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Gender differences in STEM choices in Taiwanese higher education: The male-things and female-people interest hypothesis

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ABSTRACT
This study proposes a conceptual framework for gendered processes based on the male-things vs. female-people interest (MTFPI) hypothesis, by identifying gender differences in factors relating to science, technology, engineering, and mathematics (STEM) choices in higher education in Taiwan. Longitudinal data were from the Taiwan Education Panel Survey (TEPS) for Grade 7 (n = 20,055), 9, 11, and 12 and the follow-up TEPS-Beyond (TEPS-B) for 24-25-year-olds (n = 2,700). Correlation and regression analyses were conducted with weights so that the result can represent that of the original Grade 7 population. The results generally support the MTFPI hypothesis. For male participants, STEM choice is related to high mathematics achievement and low frustration in mathematics in all stages of secondary education, high gender stereotyping of their jobs, and low confidence in people-smart skills (e.g., leadership, collaboration with others, and oral expression). STEM choice among female participants is related to mathematics teachers' clear explanations and desirable interactions in mathematics classrooms. These results support the MTFPI hypothesis in that boys and men are more interested in things (including 'objectified' achievement), while women and girls are more interested in interaction with people.

KEYWORDS
gender difference; longitudinal data; mathematics achievement; mathematics teaching; STEM choice

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INTRODUCTION

The Problem Context: Gender Differences in STEM from Differential Processes

The underrepresentation of women and girls in science, technology, engineering, and mathematics (STEM) fields as remained a persistent concern (European Commission, 2019; Organization for Economic Cooperation and Development [OECD], 2019). This represents a missed opportunity for women to participate fully in STEM professions. One of the proposed ways to increase the number of women in STEM studies and professions is by introducing adaptive educational processes geared towards gender differences. One defense of this approach is based on the traditional perception that the key to gender differences in STEM choice is due to differences in STEM achievements, capacities, or abilities (Good et al., 2008). Such differences are often perceived as an outcome of fixed and gender-differentiated intelligence and may lead to women and girls' under-representation in STEM (Clark et al., 2021). Yet, when interpreting the effects of achievement on underrepresentation, we must also account for evidence that parental and socioeconomic status (SES) factors are strong predictors of children's STEM achievements (Penner & Paret, 2008). So, introducing gendered problem-solving processes as an educational intervention or malleable skills could be a key element in overcoming parental and SES constraints on participation of girls in STEM (Zhu, 2007).

Learning processes and gender differences are embedded within macro cultures, say at the macro-level of a country, and these are very resistant to change. Nevertheless, we can assume that there are cultural domains and artifacts at the local level that may both be conducive to change through learning processes, but also ways of tracing gender differences – not least of all because these have been co-created by both genders and are therefore attractive to both. For instance, among the diverse STEM fields, gender gaps favour men in engineering, mathematics, computer science, and physics, but biology and veterinary medicine women are more highly represented (Hyde, 2014). Therefore, domains, tasks, or problem types within a cultural artifact or domain can serve as micro-cultures that can be used to detect and test factors concerning gender differences and any proposed or implemented learning interventions.

This study proposes a gendered problem-solving process: *The male-things vs. female-people interest (MTFPI) hypothesis (Chiu, 2021)*.

Complicating questions about the influence of students' achievement and socio-cultural influences on STEM choices is a significant gender difference in interests at the domain level: Men tend to have more interest in things, engineering, science, and mathematics, whereas women are more likely to be interested in people and are more agreeable or tender-minded (Hyde, 2014). A meta-analysis on interest inventory finds that male students prefer engineering disciplines and female students prefer medical services or social sciences (Su & Rounds, 2015). Worldwide, more girls expect to become health professionals and more boys expect to become scientists, engineers, and ICT professionals, engage in science activities, and boys are more interested in learning science (OECD, 2016, pp. 119, 125).

This evidence suggests a need to further investigate gendered differences between thing- and people-focused interests and their influence on STEM choice and propose appropriate gendered problem-solving and learning processes. The objective of this study is to undertake such an investigation by exploring the *male-things vs. female-people interest (MTFPI) hypothesis*.

