEM based on ethnicity

		Malay (n = 222)	Chinese (n = 36)	Indian (n = 26)	Others (n = 16)
Science	*Pearson Chi-Square*	32.528	17.205	13.678	15.922
	df	35	15	18	12
	p-value	0.588	0.307	0.750	0.195
Technology	*Pearson Chi-Square*	24.861	33.783	7.270	11.852
	df	28	25	18	12
	p-value	0.635	0.113	0.988	0.458
Engineering	*Pearson Chi-Square*	18.331	37.777	20.713	18.154
	df	28	25	36	12
	p-value	0.918	0.049	0.981	0.111
Mathematics	*Pearson Chi-Square*	256.929	23.205	17.054	11.711
	df	42	20	30	12
	p-value	0.000	0.279	0.972	0.460

The previous study showed that there are no statistically significant associations between mothers' education levels and students' performance in engineering and technology but there are statistically significant associations between mothers' education levels and students' performance in science and mathematics. On the contrary, the present study revealed that there is a statistically significant association between mothers' education levels and students' performance in mathematics, but not in science. In addition, the association between mothers' education levels and

students' performance in mathematics is found only for the Malay ethnic group $\chi^2(42, N = 222) = 131.522, p = 0.000$, as seen in Table 5.

TABLE 5. Association between mothers' education and students' performance in STEM based on ethnicity

		Malay (n = 222)	Chinese (n = 36)	Indian (n = 26)	Others (n = 16)
Science	*Pearson Chi-Square*	30.589	16.931	5.432	13.387
	df	35	18	15	9
	p-value	0.681	0.528	0.988	0.146
Technology	*Pearson Chi-Square*	21.839	29.306	4.839	7.467
	df	28	30	15	9
	p-value	0.789	0.502	0.993	0.589
Engineering	*Pearson Chi-Square*	31.501	43.556	13.715	8.615
	df	28	30	30	9
	p-value	0.295	0.052	0.995	0.474
Mathematics	*Pearson Chi-Square*	131.522	33.554	16.875	5.013
	df	42	24	25	9
	p-value	0.000	0.093	0.886	0.833

Table 6 shows the distribution of parents' occupations for the different ethnic groups whereby most of the parents are managers (J1) and professionals (J2). In specific, 27.48% (122 out of 444) of the Malay parents and 30.77% (16 out of 52) of the Indian parents are professionals (J2) while 25% (18 out of 72) of the Chinese parents are managers (J1). The others category (J11) includes missing data and those who never worked. Table 6 implies that ethnicity diversity has an impact on their occupations, as suggested by previous researchers (e.g., Fry et al., 2021; Ravallion, 2020). For example, there are no Chinese or Indian parents in the armed forces (J10) whereas the percentage of Malay parents in the armed forces (J10) is 3.38% (15 out of 444). Another example is there are only 2.78% (2 out of 72) and 3.85% (2 out of 52) of Chinese and Indian parents respectively in the craft related trades (J7) but there is 5.63% (25 out of 444) of Malay parents in this job category. The categorization in Table 6 follows the International Standard Classification of Occupations (ISCO) of the United Nations.

TABLE 6. Distribution of parents' occupations based on ethnicity

	Malay (n = 222)		Chinese (n = 36)		Indian (n = 26)		Others (n = 16)		Total
	Father	*Mother*	*Father*	*Mother*	*Father*	*Mother*	*Father*	*Mother*	
Managers	27	11	11	7	4	3	2	1	66
Professionals	54	68	3	5	7	9	2	3	151
Technicians and associate professionals	19	3	5	1	4	0	3	1	36
Clerical support workers	8	14	0	3	1	3	1	0	30
Service and sales workers	13	13	5	3	2	1	1	1	39

Skilled agricultural, forestry and fishery workers	10	1	2	1	1	0	0	0	15
Craft related trades workers	18	7	2	0	2	0	0	0	29
Plant and machine operators, and assemblers	8	4	2	1	1	0	0	1	17
Elementary occupations	10	6	2	1	2	0	1	0	22
Armed forces occupations	12	3	0	0	0	0	2	0	17
Others	43	92	4	14	2	10	4	9	178

