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The influence of gender on STEM career choice: A partial least squares analysis

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Abstract

Students' participation in science, technology, engineering, and mathematics (STEM) is still one of the most critical worldwide educational challenges despite efforts to promote STEM. Debates about gender disparities in STEM careers also remain perpetual. Early documented literature suggested shifts in students' STEM choices were due to students' significant others, media exposure and attitude. Therefore, the first aim of this paper was to examine the direct and indirect relationships in a proposed model, and analyze the mediating roles of media exposure and students' attitude in the relationship between subjective norms and STEM career choice intention. The second aim was to analyze the moderating role of students' gender. Respondents of this study were 806 secondary school students in Malaysia. Based on the results from partial least squares structural equation modeling, (i) subjective norms had both direct and indirect influence on students' career choice intention in STEM, (ii) media exposure and students' attitude were significant mediators between subjective norms and career choice intention in STEM, and (iii) gender moderated the influence of subjective norms on media exposure. The findings drawn from this study provide insights into the design and development of STEM initiatives for parents, teachers, and peers by considering the importance of the media, students' attitude, and gender. Recommendations for policy and practice enhancements were suggested for future research directions to support STEM interventions in Malaysia.

Keywords: STEM, Media exposure, Subjective norms, Attitude, Career choice intention, Gender

Introduction

Digital technology has expanded rapidly and it has changed how students receive information and behave (Tirado-Morueta et al., 2023). Many nations around the world have been investing heavily in science, technology, engineering, and mathematics (STEM) fields due to the constant high demand for STEM talents (Dockery et al., 2021; Shin et al.,



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2018). A high-capacity STEM workforce and rapid growth of the STEM industries are believed to guarantee perpetual innovations and growth of a nation. Hence, STEM industries are often seen as the key drivers which escalate a nation's competitiveness and productivity alongside digital advancement (Shin et al., 2018).

However, the shortage of competent STEM talents remains a worldwide challenge and has raised concerns about whether the existing education systems are compatible with the demand of STEM industries (Li et al., 2021). It was mentioned that the effective incorporation of STEM components to the respective education systems can be a solution to this global issue (Navy et al., 2020). Warne et al. (2019) revealed that preparing middle school students for STEM careers is indeed one of the most critical educational challenges in the United States. The educational issue is pressing in the United States not only because it is important to ensure constant economic growth and technological innovation at large, but also to fill vacancies in the STEM workforce (Warne et al., 2019; Wyss et al., 2012).

This is not uncommon in the Asian context because changes in national policies have been attempted in view of the challenges in Asia as well. In developing Asian countries like Indonesia, the government offered lucrative financial incentives for STEM employees to encourage more Indonesian students to pursue careers in STEM (Shin et al., 2018). Shin et al. (2018) also reported that Korea has implemented a national policy for STEM enhancement to attract more students to STEM fields, but it was only effective in the short term.

In Malaysia, STEM reformation has also been implemented to encourage students' participation in STEM. One of the most extensive initiatives was the enactment of the new national curriculum at the secondary level. Alongside the implementation of the new national curriculum, STEM subjects have been made eligible to all upper secondary school students (Form Four and Form Five, equivalent to Year 10 and 11) nationwide (Curriculum Development Division, 2016). In this curriculum, the STEM-oriented curriculum aims to create STEM awareness among all upper secondary school students and to prepare them for STEM careers. STEM subjects offered in Malaysian schools are such as Computer Science, Invention, and Technical Graphic Communication (Curriculum Development Division, 2016).

In view of immense attempts to encourage students' participation in STEM, Li et al. (2021) indicated that there could have been a shift in perception of how students perceive STEM careers in tandem with technological advancement. It was suggested that media and students' close socializers could be particularly important for their STEM career decisions (Li et al., 2021). Besides, Wyss et al. (2012) suggested that adolescents' attitudes and perceptions towards STEM are associated with their exposure to media. Batool and Ghayas (2020) also found that adolescents' career choices can be affected by multiple factors such as parents, teachers, peers, and media.

One of the most popular issues about STEM always surrounds a debatable topic – gender. Discussions on the STEM workforce and education are frequently linked to issues concerning gender disparity, gender gap, gender inequality, gender stereotype, gender discrimination, and underrepresentation of females. For example, Wegemer and Eccles (2019) reported that female representation in the STEM fields remains uneven. Another recent study also found that women perceived mathematics and science industries as unwelcoming because of gender bias (Cardador et al., 2021). While gender issues are widely believed to be a deeply entrenched issue in the STEM fields, it is important to improve our understanding of gender differences in career choices because attributions to professions vary across cultural and subject-specific contexts (Luttenberger et al., 2019). Such understanding would inform administrators, policymakers, and educators to make evidence-based decisions to enhance policies and practices. Therefore, this study seeks to answer these research questions: (i) what is the influence of subjective norms (parents, teachers, and peers), media exposure, and students' attitude towards STEM career choice intention?, (ii) do media exposure and students' attitude mediate the relationship between subjective norms and career choice intention?, and (iii) does gender influence the relationships in the proposed model?

Literature review

According to Chen et al. (2020), students' career choice intention is an indication of their job pursuit after they complete their education. Mokhtar et al. (2016) proposed that students' career intention can be determined through factors such as subjective norms and attitude as presented in the Theory of Planned Behavior. In this theory, subjective norms refer to an individual's perceived social pressure from significant others to perform or avoid a specific behavior (Ajzen, 2002). Based on the review of literature, it was noticed that the most frequently mentioned significant others were parents (Razali, 2021; Sheehan et al., 2018), teachers (Avargil et al., 2020; Kong et al., 2020), and peers (Batool & Ghayas, 2020; Raabee et al., 2019).