Conceptual Framework based in MTFPI

This study aims to examine the male-things vs. female-people interest hypothesis at a more detailed level through a proposed conceptual framework, presented in Figure 1. The proposed framework uses STEM choice in higher education as the outcome variable, and mathematics achievement, frustration, and social aspects of mathematics learning as predictors. More precisely, the study draws upon the objectified and psychological aspects of student achievement, respectively, to capture the 'things' dimension of interests. Whereas traces of the 'people' dimension of interests are revealed in external and interactional aspects of education, as well as internal personal and sociocultural factors.

Diverse micro-level domains of knowledge have an innate characteristic of focusing on things (e.g., mathematics, science, and engineering) or more on people (e.g., social sciences, humanities, and health). The characteristics of these domains of knowledge, however, should not be viewed as a dichotomy or arbitrary. For example, health which deals with human beings and their well-being is people-focused but also deals with objective things such as viruses and diseases, and human bodies. Mathematics itself focuses on abstract knowledge of patterns and relationships between things, although the category of things may include people-focused human variables (e.g., family income or psychological constructs). These domain characteristics of mathematics suggest that mathematics provides a good test-case for the MTFPI hypothesis.

Further, mathematics processes are helpful in exploring relationships between the internal and external dimensions of thing-interest in our model. For instance, stable research findings support the claim that academic achievement is robustly correlated with affective (or academic emotion) variables. The affective variable may be in a positive valence such as confidence and interest (Marsh & Hau, 2013), or a negative valence such as frustration and anxiety. Achievement is often objectified – made thing-like – through external and objective measures of success, competence, external validation, etc. Yet, the 'objectivity' of achievement may also manifest in internal states of frustration, anxiety, confidence, etc.

People-focused interest is also in, and accessible through, mathematics processes. The process of learning and teaching mathematics appears to involve more salient social or people aspects, such as teacher behaviours in mathematics classrooms, social stereotyping (e.g., gender stereotyping), and social competencies. These too have internal aspects (e.g., psychosocial perceptions of stereotypes) and external aspects (e.g., the affordances of interactional, educational practice in the mathematics classroom).

Thus, mathematics achievement and its related affective variables can serve as operational variables for things, while the social aspect of mathematics teaching and learning can serve as operational variables for people, as shown in Figure 1.

