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# THE EFFECT OF LEARNING EXPERIENCES ON INTEREST IN STEM CAREERS: A STRUCTURAL EQUATION MODEL

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## Introduction

In today's knowledge and technological era, science, technology, engineering, and mathematics (STEM) workers are the driving force behind economic progress of many economies. However, countries around the world are facing a shortage of STEM workers to varying degrees. For instance, the US Bureau of Labor Statistics (2017) predicted that the demand for STEM workers would grow by 1 million between 2012 and 2022. Despite the increase in demand, the number of students studying in STEM majors is declining (National Science Board, 2016). This disparity between demand and supply of skilled STEM graduates has led to a shortage of workers in the STEM field. The difficulty in filling job vacancies in the STEM field (Wyss et al., 2012) has resulted in an effort to improve the quantity and quality of STEM workers through reformation of the core goals of the current global education.

To encourage more students to pursue STEM majors and careers, development of interest in STEM careers is fundamental. Personal interest is the critical factor that affects one's career choice, especially in STEM fields (Bahar et al., 2016; Lloyd et al., 2018; Miller, et al., 2018; Nugent et al., 2015). Interest in STEM careers refers to personal pursuits and aspirations for STEM careers, which can predict students' inclinations to engage in STEM careers in the future to a large extent. However, as adolescents grow, they become less interested in STEM careers (Chachashvili-Bolotin et al., 2019; Osborne et al., 2003), and their aspirations for STEM careers fades. The 2015 Programme for International Student Assessment (PISA) reported that the proportion of Chinese 15-year-old students who are willing to pursue STEM-related careers in the future is relatively low, far below the average level of the OECD (OECD, 2016a). Research (Lindahl, 2007) has shown that the best time to cultivate adolescents' interest in STEM careers is before the age of 13-14. Therefore, understanding how interest in STEM careers can be cultivated among adolescents could be one way to enhance the number and quality of individuals for the STEM workforce.



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**Abstract.** *Learning experiences can affect students' interest in STEM (science, technology, engineering, and mathematics) careers. Applying the social cognitive career theory, this study tested and compared the effect size and effect mechanism of formal learning experiences (FLE) and informal learning experiences (ILE) on 1133 tenth-grade students' interest in STEM careers (ISC) through a paper questionnaire survey. The results of structural equation model analysis showed that: 1) The total effect of ILE on students' ISC is much greater than that of FLE; 2) ILE, STEM self-efficacy (SSE) and STEM careers perceptions (SCP) can directly affect students' ISC; FLE and ILE can also indirectly affect students' ISC through the mediating role of SSE and SCP. The analyses suggest that in order to improve students' ISC, STEM education (especially informal STEM education) should be strengthened, both formal and informal education should pay attention to the cultivation of students' SSE and SCP.*

**Keywords:** *interest in STEM careers, learning experiences, social cognitive career theory, STEM careers perceptions, STEM self-efficacy, structural equation model*

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Earlier studies (Archer et al., 2012; Dewitt 2013; Mohtar et al., 2019) conducted to understand interest in STEM careers (ISC) have revealed that factors such as gender, school, society, media, scientific capital and personality characteristics exert profound effects on ISC. Comparatively, there are fewer studies relating formal learning experiences (FLE) and informal learning experiences (ILE) to students' ISC (Maiorca et al., 2021; Mohr-Schroeder et al., 2014; Roberts et al., 2018). Further, the foci of current studies have not compared the effects between FLE and ILE on ISC and centered on university students' experiences with little attention paid to high school students although it has been shown that intention to pursue STEM careers could start in high school (Bottia et al., 2015). Consequently, this study was carried out to focus on the effects of FLE and ILE on ISC among tenth-grade students, so as to provide theoretical reference for relevant policy makers and educators to cultivate students' ISC. The research questions guiding this study were: 1) Whether FLE and ILE can affect ISC? If so, which has greater effect? 2) What is the effect mechanism of FLE and ILE on students' ISC?

### *Literature Review*

Based on Bandura's Social Cognitive Theory, the Social Cognitive Career Theory (SCCT) was proposed by Lent et al. (1994). This theory integrates external factors such as learning experiences and personal cognitive factors (such as self-efficacy, outcome expectation and career interest) dynamically to reveal the process of career choice. The SCCT is one of the most powerful theories to explain career choice at present. As such, the literature review was based on the three major components of SCCT that have significant effects on ISC: 1) learning experiences, 2) STEM self-efficacy, and 3) STEM careers perceptions.

