



Abstract: Currently, nations grapple with a noticeable shortage of STEM talent, particularly within fields like agroforestry. The study applied the structural equation modelling and the mediation effect model to analyze the mechanisms through which STEM value perception influences STEM career preferences, as well as the roles played by STEM self-efficacy and STEM learning interest among 1,604 undergraduates majoring in agroforestry. The results revealed that students' STEM value perception was found to directly and positively correlate with their STEM career preferences. STEM value perception also has an indirect impact on STEM career preferences by influencing STEM learning interest and STEM self-efficacy. Furthermore, STEM value perception plays a sequential mediation role in promoting STEM learning interest, STEM self-efficacy and STEM career preferences. Based on these findings, it is recommended that institutions bolster STEM career education for students majoring in agroforestry from the outset of their enrollment, enhancing students' professional awareness and identity, by addressing gaps in students' value perceptions of STEM education. Furthermore, efforts to improve students' interest in relevant courses and their confidence in learning these subjects can be beneficial. Ultimately, such initiatives can contribute to a more balanced development of students' STEM career preference.

Keywords: STEM career preference, STEM learning interest, STEM self-efficacy, STEM value perceiving, Agroforestry undergraduates

Jianjun Sheng

Zhejiang Agriculture and Forestry
University, China

Peiyao Tian, Daner Sun

The Education University of Hong Kong, China

Yanhua Fan

Henan University, China



INFLUENCE OF STEM VALUE PERCEPTION ON STEM CAREER PREFERENCES AMONG AGRICULTURAL AND FORESTRY UNDERGRADUATES

**Jianjun Sheng,
Peiyao Tian, Daner Sun,
Yanhua Fan**

Introduction

In order to adapt to the changes in the development of the world's economy, society, science and technology and the profound changes in the demand for talent training, countries around the world have strategically formulated policies to promote the training of STEM talents in order to develop the national economy and increase the pool of scientific and technological innovation talents (NRC, 2011; OECD, 2012). However, despite the fact that governments have introduced policies and implemented reforms to improve the quality and quantity of STEM-related talent training at universities, few people are engaged in STEM-related careers after university graduation, and there is still a serious shortage of STEM talent (Gago et al., 2005; OECD, 2018; Stipanovic & Woo, 2017). Consequently, numerous researchers have embarked on exploring the STEM career aspirations of students across all age groups, aiming to gain insights into their preferences within the realm of STEM careers (Carpi et al., 2017; Chachashvili-Bolotin et al., 2016; Lent et al., 2010; Zhan, et al., 2023).

According to Social Cognitive Career Theory (SCCT), an individual's career interest is determined by the core variables of self-efficacy, learning interest, outcome expectations, and learning experience, along the lines of Individual-Behavior-Environment (Lent et al., 2010). Currently, many researchers have explored the status of students' STEM career preferences and the factors that influence students' expectations of pursuing STEM-related careers, such as self-efficacy (Blotnick et al., 2018), learning interest (Luo et al., 2021), impressions of STEM (Chen et al., 2022), family (Balt et al., 2023), formal or informal learning environments (Cheng et al., 2021; Drymiotou et al., 2021), and so on. While undeniably valuable, a majority of these studies have primarily concentrated on the elementary and secondary education tiers, leaving a noticeable gap in terms of studies conducted at the university level. The significance of this omission becomes particularly pronounced

when considering that university-level students, typically aged 18 to 23, have already made their major selections. This phase of education is especially pivotal for students within science and engineering fields, as it represents a crucial juncture for assimilating specialized knowledge, refining professionalism, cultivating a sense of professional identity, and nurturing a heightened professional interest (Liu et al., 2022). The STEM career inclinations exhibited by this cohort of students hold a stronger predictive power for their subsequent career trajectories within the field, surpassing the predictive significance observed in students of different age brackets (Liu et al., 2022). Consequently, delving into the STEM career propensities of students enrolled in science and technology programs at colleges and universities holds immense value.

Amidst the swift progression of the latest global scientific and technological revolution, coupled with industrial transformations, the significance of agricultural and forestry disciplines has become even more pronounced. Pioneering technologies encompassing biotechnology, engineering advancements, information technology, and other forefront innovations are consistently permeating the realm of agriculture, fostering an innovative resurgence in agricultural science and technology. This phenomenon presents a series of intricate challenges and requisites for structuring disciplines and specializations, along with nurturing talent, within educational institutions focusing on agriculture (Ameyaw et al., 2017; Sharik et al., 2015). However, data showed that among all STEM majors, the proportion of students majoring in agriculture and forestry who are engaged in majors-related occupations after graduation is the smallest (Kim et al., 2022, World Bank, 2019). Parents and students generally perceive agriculture and forestry majors to be difficult to employ and of little value (Cosby et al., 2022). Therefore, studying the influence of this group's STEM value perception on their STEM career tendency can help relevant professional teachers, schools and the state to analyze the academic situation, improve career education in agricultural and forestry colleges and universities, and cultivate urgently needed and scarce reserve agricultural and forestry science and technology talents.

Based on the above background, this study explored the influence of STEM value perceptions of Chinese agricultural and forestry university students on their future STEM career preferences by means of a questionnaire survey, and explored the mediating roles of STEM learning interests and STEM self-efficacy, with a view to providing references to improve the future STEM career preferences of this group of students.