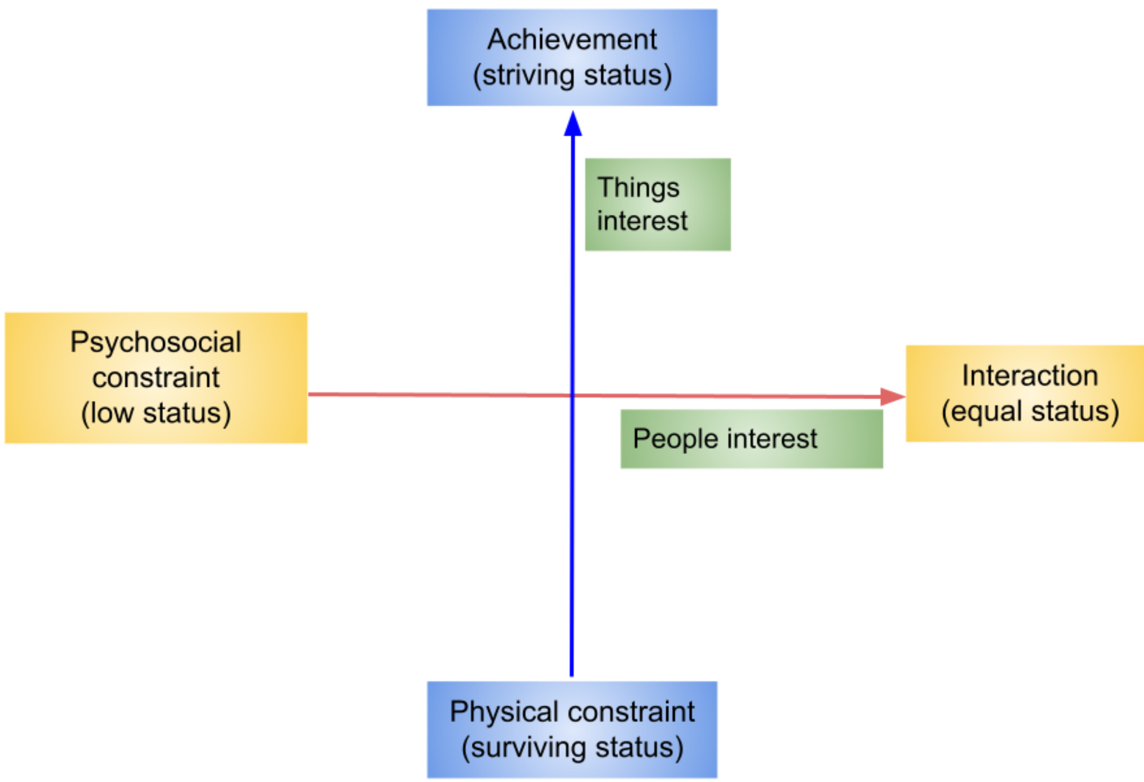

Figure 1: *A Conceptual Framework for Gendered Processes Based on the Male-Things vs. Female-People Interest (MTFPI) Hypothesis*

We will define 'things' and 'people' in terms of mathematics achievement and interaction affordances in the external aspects, and their related feelings, beliefs, and attitudes in the internal aspects. Gender differences in these aspects are addressed in the related literature as follows.

Gender Differences in 'Things Interest'

External Aspects: Mathematics or STEM Achievement

The conception that boys have higher achievements in STEM and girls have higher achievement in languages not only matches public expectation but is also evidenced in some research (Robinson & Lubienski, 2011), though not universally (Chen & Zimmerman, 2007). Gender differences in STEM achievements and related affective factors (e.g., values of tasks and confidence or self-concept in mathematics) have long been viewed as the main factors for the consistent phenomenon in most human societies that more men than women are involved in advanced studies and careers in STEM (Wang et al., 2015).

Most recent cross-cultural and meta-analysis studies, however, indicate that social-cultural factors are the main cause of gender differences in STEM choices and achievements, which is known as the gender stratification hypothesis (Else-Quest et al., 2010). A salient example is that from pre-K to high school: gender differences in STEM achievement are small, with gender-equal societies having fewer gender differences in STEM, especially mathematics achievement (Guiso et al., 2008). This also lends support to the gender similarities hypothesis (Hyde, 2005), which is the hypothesis that both genders are alike on most achievement and psychological variables.

Psychosocial Aspects

In the psychosocial aspect, research has found that boys have more positive attitudes, affect, or emotions toward STEM than girls do (Barkatsas et al., 2009). There are few exceptions, and these are found primarily among primary school students (Yüksel-Şahin, 2008). Boys' more positive emotions (e.g., higher self-efficacy and lower anxiety in mathematics) in turn may lead to higher mathematics achievements (Pajares & Miller, 1994), or, controlling for achievements, may even lead directly to STEM choice (Carli et al., 2016; OECD, 2016). These emotions are psychological phenomena, including both innate ones (e.g., interest) and social-cultural, nurtured ones (e.g., usefulness for future employment; Miller & Halpern, 2014), although it is hard in practice to distinguish the biological and social bases of these phenomena.

Learning approaches, on the other hand, appear to favour female students. Girls show a larger increase in the quantity and frequency of using learning approaches to reading but less with respect to mathematics, starting from primary school (Cameron et al., 2015). Compared with German grade-9 boys, girls have lower intrinsic value and personal importance, place a lower value on the job and future-life utility, and perceive more cost in effort and emotional arousal (Gaspard et al., 2015).

The picture that emerges is that girls tend to have negative experiences in both achievement (as external and objectified outcomes, vis-a-vis- 'things') and achievement-related internal factors. Boys appear to aim towards the pursuit of achievement (one of the important 'things' in society), especially in STEM. If the pursuit of achievement is reachable, or good progress is being made towards it, a 'striving status' emerges. If, on the contrary, the aim to pursue achievement is thwarted, then constraints are perceived and perceived as external. Accompanying achievement-related negative psychological emotions generates a 'surviving status'. In our operational model (Figure 1.), achievement is directed (positively) away from external constraints.