This is consistent with findings reported by Hoag et al. (2017) that students regarded parents, teachers, and peers as significant others who had influence over their choices and decisions. Mohtar et al. (2019) also found that parents, teachers, and peers were students' close contacts who offered support to students, and they could ultimately affect students' career choices in the STEM fields. More specifically, it was found in previous research that parental support was significant for STEM career choice among Indonesian students (Shin et al., 2018). It was also explained by Sheehan et al. (2018) that the family environment provided early exposure to STEM concepts, hence promoting their engagement with STEM from young at home. Besides, Avargil et al. (2020) suggested that teachers could also create awareness about career opportunities and increase students' likelihood to pursue

careers in the respective taught subjects. A similar finding is also reported by Batool and Ghayas (2020) that students considered teachers as role models whose encouragement and comments could affect their future career paths. In the same study, students' career choice was influenced by peers (Batool & Ghayas, 2020). Rabee et al. (2019) explained that while the roles of family members were important, the roles of peers also become more crucial as children grow older. This is supported by Brenøe and Zölitz (2020) that peers are students' crucial social environment that shapes their preferences in various aspects such as occupation.

Besides, Gómez-Galán (2020) suggested that technologies and media do not only change how students learn, but also how they develop habits and understanding about their environment. This is because students in primary and secondary education today are digital natives in which technology has an important part in developing their career paths (Ottestad & Gudmundsdottir, 2018). It was reported that students learnt about STEM from the media (Sheehan et al., 2018), and STEM media consumption played a vital role in teenage students' career aspirations (Chen et al., 2022). Batool and Ghayas (2020) also explained in their study that the media could affect students' preferences towards careers as how they were portrayed in media such as television shows, dramas, and songs. Li et al.'s (2021) research also found that students believed they would be able to pursue STEM careers when they received positive information regarding STEM careers via social media. Additionally, Kettunen et al. (2020) described the Internet as the first contact point for students to explore career opportunities. This is supported by Hasin and Nasir (2021) that the Internet was important for students not only for learning but also to seek information about careers. Students are indeed very resourceful that they can also retrieve occupational information from various types of media. These emerging adults use the media, especially the Internet, to gather career information and prepare for future careers (Levine & Aley, 2020). Kricorian et al. (2020) also revealed that students would take the initiative to follow STEM news on social media or websites and watch movies about STEM careers that they perceived useful.

In addition, Badri et al. (2016) suggested that students' willingness to engage in STEM career pathways is associated with their attitude. This is consistent with the Aziz et al.'s (2020) study which found a significant positive relationship between attitude and intention. Attitude is an indication of favorable or unfavorable judgement and individuals were more inclined to choose a career in which they had more favorable judgement (Aziz et al., 2020). James et al.'s (2018) reported that students who showed a positive attitude towards the pharmacy career had greater intention for careers related to the field. A similar finding was also found in Solikhah (2014) that attitude had significant influence on students' career choice intention in accounting context.

As reviewed earlier, many past studies confirmed that subjective norms (parents, teachers, and peers) had a direct influence on students' career choice intention. It was also noticed that media exposure and attitude could have mediating effects between subjective norms and career choice intention. For example, Batool and Ghayas (2020) pointed out that students did not follow their parents' advice uncritically although students perceived them as influential significant others who were wise and reliable. Steinke et al. (2022) also emphasized in their study that information on the media and online resources are seemingly more accessible than in real life for students. Therefore, teachers were recommended to use the media to introduce STEM professions and highlight the achievements of the professionals to reinforce students' sense of STEM belonging (Kricorian et al., 2020). Moreover, Aziz et al.'s (2020) study also confirmed that attitude had a significant mediating effect between subjective norms and intention. This finding is in line with the finding of Al-Swidi et al. (2014) that subjective norms had both direct and indirect effects on intention, and attitude was a significant mediator between subjective norms and intention.

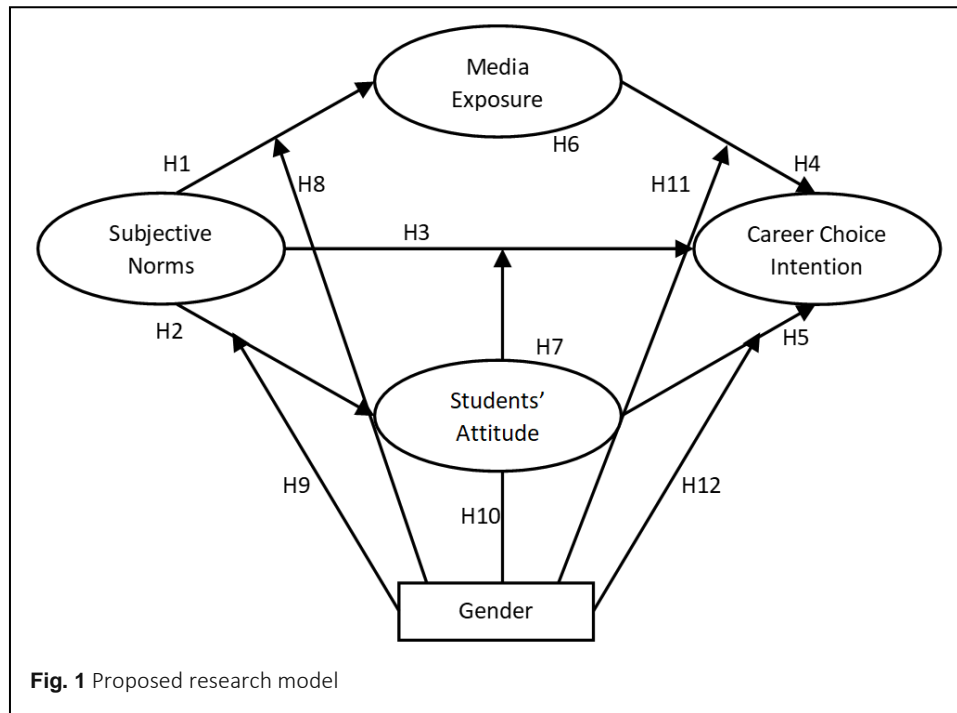
The extant literature frequently discussed the role of gender in the context of STEM career trajectories for students. Most of the research reported that gender gaps and differences in the STEM fields remain undesirable across cultural backgrounds. Luttenberger et al. (2019) emphasized that females in today's Western nations still strongly believe that the STEM fields are male domains. In fact, researchers and policymakers have pointed out that gender gaps in STEM are primarily caused by gender stereotypes. According to Starr and Simpkins (2021), endorsing the gender stereotype that male students were better at mathematics and science could influence students' STEM outcomes including their future decision to pursue advanced STEM courses.