#### *Learning Experiences (LE)*

STEM Learning experiences (whether formal or informal) have effects on students' ISC. Formal learning experiences (FLE) mainly refer to the learning experiences through school organization, classroom teaching and other formal learning institutions (Eshach, 2007). FLE are usually regulated by the state, planned with clear goals and curriculum knowledge system, and realized by relying on standardized learning materials. FLE include professional information provided by teachers, teacher support, teaching methods, courses and teaching environment, etc. Rowan-Kenyon et al. (2011) have pointed out that careers information and careers projects have significant effects on adolescents' career planning. STEM curriculum and classroom environment have important impacts on students' interest in STEM (Maltese et al., 2011; Wieselmann et al., 2020). Adding research projects and cooperative inquiry activities to STEM courses is conducive to enhancing students' ISC (Hampden et al., 2013; Kang et al., 2017). Teaching strategies (such as student-centered teaching, project-based learning, and inquiry-based teaching) can also affect students' ISC (Lou et al., 2011; Wyss et al., 2012; Zhou et al., 2019). As such, with deliberate structures and intentions to engage students with inquiry ways of learning, formal education can be designed to affect students' STEM self-efficacy and STEM careers perceptions, as well as their ISC (Mohtar et al., 2019; Wang et al., 2020).

Compared with FLE, informal learning experiences (ILE) refer to the learning experiences of acquiring new knowledge and skills outside the classroom, in informal occasions such as work, life and society. The sphere of informal learning includes visiting science and technology museums, other museums and science centers, participating in various STEM competitions and summer camps (Eshach, 2007). Numerous studies (Halim et al., 2018; Kitchen et al., 2018; Melchior et al., 2018; Miller et al., 2018) have shown that informal STEM learning can affect students' ISC. Students who participate in informal STEM-related programs and STEM competitions are more interested in STEM careers than those who do not participate, and the effect can be increased by three times if students participate in more than one competition (Miller et al., 2018). STEM projects outside the classroom can affect students' choice of STEM-related subjects and college majors (Melchior et al., 2018). Students participating in summer STEM programs are 1.4 times more likely to pursue a STEM career than other ones (Kitchen et al., 2018). ILE related to STEM also improve students' STEM self-efficacy and STEM careers perceptions (Halim et al., 2018).

#### *STEM Self-efficacy (SSE)*

Similar to learning experiences, SSE has an important impact on ISC. Self-efficacy was proposed by Bandura (1977) and it refers to a personal subjective judgment or confidence in one's ability to engage in a certain posi-



tion or complete a certain task. Self-efficacy can predict a person's career interest to a large extent, and students are more likely to be interested in careers that they have better abilities and performance, and less likely to be attracted to careers that they are not confident in. This is supported by theory-based models, such as SCCT (Lent, 1994). Many studies (Halim et al., 2018; Maiorca et al., 2021; Mohtar et al., 2019; Nugent et al., 2015; Wang et al., 2020) have demonstrated that SSE is an important factor for individuals to pursue STEM careers. In this study, SSE was assessed by students' confidence in their own abilities and performance in the four subjects of STEM (Mohtar et al., 2019).

#### *STEM Careers Perceptions (SCP)*

Another factor that has effect on ISC is SCP. SCP refer to students' understanding and knowledge of STEM career prospects, skills required and self-development (Franz-Odendaal et al., 2016; Mohtar et al., 2019; Wyss et al., 2012). Recent studies have found that SSE and SCP are important factors in predicting whether adolescents are interested in STEM careers (Mohtar et al., 2019; Nugent et al., 2015; Schumacher et al., 2009; Wyss et al., 2012; Mohr-Schroeder et al., 2014; Kitchen et al., 2018). Research by Wyss et al. (2012) has shown that students may not be interested in STEM careers if the relevant information about skills, qualifications, requirements and employment prospects are not clearly presented to them. As such, the low ISC could be due to the fact that most schools do not introduce information about STEM careers to students. Informal STEM learning experiences can positively influence students' STEM careers perceptions and enhance their ISC (Kitchen et al., 2018; Mohr-Schroeder et al., 2014).

#### *Research Hypothesis*

SCCT is a theory with the most explanatory power for career choice at present. There are a large number of studies (Bahar et al., 2016; Kang et al., 2017; Kier et al., 2014; Maiorca et al., 2021; Mohtar et al., 2019; Nugent et al., 2015) applying SCCT to study students' interests in STEM careers and career aspirations. According to SCCT, positive environmental factors (such as learning experiences) can improve students' self-efficacy and outcome expectation of careers, deepen students' perceptions of related careers, and thus enhance students' interest and aspirations for related careers. In this study, the outcome expectations of STEM careers are measured by SCP (Mohtar et al., 2019). Based on the theoretical constructs of SCCT and the literature reviewed, ISC is affected by FLE, ILE, SSE, and SCP, so this study proposed the following four direct hypotheses ( $H_1 \sim H_4$ ).

$H_1$ : FLE can directly and positively affect students' ISC.

$H_2$ : ILE can directly and positively affect students' ISC.

