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Research article

Effects of teaching approaches on science subject choice toward STEM career orientation of Vietnamese students

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Abstract: This study aims to examine the effects of science teaching approaches such as experiential teaching and learning, teaching the relevance of studying and careers, science application teaching on the science subjects choices and science, technology, engineering, and mathematic (STEM) career aspirations of upper secondary students', and recommendations for science teachers using teaching approaches and methods to promote the effectiveness of STEM-oriented teaching in their lectures. A online survey questionnaire that combined with a direct investigation using contact and interview methods, in which the students measured three teaching approaches, such as 'experiential teaching,'

‘teaching the application of science,’ and ‘teaching the relevance of study and career,’ was distributed to 1768 Vietnamese students in 10th grade (aged 16 years) in Hanoi and some northern, central, and southern provinces of Vietnam. Data were collected using a questionnaire and analyzed through correlations and regressions. These findings revealed that teaching the ‘applications of science’ and ‘the relevance of study and career’ were measured teaching approaches to associate with a high school students’ choice of science subject and their STEM career aspiration, alongside accounting for other teaching approaches. Conversely, the findings showed that the “experiential teaching” had no association with a students’ utility of science, self-efficacy, or the science subject choice. This study's implications offer valuable guidance to science educators in selecting and implementing teaching strategies that boost the impact of STEM education in their classrooms and inspire students to choose science-related paths.

Keywords: science teaching, subject choice, career orientation, STEM career aspiration, Vietnamese student

1. Introduction

The improvement of a students' interest and approaches to STEM disciplines to lead them into science, technology, engineering, and mathematic (STEM) fields is important [1]. The middle school period is a key time for young people's impressions of science and influences their future career decisions [2]. Recently, fewer school students are drawn to study science or pursue careers in scientific fields [3]. The root of this issue can be traced back to both a deficiency in scientific literacy and an unfavorable public sentiment towards science-related careers [4]. The science-related courses students take during their education can have a bearing on their eventual career paths [5], as they must provide students with the skills to face the demands of challenging employment and working life. Thus, selecting and mastering science-related subjects such as biology, chemistry, and physics in upper secondary school is a fundamental prerequisite for advanced science studies at the university level, which ultimately pave the way for a profession in STEM.

While achieving high completion rates, the Vietnamese education system faces challenges in STEM education and career guidance. In addition to compulsory subjects, there are elective subjects within the Vietnamese General Education Curriculum at the upper secondary school level. Allowing students to choose subjects according to their interests and strengths is an important aspect that demonstrates the progressive spirit of the curriculum. Accordingly, in addition to the compulsory subjects and educational activities, 10th grade students can choose 4 out of 9 elective subjects: Geography, Economic and Legal Education, Physics, Chemistry, Biology, Technology, Informatics, Music, and Fine Arts [6]. These electives are in addition to mandatory subjects and career guidance activities. Vietnamese education reform will create choices and opportunities for students to meet their career orientation needs. Students will choose subjects according to their interests with the knowledge requirements for diverse career orientations in society. However, the integration of STEM into the curriculum faces obstacles such as an inadequate teacher capacity, insufficient resources, and a lack of systematic implementation beyond extracurricular activities; moreover, the number of students who choose STEM-related subjects is lower than that of social science subjects [7,8]. Furthermore, career guidance in high schools needs strengthening to help students make informed

choices that are aligned with their abilities and future goals, thus addressing the current situation where many students lack an understanding of their strengths and career options. Improving STEM education and the associated career orientations is crucial to develop a skilled workforce and foster technological advancements in Vietnam. Therefore, it is necessary to study more about the teaching approaches to promote a students' career orientation, enhance their interest in the science subjects, and support their choice of science subjects in upper secondary schools in Vietnam.

2. Literature review

Career-oriented subjects choice

Previous investigations have commonly found that a student's inherent interest in a subject is typically a key prerequisite for successful academic engagement and learning [9]. Initiatives designed to improve the appeal of STEM professions should be gender inclusive. Educational interventions that bolster student motivation can enhance the perceived intrinsic value of mathematics and science, which consequently increases the probability of students selecting a STEM career [10]. There is a significant challenge to directly influence the educational and career goals that students hold [4]. Effectively increasing the number of students interested in careers within science, technology, and related fields hinges on teachers developing the students' awareness. This includes showcasing the applications of science and technology, demonstrating how these subjects explain real-world events and link to various professions, and utilizing diverse teaching methods to captivate and motivate students. However, in Vietnam, despite the new curriculum's potential to foster STEM education, its implementation is hampered by a lack of robust policy support, resource scarcity, and under-equipped teachers [11].