Literature Review

STEM Career Preference

Career preference encompasses an individual's future career intentions, along with their ambitions and anticipations for a specific occupational trajectory before entering the human resource market (Gottfredson, 1981). This personalized selection plays a pivotal role in shaping one's prospective career orientation, carrying significant motivational weight (Davey & Stoppard, 1993). Within this context, STEM careers encompass domains such as engineering, healthcare, information technology, and more (Blotnicky et al., 2018). Synthesizing the concepts of STEM careers and career aspirations, STEM career preference can be defined as an individual's inclination or subjective readiness to pursue a future in STEM careers at a specific juncture (Mau & Li, 2018). The career preferences of students serve as a predictive and analytical lens into their future professional paths (Salehjee & Watts, 2015). Consequently, an array of studies has explored and scrutinized the current landscape of STEM career aspirations across students of varying ages, with a focus on three primary spheres. The first domain centers on investigating the present landscape of students' inclinations towards STEM careers. For instance, Koyunlu Ünlü and Dökme (2020) gauged the level of interest among Turkish secondary school students in STEM careers, employing the STEM Career Interest Survey (STEM-CIS) devised by Kier et al. (2014). The second realm delves into the principal factors influencing students' attraction to STEM careers. Cheng et al. (2021), for instance, integrated 3D printing into STEM learning and examined its influence on students' inclinations towards STEM careers. Similarly, Luo et al. (2021) probed the impact of stereotypes surrounding STEM careers on upper primary school students, highlighting the mediating roles of self-efficacy and outcome expectations. Moreover, So et al. (2020) explored the potential effects of elementary school students' perceptions of STEM careers on their interest in the field. The third domain revolves around the implementation of specific methods aimed at fostering students' fascination with STEM careers. Chen (2022) and others adopted an approach involving hands-on STEM activities to heighten interest among elementary students in STEM careers.



STEM Self-Efficacy, STEM Value Perception, STEM Learning Interest, and STEM Career Preference

Students' value perception of a career refers to the individual's expectation of the likelihood of success in developing a career with this career as well as the values that are identified with the career (Compeau, 2016). An individual's motivation to pursue a particular career is determined by his value perception of that career (Salehjee & Watts, 2015). The easier an individual perceives himself to be valued in this occupation, the more likely he/she is to be motivated and thus the more motivated he/she is to pursue that occupation (Nugent et al., 2015; Zhang & Barnett, 2015). Prior research has found that students' perceptions of value in STEM careers can had an impact on students' STEM career expectations (Blotnicky et al., 2018; Heilbronner, 2009; Luo et al., 2021). However, despite the relationship between the two, few studies have explored how students' perceived STEM values influence their career preferences towards STEM.

Learning interest is a fundamental motivator and driver of learning (Dewey, 1913; Hidi & Renninger, 2006). In this study, STEM learning interest refers to students' interest in learning STEM-related courses. Students' interest in learning a subject is a key predictor of future participation in related careers (NRC, 2007). Currently, there are many studies that have examined the influence of students' interest in STEM learning toward career preference, confirming that students' interest in STEM learning is a significant positive predictor of students' occupational dispositions (DeBacker & Nelson, 1999), and that students' learning interest is a positive predictor of students' self-efficacy (Jiang et al., 2022). In addition, self-efficacy has been also shown to play an important mediating role in STEM education (Cabell, 2021, Halim et al., 2021).

Research Questions and Hypotheses

In order to clarify how the STEM value perception influence the STEM career preference of university students majoring in agriculture and forestry, and then to better enhance students' STEM career preference, this study posed the following research question:

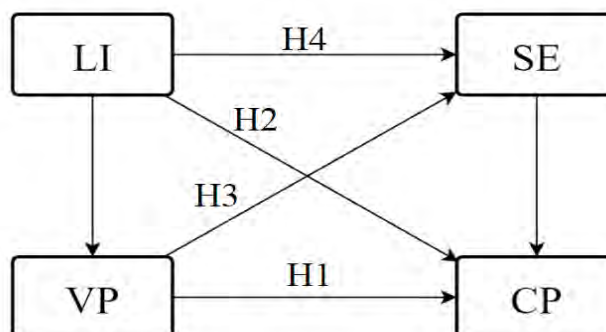
1. How does the perception of STEM value (VP) among undergraduate students majoring in agroforestry impact their preferences for STEM careers (CP)?
2. What underlying mechanisms drive this influence, and how do STEM learning interest (LI) and STEM self-efficacy (SE) contribute to the pathway through which STEM value perceptions (VP) shape STEM career preferences (CP)?

To answer the research question, below hypotheses were made about the influence mechanisms between the independent and dependent variables based on the existing literature.

- H1:** Agroforestry students' STEM value perceptions (VP) can directly influence students' STEM career preferences (CP);
- H2:** Agroforestry students' STEM value perceptions (VP) can influence STEM career preferences (CP) by influencing STEM learning interest (LI);
- H3:** Agroforestry students' STEM value perceptions (VP) can influence STEM career preferences (CP) by influencing STEM self-efficacy (SE);
- H4:** There is a chain effect between STEM value perceptions (VP), STEM learning interest (LI), STEM self-efficacy (SE), and STEM career preferences (CP) of agroforestry students.

The hypothetical model for this study is shown in Figure 1.



Figure 1*Hypothetical Model*

Research Methodology

Background

This research employed a quantitative research methodology, specifically utilizing Structural Equation Modeling (SEM), to explore the influences among STEM value perceptions, STEM learning interest, STEM self-efficacy, and STEM career preferences within the context of students majoring in Agriculture and Forestry. The study employed a standardized questionnaire to collect data. Prior to the main survey, a preliminary test was conducted with a subset of participants, which facilitated the refinement of the questionnaire through Confirmatory Factor Analysis (CFA) and reliability analysis. The final survey took place in March 2023, and an electronic distribution method was employed to administer the questionnaire to the entirety of students enrolled in agricultural and forestry programs at Zhejiang Agriculture and Forestry University, China. The coordination of this process was overseen by class lecturers, and the data collection spanned approximately one month. Subsequent to collecting the completed questionnaire, a rigorous analysis was undertaken employing statistical tools such as SPSS and Amos. The primary goal of this analysis was to uncover the extent to which students' perceived values in STEM education influence their preferences for STEM careers. Additionally, the study sought to elucidate the underlying mechanisms that mediate this connection and rigorously test the research hypotheses.