In relation to that, Wang and Degol (2017) found that the pervasive nature of gender stereotypes in the fields of STEM is closely linked to student's school and home environments. They are important sources for students to spark interest in STEM, and transfer gendered-messages related to STEM to students. Students' primary socializers in their school and home environments include parents and teachers (Heyder et al., 2019; Luttenberger et al., 2019), as well as their peers (Brenøe & Zölit, 2020; Tey et al., 2020). While adolescents use cues from their everyday lives and significant others to determine what they should pursue, the media may also associate with their development of gender stereotypes (Starr & Simpkins, 2021). Indeed, gender stereotype has dominated the media and popular cultures. These gender-normative messages are transmitted via various forms of media such as television programs and advertisements, which may lead to changes in attitudes and behaviors (Starr & Simpkins, 2021). Long-term exposure to gender-stereotyped media content and repetition of gendered messages in the media can eventually affect gender beliefs about the actual world (Starr & Simpkins, 2021).

Based on the review of literature, subjective norms (parents, teachers, and peers), media exposure, and students' attitude intrigued the researchers' curiosity to examine how these variables influence students' career choice intention in STEM. The literature has also documented a wide range of research about gender disparities and inequality in STEM, but it is important to improve our understanding of the gender differences in making STEM career choices especially in the context of Malaysia where STEM curriculum has undergone a major reform in recent years.

Therefore, the purpose of this study was to examine students' STEM career choice intention through the lens of subjective norms (parents, teachers, and peers), media exposure, students' attitude, and gender. Specifically, the first aim was to analyze the direct and indirect relationships in the proposed model, and analyze the mediating roles of both media exposure and students' attitude in the relationship between subjective norms and STEM career choice intention. Moreover, the moderating role of students' gender was examined to determine its effect on the causal relationships of the model. A research model (Figure 1) and the hypotheses were formulated based on the objectives and literature review:

- H1: Subjective norms significantly influence media exposure.
- H2: Subjective norms significantly influence students' attitude.
- H3: Subjective norms significantly influence career choice intention.
- H4: Media exposure significantly influences career choice intention.
- H5: Students' attitude significantly influences career choice intention.
- H6: Media exposure mediates the relationship between subjective norms and career choice intention.
- H7: Students' attitude mediates the relationship between subjective norms and career choice intention.
- H8: Gender moderates the relationship between subjective norms and media exposure.
- H9: Gender moderates the relationship between subjective norms and students' attitude.
- H10: Gender moderates the relationship between subjective norms and career choice intention.
- H11: Gender moderates the relationship between media exposure and career choice intention.
- H12: Gender moderates the relationship between students' attitude and career choice intention.



Methods

This study was carried out in accordance with the standard procedures and protocols approved by the Ministry of Education, Malaysia. Prior to data collection, permissions were sought from the ministry, as well as the state educational departments, school authorities, and students' guardians associated with this study. In compliance with the guidelines, students' participation was voluntary and guardians' written informed consent was given.

Data was collected using a bilingual online questionnaire in which students were given the option to answer in either English or Malay (the official language of Malaysia). Three experts in the research areas were invited to review the questionnaire for its face and content validity. This allows the researchers to ensure the items of the survey reflect the aspects being studied in this study are in line with the research objectives. Besides, three language experts were invited for translation and back translation of the survey to ensure language accuracy and to avoid reliability and validity issues related to the instrument (Brace, 2018).

The questionnaire comprised 32 adapted and self-developed items to meet the objectives of this research. The measures adapted for this study are listed in Table 1. In this questionnaire, respondents indicated their responses on a five-point Likert scale, from strongly disagree (1) to strongly agree (5).

Table 1 Referenced sources for questionnaire development

| Constructs | Number of items | Referenced sources |
|-------------------------|-----------------|--|
| Subjective norms | 15 | Ajzen (2002); Francis et al. (2004) |
| Media exposure | 7 | Hoag et al. (2017); Qader and Zainuddin (2011) |
| Students' attitude | 6 | Ajzen (2002); Francis et al. (2004) |
| Career choice intention | 4 | Ajzen (2002); Francis et al. (2004) |

The respondents in this study were 16-year-old adolescents in Malaysia. All of them were Form Four (equivalent to Year 10) students recruited using a proportional stratified sampling approach. Among the 806 respondents, 60.8% ($n = 490$) of them were female, whereas 39.2% ($n = 316$) of them were male.