The previous study showed that there is a statistically significant association between parents' occupations and students' performance in mathematics. Further, this study found that this statistically significant association exist for the Malay and Indian students. However, for the Indian parents, the statistically significant association was only found among the fathers. With reference to Table 7 and Table 8, there are statistically significant associations between fathers' occupations and students' performance in mathematics $\chi^2(66, N = 222) = 133.23, p = 0.000$ and between mothers' occupations and students' performance in mathematics $\chi^2(66, N = 222) = 93.93, p = 0.014$ for the Malay students. There is also a statistically significant association between fathers' occupations and students' performance in mathematics among the Indian students $\chi^2(45, N = 26) = 65.13, p = 0.026$. An additional information obtained from Table 8 which was not found in previous study is that there is a statistically significant association between mothers' occupations and students' performance in science for the Malay ethnic group $\chi^2(55, N = 222) = 84.71, p = 0.006$.

TABLE 7. Association between fathers' occupations and students' performance in STEM based on ethnicity

		Malay (n = 222)	Chinese (n = 36)	Indian (n = 26)	Others (n = 16)
Science	*Pearson Chi-Square*	46.648	23.843	24.416	17.533
	df	55	24	27	21
	p-value	0.781	0.471	0.607	0.678
Technology	*Pearson Chi-Square*	23.840	46.459	19.190	18.370
	df	44	40	27	21
	p-value	0.994	0.224	0.863	0.625
Engineering	*Pearson Chi-Square*	37.191	32.681	49.214	12.923
	df	44	40	54	21
	p-value	0.756	0.788	0.659	0.911
Mathematics	*Pearson Chi-Square*	133.228	27.248	65.129	31.200
	df	66	32	45	21

	p-value	0.000	0.706	0.026	0.070

TABLE 8. Association between mothers' occupations and students' performance in STEM based on ethnicity

		Malay (n = 222)	Chinese (n = 36)	Indian (n = 26)	Others (n = 16)
Science	*Pearson Chi-Square*	84.709	24.953	18.044	24.652
	df	55	27	12	15
	p-value	0.006	0.577	0.114	0.055
Technology	*Pearson Chi-Square*	40.074	55.054	4.975	14.420
	df	44	45	12	15
	p-value	0.641	0.145	0.959	0.494
Engineering	*Pearson Chi-Square*	47.908	37.745	17.073	17.641
	df	44	45	24	15
	p-value	0.317	0.770	0.846	0.282
Mathematics	*Pearson Chi-Square*	93.926	46.165	19.813	19.911
	df	66	36	20	15
	p-value	0.014	0.119	0.470	0.175

Table 9 shows the distribution of parents' income for the different ethnic groups whereby the salary range follows the household income classification in Malaysia. Most of the Malay and Indian parents' income are in the B40 group (at most RM4,850) that is 48.20% (107 out of 222) and 50.0% (13 out of 26) respectively. Meanwhile, most of the Chinese parents' income are in the M40 group (between RM4,851 and RM10,970) that is 52.78% (19 out of 36) of them. The percentage of parents' income in the T20 group (at least RM10,971), in ascending order, is 7.69% (2 out of 26) of the Indian parents, 13.89% of the Chinese parents (5 out of 36) and 20.27% (45 out of 222) of the Malay parents.

TABLE 9. Distribution of parents' income based on ethnicity

	Malay (n = 222)	Chinese (n = 36)	Indian (n = 26)	Others (n = 16)	Total
At most RM 4,850	107	12	13	7	139
Between RM 4,851 and RM 10,970	70	19	11	7	107
At least RM 10,971	45	5	2	2	54

The previous study showed that students' performance in science and mathematics are significantly associated with their parents' income. In contrast to the earlier finding, Table 10 reveals that when the parents' income are investigated from the perspective of ethnicity, there is no significant associations between income and students' performance in STEM subjects.