Participants

To ensure a balanced representation, accuracy, and ease of sample collection, a purposive sampling method was employed to survey students from agriculture and forestry universities. Zhejiang Agriculture and Forestry University, dedicated to education and research in these fields, offers a diverse range of programs encompassing agricultural and forestry sciences. Furthermore, the university attracts students from various backgrounds and regions, which also guarantees the collection of a comprehensive and expansive sample.

The formal questionnaire encompassed students from diverse academic years (freshmen to seniors), with ages ranging from 17 to 23 and an average age of 19. The distribution of the online questionnaire facilitated tracking of the respondents' count, culminating in a total count of 1610 responses. The questionnaire was disseminated under the supervision of lecturers, and the electronic format included mandatory questions that needed to be answered comprehensively before submission. This meticulous approach led to a higher level of diligence and completion, consequently resulting in a minimal number of invalid responses. Finally, 1,604 (99.6%) valid questionnaires were identified. Table 1 presents the demographic characteristics of the participants involved in the data collection process.



Table 1
Demographics of the Participants

	Variables	Participants	Percentage (%)
Gender	Male	577	36
	Female	1027	64
Major	Agronomy	113	7
	Plant Protection	76	4.7
	Smart agriculture	18	1.1
	Forestry	170	10.6
	Biotechnology	75	4.7
	Ecology	70	4.4
	Agricultural Resources and Environment	178	11.1
	Horticulture	140	8.7
	Landscape Architecture	209	13
	Agricultural and Forestry Economic Management	115	7.2
	Animal Science	31	1.9
	Veterinary medicine	58	3.6
	Facility Agricultural Science and Engineering	86	5.4
	Tea science	36	2.2
	Cultural Industry Management (Tea Culture)	54	3.4
	Traditional Chinese Medicine	94	5.9
	Biopharmaceuticals	81	5
	Grade	Freshman	615
Sophomore		490	30.5
Junior		288	18.0
Senior		211	13.2

Instrument

This study formed a questionnaire on students' STEM learning interest, STEM self-efficacy, STEM values perceptions, and STEM career preferences consisting of four sub questionnaires. The instrument contains a total of 14 items with a 5-point Likert scale (1=strongly agree, 2=agree, 3=neutral, 4=disagree, 5=totally disagree). The specific distribution of the questionnaire items is shown in Table 2.

Table 2
Distribution of the Questionnaire Items

Sub-questionnaire	Item
STEM Learning Interest	1, 2, 3, 4
STEM Self-Efficacy	5, 6, 7, 8
STEM Value Perception	9, 10, 11, 12
STEM Career Preference	13, 14



The STEM Learning Interest sub-questionnaire was structured into four distinct dimensions, mirroring interest in knowledge comprehension, engagement in activity participation, focus on skill acquisition and enthusiasm for course learning. Each dimension was represented by a singular item, inspired by the work of McGuire et al. (2021). Regarding the STEM Self-Efficacy sub-questionnaire, following the questionnaire's development and validation by Luo et al. (2021), students' STEM self-efficacy was categorized into four facets: understanding of knowledge, mastery of skills, aptitude for problem solving, and performance in tests. Each of these sections corresponded to an individual item. As for students' perceptions of STEM value, guided by the research of Halim et al. (2018), it was compartmentalized into four dimensions: recognition within society, economic standing, prospects for employment, and personal ability enhancement. A set of questions was designated for each dimension to capture students' perspectives. To gauge students' career inclinations, the study drew inspiration from Karen et al.'s (2018) research. Specifically, two questions were employed: "In my future career, I will utilize knowledge linked to mathematics, science, engineering, and technology to resolve challenges" and "I possess a keen interest in pursuing a career as a scientist, engineer, or technologist." These questions provided insights into students' preferences for STEM-related career paths.

In this study, the main factors were measured in the form of sub-questionnaires, so testing the quality of the measured data is an important prerequisite to ensure that the subsequent analysis is meaningful. First, the internal consistency of the scales was tested by the Cronbach reliability coefficient. As shown in Table 2, the reliability coefficient values of the sub-questionnaires are all above 0.8, and the instrument has good reliability. In addition, the Confirmatory Factor Analysis (CFA) model fit sub-questionnaire of STEM learning interest, STEM self-efficacy and the STEM career preferences was also required. The CFA was used to judge the model fit mainly by referring to χ^2/df , RMR, RMSEA, CFI and other indicators. Among them, the cardinality freedom ratio is always greatly influenced by the sample size, therefore, in large samples, it is usually combined with other indicators for comprehensive evaluation. The results of model fitness tests for the subscale of STEM learning interest, STEM self-efficacy and the STEM career preferences are shown in Table 4. It can be seen that each indicator basically meets the requirements, and the model has an acceptable fitness.

Table 3*Reliability of the Sub-questionnaires*

Sub-questionnaire	Cronbach's α	Items
LI	.928	4
SE	.948	4
VP	.884	4
CP	.837	2
Total	.948	16

Table 4*Model Fit*

Sub-questionnaire	GFI	AGFI	RMSEA	NFI	RFI	IFI	CFI	RMR	χ^2/df
LI	.999	.993	.026	.999	.998	1.000	1.000	.004	2.072
SE	.995	.974	.069	.997	.992	.998	.998	.006	7.662
VP	1.000	.999	.001	1.000	1.000	1.000	1.000	.001	.195
Reference Value	> .9	> .9	< .1	> .9	> .9	> .9	> .9	< .1	<10



Based on the goodness of fit, convergent validity (Average Variance Extracted, AVE) and composite reliability (CR) were further examined. The standardized factor loadings of each item in the corresponding dimension were calculated by the established CFA model. The AVE and CR values were calculated. The CR > 0.8 and the AVE > 0.5 (Table 5), which proves that the convergent validity and combined reliability are good.