Results

Structural Equation Modeling (SEM) was used in this study to examine the relationships of the constructs as proposed in the research model. A two-stage analytical procedure was conducted using the SmartPLS 3.2.8 software by Ringle et al. (2015). Through this approach, reliability and validity can be established with a measurement model, whereas hypotheses can be tested with a structural model.

Assessment of measurement model

Construct reliability of the model was assessed with Cronbach's alpha (α), composite reliability (CR), and the average variance extracted (AVE). According to Hair et al. (2017), the recommended threshold values for α and CR indices are 0.70 and 0.50 for AVE respectively. Table 2 shows that the α values of the constructs range from 0.808 to 0.948, while CR values range from 0.858 to 0.962, hence verifying the internal consistency of the constructs. In the same table, it was shown that the AVE values of the construct are larger than the recommended threshold of 0.50 except for media exposure (CR = 0.465). However, AVE is a stringent measure of convergent validity (Malhotra, 2010). This is supported by Fornell and Larcker (1981) that the convergent validity of a construct is adequate and acceptable when AVE is below 0.50, with CR above 0.60. As the CR value of media exposure was above 0.60 (CR = 0.858), the convergent validity of the construct was established.

Table 2 Measurement model assessment

| Constructs | α | CR | AVE | HTMT | | | |
|---------------------------|----------|-------|-------|-------|-------|-------|---|
| | | | | 1 | 2 | 3 | 4 |
| 1 Subjective norms | 0.948 | 0.953 | 0.577 | | | | |
| 2 Media exposure | 0.808 | 0.858 | 0.465 | 0.451 | | | |
| 3 Students' attitude | 0.881 | 0.910 | 0.627 | 0.728 | 0.447 | | |
| 4 Career choice intention | 0.947 | 0.962 | 0.862 | 0.722 | 0.455 | 0.753 | |

At this stage, outer loadings of the constructs were also assessed. Hair et al. (2017) suggested that it is ideal to obtain all loadings larger than 0.708, but it is also common to see outer loadings less than 0.70, especially in social science research. It was suggested to retain the items for content validity if they load between 0.40 and 0.70, unless the AVE and CR values increased after removing the items (Hair et al., 2017; Wong, 2016). Based on the results, all items in the measurement model were retained because the outer loadings of the items ranged from 0.612 to 0.941 (>0.40), and the values of AVE and CR did not increase after removing items that loaded <0.70 .

The discriminant validity of the constructs was verified with the Heterotrait-Monotrait Ratio of Correlations (HTMT) (Henseler et al., 2015). HTMT ratio with values above 0.85 indicates issues of discriminant validity, whereas values below 0.85 suggest the constructs are distinctively different from one another (Hair et al., 2017; Henseler et al. 2015). As presented in Table 2, the constructs were distinctively different from one another as the HTMT values of the constructs range between 0.447 and 0.753 (<0.85). Hence, discriminant validity was not a threat in this study.

Assessment of structural model

In the assessment of the structural model, the Variance Inflation Factor (VIF) was calculated to examine multicollinearity issues. It was found that the highest VIF was 2.238 ($VIF < 5$), implying that there was no multicollinearity issue among the exogenous constructs because the VIF values were smaller than the recommended cut-off (Hair et al., 2017). In Table 3, the results show that all path coefficients were significant because the t -values were larger than 2.58 ($p < 0.01$), and there was no zero straddled between the 95% confidence intervals.

Partial least squares (PLS) SEM was employed to test the hypotheses and the significance of path coefficients (β) was assessed with a bootstrapping setting of 5000 resamples. Table 3 shows that all hypotheses proposed in this study were supported by the results with $p < 0.01$. In specific, subjective norms had a positive significant influence on students'

Table 3 Structural model assessment and hypothesis testing

| Direct Paths | β | SD | t-value | p-value | BC LL | BC UL | Significance |
|-------------------------|---------|-------|---------|---------|-------|-------|--------------|
| H1 SN \rightarrow ME | 0.467** | 0.036 | 13.003 | 0.000 | 0.387 | 0.532 | Yes |
| H2 SN \rightarrow SA | 0.732** | 0.022 | 32.84 | 0.000 | 0.686 | 0.773 | Yes |
| H3 SN \rightarrow CCI | 0.447** | 0.046 | 9.727 | 0.000 | 0.686 | 0.773 | Yes |
| H4 ME \rightarrow CCI | 0.082* | 0.030 | 2.766 | 0.006 | 0.025 | 0.141 | Yes |
| H5 SA \rightarrow CCI | 0.392** | 0.047 | 8.28 | 0.000 | 0.298 | 0.486 | Yes |

Note: $p < 0.01^*$, $p < 0.001^{**}$. t -value > 2.58 for $p < 0.01$; t -value > 1.96 for $p < 0.05$. BC LL: Bias corrected lower level (5%), BC UL: Bias corrected upper level (95%). $VIF < 5$.