Gender Differences in 'People Interest'

External Aspects: Social Affordances

Girls appear to be sensitive to social messages during learning. Collaborative cognition activation teaching increases girls' interest in mathematics, but not boys (Cantley et al., 2017). There is some evidence that women prefer face-to-face classes to distance learning. For example, a study comparing Ukraine, Portugal and Emirates, found that women expressed concern about interaction, communication, motivation, and organizational skills, while men expressed more positive attitudes toward technology and distance learning (Fidalgo et al., 2024). In game-based mathematical problem-solving, for example, boys report more about scores, levels, obstacles, and tricks – relatively relevant to the game – whereas girls report more on their feelings and social communication with others, which are relatively irrelevant to the game (Ke, 2008).

Girls also tend to deeply process social messages in a learning environment. Their communal perceptions (e.g., working with people and helping others) can lead to both a sense of belonging and interest, in turn leading to future motivation and persistence in science. This pathway, however, is simpler for boys: from communal perceptions straight to interest and future motivation, without involving belonging and persistence (Allen, 2021). In contrast, early-career academic women, particularly those of ethnic minority background, experience feelings of being an impostor or lack of belonging to 'brilliance-valued' fields such as mathematics (Muradoglu et al., 2021). This impostor syndrome may further lead to a low sense of belonging in STEM programs and to dropout consideration (Clark et al., 2021).

Psychosocial Aspects

Men appear to exhibit more social dominance behaviour than women (Jonkmann et al., 2009). Boys are more likely to be aggressive or aggressive and then victimized than girls, while boys and girls have similar chances of being victimized (Shao et al., 2014). Girls' interpersonal skills mediate the effect of their body weights (at the kindergarten stage) on mathematics achievements (in Grade 5), but this mediating effect does not apply to boys (Gable et al., 2012).

Girls may be vulnerable to the stereotype threat of inferior female ability in STEM (e.g. boys are better at mathematics), causing lower test results (Good et al., 2008). This stereotype threat, together with the perception that STEM is for brilliant people, may be one of the reasons for the underrepresentation of women in such fields (Meyer et al., 2015). This raises anxiety and results in lowered achievement in solving mathematical problems – but not in solving general problems (Johns et al., 2005). Unlike the detrimental effect of stereotype threat on achievement, an emphasis on differential problem-solving processes between genders may go beyond the debate between the *gender similarity hypothesis* and *gender reality hypothesis* (Lippa, 2006) and thus directly benefit adaptive instruction.

In summary, people interest among women and girls is accompanied by a sense of equal status with others, and by engaging and interacting with people through complex networking. This may be due to women's response to the long-standing lower social status they experience compared with men in organizations or human societies (Seo et al., 2017). Hence in our model the positive direction along the interaction axis is away from low-status to equal-status (Figure 1.). On the other hand, men tend to form a self-image of gender-neutral standards, with men in the centre and women in the periphery of the world (Bailey et al., 2019). This tendency may lead to men's objectification of people – transforming people into things – which can then be measured and organized.

HYPOTHESES

The above review of the literature suggests that there are differential features between genders in problem-solving process interest. Although the differences are qualitative, they could be conceptually depicted using a two-dimensional scale, as shown in Figure 1.

Based on the above literature review, this study aims to examine the male-things vs. female-people interest hypothesis. In terms of statistical examinations, this study aims to examine the following two hypotheses.

<u>Hypothesis 1</u> (Things interest). In men and boys, STEM choices are more positively associated with achievement and are more sensitive to achievement-related feelings (e.g., frustration).

<u>Hypothesis 2</u> (People interest). For women and girls STEM choices are more positively associated with interaction affordances in their learning contexts and more resilient to social constraints (e.g., gender stereotypes and social competencies).

METHOD

Data Source and Sample

This study used cohort data from the Taiwan Education Panel Survey (TEPS) (Chang, 2001–2007) and its follow-up (TEPS-B) (Kuan, 2017), compiled by the Survey Research Data Archive, Taiwan. The first wave of the TEPS data was collected in 2001 from grade-7 students (born in 1988/1989) and their parents (n = 20,055). The participants were followed up at grades 9, 11, and 12. TEPS-B started to follow up the TEPS's participants at ages of 24–25 years (n = 2,722) in 2014.