Increasing a students' motivation in learning science-related subjects can promote their desire to choose STEM-oriented subjects [12]. Aeschlimann et al. [10] studied how to improve academic motivation in math and science to increase career choices in STEM fields in Swiss secondary schools. The study used Eccles' expectation-value model and built a simulation model to prove that classroom support measures will promote a students' learning motivation in mathematics and science and enhance the STEM subject and career choices. Aeschlimann's research evaluated the students' personal characteristics expressed in two aspects: learning motivation and learning results. The lesson design to promote learning motivation was evaluated in the following aspects: personal support from teachers, easy-to-understand teaching, and connection to a students' life experiences. These factors will be evaluated for their influence on the choice to study within STEM fields.

The educational system itself significantly shapes the opportunities and constraints surrounding career-oriented subject choices. The availability and quality of specific subject streams in secondary and tertiary education, the curriculum design, and the provision of career guidance services all play critical roles. Research in Japan [13] has explored the implications of early tracking on the students' career trajectories. The quality of teaching and the availability of resources in different subject areas can also influence a students' interest and performance, which indirectly affects their subject choices [14]. Furthermore, the presence and effectiveness of career counseling and guidance programs are crucial in providing students with information about different career paths, the required academic preparation, and helping them align their interests and abilities with potential career options [15]. The selection of career-oriented subjects in Vietnam is a complex process driven by individual interests, perceived job prospects, and potential financial gains, often alongside parental

influence and cultural norms. While the Vietnamese education system is working to enhance career guidance to better connect academic choices with future careers and national development, disparities in the access to resources persist across regions and socioeconomic levels [16]. The country's rapid economic growth and global integration necessitate a flexible approach to career-oriented education to meet the evolving demands of new industries and technological advancements.

Experiential teaching and learning

Regarding the impact of objective contextual factors on self-efficacy and career choice, Nauta and Epperson [17] found that the number of years of schooling and the number of science and mathematics courses in high school were positively related to choosing science and mathematics as a major in college. Understanding the college requirements and self-efficacy in math and science were more positively related to the major choice. Additionally, participation in career experience activities and learning environments was shown to significantly influence an individual's level of educational aspirations in a field [18].

Teaching relevance of study and career

Many approaches have been applied to enhance a students' interest in subjects, such as clarifying the relationship between scientific knowledge and explaining the experiences and work of scientists [19]. Likewise, promoting the relevance and practical application of the subject area to students and their parents has been linked to increased interest and learning outcomes among students, thus influencing the students' choice of subject-related majors [20]. Our previous study has shown the theoretically determined and empirically analyzed correlation between the characteristics of the 5E teaching model, experiential teaching, and the corresponding manifestations of teaching career-oriented competence.

Recent research has highlighted the increasingly important role that science teachers play in encouraging students to explore the links between science and the professional field [21]. Cohen and Patterson worked to find solutions to help ensure the breadth and depth of the STEM workforce. The project researched strategies for teaching science subjects to promote career awareness among high school students. These strategies focused on four goals to develop STEM career orientation for students: Awareness: expanding career awareness; Relevance: the relevance of the topic to your life; Engagement: participating in STEM learning and career topics; and Self-Efficacy: feeling comfortable using scientific tools.

Science application teaching

Sheldrake's analysis of UK student performance in the Programme for International Student Assessment (PISA) test between 2006 and 2015 [19] suggested that highlighting the real-world applications of science significantly boosted the students' interest, improved the understanding of its relevance, and ultimately, increased their desire to pursue science-related careers. While Sellami [22] found that Qatari high school students' STEM career interests aligned with their math and science skills, the study also revealed notable differences based on gender and nationality. Specifically, female students reported a greater interest in STEM fields compared to male students. However, there is currently no specific research in Vietnam on the impact of applied science teaching related to the STEM career orientation for 10th grade students.

3. Research objectives, research questions, and hypothesis

This study aims to (1) investigate which teaching approaches will significantly support STEM career-related subject choices in upper secondary schools in Hanoi and some northern, central, and southern provinces of Vietnam, and (2) suggest recommendations for teaching strategies and methods to promote the effectiveness of STEM career orientation teaching in teacher's lectures.

The research question is as follows: which specific teaching approaches in science, such as experiential teaching and learning, teaching the relevance of studying and careers, and the application of science education, effectively impacts Vietnamese students' interest, subject utility, and self-efficacy in science, their science subject selection, and their future STEM career aspirations?