Table 4 Coefficient of determination (R^2), predictive relevance (Q^2), and effect size (f^2)

| Constructs | R^2 | Q^2 | f^2 | | |
|-------------------------|-------|-------|----------------|--------------------|-------------------------|
| | | | Media exposure | Students' attitude | Career choice intention |
| Media exposure | 0.218 | 0.068 | | | 0.016 |
| Students' attitude | 0.536 | 0.263 | | | 0.172 |
| Career choice intention | 0.682 | 0.499 | | | |
| Subjective norms | | | 0.202 | 0.324 | 0.289 |

attitude ($\beta = 0.732$, $p < 0.001$), media exposure ($\beta = 0.467$, $p < 0.001$), and career choice intention ($\beta = 0.447$, $p < 0.001$). The results thus supported H1, H2, and H3 of this research. Besides, H4 and H5 were also supported by the results shown in Table 3. Career choice intention was significantly influenced by students' attitude ($\beta = 0.392$, $p < 0.001$) and media exposure ($\beta = 0.082$, $p < 0.01$).

In addition to the assessment of path coefficients, this study also evaluated the coefficient of determination (R^2), predictive relevance (Q^2), and effect size (f^2) of hypothesized causal relationships. Results in Table 4 suggested that 68.2% ($R^2 = 0.682$) of the variance of career choice intention can be explained by the research model of this study. It was also found that the research model explained 53.6% ($R^2 = 0.536$) of students' attitude variance and 21.8% ($R^2 = 0.218$) of media exposure variance.

Stone-Geisser's Q^2 index was used to determine the predictive relevance of the model. Hair et al. (2017) noted that Q^2 values above zero indicate that the exogenous constructs have predictive relevance toward the respective endogenous constructs. As displayed in Table 4, the Q^2 values ranged from 0.068 to 0.499 ($Q^2 > 0$). Therefore, the predictive relevance of the exogenous constructs towards the endogenous constructs (media exposure, students' attitude, and career choice intention) was established. Besides, the effect sizes of the paths were also calculated with f^2 . Cohen (1988) recommended that the magnitude effect size is considered small when $f^2 = 0.02$, medium when $f^2 = 0.15$, and large when $f^2 = 0.35$. Table 4 shows that all paths had medium to large effect ($f^2 = 0.172$ - 0.324) except for media exposure to career choice intention, hence suggesting small effect with $f^2 = 0.016$.

Mediation

In line with the purpose of this study, the mediating relationships of the research model were assessed using the bootstrapping procedure on SmartPLS (Zhao et al., 2010). As shown in Table 5, H6 proposed that media exposure is a mediator between subjective norms and career choice intention, whereas H7 hypothesized students' attitude as the mediator between subjective norms and career choice intention. Based on the results in mediation analysis, it was found that both students' attitude ($\beta = 0.287$, $p < 0.001$) and media exposure ($\beta = 0.038$, $p < 0.01$) were significant mediators between subjective norms

Table 5 Mediation effect testing

| Indirect Paths | Indirect β | SD | t-value | p-value | BC LL | BC UL | Direct β | Mediation |
|----------------|------------------|-------|---------|---------|-------|-------|----------------|-----------|
| H6 SN→ME→CCI | 0.038* | 0.015 | 2.629 | 0.009 | 0.012 | 0.069 | 0.447** | Partial |
| H7 SN→SA→CCI | 0.287** | 0.036 | 7.891 | 0.000 | 0.217 | 0.361 | | Partial |

Note: $p < 0.01^*$, $p < 0.001^{**}$. t-value > 2.58 for $p < 0.01$; t-value > 1.96 for $p < 0.05$. BC LL: Bias corrected lower level (5%), BC UL: Bias corrected upper level (95%). VIF < 5 .

and career choice intention. Since subjective norms had significant direct influence on career choice intention with $\beta = 0.447$, it can be concluded that students' attitude and media exposure had partial mediating effects in the relationship between subjective norms and career choice intention in this model.

Multigroup analysis

In this paper, the researchers proposed that gender moderates all the relationships that constitute the conceptual model. Multigroup analysis (MGA) in PLS path modeling is a powerful method to identify meaningful differences in the relationships across group-specific results (Cheah et al., 2020; Hair et al., 2017; Picón-Berjoyo et al., 2016).

Prior to MGA, it is important to first conduct the three-step measurement invariance of composite models (MICOM) test to ensure the validity of results (Henseler et al., 2016), and determine whether an MGA is indeed required (Cheah et al., 2020). The procedure includes the assessments of configural invariance (Step 1), compositional invariance (Step 2), and the equality of a composite's mean value and variance across groups (Step 3).

In this study, configural invariance was established automatically using the SmartPLS 3.2.3 software. It was followed by Step 2 which the compositional invariance was assessed at a significance level of 0.05 (two-tailed). Table 6 shows the results of the compositional invariance assessment. The correlation c between the composite scores with the 5% quantile suggests that the quantiles for most of the constructs (composites) were smaller than or equal to correlation c , and no c is significantly different from 1, hence the compositional invariance of the model was established (Cheah et al., 2020; Picón-Berjoyo et al., 2016). In the same table, permutation p-values are also larger than 0.05 which indicate the compositional invariance was established for the model (Cheah et al., 2020). Therefore, the results in Step 2 suggest the necessity to compare standardized path coefficients between the males and females using MGA in PLS path modeling.

As shown in Table 7, the equality of means and cross-group variances was assessed. In Step 3, partial measurement invariance is achieved when both mean and variance original differences do not straddle between the confidence interval boundaries; full measurement invariance otherwise (Cheah et al., 2020). For example, both the mean differences in

Table 6 Compositional invariance assessment

| Composite (Step 2) | Original correlation | 5.00% | Permutation p-value | Compositional invariance* |
|-------------------------|----------------------|-------|---------------------|---------------------------|
| Students' attitude | 1 | 0.999 | 0.367 | Acceptable |
| Career choice intention | 1 | 1 | 0.090 | Acceptable |
| Media exposure | 0.988 | 0.989 | 0.038 | Acceptable |
| Subjective norms | 1 | 1 | 0.058 | Acceptable |

Note: * \leq correlation c ; not significantly different from 1.