This first wave of TEPS-B data was used as the basis to merge with all four waves of TEPS data. To generalize to the original grade-7 student population, this study used sampling weights provided by TEPS-B. Cases without weights were deleted, which resulted in a final sample size of 2,700 for later data analysis.

Measures

Outcome: STEM Choice in Higher Education

At the ages of 24–25 years (the TEPS-B), the participants indicated their latest study fields. The participants’ STEM choices were coded as 4 = STEM (32.8%), 3 = agriculture and medicine (10.7%), 2= social sciences (44.4%), and 1=humanities (12.1%), in order from more to less use of mathematics (Mean = 2.64; Standard Deviation = 1.06).

‘Things’ Factors Relating to Mathematics

1. Mathematics achievements (external aspects): The participants underwent mathematics tests at each of the four waves of TEPS (i.e., grades 7, 9, 11, and 12). The mathematics tests were developed by experts on mathematics and tests, with reference to related international large-scale tests. The scores of the four tests were scaled using the 3-p model of item response theory, allowing for comparison of competencies between the four waves. Table 1 presents the detailed descriptive statistics of the predictors.

Table 1: *Descriptive Statistics, Correlations, and Regression Solutions with STEM Choices as the Outcome*

	scale range		mean	SD	correlations				beta	
Measures	min.	max.			All	Men	Women	All	Male	Female
Things Interest										
Physical aspects										
MathAch grade 7	-2.52	2.57	0.357	0.954	***0.136***	***0.155***	0.076	-0.008	0.023	-0.013
MathAch grade 9	-2.03	3.68	1.169	1.225	***0.148***	***0.163***	0.087	0.029	0.099	0.009
MathAch grade 11	-1.51	4.35	1.998	1.281	***0.191***	***0.190***	***0.105***	***0.172***	0.169	0.067
MathAch grade 12	-2.15	5.58	1.780	1.700	***0.127***	***0.124***	0.081	-0.011	-0.051	-0.011
Psychosocial aspects										
MathFrustration before grade 4	0	1	0.090	0.286	***-0.095***	-0.063	-0.081	-0.027	0.008	-0.060
MathFrustration grades 5-6	0	1	0.200	0.397	***-0.0161***	***-0.100***	***-0.118***	***-0.106***	-0.089	-0.075
MathFrustration grades 7-9	0	1	0.380	0.486	***-0.143***	***-0.124***	-0.086	-0.040	-0.027	-0.033
MathFrustration grade 10	0	1	0.560	0.497	***-0.100***	***-0.094***	-0.040	***-0.115***	-0.097	-0.087
MathFrustration grade 11	0	1	0.450	0.498	-0.030	-0.038	0.046	0.045	0.018	0.096
People Interest										

Physical aspects										
MathTeach clear lecture, grade 9	0	1	0.600	0.490	0.058	0.021	***0.132***	0.035	-0.002	0.101
MathTeach good interaction, grade 9	0	1	0.410	0.492	0.016	-0.019	***0.095***	-0.013	-0.045	0.040
MathTeach clear lecture, grade 12	0	1	0.620	0.485	0.015	0.024	0.029	0.005	0.026	0.003
MathTeach good interaction, grade 12	0	1	0.600	0.490	-0.019	-0.045	0.049	-0.056	-0.075	0.014
Psychosocial aspects										
others to make study-field choices, grade 12	1	2	1.200	0.399	0.050	0.090	0.010	0.071	***0.140***	0.021
Gender stereotype in chosen study fields, grade 12	1	2	1.255	0.436	***0.122***	***0.170***	0.041	***0.089***	***0.116***	0.039
Gender stereotype in chosen jobs, grade 12	1	2	1.228	0.420	0.086	***0.136***	0.053	0.064	***0.113***	0.050
Confidence in oral expression, age 24–25 years	1	4	2.950	0.580	***-0.105***	***-0.119***	-0.033	***-0.106***	***-0.144***	-0.037
Confidence in collaboration, age 24–25 years	1	4	3.220	0.560	***-0.036***	***-0.064***	0.015	0.032	0.029	0.044
Confidence in leadership, age 24–25 years	1	4	2.730	0.687	-0.026	***-0.056***	-0.003	-0.015	0.011	-0.031
Background										
Family income	1	6	2.560	0.980	-0.011	-0.039	-0.006	-0.038	-0.091	-0.001
Parental educational levels	1	5	2.113	0.920	-0.026	***-0.056***	-0.019	-0.010	0.013	-0.025

Note. Correlation coefficients and regression standardized solutions (Betas) in bold and italic are significant at the 0. 050 level. MachAch = mathematics achievement; MachFrus = frustration in mathematics; MathTeach = mathematics teaching.