TABLE 10. Association between parents' income and students' performance in STEM based on ethnicity

		Malay (n = 222)	Chinese (n = 36)	Indian (n = 26)	Others (n = 16)
Science	*Pearson Chi-Square*	12.216	9.650	2.999	3.543
	df	10	6	6	6

	p-value	0.271	0.140	0.809	0.738
	Pearson Chi-Square	15.009	9.937	1.778	3.810
Technology	*df*	8	10	6	6
	p-value	0.059	0.446	0.939	0.702
	Pearson Chi-Square	5.317	9.807	14.436	9.846
Engineering	*df*	8	10	12	6
	p-value	0.723	0.458	0.274	0.131
	Pearson Chi-Square	13.727	8.461	7.277	6.400
Mathematics	*df*	12	8	10	6
	p-value	0.318	0.390	0.699	0.380

DISCUSSION AND CONCLUSION

In the context of STEM education research, the Chi-Square test of independence was utilized to explore potential associations between students' academic performance and key parental background variables including academic qualifications, occupational status, and household income. These variables are often linked to educational outcomes, and understanding their influence is especially critical in efforts to promote equity and inclusitivity in STEM fields. The Chi-Square test is well-suited for this analysis, as it investigates possible associations between categorical variables. In this study, the categorical variables are students' grade and the socioeconomic characteristics of their parents. By analyzing the associations between students' performances and parents' soci-econiomic status across different ethnic groups, the test identifies whether patterns of achievement are statistically independent of family background where ethnicity is concerned. Identifying significant associations can help educators and policymakers better understand how socioeconomic factors shape STEM learning outcomes and inform strategies to support underrepresented or disadvantaged student populations.

In the previous study, statistically significant associations were found between parents' socio-economic status and the students' performance in STEM subjects, albeit not for all the constructs of the study. This study further investigated these associations for the different ethnic groups in Malaysia, predominantly the Malay, Chinese and Indian ethnic groups. While the independent variable and the dependent variable remained the same as the previous study, the moderating variable in this study is ethnicity. Using the Chi-Square tests for association, this study found statistically significant association between fathers' education levels and students' performance in engineering for the Chinese ethnic group and statistically significant association between fathers' education levels and students' performance in mathematics for the Malay ethnic group. In addition, statistically significant association between mothers' education levels and students' performance in mathematics was found also for the Malay ethnic group.

As to association between parents' occupations and students' performance in STEM subjects, this study found statistically significant associations between both parents' occupations and students' performance in mathematics for the Malay ethnic group. Additionally, this study also revealed that there is are statistically significant associations between fathers' occupation and students' performance in mathematics for the Indian ethnic group and between mothers' occupation and students' performance in science for the Malay ethnic group. However, in contrast to the previous study, this study did not find any associations between parents' income and students' performance in STEM subjects, for the different ethnic groups. In conclusion, this study

found that students belonging to the Malay ethnicity largely contributes towards the performance in mathematics. In particular, the performance of students from the Malay ethnic group, in Mathematics, is significantly associated to their parents' education levels and their parents' occupations. Further, the socio-economic status of the Malay students influences their performance in science while the socio-economic status of the Chinese students and Indian students contribute toward performance in engineering and mathematics respectively.

A limitation of this study is that the use of multiple Chi-Square analyses may have increased the error rate, specifically the Type I error rate. To control this error rate, future studies can consider using multiple comparison correction methods such as the Bonferroni correction or the Holm-Bonferroni method. In addition, use of Chi-Square analysis alone may not be sufficient because mediating variable implies causal pathways while the Chi-Square analysis shows associations between two categorical variables. While the introduction of ethnicity as a potential mediating variable adds a valuable dimension to the analysis of the relationship between students' performance in STEM subjects and their parents' socio-economic status, the present study employs Chi-Square tests to explore primary associations among the categorical variables involved. Given the exploratory nature of this phase, the focus remains on identifying significant pairwise relationships. Although logistic regression or mediation modeling may offer a more nuanced understanding of indirect effects and causal pathways, since these analyses are not in the current scope. However, future writings will extend these findings by employing multivariate techniques to formally test mediation effects and further elucidate the underlying mechanisms.