Table 5
AVE and CR Results

	Path		β	AVE	CR
LI1	<---	LI	.854	.764	.928
LI2	<---	LI	.894		
LI3	<---	LI	.890		
LI4	<---	LI	.858		
SE1	<---	SE	.865	.821	.948
SE2	<---	SE	.918		
SE3	<---	SE	.927		
SE4	<---	SE	.912		
VP1	<---	VP	.823	.661	.886
VP2	<---	VP	.790		
VP3	<---	VP	.865		
VP4	<---	VP	.770		
CP1	<---	CP	.863	.722	.838
CP2	<---	CP	.836		

Ultimately, as depicted in the findings presented in Table 6, the discriminant validity assessment highlights that the standardized correlation coefficient between each pair of sub-scales remains below the square root of the corresponding dimension's value. This outcome underscores the robustness of discriminant validity among all sub-questionnaires, signifying that each sub-questionnaire effectively distinguishes itself from others within the construct.

Table 6
Discriminant Validity Test

Subscale	LI	SE	VP	CP
LI	.764			
SE	.814	.821		
VP	.581	.537	.661	
CP	.835	.766	.679	.722
AVE square root	.874	.906	.813	.850

Data Analysis

Following the collection of data, an analysis was performed employing SPSS 27.0 and Amos 27.0. The initial steps encompassed reliability assessments, validity analyses for confirmation, evaluations of convergent validity, combined reliability measurements, and differential validity tests. These evaluations aimed to ascertain that the indicators adhered to the prescribed model fit standards. The research subsequently proceeded to examine the



interconnections among students' STEM learning interest, STEM self-efficacy, STEM value perceptions, and STEM career preferences. In this analysis, STEM value perceptions served as the independent variables, while STEM learning interest and STEM self-efficacy functioned as mediating variables. The primary focus was on STEM career preference as the dependent variable. This examination encompassed the calculation of both the direct impact of STEM value perceptions on STEM career expectations and their indirect influence via STEM learning interest and STEM self-efficacy pathways.

Research Results

Descriptive Statistics and Normality Test

Descriptive statistical analysis and normality tests were conducted on the overall student performance, and the results are shown in Table 7. According to the results of the overall descriptive statistical analysis, it can be seen that the mean score of each Subscale is between 3 and 4. This shows that college students in agriculture and forestry as a whole had above-average levels of STEM learning interest, STEM self-efficacy, STEM value perception, and STEM career preferences. The highest mean value of the four elements is the STEM value perception, which indicates that students all believed that knowledge related to STEM subjects had some value. Also, the lowest is STEM self-efficacy, indicating that students' confidence in their ability to master learning and activities related to STEM subjects needs to be further improved.

In addition, for each item, a normality test was conducted using kurtosis and skewness. The kurtosis coefficients of the data in this study are within 3 in absolute value and the skewness coefficients are within 8 (Table 7), indicating that the measured items met the approximate normal distribution.

Table 7

Descriptive Statistics and Normality Test

Subscale	Item	M	SE	Skewness	Kurtosis	M	SD
LI	LI1	3.08	1.006	-.290	-.068	3.155	3.610
	LI2	3.05	.998	-.242	-.194		
	LI3	3.23	.993	-.441	-.028		
	LI4	3.26	.983	-.429	.072		
SE	SE1	3.13	.967	-.356	-.020	3.123	3.584
	SE2	3.09	.974	-.310	-.002		
	SE3	3.19	.954	-.414	.115		
	SE4	3.08	.960	-.265	.023		
VP	VP1	3.56	.912	-.776	.872	3.55	3.134
	VP2	3.64	.912	-.872	1.026		
	VP3	3.51	.898	-.633	.756		
	VP4	3.47	.916	-.656	.658		
CP	CP1	3.21	1.008	-.360	-.038	3.18	1.911
	CP2	3.15	1.052	-.270	-.271		

Correlation of STEM Learning Interest, STEM Self-Efficacy, STEM Value Perception and STEM Career Preferences

Pearson correlation analysis was conducted on the scores of four sub-questionnaires: students' STEM value perception, STEM learning interest, STEM self-efficacy, and STEM career preferences. Exploratory analysis of the correlations among multiple variables shows that the correlation coefficients r between each variable are greater than 0 and all are significant (Table 8). This indicates that there was a significant positive correlation between students' STEM value perception, students' STEM learning interest, STEM self-efficacy, and STEM career preferences supporting further regression analysis and mediation effect tests.



Table 8*Pearson's Correlation Coefficient Between Sub-questionnaires*

	LI	SE	VP	CP
LI	1			
SE	.766**	1		
VP	.541**	.502**	1	
CP	.739**	.683**	.588**	1

**. Significant correlation at the .01 level (two-tailed).

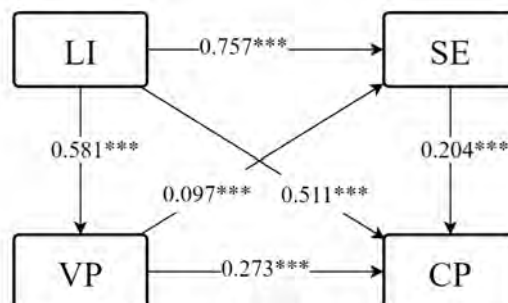
Path Hypothesis Testing

The path hypothesis of the model was tested, and the data obtained are shown in the table. As can be seen from Table 9, the p-values are less than .001 for each path of the model, indicating that there was a significant positive predictive relationship between the independent variables on the dependent variable. That is, students' interest in STEM learning, perceptions of STEM values, and STEM self-efficacy all significantly and positively predicted students' STEM career preferences.

