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A Case Study of Secondary Students' Perceptions of STEM Education

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Abstract: This paper presents a preliminary analysis of a case study which investigated students' perceptions of STEM education in terms of (i) STEM interests, (ii) STEM values, and (iii) STEM-related career interests. The participants were 122 Grade-2 students (i.e., K8) from a secondary school in Hong Kong. Through a questionnaire-based survey, quantitative data were gathered from the participants before they were engaged in a STEM education program. Results showed that, before the program, there were connections between the participants' STEM interests, STEM values and STEM-related career interests. Furthermore, boys demonstrated higher STEM-related career interests than girls.

Keywords: STEM education, secondary education, students' perceptions, STEM interests, STEM values, STEM-related career interests

1. Introduction

Since the 21st century, the world has recognized the importance of STEM (Science, Technology, Engineering, and Mathematics) education. As a comprehensive discipline (Shanahan et al., 2016), STEM education implies interdisciplinarity (Sengupta et al., 2019), but few of these studies are considered interdisciplinary because they explicitly emphasize two or more disciplines (Takeuchi et al., 2020). With a combination of different disciplines, STEM could be more capable than a single discipline in solving complex real-world problems (Jong et al., 2022; Lau & Jong, 2022; Takeuchi et al., 2020). STEM education is fundamental for science or engineering professionals, people who do not receive STEM education can hardly pursue STEM careers (Xie, 2003; Killewald, 2012). In fact, the number of students who want to pursue STEM careers has been insufficient (Maiorca et al., 2021). Studies have investigated how to potentially increase students' career interests in STEM (Huang, Jong, King et al., 2022). Students' perceptions, especially career interests, are closely associated with their future career development. In this preliminary work, we examined the correlations between STEM interests, STEM values and STEM-related career interests, as well as the gender differences in students' STEM-related career interests.

2. Literature Review

STEM interest is one of the best predictors regarding students' future career choices. Students with higher interests in STEM are more likely to pursue a STEM-related career path (Nugent et al., 2015; Riskowski et al., 2009; Sanders, 2009). Previous research reported that students begin to think about their future careers at the secondary school level, and their career aspirations at this stage may forecast their future professions (Tai et al., 2006). Nevertheless, considerable data revealed that secondary students display a lack of interest in learning STEM (Subotnik et al., 2010).

Some studies have provided examples of how engineering design, i.e., connecting science, mathematics, and technology with real-world design tasks, can be used to increase students' interest in STEM (Shahali et al., 2016; Weng et al., 2022). The results showed that the real-world design tasks increased students' interest in STEM careers and enhanced their interests in cross-disciplinary education (Hiğde & Aktamış, 2022; Huang, Jong, & Chai, 2022). Thus, more institutions are exploring effective approaches for enhancing STEM interests and career interests based on cross-disciplinary real-world design tasks (Hernández-Serrano & Muñoz-Rodríguez., 2020).

In addition, other elements, such as STEM values and gender, have been reported to have direct or indirect connections to future STEM and college outcomes, and high mathematical proficiency moderates these outcomes (Fong & Kremer, 2020; Siregar & Rosli, 2021). Therefore, it would also be interesting to examine students' STEM values and their correlations to STEM interests and STEMrelated career interests.

Building on the experiences shared by researchers, we conducted a survey before the STEM project implementation to investigate secondary students' perceptions of STEM education including STEM interests, STEM values, and STEM-related career interests. In the meantime, the study also examined whether there was an association between gender, STEM interests, STEM values, and STEM-related career interests.

3. Methodology

3.1 Participants and Procedure

The participants of this study were Secondary-2 students (i.e., K8) in Hong Kong. Furthermore, at the time of investigation, they had not participated in our STEM programs. Thus, we could gather their prior perceptions of STEM before their participation in our program. After discarding incomplete responses, we retained 122 valid responses (n =122) in the analysis. Among the participants, 59.8% were boys and 40.2% were girls.