$H_3$ : SSE can directly and positively affect students' ISC.

$H_4$ : SCP can directly and positively affect students' ISC.

In SCCT, positive learning experiences can improve self-efficacy and outcome expectation, and individuals with high self-efficacy also have high outcome expectation for specific careers. Self-efficacy and outcome expectation play key roles in the formation of careers interest, both of which are the basis of the development of careers interest. In other words, self-efficacy and outcome expectation play important mediating roles in the effects of learning experiences on careers interest. Based on the above analysis, this study assumed that SSE and SCP play mediating roles between LE and ISC and proposed the following six mediating hypotheses ( $H_5 \sim H_{10}$ ).

$H_5$ : SSE play a mediating role between FLE and ISC.

$H_6$ : SCP play a mediating role between FLE and ISC.

$H_7$ : SSE and SCP play a chain mediating role between FLE and ISC.

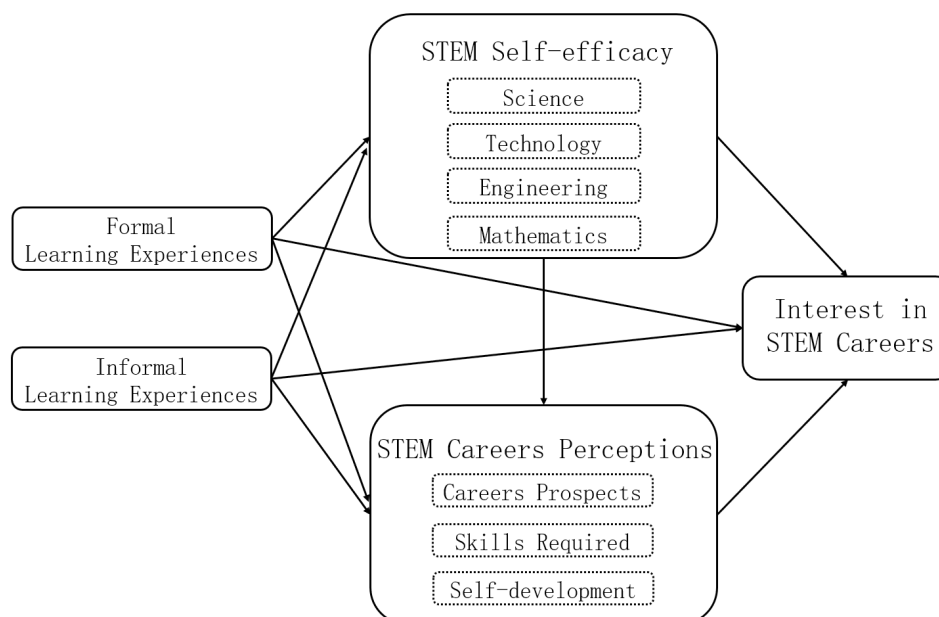
$H_8$ : SSE play a mediating role between ILE and ISC.

$H_9$ : SCP play a mediating role between ILE and ISC.

$H_{10}$ : SSE and SCP play a chain mediating role between ILE and ISC.

In order to explore the effect mechanism of FLE and ILE on ISC, a total of 10 hypotheses were proposed, and the hypothesis model (Figure 1) was constructed based on SCCT to test: 1) Whether FLE, ILE, SSE, and SCP can affect ISC? 2) Do SSE and SCP play mediating roles between LE and ISC?



**Figure 1***Hypothesis Model of the Effect of Learning Experiences on Interest in STEM Careers*

## Research Methodology

### *General Background*

Based on the SCCT as the framework, five constructs of this study were FLE, ILE, SSE, SCP and ISC. The final questionnaire was obtained through the revision of several well-known international questionnaires related to interest in STEM careers (Archer et al., 2013; Buday et al., 2012; Kier et al., 2014; Mohtar et al., 2019; Nugent et al., 2015) and the test of their reliability and validity. The paper questionnaire survey was conducted among tenth-grade students in Hunan Province, China from September to December 2020, and the data were analyzed through structural equation modeling to explore the effect mechanism of FLE and ILE on ISC among high school students.