Table 9*Direct Effects Test*

Path	β	S.E.	C.R.	p
LI → VP	.581	.033	21.147	***
SE → LI	.757	.026	29.703	***
SE → VP	.097	.028	4.335	***
CP → LI	.511	.038	14.034	***
CP → SE	.204	.033	6.104	***
CP → VP	.273	.029	11.458	***

Based on the results of the hypothesis test, the path is derived as shown in Figure 2.

Figure 2*Path Testing*

The total influence of students' STEM value perceptions on students' STEM career preferences was tested with a confidence interval of [0.3345, 0.3828] without 0 and an effect size of 0.3587, indicating that students' value perceptions of STEM had a significant predictive effect on STEM career preferences (Table 10). After that, the mediating variables of students' STEM learning interest and STEM self-efficacy were added for testing, at which point the confidence interval of students' perceptions of STEM values on students' STEM career preferences is [0.0114, 0.1224], which do not contain 0, indicating a significant direct effect. The confidence interval for the total indirect effect is [0.0126, 0.1895], which does not contain 0, indicating that the total indirect effect was significant, and the mediating effect existed and was partially mediated. The amount of total indirect effect accounts for 59.63% of the total effect. The indirect effects were divided into three paths, none of which confidence intervals contain 0, indicating that the mediating effect of STEM learning interest, the mediating effect of STEM self-efficacy, and the chain mediating effect of STEM learning interest and STEM self-efficacy all held true.

Table 10*Bootstrap Analysis of Mediation Effects*

Path	β	S.E.	Bootstrap 95% CI		p
			Lower	Upper	
Total Effect	.3587	.0123	.3345	.3828	Significant
Direct effect	.1447	.0114	.1224	.1670	Significant
Total Indirect Effect	.2139	.0126	.1895	.2383	Significant
Path 1: VP \rightarrow LI \rightarrow CP	.1428	.0121	.1196	.1169	Significant
Path 2: VP \rightarrow LI \rightarrow SE \rightarrow CP	.0176	.0042	.0103	.0264	Significant
Path 3: VP \rightarrow SE \rightarrow CP	.0536	.0077	.0391	.0695	Significant

Discussion

This study examined the influence of STEM value perceptions of university students majoring in agriculture and forestry on their STEM self-efficacy, STEM learning interest and STEM career preference. A sample of 1604 agriculture and forestry students from the first to fourth year of university was chosen to be analyzed with their STEM value perception as the independent variable, STEM career preference as the dependent variable, and STEM learning interests and STEM self-efficacy as mediating variables.

The results underscore that students' STEM value perceptions possess a direct influence over their preferences for STEM careers. Previous research has revealed that heightened STEM career knowledge correlates with an increased likelihood of selecting STEM professions among secondary school students (Blotnick et al., 2018; Drymiotou et al., 2021). Additionally, STEM stereotypes can predict the interest secondary school students show in STEM careers (Shen et al., 2014), while there are noteworthy implications on primary school students' perceptions and interest in STEM careers (So et al., 2020). This study extends these previous findings by delving deeper into the domain of college students majoring in agriculture and forestry. It specifically shows how the perceived value of STEM-related knowledge influences the likelihood of such students opting for STEM careers. This research reinforces the significance of STEM value perceptions in shaping career aspirations within this student demographic. Given the historical trend of agriculture and forestry majors facing lower popularity, coupled with the prevalent belief that career prospects in these fields are limited, it becomes pivotal to educate these students about their career options upon enrollment, clarifying the value and potential trajectories that their chosen major can offer (Drymiotou et al., 2021).

Furthermore, this study demonstrates that STEM value perceptions can influence students' pursuit of STEM careers through their impact on STEM learning interest and STEM self-efficacy. This correlation aligns with prior research indicating that students' interest in learning and their perceived self-efficacy significantly impact their expectations for STEM careers (Brown et al., 2016; Lent et al., 2018; Potvin & Hasni, 2014). It is also consistent with



findings showing that students' perceptions of STEM values can indirectly influence their self-efficacy and, in turn, their career expectations (Garriott et al., 2017; Luo et al., 2021). Building upon this foundation, the present study not only validates the role of STEM value perceptions in shaping STEM learning interest and self-efficacy but also unveils a chain mediating effect encompassing STEM value perceptions, STEM learning interest, STEM self-efficacy, and STEM career preferences.

The identified chain effect highlights that when students perceive a specific piece of knowledge as valuable, their interest in learning it amplifies, fostering greater enthusiasm and self-efficacy for mastering the subject. Consequently, this heightened self-efficacy drives their career expectations linked to that particular field of knowledge (Cromley et al., 2016; Hidi & Renninger, 2006; Liu et al., 2022). As a result, educators hold the potential to enhance students' inclinations toward STEM careers by focusing on elevating their perceptions of the value of STEM. This, in turn, can stimulate greater interest in STEM-related courses and bolster students' confidence in their ability to excel in these areas.

Conclusions and Implications

This study aimed to explore the influence of STEM values perceptions on the STEM career preferences of undergraduates majoring in agriculture and forestry. Through SEM analysis and mediation effect analysis, it has been found that students' STEM values perceptions directly influence students' STEM career preferences, as well as influence students' career preferences by influencing their STEM learning interests and STEM self-efficacy, and there is also a chain-mediated effect between students' STEM values perceptions, STEM learning interests, STEM self-efficacy and STEM career preferences. The results extended previous research that did not identify factors influencing STEM career dispositions among agroforestry students at college and university and highlighted the importance of professional perceptions in students' future career choices, as well as the important mediating role of enhancing students' interest in learning and self-efficacy. Therefore, a few suggestions are provided for teachers to cultivate students' STEM career preferences in the future. Firstly, teachers should pay attention to creating informal learning environments, such as extracurricular activities, to stimulate students' interest in STEM learning when conducting teaching. Second, teachers should pay attention to improving students' knowledge transfer and application abilities, cultivating students' problem-solving skills, and helping students to improve their sense of self-efficacy. In addition, in the future, educators should pay more attention to students' perception of STEM values, actively carry out career education, and help agricultural and forestry majors to improve their perception of career values and their sense of professional and occupational identity.