This study tested the following hypotheses to address the research question:

Hypothesis 1a (H1a): The teaching method of experiential activities contributes to the students' utility of science.
Hypothesis 1b (H1b): The teaching method of experiential activities contributes to the students' career awareness.
Hypothesis 1c (H1c): The teaching method of experiential activities contributes to the students' self-efficacy of science.
H2a: Teaching about the application of science contributes to the students' utility of science.
H2b: Teaching about the application of science contributes to the students' career awareness.
H2c: Teaching about the application of science contributes to the students' self-efficacy of science.
H3a: Teaching of the relevance of studying and careers contributes to the students' utility of science.
H3b: Teaching of the relevance of studying and careers contributes to the students' career awareness.
H3c: Teaching of the relevance of studying and careers contributes to the students' self-efficacy of science.
H4: The students' subject utility of science contributes to the students' science subject choice.
H5: The students' career awareness contributes to the students' science subject choice.
H6: The students' self-efficacy of science contributes to the students' science subject choice.
H7: The students' subject choice contributes to the students' STEM-related career aspiration.

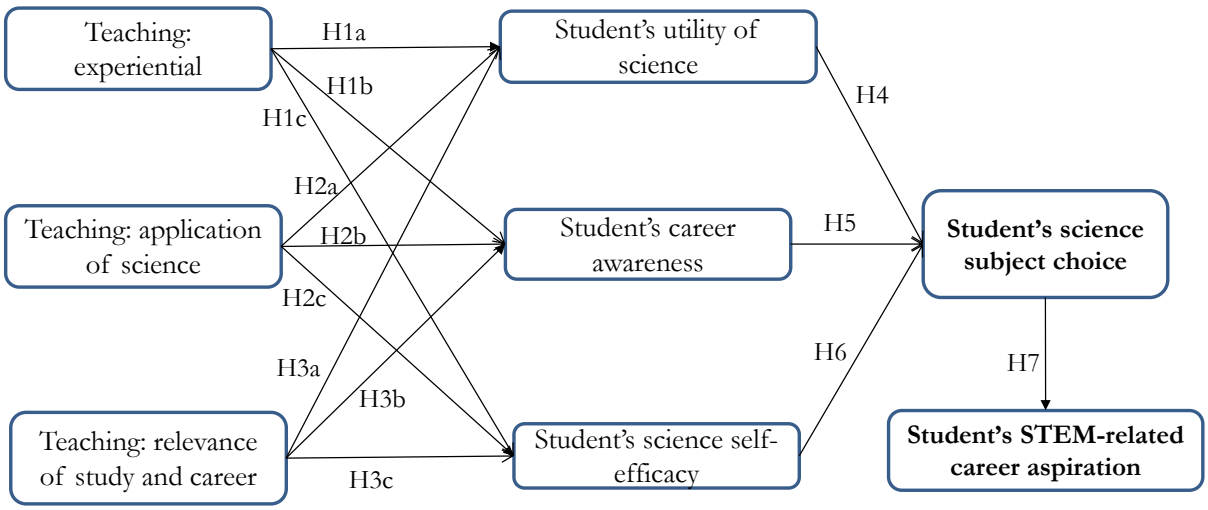

Figure 1. Research framework.

4. Theoretical framework

This study is based on Eccles' expectation-value theory [23]. The theory developed a comprehensive model for the study of educational and career choices based on aptitudes, expectations, subjective task values, and life goals. Eccles' model of expected value includes three main factors: psychological factors, which include beliefs, goals, interests, and values; biological factors, which include genetic factors and the impact of hormones on the development of abilities, beliefs, and values; and socialization factors, which include social, cultural, and contextual influences on the development of the learners' confidence, goals, interests, and values. An analysis on the expectancy-value theory showed that choices related to academic performance (e.g., high school admission and university admission), aspirations, and career choices are mostly directly influenced by the subject's ability, perceived capacity (e.g., expectations for success), and task performance value (motivation) given the various available options [24]. The theoretical model demonstrated factors related to the high school students' choices of career-oriented subjects, which include personal beliefs, goals, interests, and social influences such as interactions with friends, teachers, and parents. Based on this theory, we conducted research in Vietnam utilizing factors that reflect the theory.

The subjective task value includes the interest value (preference or feeling comfortable), the utility value (instrumental value of the task to help complete personal goals), the acquisition value (link between task and sense of self and personality), and the costs (predicted psychological, economic, and social costs of various tasks or options). When individuals feel confident that they can learn and succeed in specific subjects such as math and science, they are more likely to persist and engage in deeper cognitive strategies related to achievements, academic performance, and the course enrollment [25]. Value-related beliefs are predictive of academic engagement and outcomes, which are also fairly predictive of STEM choice behaviors and career aspirations [26]. Applying this theory to support students in choosing science subjects in terms of the subjective task value, we examined the hypothesis that teachers can organize teaching subjects using active teaching methods, applying experiential and exploratory teaching models related to the professional’s career to increase a students' interest in the subject, thereby improving their learning outcomes and career aspirations related to the subject.