### *Sample*

This research selected the tenth-grade students in Hunan Province, China who sat for the new college entrance examination in September 2020. The considerations for the selection of the sample were: 1) Under the new college entrance examination format, tenth-grade students have to make choices of courses, subjects and examinations, etc. As such, they are in the position to make independent judgments of their career interest. 2) Tenth-grade students are relatively mature in physical and mental development, so they are able to accurately assess the effects of LE on themselves. 3) Compared with students in Grade 11 and Grade 12, students in Grade 10 have less study pressure and have enough time to answer the questionnaire carefully. 4) An early intervention at lower grades is more beneficial hence tenth-grade students were chosen. Considering the different levels of economic developments in different regions, this study adopted multi-level random sampling method to select tenth-grade students in Changsha, Changde, and Xiangxi Autonomous Prefecture of Hunan Province, China to conduct on-site questionnaire surveys. Hair et al. (2014) suggested that the sample size should be at least 10 times the number of variables. As there were 40 variables in this study, at least 400 samples were needed. In addition, Comrey and Lee (1992) considered that a sample size greater than 1000 is the best, so a total of 1240 paper questionnaires were collected finally in this study. After inspection, 107 invalid questionnaires (missing answers and random answers) were eliminated. In total 1133 valid questionnaires were obtained, and this worked out to an effective rate of 91.37%. Among them, 549 were boys, accounting for 48.5%, and 584 were girls, accounting for 51.5%. There were 383 in



provincial-level demonstration senior high schools, accounting for 33.8%, 369 in municipal-level demonstration senior high schools, accounting for 32.6%, 381 in general senior high schools, accounting for 33.6%.

### Procedures

In order to protect the privacy of participants, after obtaining the consent of the head teacher and the students, an anonymous questionnaire survey was administered on a class basis. Each class was equipped with one or two graduate students majoring in science education as the main tester, who explained the instructions and requirements for the participants. The participants filled in the questionnaires within the specified time (about 20 minutes) and the questionnaires were collected on site after completion.

### Instrument

The questionnaire was divided into five parts: FLE, ILE, SSE, SCP and ISC (Table 1). All items were measured using the 5-point Likert scale, from "strongly disagree" to "strongly agree". The higher the score, the greater the degree of agreement. Among the constructs, the FLE, ILE and SCP parts were adapted from the instrument developed by Mohtar et al. (2019). The SSE part was adapted from the instruments developed by Buday et al. (2012), Kier et al. (2014) and Nugent et al. (2015). The ISC part was adapted from the instrument developed by ASPIRES Project Group, King's College London, UK (Archer et al. 2013). Combining the suggestions of two experts engaged in science education, one expert engaged in educational statistics, and three front-line teachers, and after two expert meetings, an exploratory factor analysis (EFA) was conducted on all items. The EFA showed that the Kaiser-Meyer-Olkin (*KMO*) is .914, and the value of Bartlett's test of sphericity is 12687 ( $df=171, p<.001$ ), meeting the judgement standards ( $KMO>.70, p<.05$ ) proposed by Howard (2016). After deleting items with unobvious factor loading, the item factor loading of each construct is between .594 and .887, indicating that the structure of the questionnaire was well divided. As shown in Table 1, among all the constructs, SSE and SCP include four and three sub-constructs respectively, and the score of each sub-construct was calculated by the average score of the items it includes. For example, the three sub-constructs of SCP are "Careers Prospects", "Skills required", "Self-development". Each sub-construct of SCP contains three items, and the score of each sub-construct was calculated by the average score of the three items.

**Table 1**  
*Constructs of the Questionnaire*

Construct	Sub-construct	Number of Items	Examples of Item
Demographic variables		3	School, Gender, Grade
FLE		4	In class, teacher introduce STEM careers to us.
ILE		4	I have participated in STEM-related competitions.
SSE	Science	4	I can carry out scientific experiments properly.
	Technology	4	I can use everyday technological products easily.
	Engineering	4	I can repair a broken toy.
	Mathematics	4	I can draw a graph from the provided data.
SCP	Careers Prospects	3	Those in STEM fields can get jobs easily.
	Skills required	3	STEM careers require creative problem-solving skills.
	Self-development	3	STEM careers contribute to self-development.
ISC		4	I will pursue a STEM career in the future.
Total		40	

The reliability and validity of the questionnaire are shown in Table 2. First of all, the overall Cronbach's  $\alpha$  reliability coefficient of the questionnaire is .916, and the Cronbach's  $\alpha$  of each part "FLE", "ILE", "SSE", "SCP", and "ISC" are .824, .811, .832, .834, .928 respectively, indicating that the questionnaire has high internal consistency and high



reliability. Second, confirmatory factor analysis (CFA) was used to test the validity. The results showed that all the standardized factor loadings are between .559 and .935, which reach the standard of 0.5 to 0.95 and the significance level, indicating that all the items and constructs are effective. The composite reliability ( $CR$ ) $>0.8$  and the average variance extracted ( $AVE$ ) $>0.5$ , indicating each construct has high convergent validity. The correlation coefficients between the constructs are less than the square root of  $AVE$  in each construct, indicating that the questionnaire has good discriminant validity. From the fitting index,  $RMSEA=.063<.08$ ,  $SRMR=.043<.08$ , and all other goodness-of-fit indexes are greater than 0.9, indicating that the data fit well.