There are some limitations in this study, due to time and other limitations, there are many factors influencing students' career preferences, this study only chose students' STEM value perceptions, STEM learning interest and STEM self-efficacy for the study, and didn't add the family background and other factors, in addition, in the spirit of the principle of convenience sampling, this study into the selection of a province of agriculture and forestry majors for the survey, in the future, the STEM career tendency of students majoring in agriculture and forestry in other provinces will be explored.

Declaration of Interest

The authors declare no competing interest.

References

- Ameyaw, J., Wals, A. E. J., Arts, B., & Turnhout, E. (2017). Does a transdisciplinary approach to forestry education meet students' career aspirations? lessons from a curriculum innovation in Ghana. *International Forestry Review*, 19(4), 397-412. <https://doi.org/10.1505/1465548822272365>
- Blotnick, K. A., Franz-Odenaal, T., French, F., & Joy, P. (2018). A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. *International Journal of STEM Education*, 5, 1-15. <https://doi.org/10.1186/s40594-018-0118-3>
- Brown, P. L., Concannon, J. P., Marx, D., Donaldson, C., & Black, A. (2016). An examination of middle school students' STEM self-efficacy, interests and perceptions. *Journal of STEM Education: Innovations and Research*, 17(3), 27-38. <https://www.jstem.org/jstem/index.php/JSTEM/article/view/2137>
- Cabell, A. L. (2021). Career search self-efficacy and STEM major persistence. *The Career Development Quarterly*, 69(2), 158-164. <https://doi.org/10.1002/cdq.12256>



- Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching*, 54(2), 169-194. <https://doi.org/10.1002/tea.21341>
- Chachashvili-Bolotin, S., Milner-Bolotin, M., & Lissitsa, S. (2016). Examination of factors predicting secondary students' interest in tertiary STEM education. *International Journal of Science Education*, 38(3), 366-390. <https://doi.org/10.1080/09500693.2016.1143137>
- Chen, Y., Chow, S. C. F., & So, W. W. M. (2022). School-STEM professional collaboration to diversify stereotypes and increase interest in STEM careers among primary school students. *Asia Pacific Journal of Education*, 42(3), 556-573. <https://doi.org/10.1080/02188791.2020.1841604>
- Cheng, L., Antonenko, P. P., Ritzhaupt, A. D., & MacFadden, B. (2021). Exploring the role of 3D printing and STEM integration levels in students' STEM career interest. *British Journal of Educational Technology*, 52(3), 1262-1278. <https://doi.org/10.1111/bjet.13077>
- Compeau, S. (2016). The calling of an engineer: high school students' perceptions of engineering.
- Cosby, A., Manning, J., Fogarty, E., McDonald, N., & Harreveld, B. (2022). High school technology teacher's perceptions of agriculture and careers: An Australian perspective. *The Journal of Agricultural Education and Extension*, 1-22. <https://doi.org/10.1080/1389224X.2022.2153887>
- Cromley, J. G., Perez, T., & Kaplan, A. (2016). Undergraduate STEM achievement and retention: Cognitive, motivational, and institutional factors and solutions. *Policy Insights from the Behavioral and Brain Sciences*, 3(1), 4-11. <https://doi.org/10.1177/2372732215622648>
- Davey, F. H., & Stoppard, J. M. (1993). Some factors affecting the occupational expectations of female adolescents. *Journal of Vocational Behavior*, 43(3), 235-250. <https://doi.org/10.1006/jvbe.1993.1045>
- DeBacker, T. K., & Nelson, R. M. (1999). Variations on an expectancy-value model of motivation in science. *Contemporary Educational Psychology*, 24(2), 71-94. <https://doi.org/10.1006/ceps.1998.0984>
- Dewey, J. (1913). *Interest and Effort in Education*. Houghton Mifflin.
- Drymiotou, I., Constantinou, C. P., & Avramidou, L. (2021). Enhancing students' interest in science and understanding of STEM careers: The Role of career-based scenarios. *International Journal of Science Education*, 43(5), 717-736. <https://doi.org/10.1080/09500693.2021.1880664>
- Gago, J. M., Ziman, J., Caro, P., Constantinou, C. P., Davies, G. R., Parchmann, I., ... & Sjoberg, S. (2005). *Europe Needs More Scientists: Report by the High Level Group on Increasing Human Resources for Science and Technology*. Office for Official Publications of the European Communities. <https://oceanrep.geomar.de/id/eprint/38088>
- Garriott, P. O., Hultgren, K. M., & Frazier, J. (2017). STEM stereotypes and high school students' math/science career goals. *Journal of Career Assessment*, 25(4), 585-600. <https://doi.org/10.1177/1069072716665825>
- Gottfredson, L. S. (1981). Circumscription and compromise: A developmental theory of occupational aspirations. *Journal of Counseling psychology*, 28(6), 545. <https://doi.org/10.1037/0022-0167.28.6.545>
- Halim, L., Mohd Shahali, E. H., & H Iksan, Z. (2021). Effect of environmental factors on students' interest in STEM careers: The mediating role of self-efficacy. *Research in Science & Technological Education*, 1-18. <https://doi.org/10.1080/02635143.2021.2008341>
- Heilbronner, N. N. (2009). *Pathways in STEM: Factors affecting the retention and attrition of talented men and women from the STEM pipeline*. University of Connecticut.
- Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41(2), 111-127. https://doi.org/10.1207/s15326985ep4102_4
- Holmes, K., Gore, J., Smith, M., & Lloyd, A. (2018). An integrated analysis of school students' aspirations for STEM careers: Which student and school factors are most predictive? *International Journal of Science and Mathematics Education*, 16, 655-675. <https://doi.org/10.1007/s10763-016-9793-z>
- Jiang, H., Turnbull, D., Wang, X., Chugh, R., Dou, Y., & Chen, S. (2022). How do mathematics interest and self-efficacy influence coding interest and self-efficacy? A structural equation modeling analysis. *International Journal of Educational Research*, 115, Article 102058. <https://doi.org/10.1016/j.ijer.2022.102058>
- Kennedy, J., Lyons, T., & Quinn, F. (2014). The continuing decline of science and mathematics enrolments in Australian high schools. *Teaching Science*, 60(2), 34-46. <https://search.informit.org/doi/10.3316/aeipt.203841>
- Kier, M. W., Blanchard, M. R., Osborne, J. W., & Albert, J. L. (2014). The development of the STEM career interest survey (STEM-CIS). *Research in Science Education*, 44, 461-481. <https://doi.org/10.1007/s11165-013-9389-3>
- Kim, K., Kumar Chaudhary, A., Han, A., Ma, S., & Threeton, M. D. (2022). Factors associated with employment intentions of agriculture school students in South Korea. *The Journal of Agricultural Education and Extension*, 28(4), 459-477. <https://doi.org/10.1080/1389224X.2021.1942091>
- Koyunlu Ünlü, Z., & Dökme, İ. (2020). Multivariate assessment of middle school students' interest in STEM career: A profile from Turkey. *Research in Science Education*, 50, 1217-1231. <https://doi.org/10.1007/s11165-018-9729-4>
- Lent, R. W., Paixão, M. P., Da Silva, J. T., & Leitão, L. M. (2010). Predicting occupational interests and choice aspirations in Portuguese high school students: A test of social cognitive career theory. *Journal of Vocational Behavior*, 76(2), 244-251. <https://doi.org/10.1016/j.jvb.2009.10.001>
- Lent, R. W., Sheu, H. B., Miller, M. J., Cusick, M. E., Penn, L. T., & Truong, N. N. (2018). Predictors of science, technology, engineering, and mathematics choice options: A meta-analytic path analysis of the social-cognitive choice model by gender and race/ethnicity. *Journal of Counseling Psychology*, 65(1), 17. <https://doi.org/10.1037/cou0000243>
- Liu, A., Shapiro, C., Gregg, J., Levis-Fitzgerald, M., Sanders O'Leary, E., & Kennison, R. L. (2022). Scaling up a life sciences college career exploration course to foster STEM confidence and career self-efficacy. *Research in Science & Technological Education*, 1-17. <https://doi.org/10.1080/02635143.2022.2083599>