2. Frustration in mathematics (psychosocial/internal aspects): At Wave 3 (i.e., grade 11), the participants self-reported whether they felt frustrated before grade 4, at grades 5-6, at grades 7-9, at grade 10, and at grade 11, respectively (1 = yes; 0 = no).

'People' Factors Relating to Mathematics

1. Mathematics teaching (physical aspects): At both Waves 2 and 4 (i.e., grades 9, and 12), the participants self-reported whether their mathematics classes had clear lectures and good interaction, respectively (1 = yes; 0 = no).

2. Social influence for choosing study fields (psychosocial aspects): In grade 12 (Wave 4), students indicated who influenced their study-field decision-making. The options included: self, class, subject-matter teachers, guidance teachers (or school counsellors), parents, siblings, and friends. In this study, 'self' was coded as 1 and 'others' as 2.

2. Gender stereotyping (psychosocial aspects): At Wave 4 (i.e., grade 12), the participants self-reported whether their choice of major study field and favourite job

10 years after graduation are suitable for both genders (= 1), suitable only for men (= 2), or suitable only for women (= 2). A higher score (i.e., 2 = suitable only for all) represented a higher degree of gender stereotyping in their chosen fields and jobs.

3. Social competencies (psychosocial aspects): At the ages of 24–25 years, the participants indicated their perceptions of how good their current skills are in oral expression, collaboration with others, and leadership, respectively (1 = very good to 4 = very bad). The scores were reversely coded to allow higher scores to represent higher confidence in the competencies.

Family Background Factors

1. Family income: At Wave 1 (i.e., grade 7), the participants' parents indicated their family income (1= fewer than 20,000NTD to 6 = more than 200,000NTD).

2. Parental education: At Wave 1 (i.e., grade 7), the participants' parents indicated their own and their spouses' education levels (1 = junior high school or below to 5 = graduate school).

Data Analysis

Correlation and regression analyses were conducted for three samples: the whole sample (further referred to as the 'all student' sample), the female sample, and the male sample. Sampling weights were activated, so that the results obtained by the 2,700 cases of TEPS-B can be generalized to the original TEPS population at grade 7.

RESULTS

The correlation analysis results are presented in Table 1. All the correlations are small (i.e., below 0.360; Taylor, 1990). The correlation patterns are different for each of the three samples.

All Students

For the all-student sample, in terms of 'Things interest', the correlation analysis results find that significant measures related to STEM choices are the four mathematics achievements in secondary education stages in the external aspects. Frustration in mathematics (in the internal aspect) from primary education up to grade 10 is negatively related to STEM choices. The regression analysis finds fewer significant predictors: Mathematics achievement at grade 11, and self-reported frustration in mathematics in grades 5, 6, and 10.

In terms of 'People interest', external aspects, correlation, and regression analyses reveal the same results: Social affordances fail to relate to STEM choices. In the internal aspects, STEM choices are related to (and predicted by) gender stereotypes in chosen fields of study and negatively related to (and predicted by) confidence in oral expression. STEM choice is also correlated with (but not predicted by) confidence in collaboration with others.

No background factor has a significant relationship with STEM choice for the all-student sample.

Male Students

In terms of 'Things interest', by correlation analysis, male students' STEM choices are related to mathematics achievements at all four levels of education. Frustration in mathematics was negatively related to STEM choices from grades 5-10. However, regression analysis found no significant predictors.