**Table 2**  
*Reliability and Validity of the Questionnaire*

Construct	Item	Factor Loading	Cronbach's $\alpha$	CR	AVE	FLE	ILE	SSE	SCP	ISC
FLE	FLE1	.760	.824	.825	.542	.736				
	FLE2	.775								
	FLE3	.665								
	FLE4	.741								
ILE	ILE1	.754	.811	.817	.528	.700	.726			
	ILE2	.728								
	ILE3	.721								
	ILE4	.702								
SSE	Science	.833	.832	.836	.567	.708	.695	.753		
	Technology	.559								
	Engineering	.697								
	Mathematics	.880								
SCP	Prospects	.623	.834	.841	.643	.410	.367	.479	.802	
	Skills	.853								
	Development	.901								
ISC	ISC1	.916	.928	.929	.767	.432	.548	.507	.507	.876
	ISC2	.935								
	ISC3	.813								
	ISC4	.833								

### Data Analysis

Firstly, the analysis of reliability and validity was carried out by the following methods. Cronbach's  $\alpha$  was used to analyze the reliability of the whole questionnaire and each construct. The content validity of the questionnaire was established through consultation with relevant experts engaged in science education and educational statistics. The structural validity and convergence validity were tested through EFA and CFA, and the discriminant validity was tested by judging whether the correlation coefficient between dimensions was less than the square root of  $AVE$  of the construct. Secondly, the Harman single factor test (Podsakoff et al., 2003) was performed to ensure that there was no serious common method deviation in this study. The structural equation model was constructed, and the fitting degree of the model was judged by the goodness of fit indexes. The  $p$ -value was used to determine whether the direct effects of FLE, ILE, SSE, and SCP on ISC were significant, and the sizes of the effects were analyzed by the standardized path coefficients ( $\beta$ ). Finally, whether the 95% confidence interval of Bootstrap mediation test (Preacher & Hayes, 2004) included 0 was used to test whether the indirect effects of FLE and ILE on ISC were significant and the size of the total effect. All the above analyses were performed in SPSS23.0 and AMOS23.0.

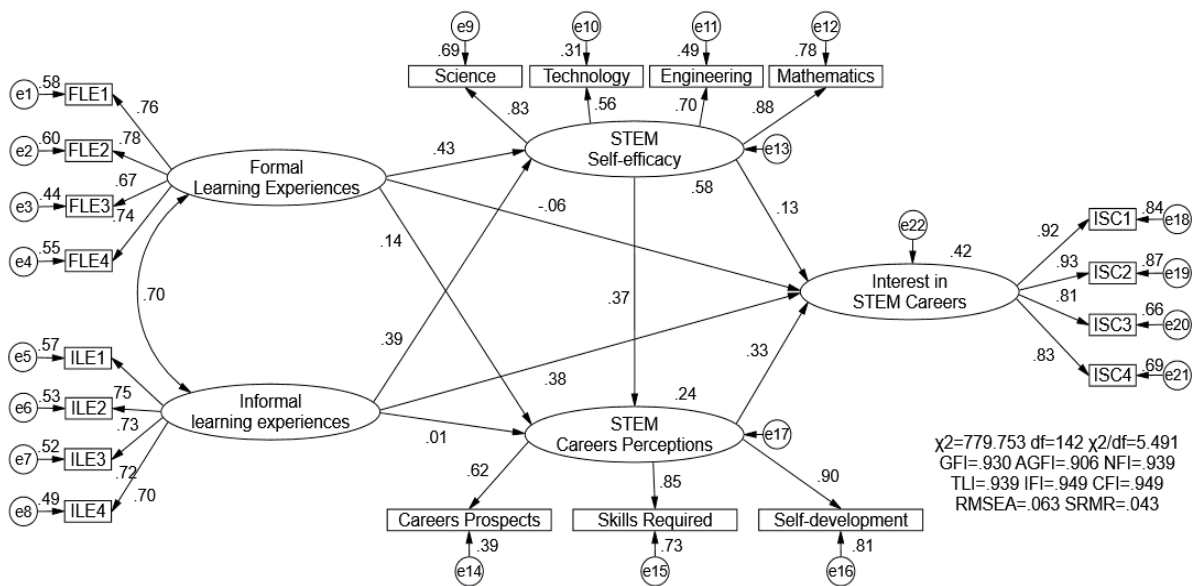


**Research Results**

Harman single factor test was used to test the data for common method deviation (Podsakoff et al., 2003). The results showed that there are five factors with eigenvalues greater than 1, which account for 72.12% of the variation, and the explanation rate of the maximum factor variance is 40.54%, which is less than the 50% judgment standard recommended by Hair et al. (2014). Therefore, there is no serious common method bias in this study.