Table 7 Measurement invariance assessment

| Composite (Step 3) | Differences [95% confidence interval] | | Measurement invariance |
|-------------------------|---------------------------------------|-------------------------|------------------------|
| | Mean-original | Variance-original | |
| Students' attitude | 0.191* [-0.130; 0.133] | -0.215* [-0.199; 0.211] | Partial |
| Career choice intention | 0.068 [-0.127; 0.131] | 0.065 [-0.186; 0.192] | Full |
| Media exposure | -0.049 [-0.144; 0.144] | 0.129 [-0.229; 0.245] | Full |
| Subjective norms | 0.161* [-0.135; 0.128] | -0.124 [-0.183; 0.200] | Partial |

Note: * indicates permutation p-values <0.05.

students' attitude did not fall within the 95% confidence interval of its lower (2.5%) and upper (97.5%) boundaries whereas career choice intention straddled between the confidence intervals. This result thus offers initial evidence for a significant difference between female and male students' mean values. Based on the results in Table 7, not all composites' confidence intervals straddled between the 95% confidence intervals with statistical significance. Therefore, it can be concluded that not all the composite mean values and variances were equal, thus partial measurement invariance was established in this model (Cheah et al., 2020).

As partial measurement invariance was established through MICOM, group differences can be assessed using MGA in PLS path modeling to compare the parameters between female and male students (Cheah et al., 2020). Hence, MGA was conducted using SmartPLS to test the moderating role of gender on the relationships in the research model (H8 – H12).

Based on the results in Table 8, only H8 was statistically different between Group 1 (female) and Group 2 (male). In other words, the moderating effect of gender on the causal relationship between subjective norms and media exposure was significant ($p = 0.029$, $p < 0.05$). This result was also supported by the results from the Welch-Satterthwaite test that there was a significant difference across students' gender in the relationship between subjective norms and media exposure ($p = 0.015$, $p < 0.05$). Specifically, results from bootstrapping revealed that male ($\beta = 0.507$) students had a stronger path coefficient than female ($\beta = 0.366$) students. On the other hand, the moderating role of gender on other paths (H9 – H12) in the model was statistically insignificant.

Table 8 Multigroup comparison test results

| Paths | Difference (Female-Male) | t-parametric (EV) | t-parametric (NEV) | Permutation p-values | Significance |
|------------|--------------------------|-------------------|--------------------|----------------------|--------------|
| H8 SN→ME | -0.142 | 2.296* | 2.442* | 0.029 | Yes |
| H9 SN→SA | -0.033 | 0.782 | 0.786 | 0.458 | No |
| H10 SN→CCI | -0.044 | 0.62 | 0.617 | 0.541 | No |
| H11 ME→CCI | -0.028 | 0.541 | 0.525 | 0.587 | No |
| H12 SA→CCI | 0.045 | 0.608 | 0.589 | 0.556 | No |

Note: * indicates statistical significance at 0.05.

Discussion

In response to the first research question, this study examined the direct and indirect relationships in the proposed model, and analyze the mediating roles of both media exposure and students' attitude in the relationship between subjective norms and STEM career choice intention. Based on the results, subjective norms had a positive significant influence on media exposure, students' attitude, and career choice intention in STEM, hence supporting H1, H2, and H3. In other words, parents, teachers, and peers were significant others who had direct influence over students' media exposure, attitude, and intention to pursue careers in STEM. This finding is consistent with those from Bergin (2016) and Hoag et al. (2017) that parents, teachers, and peers play the biggest roles in students' career choice intention, and they develop students' exposure and shape their preferences at school and at home. This finding is also aligned with Mohtar et al. (2019) that parents, teachers, and peers' support and encouragement would increase their intention to opt for STEM careers in the future.

Results also supported the proposition that students' career choice intention in STEM can also be predicted by media exposure and attitude (H4 and H5). This finding is indicative of the importance of students' media exposure and attitude in their intention to choose a career in STEM. Similar to the findings from Gómez-Galán (2020), this study confirms that the power of media was beyond teaching and learning that students' exposure to media also developed their understanding about the environment. This can be explained by Chen et al.'s (2022) that teenage students' consumption of STEM media increased their career aspirations in STEM fields. In the context of this study, media exposure in general refers to the opportunities for a secondary school student to attain information from different types of media. This finding implies that students explored information about STEM careers via various forms of media such as the Internet, social media platforms, and television contents. Besides, the finding of this study concurs with Badri et al. (2016) and James et al. (2018) that students' attitude had significant influence on students' STEM career choice intention. This means that students were more likely to choose a STEM career when they showed greater preference and judgement to STEM careers.

Another important finding of this study highlighted that media exposure and students' attitude were significant mediators between subjective norms and career choice intention in STEM. This study confirmed that both media exposure and students' attitude had partial mediating effects in the relationship between subjective norms and career choice intention, thus supporting H6 and H7. Previous studies suggested media exposure (Steinke et al., 2022) and attitude (Aziz et al., 2020) as the mediators between subjective norms and career choice intention. Similar to these studies, the results indicate that parents, teachers, and peers had a direct influence on students' career choice intention and the influence could also take place via media and attitude. This finding could imply that students took significant others' encouragement and advice while considering STEM careers, but they did not follow their advice uncritically. Instead, students also took into consideration the information they obtained from the media and their personal evaluations to decide whether they are likely to choose a career in STEM.