- Luo, T., So, W. W. M., Wan, Z. H., & Li, W. C. (2021). STEM stereotypes predict students' STEM career interest via self-efficacy and outcome expectations. *International Journal of STEM Education*, 8, 1-13. <https://doi.org/10.1186/s40594-021-00295-y>
- Mau, W. C. J., & Li, J. (2018). Factors influencing STEM career aspirations of underrepresented high school students. *The Career Development Quarterly*, 66(3), 246-258. <https://doi.org/10.1002/cdq.12146>
- McGuire, L., Monzavi, T., Hoffman, A. J., Law, F., Irvin, M. J., Winterbottom, M., ... & Mulvey, K. L. (2021). Science and math interest and gender stereotypes: the role of educator gender in informal science learning sites. *Frontiers in Psychology*, 12, 503237. <https://doi.org/10.3389/fpsyg.2021.503237>
- National Research Council. (2011). *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*. National Academies Press.
- Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C., & Nelson, C. (2015). A Model of Factors Contributing to STEM Learning and Career Orientation. *International Journal of Science Education*, 37(7), 1067-1088. <https://doi.org/10.1080/09500693.2015.1017863>
- Organization for Economic Cooperation and Development. (2012). *Strengthening Education for Innovation*. https://www-oecd-org.ezproxy.eduhk.hk/media/oecdorg/satellitesites/stie-outlook/files/policyprofile/STI%20Outlook%2012_%20PP%20HR_Education.pdf
- Organisation for Economic Co-operation and Development. (2018). *Education at a Glance 2018: OECD Indicators*. OECD Publishing. <https://doi-org.ezproxy.eduhk.hk/10.1787/eag-2018-en>
- Organisation for Economic Co-operation and Development. (2019). *Education at a Glance 2019: OECD indicators*. OECD Publishing. <https://doi-org.ezproxy.eduhk.hk/10.1787/f8d7880d-en>
- Potvin, P., & Hasni, A. (2014). Interest, motivation and attitude towards science and technology at K-12 levels: A systematic review of 12 years of educational research. *Studies in Science Education*, 50(1), 85-129. <https://doi.org/10.1080/03057267.2014.881626>
- Salehjee, S., & Watts, M. (2015). Science lives: School choices and 'natural tendencies'. *International Journal of Science Education*, 37(4), 727-743. <https://doi.org/10.1080/09500693.2015.1013075>
- Sharik, T. L., Lilieholm, R. J., Lindquist, W., & Richardson, W. W. (2015). Undergraduate enrollment in natural resource programs in the United States: Trends, drivers, and implications for the future of natural resource professions. *Journal of Forestry*, 113(6), 538-551. <https://doi.org/10.5849/jof.14-146>
- Shen, F. C., Liao, K. Y. H., Abraham, W. T., & Weng, C. Y. (2014). Parental pressure and support toward Asian Americans' self-efficacy, outcome expectations, and interests in stereotypical occupations: Living up to parental expectations and internalized stereotyping as mediators. *Journal of Counseling Psychology*, 61(2), 241. <https://doi.org/10.1037/a0036219>
- So, W. W. M., Chen, Y., & Chow, S. C. F. (2020). Primary school students' interests in STEM careers: How conceptions of STEM professionals and gender moderation influence. *International Journal of Technology and Design Education*, 1-21. <https://doi.org/10.1007/s10798-020-09599-6>
- Stipanovic, N., & Woo, H. (2017). Understanding African American students' experiences in STEM education: An ecological systems approach. *The Career Development Quarterly*, 65(3), 192-206. <https://doi.org/10.1002/cdq.12092>
- World Bank. (2019). Employment in agriculture (% of total employment) (modeled ilo estimate). *World Bank Open Data*.
- Xu, C., & Lastrapes, R. E. (2022). Impact of STEM sense of belonging on career interest: The role of STEM attitudes. *Journal of Career Development*, 49(6), 1215-1229. <https://doi.org/10.1177/08948453211033025>
- Zhan, X., Sun, D., Song, R., Yang, Y., & Zhan, Y. (2023). Empowering students' engineering thinking: An empirical study of integrating engineering into science class at junior secondary schools. *Thinking Skills and Creativity*, 49, <https://doi.org/10.1016/j.tsc.2023.101364>
- Zhang, L., & Barnett, M. (2015). How high school students envision their STEM career pathways. *Cultural Studies of Science Education*, 10, 637-656. <https://doi.org/10.1007/s11422-013-9557-9>