IMPLICATIONS OF STUDY AND POLICY RECOMMENDATIONS

Vernacular schools in Malaysia, particularly Chinese and Tamil medium schools have garnered attention for their distinctive educational approaches and their impact on students' performance in STEM subjects. These schools often offer a bilingual or trilingual curriculum, which may contribute to enhanced cognitive skills and academic performance. Research showed that students from vernacular schools tend to outperform their peers in national examinations, including in STEM subjects. For instance, students from Chinese-medium schools often exhibit higher proficiency in mathematics and science compared to those from national schools. This advantage is attributed to factors such as a rigorous curriculum, a culture of academic excellence, and strong community support. However, challenges persist in integrating vernacular school students into the broader national STEM agenda.

In the latest 2022 Programme for International Student Assessment (PISA) results, Malaysia's score in mathematics dropped from 440 in 2018 to 409. Worse, almost all the students have become weaker in mathematics and their mathematics scores are lower than the OECD average. More seriously, the scores of high-achievers declined more compared to the scores of the low-achievers. Similarly, in the latest 2023 Trends in International Mathematics and Science Study (TIMSS) results, Malaysia's scores in mathematics dropped from 461 in 2019 to 411. Malaysia's scores in science also dropped in both international assessments. In PISA, Malaysia's performance dropped from 438 points to 416 points and in TIMMS Malaysia's performance dropped from 465 points to 426 points. This study revealed that the largest ethnic group in Malaysia have a major contribution to the performance in mathematics and science. As such, some new strategies have to be implemented to enhance the learning of science and mathematics among students from this group in particular, while not neglecting students from other ethnicities.

The Malaysia Education Blueprint (2013–2025) aims to increase student participation in STEM fields, yet disparities in resources and opportunities between urban and rural schools continue to affect outcomes. A report by the Academy of Sciences Malaysia (2023) highlighted that nearly half of the science teachers in the country lack a bachelor's degree, and infrastructure issues, such as inadequate laboratories and unstable internet connectivity, hinder effective STEM education, particularly in rural areas. Despite these challenges, initiatives like the "Adopt a Kampung" program by Universiti Teknologi Malaysia have been implemented to bridge the rural-urban divide in STEM education. This program has established STREAM (Science, Technology, Reading, Engineering, Arts, and Mathematics) Fun Learning Toy Libraries in rural schools, aiming to enhance student engagement and interest in STEM subjects through interactive learning tools.

While vernacular schools in Malaysia demonstrate strong student performance in STEM subjects, systemic challenges such as teacher qualifications and resource disparities necessitate targeted interventions. Addressing these issues is crucial for achieving the national objectives outlined in the Malaysia Education Blueprint and ensuring equitable access to quality STEM education for all students. There could be further in-depth studies on the learning habits and pattern of the students from different ethnic groups to understand why and how they excel in certain subjects. More importantly, by obtaining a thorough understanding of the challenges faced by the main ethnic group in the learning of mathematics and science, suitable action plans tailored to address these challenges can be implemented. Promoting inclusivity in STEM education requires creating environments that embrace diversity and celebrate different cultural perspectives. Educators play a critical role in shaping the perceptions of STEM disciplines and so by adopting suitable teaching practices and using inclusive curriculum that reflect the diversity of the student population, educators can foster a sense of belonging for all ethnic groups.

A significant opportunity for promoting inclusivity in STEM is through mentorship programs that connect students with STEM professionals from similar ethnic communities. These programs can increase students' belief in their ability to succeed in STEM fields and enhance their retention and success rates. Additionally, activities that help students from ethnic groups that underperform can be implemented at different levels for continuous life-long learning. One such approach is to create collaborative communities within STEM education that provide a platform for different ethnic students to receive mentoring from their successful peers. Policies aimed at diversifying the STEM workforce through targeted recruitment and retention strategies can also help ensure a more equitable representation of ethnicity in STEM professions. Furthermore, universities and research institutions must commit to creating inclusive STEM environments through diversity training for staff and students, implementing support services for ethnic minority students, and prioritizing research on ethnic disparities in STEM education.