The “Structural Equation Model of The Effect of Learning Experiences on Interest in STEM Careers” was constructed in AMOS23.0 (Figure 2), which shows all path coefficients, factor loadings, residual values, etc. of the model using the maximum likelihood method. The standardized factor loadings of all observed variables are between 0.56 and 0.93, which reach the test standard of 0.5 to 0.95. All residual values are positive, indicating that the model definition is reasonable. The lower right part of Figure 2 shows the fit of the model. In the structural equation model, when the sample size is greater than 200, it is easy to cause the chi-square value of the model to expand, resulting in poor model fit (Bollen & Stine, 1993). Therefore, it is recommended to use other goodness-of-fit indexes to evaluate the model (Bentler, 1990). Although the  $\chi^2/df=5.491$  of the model is slightly higher than the standard value of 5 due to the large sample size, other fitting indicators are at a good level, RMSEA=.063 (<.08, indicating a good fit), SRMR=.043 (<.08, indicating good fit), and all other goodness-of-fit indexes are greater than 0.9 (GFI=.930, AGFI=.906, NFI=.939, TLI=.939, IFI=.949, CFI=.949). These showed that the constructed model better demonstrates the effect mechanism of FLE and ILE on high school students’ ISC, which is suitable for further exploring the relationship between variables. Figure 2 also shows the direct standardized path coefficients between the variables.

**Figure 2**  
*The Structural Equation Model of the Effect of Learning Experiences on Interest in STEM Careers*



The significance test of the direct effects between each variable is shown in Table 3. The direct effect of FLE on ISC is not significant ( $\beta=-.061$ ,  $p>.05$ ), indicating hypothesis  $H_1$  is not supported; the direct effect of ILE on ISC is significant ( $\beta=.382$ ,  $p<.001$ ), indicating hypothesis  $H_2$  is supported; the direct effect of SSE on ISC is significant ( $\beta=.127$ ,  $p<.05$ ), indicating hypothesis  $H_3$  is supported; the direct effect of SCP on ISC is significant ( $\beta=.331$ ,  $p<.001$ ), indicating hypothesis  $H_4$  is supported. From the perspective of effect size, ILE > SCP > SSE. FLE have no significant direct effect on ISC, but they may indirectly affect the ISC among high school students by affecting SSE and SCP.



**Table 3***The Direct Effects Test of the Model*

Hypothesis	$\beta$	S.E.	t	p	Supported /Not supported
H <sub>1</sub> : FLE → ISC	-.061	.072	-1.212	.226	Not supported
H <sub>2</sub> : ILE → ISC	.382	.072	7.368	***	Supported
H <sub>3</sub> : SSE → ISC	.127	.066	2.559	.010**	Supported
H <sub>4</sub> : SCP → ISC	.331	.072	9.073	***	Supported

Note: \*\*\* $p < .001$ ; \*\* $p < .01$ ; \* $p < .05$ .

In order to test whether the indirect effects of learning experiences (FLE and ILE) on interest in STEM careers are significant, the Bootstrap mediating effect test method (Preacher & Hayes, 2004) was adopted to repeat the sampling 5000 times and calculate the 95% confidence interval (CI). If the 95% CI does not include 0, the mediation effect of the path is significant. Table 4 shows the direct effect, indirect effect, indirect total effect, total effect, and the difference between the total effects of FLE and ILE on ISC. The 95% confidence interval of the mediating effect ( $\beta = .055$ ) of H<sub>5</sub> (FLE → SSE → ISC) is [.009, .108], which does not contain 0, so H<sub>5</sub> is supported; The 95% confidence interval of the mediating effect ( $\beta = .046$ ) of H<sub>6</sub> (FLE → SCP → ISC) is [.005, .092], which does not contain 0, so H<sub>6</sub> is supported; The 95% confidence interval of the mediating effect ( $\beta = .054$ ) of H<sub>7</sub> (FLE → SSE → SCP → ISC) is [.033, .082], which does not contain 0, so H<sub>7</sub> is supported. These showed that FLE can affect ISC through parallel mediation and chain mediation of SSE and SCP. The indirect total effect of FLE on ISC is significant ( $\beta = .155$ ,  $p < .01$ ) and the direct effect of FLE on ISC is not significant ( $\beta = -.061$ ,  $p = .226 > .05$ ), so the effect of FLE on ISC is completely mediated by SSE and SCP. The 95% confidence interval of the mediating effect ( $\beta = .049$ ) of H<sub>8</sub> (ILE → SSE → ISC) is [.008, .091], which does not contain 0, so H<sub>8</sub> is supported; The 95% confidence interval of the mediating effect ( $\beta = .003$ ) of H<sub>9</sub> (ILE → SCP → ISC) is [-.033, .039] which contains 0, so H<sub>9</sub> is not supported; The 95% confidence interval of the mediating effect ( $\beta = .048$ ) of H<sub>10</sub> (ILE → SSE → SCP → ISC) is [.029, .074], which does not contain 0, so H<sub>10</sub> is supported. The total indirect effect of ILE on ISC is significant ( $\beta = .101$ ,  $p < .01$ ), and the direct effect of ILE on ISC is also significant ( $\beta = .382$ ,  $p < .001$ ), therefore, the effect of ILE on ISC is partially mediated by SSE and SCP. Overall, the total effect of ILE ( $\beta = .483$ ,  $p < .001$ ) on ISC is much greater than that of FLE ( $\beta = .155$ ,  $p < .01$ ), and the difference between their effect size is significant ( $\beta = .328$ ,  $p < .001$ ), indicating that the total effect of ILE on ISC is much greater than that of FLE.