Aligned with the second research objective, the researchers analyzed the moderating role of students' gender and found that gender only had a marginal moderating effect on the causal relationships in the proposed model. Interestingly, gender had a moderation effect on the influence of subjective norms on media exposure, whereas other paths in the model were not moderated by gender. In other words, the influence of significant others (parents, teachers and peers) on media exposure varied between male and female students. This implies that adolescents' school and home environments endorse different beliefs and expectations towards male and female students, thus leading to varied exposure to media. Students' exposure to media was influenced by the deeply entrenched gender roles in school and home environments. These environments function as important sources for students (Wang & Degol, 2017), accompanying gender-normative beliefs, messages, and stereotypes from their parents, teachers and peers.

However, these gendered endorsements did not influence the students' career choice intention in STEM. This is an important finding because it contradicts many past studies that gender gaps in STEM were evident (Brenøe & Zölitz, 2020; Jiang et al., 2020; Wegemer & Eccles, 2019). Although teachers and parents are students' socializers in their social contexts, students varied in what they adopt from their significant others (Luttenberger et al., 2019). This is likely because the beliefs held by students' socializers such as teachers did not play a role in explaining gender differences (Heyder et al., 2019). For example, teacher's influence was a vital factor for female students' exposure to media as a learning resource but not for male students, and vice versa. In recent years, it was found that a majority of students endorsed the belief that female and male students were equally good at math though their parents believed that males would outperform females (Starr & Simpkins, 2021). Based on this premise, the researchers put forth despite "gender normativity" communicated through external factors (subjective norms and media

exposure) in various forms and settings, gender did not necessarily hinder or promote students' choice of career in STEM.

Implications

This study has several important ramifications for students' STEM career choice. Based on the findings, the researchers propose recommendations for policy and practice enhancements in various learning settings, and suggest future directions to support STEM interventions in Malaysia. In particular, this study offers new insights into the influence of subjective norms on STEM career choice intention as well as the mediating roles of media exposure and students' attitude. Findings of this study could be used as the latest reference for the authorities and policy-makers to support the initiatives for STEM workforce in the Malaysian context by emphasizing the importance of subjective norms, media exposure, students' attitude, and gender equality. Through the implications, the researchers anticipate the stakeholders to embrace various forms of strategies and media to enhance learning and understanding of STEM careers.

The findings concerning the direct and indirect influence of subjective norms on students' career choice intention STEM is significant from a practical standpoint. Based on the findings, parents, teachers, and peers should also be included in STEM initiatives to effectively pave students towards STEM careers. This is to ensure students' significant others are also aware of the importance of STEM and are aware of their roles in students' STEM pursuits, as well as the opportunities in STEM industries. The roles of parents, teachers, and peers are important because they can also affect students' evaluation and judgment towards STEM professions and ultimately influence their intention to participate in STEM. Therefore, parents, teachers, and peers should also be involved in the planning and implementation of STEM initiatives.

Besides, it is crucial that students know where and how to choose, critique, and use various forms of media creatively and persuasively for specific purposes. This is particularly important for secondary school students who need teacher's support for the acquisition of digital skills (Tirado-Morueta et al., 2023). Indeed, many students lack the awareness of information and opportunities related to STEM careers despite their high exposure to media and online information (Tey et al., 2020). Though students are familiar with the use of media, they might not know how to use these resources to obtain accurate information for career planning purposes (Ottestad & Gudmundsdottir, 2018). As students spend considerable time at school, teacher support is critical in this learning environment especially in guiding them on how to make use of media as a powerful learning resource to discover, analyze, and create information (Tirado-Morueta et al., 2023). Hence, when they are exposed to media for STEM-related information under the guidance of teachers whom they perceive to be more knowledgeable and reliable, they are more likely to develop

likelihood for STEM careers with accurate understanding of the professions. This finding is potentially applicable to other contexts because students today are digital natives who depend on media for career information acquisition regardless of nationality.

Though the findings indicated that the gender gap was not a major issue in this study, gender difference in the influence of subjective norms on media exposure implies the necessity to continue emphasizing STEM equality. Policy and practice enhancements could consider enhancing regular exposure to counter-stereotypic contents in the media as an operative strategy to promote gender flexibility in view of the deeply entrenched gender roles in STEM (Spinner et al., 2018). Since the students' significant others could potentially transfer gendered-messages related to STEM to students, this strategy could be extended to both students' school and home environments by involving parents and teachers through the media.

Besides, equal representation of female and male STEM professionals can be increased in the contents of media. Creating equal portrayals of successful figures in STEM would reduce gender stereotypes in the fields of STEM. For example, classroom and non-academic activities can include video interviews of STEM professionals who are able to provide students with accurate information and real-life stories about STEM careers (Wyss et al., 2012). Additionally, a support system can also be established via media to form a sense of connectedness for contexts where females are underrepresented in STEM (Wang & Degol et al., 2017). Schools or STEM departments could introduce female STEM role models to students via media or even encourage networking opportunities with the role models. Students are more likely to make realistic connections between their encounter and exposure with these role models and subsequently increased their interests in STEM.