3.2 Measurements

The questionnaire consisted of three dimensions: STEM interests, STEM values, and STEM-related career interests. All items were measured on a 6-point Likert scale ranging from strongly disagree to strongly agree. The Cronbach's Alpha coefficient of each dimension is 0.88 for STEM interests (Luo et al., 2019), 0.91 for STEM values (Shin et al., 2019), and 0.94 for STEM-related career interests (Vennix et al., 2018). All alpha coefficients were above the cut-off point of 0.8, indicating the high reliability of each construct.

4. Results

4.1 Descriptive Statistics and Correlation Analysis

The means and standard deviations were computed. As shown in Table 1, students' perceptions of STEM were overall positive, with the means of all the examined dimensions above 3. Students' perceived STEM values (M = 3.89) and STEM interests (M = 3.78) were more positive than their perceived STEM-related career interests (M = 3.49). In addition, correlation analysis indicated that STEM interests, STEM values, and STEM-related career interests were strongly correlated with each other, with correlations ranging from 0.74 to 0.82 ($p < 0.001$).

Table 1. *Descriptive Statistics and Correlation Coefficient Matrix*

	Mean	SD	STEM interests	STEM values	STEM-related career interests
STEM interests	3.78	1.15	1	0.82***	0.74***

STEM values	3.88	1.12	1	0.78***
STEM-related career interests	3.49	1.32		1

*** Correlation is significant at the 0.001 level (2-tailed).

4.2 Independent Sample T-test

The independent sample t-test was conducted to test the difference between boys and girls in the three dimensions. As presented in Table 2, boys (M = 3.75, SD = 1.47) had significantly higher levels of STEM-related career interests than girls (M = 3.11, SD = 0.97), t (120) = 2.65, $p < 0.05$. Further analysis indicated that there were no significant differences between students' STEM interests and STEM values.

Table 2. *Independent Sample T-test*

	Gender				*t*	Sig. (2-tailed)
	Boy					0.68
		N	Mean	SD		
STEM interests		73	3.82	1.24	0.42	
	Girl	49	3.73	1.02		
STEM values	Boy	73	3.96	1.21	0.83	0.41
	Girl	49	3.79	0.99		
STEM-related career interests	Boy	73	3.75	1.47	2.65	0.01
	Girl	49	3.11	0.97		

4.3 Regression Analysis

The regression analysis was computed to test if STEM values and STEM interests predict STEMrelated career interests. As shown in Table 3, the results of the regression indicated the STEM values and STEM interests significantly predicted STEM-related career interests, $R^2 = 0.64$, $F(2,119) = 107.07$, $p < 0.001$.

Table 3. *Regression Analysis*

Dependent variable	Independent variable	Beta	*t*	Adjusted R Square	F
STEM-related career interests	STEM interest	0.30	3.07***	0.64	107.07***
	STEM value	0.54	5.63***		
	STEM value	0.54	5.63***		

*** Correlation is significant at the 0.001 level.

5. Conclusion and Discussion

This case study showed that there was a significant relationship between STEM values, STEM interests and STEM-related career interests before secondary students were exposed to our STEM education program. Therefore, educators and program designers can cast more attention on the promotion of STEM values and

STEM interests in order to achieve the purpose of promoting students' willingness to pursue STEM careers. Studies have shown that students' attitudes toward STEM have important potential for interest in future STEM careers (LaForce, 2017). Students' attitudes toward STEM careers tend to be stable and level in middle school, which is related to their future STEM careers (Wiebe, 2018). The results of the survey showed that gender had a strong correlation with STEM-related career interests, and girls had relatively low STEM-related career interests. Previous studies have also reported that girls are less likely to choose STEM careers in the future, despite having equally important potential in STEM fields (Ünlü & Dökme, 2020). In the future, we will further study how to promote girls' motivation in pursuing STEM careers.

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