**Table 4***The Indirect Effects Test of the Model*

Path	Direct effect			Indirect effect			Total effect		
	$\beta$	S.E.	p	$\beta$	S.E.	Bootstrap 95% CI			
						Lower	Upper	p	
FLE → ISC	-.061	.072	.226						
H <sub>5</sub> : FLE → SSE → ISC				.055	.026	.009	.108	.022*	
H <sub>6</sub> : FLE → SCP → ISC				.046	.022	.005	.092	.029*	
H <sub>7</sub> : FLE → SSE → SCP → ISC				.054	.012	.033	.082	***	
Indirect total effect of FLE				.155	.033	.092	.221	.001**	





Path	Direct effect			Indirect effect			Total effect				
	$\beta$	S.E.	p	$\beta$	S.E.	Bootstrap 95% CI			$\beta$	S.E.	p
						Lower	Upper	p			
Total effect of FLE									.155	.033	.001**
ILE→ISC	.382	.072	***								
H <sub>8</sub> : ILE→SSE→ISC				.049	.021	.008	.091	.023*			
H <sub>9</sub> : ILE→SCP→ISC				.003	.018	-.033	.039	.847			
H <sub>10</sub> : ILE→SSE→SCP→ISC				.048	.012	.029	.074	***			
Indirect total effect of ILE				.101	.026	.051	.154	.001**			
Total effect of ILE									.483	.049	***
Difference									.328	.067	***

Note: \*\*\* $p < .001$ , \*\* $p < .01$ , \* $p < .05$ ; Difference="Total effect of ILE"- "Total effect of FLE".

### Discussion

Based on the framework of SCCT, this research explored the effect size and effect mechanism of LE (FLE and ILE) on high school students' ISC. The results showed that ILE, SSE and SCP can directly and positively affect students' ISC, and FLE and ILE can also indirectly affect students' ISC through the mediating roles of SSE and SCP.

From the results of direct effects, ILE, SSE and SCP significantly affect students' ISC, which is consistent with SCCT and the results of related studies. First of all, this study found that ILE, such as visiting STEM related museums, participating in STEM related clubs, competitions and summer camps can promote ISC significantly, which is consistent with previous research results (Kitchen et al., 2018; Maiorca et al., 2021; Nugent et al., 2015). Secondly, students with higher STEM self-efficacy are more confident that they have the ability to engage in STEM careers and achieve good results, and thus more interested in STEM careers (Mohtar et al., 2019; Wang et al., 2020). Thirdly, the clearer the knowledge about STEM career prospects, skills required, and self-development, the more likely students are to make sober and wise decisions. SCP is an important factor for adolescents to be interested in STEM careers (Kitchen et al., 2018; Mohr-Schroeder et al., 2014; Mohtar et al., 2019; Nugent et al., 2015; Schumacher et al., 2009; Wyss et al., 2012). However, the direct effect of FLE on ISC is not significant, and the study of Zhou et al. (2019) also proved this conclusion that the typical school system fails to improve students' ISC. The reason may be that although teachers are encouraged to conduct inquiry-based teaching, problem-based and project-based learning (PBL) during classroom instruction, due to the impact of class hours and examination evaluation, teachers paid more attention to the imparting of knowledge in class, rather than the cultivation of students' ISC.

From the results of indirect effects, LE (FLE and ILE) can indirectly and positively affect ISC through the mediating role of SSE and SCP. This is consistent with SCCT, and further expands the application scope of SCCT. In other words, SCCT is suitable for research on students' ISC. Although in many studies (Kitchen et al., 2018; Maiorca et al., 2021; Schroeder et al., 2014), LE have important effects on students' ISC, few studies have found and proved the indirect effects of LE. Positive LE (FLE and ILE) can enhance students' SSE and promote their understanding and awareness of STEM careers, which in turn increase their ISC. However, this study also found that ILE could not affect ISC through SCP, mainly because the first half of the mediation (the effect of ILE on SCP) is not significant. The reason may be that current informal STEM education does not focus on students' understanding and awareness of STEM careers, or it may be that these STEM learning activities are not related to real STEM careers. This suggest that STEM activities and programs in schools should have similar characteristics, methods and basic principles to the work performed by professionals in STEM field (Kitchen et al., 2018). As such, both formal education and informal education, educators should adopt appropriate teaching strategies



and teaching activities, cultivate a good teacher-student relationship, stimulate students' learning initiative, optimize students' STEM learning experiences, so as to more effectively enhance the students' SSE and SCP, and then develop their ISC.