Limitations and recommendations

There are several limitations in this study. First, it was not examined how students' career choice occurred in each field of STEM. Luttenberger et al. (2019) pointed out that it is inadvisable to analyze STEM as a general category and it is imperative to segregate STEM into the four respective fields for clearer conceptualization. Focusing on differences between the disciplines within STEM may provide more valuable insight into certain disciplines and understand how the underlying mechanisms occur. Similarly, previous studies also found the differences between significant others in terms of how they influence student' career choice and perceptions of gender. For example, parents and friends had significant influence on students' STEM career choice intention, but teacher influence was not significant (Tey et al., 2020). Likewise, Starr and Simpkins (2021) found that parents' gender stereotypes could influence children whereas teachers did not. Therefore, future research is recommended to examine how students' career choice takes place in the

respective categories of STEM and subjective norms to better understand the underlying mechanisms.

Second, the research finding challenges the assumption that gendered endorsements are usually associated with STEM career choices. While these endorsements are important, they might not be the sole or direct drivers of gender disparities in STEM fields. This finding suggests interplay of other reasons that play a complex role in shaping students' career intentions. Therefore, future studies are recommended to include a qualitative method such to support or triangulate this finding. Focus groups and in-depth individual interviews are powerful approaches in data source triangulation to contextualize and enrich the quantitative findings by offering a deeper understanding of the underlying mechanisms, perspectives, and experiences of the participants (Carter et al., 2014). For example, conducting qualitative interviews or focus groups with a subset of the participants can offer detailed insights into scenarios in which gender-specific endorsements hold significance. Participants can discuss their attitudes, experiences with media exposure, interactions with significant others, and perceptions of gender-related influences in a more open-ended and nuanced manner. These qualitative narratives can shed light on the intricacies of how these factors interact and influence each other, adding depth to the quantitative findings.

Third, the proposed research model suggests a complex web of relationships among various factors that influence students' participation in STEM and their career choice intentions. However, the relationship between the mediators was not examined in this study. Future research could explore the relationship between media exposure and students' attitude in the model by providing a more comprehensive understanding of the dynamics at play. For example, investigating their two-way relationships in the research model could provide a more realistic representation of the intricate interplay among factors shaping students' STEM career intentions. Besides, exploring whether students' attitudes also influence their media exposure can provide a deeper understanding of how attitudes shape students' engagement with STEM content, or vice versa. This approach acknowledges that these factors are not static but interact with and influence each other in dynamic ways. It can also lead to more robust findings and practical implications, helping educators, policymakers, and researchers develop more effective strategies to promote STEM participation and reduce gender disparities.

Besides, the data was collected using a self-report online survey; hence this could have caused issues on common method variance. The findings of this study can only be generalized to Form Four (Year 10) students. This study was planned to involve all upper secondary students, but the scope of this study was limited to only Form Four students because Form Five (Year 11) students were preparing for national exams during the research period. In terms of locality issues, the research findings of the present study can only represent students in Peninsular Malaysia because East Malaysia which comprises

Sabah, Sarawak, and the Federal Territory of Labuan were excluded from this study due to budget and time restrictions.

Lastly, future researchers could expand the scope of this study by including both Form Four and Form Five students from Peninsular and East Malaysia for greater generalization of research findings. It would be meaningful to involve Form Five students in this study because they are generally more mature and have clearer ideas about STEM career choices since they are close to completion of secondary education. Future studies could also apply the research model presented in this study in other developed countries or Western cultures to examine if the results remain the same in other contexts. Researchers are also recommended to use a longitudinal approach in future studies. This approach will help researchers to better understand the underlying explanations of the causal and mediating relationships among constructs. A longitudinal approach will also allow researchers to observe changes in students' responses over a longer period because students' knowledge, exposure and experience will develop as they grow older (Shin et al., 2018).

Conclusion

The main purpose of this study was to examine direct and indirect relationships between subjective norms, media exposure, students' attitude, career choice intention and gender. One of the main findings from this study indicated that STEM career choice intention among secondary school students in Malaysia were influenced directly and indirectly by their parents, teachers and peers. While media exposure and students' attitude were confirmed to be significant mediators in this study, gender only had a marginal moderating effect on one out of five causal relationships in the proposed model. The findings drawn from this study provide insights into the design and development of STEM initiatives for parents, teachers, and peers, taking into account the significance of media exposure, students' attitude, and gender. In the recommendations for policy and practice enhancements, improvements in the design of effective strategies that involve various stakeholders are anticipated so that learning designs can be translated successfully into students' learning environments, particularly at home and school. The importance of media exposure, and encouraging the use of media was also highlighted in this paper to help the stakeholders embrace STEM interventions and improve their understanding of STEM careers. Secondary school is a crucial period and optimal time for interventions. In line with the limitations and recommendations for future studies, it is anticipated that future research will investigate and explore secondary school students' career choice in STEM beyond the context of Malaysia, aiming to support STEM interventions on a larger scale.

Abbreviations

STEM: Science, Technology, Engineering, and Mathematics; SEM: Structural Equation Modeling; CR: Composite Reliability; AVE: Average Variance Extracted; HTMT: Heterotrait-Monotrait Ratio of Correlations; VIF: Variance Inflation Factor; PLS: Partial Least Squares; MGA: Multigroup Analysis; MICOM: Measurement Invariance of Composite Models.

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The current study is an extension of research carried out by Tey et al. (2022).

Authors' contributions

All authors contributed conception of the study. T.C.Y.T. formulated the research topic, conducted the research, analyzed the data, wrote the manuscript, and finalized the paper. P.M. and P.K.C. were in charge of funding acquisition and provided valuable feedback on the manuscript drafts. All authors read and approved the final manuscript.

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Declarations**Competing interests**

The authors declare that they have no competing interests.

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