5. Methodology

5.1. Sample and data collection

The survey was conducted with 1768 male and female students in the 10th grade (at the age of 16) in 24 upper secondary schools in Hanoi and Hoa Binh, Ninh Thuan, and Kien Giang provinces, which represent the diversity of schools in the northern, central, and southern provinces of Vietnam. The students were provided an online survey questionnaire combined with direct investigations using contact and interview methods. We collected 1768 valid questionnaires.

5.2. Measurement

The survey instrument included questions referenced from previous research studies [27–29], which were adjusted to suit the current research context. Next, we tested the question set with 20

students to evaluate the appropriateness of each question. After pre-testing, the questionnaire was edited to ensure an ease of understanding and sufficient reliability needed for use in this study. The 4-point Likert scale was utilized for the observed variables. In particular, the level of agreement on statements related to the subject choice, hobbies, interest in subjects, and career aspirations ranged from (1) "strongly disagree," (2) "disagree," (3) "agree," and (4) "strongly agree." The frequency of organizing career-oriented teaching activities ranged from (1) “never," (2) “in some classes," (3) “in most classes,” and (4) “in every class." The observed variables in the scale are shown in Table 1.

Table 1. Some examples of items/factors in the questionnaires.

Item/factor	Example item
Career orientation	“I was introduced to science-related careers available on the job market.”
Teaching: experiential activities	‘Students are asked to design a way to research a scientific question at the school level.”
Teaching: applications of science	“I find that studying sciences helps me understand everything around me.”
Teaching: relevance of study and career	“Students draw conclusions from an experiment they performed.”
Students seft-efficacy	“Explain the scientific information provided on the labels of food items.”
Students’ science subject choice	“I chose to study natural sciences (Physics, Chemistry, Biology).”

5.3. Data analysis

The study employed a questionnaire to collect data, which was subsequently analyzed with correlation and regression techniques. The study assessed the reliability of the measurement scales for the model's factors and dependent variables using Cronbach's alpha and correlation coefficients. To assess the reliability of the questionnaire in this study, Cronbach's alpha was calculated, and a pilot test was conducted with individuals not included in the main sample. The scale was considered reliable if the Cronbach's alpha coefficient was at least 0.6 and all items had a total correlation coefficient of 0.3 or higher. An Exploratory Factor Analysis (EFA) was utilized to evaluate the convergence of the identified factors. The suitability of the data for the EFA was confirmed by a Kaiser-Meyer-Olkin (KMO) value of 0.5 or greater, a significant Bartlett's test ($p < 0.05$), a minimum of 50% of the variance explained, and eigenvalues of 1 or more. To further examine our hypothesis, we employed a regression analysis to assess the impact of H1a through H7. Specifically, we looked at the R-squared value to determine the percentage of variance explained by these factors. We used a linear regression to explore the relationships between pairs of variables. Additionally, we utilized a logistic regression to predict whether science learning and teaching activities influenced the students' decisions regarding the science subject choices and future careers. All data were analyzed using the SPSS software.

6. Results

6.1. Reliability of the research model

The reliability analysis of the questionnaire scales revealed a strong internal consistency. The Cronbach's alpha values for each scale were above the acceptable threshold of 0.6, and ranged from 0.72 to 0.87. Furthermore, the corrected item-total correlations for all items exceeded 0.3, and fell

between 0.51 and 0.76. Additionally, the cumulative percentage of the total variance explained by the factors was greater than 50% (Table 2). These findings collectively suggest that the items effectively and reliably measure their respective constructs.

Table 2. Reliability of the research model.

Reliability	Value
Cronbach's α	0.72 - 0.87
Corrected item-total Correlation	0.51 - 0.76
Cumulative of total variance explained	>50%

6.2. Statistical analysis of studied samples

The study's descriptive analysis revealed that teachers most frequently emphasized the connection between the course content and its relevance to the students' studies and future careers, as indicated by a mean score of 2.81 (Table 3). Science application and experiential teaching were the next teaching methods considered, with mean values of 2.79 and 2.36, respectively.

Table 3. Descriptive analysis.