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APPENDIX

Dear Student,
We are engaged in a research project to study the relationship between **SES** (**S**ocio **E**conomic **S**tatus) and **STEM** (**S**cience, **T**echnology, **E**ngineering & **M**athematics) education in Malaysia. Please fill-out this questionnaire with the needed information. Be assured that your information will be treated confidentially and data will be presented only in summary forms.
Thank you very much for your time.

Name (optional) : _____

Contact number/e-mail (optional) : _____

I give permission to the researchers to use the information provided in this questionnaire.

_____
Please sign here

Please tick ✓ on **(only) one** of the options.

1. Gender [ ] Male [ ] Female

2. Ethnic group [ ] Malay [ ] Chinese [ ] Indian [ ] other ethnic groups

3. State your **highest school** qualification and year of exam.

	Before 2020	After 2020
[ ] Sijil Pelajaran Malaysia (SPM)	[ ]	[ ]
[ ] Unified Examination Certificate (UEC)	[ ]	[ ]
[ ] Sijil Tinggi Pelajaran Malaysia (STPM)	[ ]	[ ]
[ ] Others (*Please state* _____)	[ ]	[ ]

4. With reference to ***item 3*** above, what are the grades obtained for these subjects (*where applicable*)?

Science	Technology (or Computer related)	Engineering	Mathematics
[ ] A	[ ] A	[ ] A	[ ] A
[ ] B	[ ] B	[ ] B	[ ] B
[ ] C	[ ] C	[ ] C	[ ] C
[ ] D	[ ] D	[ ] D	[ ] D
[ ] E	[ ] E	[ ] E	[ ] E
[ ] F	[ ] F	[ ] F	[ ] F
[ ] not applicable	[ ] not applicable	[ ] not applicable	[ ] not applicable

5. What are your parents' **highest** academic qualification?

	Father	Mother
Not educated	[ ]	[ ]
Primary school	[ ]	[ ]
Secondary school	[ ]	[ ]
Diploma	[ ]	[ ]
Degree	[ ]	[ ]
Masters	[ ]	[ ]
Doctorate	[ ]	[ ]

Others (*Please state* _____)	[ ]	[ ]

6. What is your current field of study related to?
   [ ] Science
   [ ] Technology
   [ ] Engineering
   [ ] Mathematics
   [ ] Others

7. With reference to ***item 6*** above, what are the grades obtained for these subjects for the most recent examination (*where applicable*)?

Science	Technology (or Computer related)	Engineering	Mathematics
[ ] A	[ ] A	[ ] A	[ ] A
[ ] B	[ ] B	[ ] B	[ ] B
[ ] C	[ ] C	[ ] C	[ ] C
[ ] D	[ ] D	[ ] D	[ ] D
[ ] E	[ ] E	[ ] E	[ ] E
[ ] F	[ ] F	[ ] F	[ ] F
[ ] not applicable	[ ] not applicable	[ ] not applicable	[ ] not applicable

8. What are your parents' occupations?

	Father	Mother
Managers	[ ]	[ ]
Professional	[ ]	[ ]
Technicians and associate professionals	[ ]	[ ]
Clerical support workers	[ ]	[ ]
Service and sales workers	[ ]	[ ]
Skilled agricultural, forestry and fishery workers	[ ]	[ ]
Craft related trades workers	[ ]	[ ]
Plant and machine operators, and assemblers	[ ]	[ ]
Elementary occupations	[ ]	[ ]
Armed forces occupations	[ ]	[ ]
Others/not sure which category	[ ]	[ ]

9. What is your parents' estimated combined monthly income?
   [ ] At most RM 4,850 (≤ RM 4,850)
   [ ] Between RM 4,851 and RM 10,970 (RM 4,851 to RM 10,970)
   [ ] At least RM 10,971 (≥ RM 10,971)