In terms of the total effect, the effect of ILE on ISC is much greater than that of FLE. This finding is significant because few studies have compared the effects of FLE and ILE on ISC, which also provides inspirations for us to put forward related strategies. First of all, informal STEM education should be strongly encouraged and promoted, especially in the high school stage, because it has been shown that students' intention to pursue STEM careers could start at this stage (Bottia et al., 2015). Thus, educators and policy makers could strengthen collaboration between colleges and high schools to develop effective STEM activities that are relevant to real STEM careers; The training of STEM teachers (including pre-service and post-service training) should be strengthened, so that STEM programs can be carried out successfully; Parents should strongly support their children's participation in STEM-related competitions, clubs, camps, and museums. Secondly, if students who are limited by objective factors such as the economic and educational level of the area and the socioeconomic status of the family cannot get access to informal STEM education, the following formal education measures should be adopted to enhance students' ISC although informal STEM education has a greater effect on students' ISC than formal education. This study showed that more scientific experiments, collaborative inquiry activities and PBL in classroom instruction are conducive to improving students' ISC, and some studies (Hampden et al., 2013; Kang et al., 2017; Zhou et al., 2019) also proved this conclusion. Therefore, inquiry teaching and PBL should be adopted in formal education, and the competence and literacy of teachers in STEM-related disciplines (mathematics, physics, chemistry, biology, geography, technology, etc.) should be improved. In addition, ISC could also be raised in formal education by strengthening students' STEM careers perceptions. However, schools offer limited information on STEM careers and textbooks feature limited range of STEM careers, especially in primary school science textbooks. Therefore, it is necessary to enrich the career education environment and further explore how to integrate the introductions of STEM careers into textbooks. At the same time, the interview videos of STEM professionals could also be incorporated and synchronized into corresponding courses. For example, when students are learning DNA, they can watch a video of interviews with genetic counselors.

### Conclusions and Future Research

Referring to the two research questions that "Whether FLE and ILE can affect ISC? If so, which have greater effect?" and "What is the effect mechanism of FLE and ILE on students' ISC?", the results showed that: 1) FLE and ILE can positively affect students' ISC and the total effect of ILE on students' ISC is much greater than that of FLE; 2) ILE, SSE and SCP can directly and positively affect students' ISC, and LE (FLE and ILE) can indirectly and positively affect ISC through the mediating roles of SSE and SCP. Based on the quantitative analysis through structural equation modeling, it has been confirmed that ILE play a greater role in promoting students' ISC, and the effect mechanism model of LE (FLE and ILE) on ISC has been established.

In order to improve students' ISC, STEM education (especially informal STEM education) should be strengthened. First of all, informal STEM education should be strongly encouraged and promoted. Relevant departments should develop effective informal STEM activities, teachers should ensure the implementation of informal STEM education, and parents should support children to participate in informal STEM activities. Secondly, in formal education, teachers should try to adopt inquiry-based teaching and PBL, enrich the career education environment and explore how to integrate STEM career introductions into textbooks and courses. Finally, both formal and informal education should pay attention to the cultivation of students' STEM self-efficacy and STEM careers perception in the process. Although this research was carried out in the context of Chinese high school education, measures to improve high school students' interest in STEM careers may have implications for other countries as educational issues faced by different countries have some significant similarities, especially the issues of low interest in STEM careers among high school students. The conclusions of this study could provide some useful references to the teachers and policy makers in STEM, particularly those who are designing STEM learning experiences. The stakeholders (e.g., students, parents, teachers, policy makers, schools, private sector, etc.) should realize the critical role of informal education in fostering students' interest in STEM careers, and encourage them to form a STEM education community, to participate in, support, and develop informal STEM programs.

Based on the results of the study, future research could consider interviews on top of the questionnaire to triangulate the findings. Further, longitudinal research (from primary school to university) could be carried



out on the longevity and intensity of adolescents' interest in STEM careers and how it changes. Previous studies have found significant differences in students' interest in STEM careers in terms of gender, and the formation mechanism of interest in STEM careers of different groups is different. As such, in-depth studies can be conducted to compare across groups of learners from different genders. Finally, based on different economic and cultural backgrounds, how informal STEM programs should be designed to cater to the needs of different student groups.

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### Declaration of Interest

Authors declare no competing interest.

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