Appendix

Survey for STEM Career Preference, Learning Interest, Self-Efficacy, and Value perception of Agroforestry Undergraduates

Dear Student,

Thank you for participating in this survey, which is designed to get a basic picture of your interest in STEM (Science, Technology, Engineering and Mathematics) related subjects and your views on STEM related careers. The questionnaire is anonymous responses and is for research use only, so you can feel free to fill it out, and I hope you will follow your heart's true thoughts and fill it out carefully, thank you!

LI1 Learning knowledge about Science, Technology, Engineering and Mathematics is interesting
A totally disagree, B disagree, C neutral, D agree, F strongly agree

LI2 I enjoy completing tasks related to science and engineering courses
A totally disagree, B disagree, C neutral, D agree, F strongly agree

LI3 The Science, Technology, Engineering and Mathematics related courses I take are relevant to my life
A totally disagree, B disagree, C neutral, D agree, F strongly agree

LI4 I am curious about discoveries made during activities and events related to Science, Technology, Engineering and Mathematics
A totally disagree, B disagree, C neutral, D agree, F strongly agree

SE1 I think I am capable of solving problems encountered in my Science, Technology, Engineering and Mathematics studies

A totally disagree, B disagree, C neutral, D agree, F strongly agree

SE2 I am confident that I can perform well in learning knowledge related to Science, Technology, Engineering and Mathematics
A totally disagree, B disagree, C neutral, D agree, F strongly agree

SE3 I believe I can acquire skills related to Science, Technology, Engineering and Mathematics courses and experiments
A totally disagree, B disagree, C neutral, D agree, F strongly agree

SE4 I am confident that I can do well in exams related to Science, Technology, Engineering and Mathematics courses
A totally disagree, B disagree, C neutral, D agree, F strongly agree

VP1 Professions in Science, Technology, Engineering and Mathematics enjoy a high level of social prestige
A totally disagree, B disagree, C neutral, D agree, F strongly agree

VP2 Occupations in Science, Technology, Engineering and Mathematics have higher earnings
A totally disagree, B disagree, C neutral, D agree, F strongly agree

VP3 Jobs in Science, Technology, Engineering and Mathematics have more employment opportunities
A totally disagree, B disagree, C neutral, D agree, F strongly agree

VP4 If I work in Science, Technology, Engineering and Mathematics jobs, I can improve my teamwork skills, problem solving skills, etc.
A totally disagree, B disagree, C neutral, D agree, F strongly agree



CP1 I will use knowledge of Science, Technology, Engineering and Mathematics to solve problems in my future career.
A totally disagree, B disagree, C neutral, D agree, F strongly agree

CP2 I am interested in becoming a scientist, engineer or technologist
A totally disagree, B disagree, C neutral, D agree, F strongly agree

Received: July 12, 2023

Revised: August 19, 2023

Accepted: October 04, 2023

Cite as: Sheng, J., Tian, P., Sun, D., & Fan, Y. (2023). Influence of STEM value perception on STEM career preferences among agricultural and forestry undergraduates. *Journal of Baltic Science Education*, 22(5), 914-928. <https://doi.org/10.33225/jbse/23.22.914>

Jianjun Sheng

Student Affairs Department, Zhejiang Agriculture and Forestry University, Hangzhou, Zhejiang, China.
E-mail: 35585235@qq.com

Peiyao Tian
(Corresponding author)

MPhil, Department of Mathematics and Information Technology, The Education University of Hong Kong, Hong Kong SAR, China.
E-mail: ptian@eduhk.hk
ORCID: <https://orcid.org/0000-0002-7608-2845>

Daner Sun

PhD, Assistant Professor, Department of Mathematics and Information Technology, The Education University of Hong Kong, Hong Kong SAR, China.
E-mail: dsun@eduhk.hk
Website: <https://pappl.eduhk.hk/rich/web/person.xhtml?pid=179988&name=SUN-Daner>
ORCID: <https://orcid.org/0000-0002-9813-6306>

Yanhua Fan

PhD, Associate Professor, College of Chemistry and Molecular Sciences, Henan University, Kaifeng, Henan, China.
mail: fanyanhua9080@163.com