In terms of 'People interest', both correlation and regression analyses found that social affordances of the external aspect do not relate to STEM choices. In the four psychosocial aspects, STEM choices are positively correlated with gender stereotypes in chosen jobs and fields of study, and negatively correlated with confidence in oral expression, collaboration, and leadership. The regression analysis finds slightly different results: STEM choices are positively predicted by social influence to make study-field choices and gender stereotypes in chosen jobs and fields of study, and negatively by confidence in oral expression.
Male students have one background factor correlated to STEM choice. That is, they have a lower chance of studying STEM fields in higher education if their parents have higher educational levels.

Female Students

Factors related to STEM choices for female students are quite different from those for the all-student and male samples, respectively. In terms of 'Things interest', female students' STEM choices are only correlated to achievement at grade 11 and mathematics frustration in grades 5-6. However, no significant predictors are found by regression analysis.

In terms of 'People interest', female students' STEM choices are positively correlated to the external aspects at grade 9. These social affordances included clear lectures and good interaction in mathematics teaching. Social affordance at grade 12, though, fails to show these relationships. However, regression analysis finds no significant predictors. Like the all-student sample, background factors fail to correlate with and predict female students' STEM choices.

DISCUSSION

The MTFPI Hypothesis: Gender Differences in Factors for STEM Choice

While the patterns of factors relating to STEM choices are quite different between genders, the results for all students appear to mix the results of both genders. This suggests that the one-size-fits-all result from all students may be improper, and gender should serve as a moderating factor for STEM choice. This helps justify the need to identify differential gendered processes for both genders' STEM choices.

This study reveals that, with STEM choice as the outcome, male students are more interested in 'things' by sensitively responding to the outside world, 'external' achievement, and achievement-related 'internal' entities. On the other hand, female students choose to study STEM through participating in high-quality communicative and interactive learning communities. Female students also demonstrate resilience to psychosocial constraints by showing little response to job gender stereotypes, nor to their confidence or strength in people-related skills – to which male students reveal a more active response in STEM choice.

The results generally support the elaborated MTFPI hypothesis, with a broader scope and special focus on gendered processes as depicted by the proposed conceptual framework (Figure 1). Most studies on MTFPI obtain insights from genders' differences in career choices (OECD, 2016; Su & Rounds, 2015) or behavioural characteristics (Hyde, 2014), with girls learning better by cooperative learning (Hyde & Linn, 2006). This study extends to a whole system of gendered processes. *The gender similarity hypothesis* suggests that girls and boys are the same in mathematics achievements if social constraints are removed (Hyde, 2005). However, for STEM choice as a learning outcome, there exists at least some gender differences in problem-solving processes, such as those predicted by the MTFPI Hypothesis.
Hence, this study appears to support *the gender stratification hypothesis* more in terms of gendered processes. This is because the MTFPI hypothesis suggests that gender differences are rooted in differential processes of interests, which would link to the entire system of external and psychosocial constraints, leading to different interest routes, and manifesting as different pursuits (achievement-striving vs. interaction-status equality) (Figure 1).

'Things Interest' for STEM Choice: Agenda for All or Boys?
The results show that for the physical aspect of the 'things interest', boys' STEM choice relates to most indicators for mathematics achievements and related perceived external constraints (frustration in mathematics). Specifically, the relationships are relatively salient for boys (achievement in grades 7-12 and frustration from early to grade 10), but not so salient for girls (only achievement in grades 5-6 and frustration in grade 11). However, all the relations diminish using a predictive (regression) analysis.

The links between mathematics achievement and affect (e.g., motivation and emotion) have long been researched as factors relating to later STEM achievement, educational investment, and career choices (Wang et al., 2015). Further, men are favoured in mathematics achievement, especially in socially unequal societies (Guiso et al., 2008) and favoured by mathematical affect or emotions (Carli et al., 2016; OECD, 2016). SES has long been a significant predictor of mathematics achievement. The current results, however, suggest that all these traditional factors for mathematics achievement may only be 'significant' for men in STEM choices. 'Achievement' has become objectified and part of human-made 'things', and used to judge or even harm people, and slightly exceeds the level of interest in people for women (Figure 1). Achievements (operated or represented by key performance indicators, test results, or credits) are relatively cumulative, quantitative, and comparable, thus leading to competition. Mathematics-related drives or desires emerge, moving from survival to striving. Achievement-related internal feelings (e.g., frustration), therefore, may threaten students. Educators need to be aware of these achievement-related challenges in both external and internal aspects, especially for boys.

'People Interest': A New Agenda for Girls?
Girls' STEM choices are relatively strongly related to the external aspects of people-focused interest. The main factors are clear lectures and good interaction in mathematics teaching. A nuance finding is that these factors are only significant for grade 9, but not for grade 12. The result suggests that high-quality interactions in mathematics learning at earlier stages are especially important in determining girls' future STEM choices, compared to later stages.

The results are consistent with related findings that girls concern about communication and interaction in distance learning (Fidalgo et al., 2024) and boys report more about 'things' (e.g., the game they are playing; Ke, 2008). Educators need to pay attention to girls' need for good lecture and interaction in mathematics classrooms, which should start at an early stage, including pre-school home numeracy activities (Chiu, 2018).

In the psychosocial aspect, boys' STEM choice is related to gender stereotypes in jobs and low confidence in oral, collaborative, and leadership skills, and is predicted by social influence. Besides, the negative role of SES in STEM choice applies only to boys, not to girls. The results reveal boys' vulnerability to psychosocial constraints although mathematical affect or emotions favour men (Carli et al., 2016; OECD, 2016). On the other hand, STEM women are more resilient to these psychosocial factors, as revealed that none of them relate to girls' STEM choices.

Returning to the MTFPI hypothesis and conceptual framework (Figure 1), girls' people-focused interests may better equip them to overcome their low social status in society and push them toward equal status through interpersonal interactions especially if women have more opportunities to enter the highest paid occupations in STEM. These factors in people-focused interest appear to be relatively under-emphasized in past research. For educational practices, educators need to pay attention to strengthening girls' 'people intelligence'.

CONCLUSION

Contribution
This study builds a conceptual framework for the MTFPI hypothesis, which extends past speculation to a more concrete structure. Further, the framework is examined using STEM choice in higher education as the outcome to be correlated to things and people factors in early education in both external and psychological aspects for all, male, and female samples, separately.

The results support the MTFPI hypothesis, in that the correlation patterns are quite different between male and female samples. Boys' STEM choices are related to achievement and achievement-related internal factors. Girls' STEM choices are related to teachers' high-quality lectures and interactions in mathematics learning. Female students reveal resilience to gender stereotypes in jobs and smaller vulnerability to people interaction skills, compared with male students, in STEM choice.
For the research agenda, the one-size-fits-all use of an 'all participant' sample may

prematurely and unjustifiably mix results from both genders. Analysis for both (or diverse) genders separately may be needed. Next, mathematics achievements and traditionally highly-researched factors relating to mathematics (e.g., frustration in mathematics) may not apply to STEM choice for girls. For them, a new or more suitable research agenda for increasing their STEM choice may be interaction affordance, starting from their early mathematics or STEM learning environment. For educational practices, educators may need to pay attention to the differential interests between genders, by using adaptive teaching to invite both genders to study STEM in higher education.

Limitations of this Study and Suggestions for Future Research

The empirical data were collected solely from a specific country and culture, namely Taiwan. The findings should be explained within the context of that culture and dataset. Future research could validate the findings using data from other cultures. Also note, all the correlation coefficients are small, though significant. A reason for these small coefficients may be that study field choice in higher education is a complex issue, involving diverse individual and sociocultural factors (Chiu, 2017). The proposed conceptual framework for gendered processes based on the MTFPI Hypothesis offers a possibility to broaden its scope to additional factors beyond those researched in this study.

The proposition of the MTFPI hypothesis intends to offer an initial framework (Figure 1) for examining the hypothesis using empirical studies. This study is only a preliminary endeavour and only chooses a small set of the outcome variables (i.e., STEM choice) and precedent variables (factors or predictors about STEM choice, i.e., mathematics achievement, frustration, teacher behaviours, social influence, gender-stereotyping, and confidence in social skills), by comparing different gendered groups of students using longitudinal data. The choice of variables, though based on theories, or literature reviews, is still arbitrary and constrained by the variable availability of the data due to the nature of this study as a secondary data analysis. Future research can intend to collect data relatively directly related to the hypothesis (e.g., interesting activities for things and/or people in STEM and other fields.)

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