Item/factor (scale)	Mean	Std. Deviation
Students' science-related subject choosing (1-4)	2.74	0.85
Students' science-related career aspiration (1-4)	2.65	0.69
Teaching relevance of study and career (1-4)	2.81	0.73
Experiential teaching (1-4)	2.36	0.69
Science application teaching (1-4)	2.79	0.64
Students' science self-efficacy (1-4)	2.6	0.61
Students' utility of science (1-4)	3.16	0.46
Students' career awareness (1 – 4)	2.78	0.71
Valid N (listwise)		

6.3. Hypothesis testing

An analysis of the correlation associations between the variables showed that there were correlative associations between the various teaching approaches ('experiential teaching', 'teaching the applications of science', and 'teaching the relevance of studying and careers') and the students' utility of science, awareness of careers, self-efficacy, science subject choice, and STEM career aspiration. The Pearson correlations were considered from 0.16 to 0.741 (Table 4). Moreover, a students' STEM career aspiration was strongly associated with the students' science-related subject choice, with a Pearson correlation coefficient of 0.443. Additionally, it was significantly associated with 'teaching the relevance of studying and careers' and 'experiential teaching', with a Pearson correlation coefficient of 0.204 and 0.16, respectively. A strong positive relationship (Pearson correlation coefficient of 0.443) was observed between a students' STEM career aspirations and their choice of science-related subjects. Additionally, the study considered Pearson correlations ranging from 0.16 to 0.741 (Table 4), thus revealing significant, albeit weaker, associations between STEM

career aspirations and 'teaching the relevance of studying and careers' (Pearson correlation coefficient of 0.204) as well as 'experiential teaching' (Pearson correlation coefficient of 0.16).

Table 4. Correlations summary.

		1	2	3	4	5	6	7	8
1. Students' science-related subject choosing	Pearson Correlation	1							
	Sig. (2-tailed)								
2. Students' STEM career aspiration	Pearson Correlation	**0.443**	1						
	Sig. (2-tailed)	**0.000**							
3. Experiential teaching	Pearson Correlation	**0.160**	**0.362**	1					
	Sig. (2-tailed)	**0.000**	**0.000**						
4. Teaching relevance of study and career	Pearson Correlation	**0.204**	**0.382**	**0.452**	1				
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**					
5. Science application teaching	Pearson Correlation	**0.238**	**0.323**	**0.371**	**0.770**	1			
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**				
6. Students' career awareness	Pearson Correlation	**0.741**	**0.521**	**0.262**	**0.281**	**0.331**	1		
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**			
7. Students' utility of science	Pearson Correlation	**0.334**	**0.409**	**0.319**	**0.314**	**0.453**	**0.434**	1	
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**		
8. Students' science self-efficacy	Pearson Correlation	**0.300**	**0.335**	**0.368**	**0.418**	**0.416**	**0.407**	**0.419**	1
	Sig. (2-tailed)	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	
	N	1768	1768	1768	1768	1768	1768	1768	1768

Note: Pearson correlations are reported, with statistically significant coefficients ($p < 0.05$) highlighted in bold.

Additionally, the results indicated that a students' career awareness was clearly correlated with the students' science-related subject choice, with a Pearson correlation coefficient of 0.741. Figure 2 displays the results of the linear regression analysis. The coefficient of determination (R squares) ranged from 0.492 to 0.742, and all reported p-values were less than 0.05.

The experiential teaching methods significantly boosted the students' confidence in their science abilities, as evidenced by the positive results of the hypothesis tests H1a, H1b, and H1c. Specifically, these methods accounted for a notable portion of the variation in the students' science self-efficacy, which was indicated by a standardized coefficient of 0.152, a statistically significant finding ($p < 0.05$). However, there was no contribution of experiential teaching to the students' utility of science and awareness.

Notably, the hypothesis tests H2a, H2b, and H2c revealed that teaching the application of science

significantly boosted the students' perceived utility of science (Standardized Coefficient = 0.507), career awareness (Standardized Coefficient = 0.237), and self-efficacy of science (Standardized Coefficient = 0.218), all with p-values below 0.05 (Figure 2).

The result of the hypothesis tests H3a, H3b, and H3c revealed that there was a significant contribution of teaching the relevance of studying and careers to the students' utility of science, career awareness, and self-efficacy of science, which were shown by the Standardized Coefficients of 0.208, 0162, and 0.219, respectively, and a p-value <0.05.

The result of the hypothesis tests H4, H5, and H6 highlighted that there was a contribution of the students' career awareness to the students' science subject choice, with a Standardized Coefficient of 0.737 and a p-value <0.05. However, there were no contributions of the student's utility of science and self-efficacy to their science subject choice.

Furthermore, the results of hypothesis test 7 (H7) highlighted that the students' selection of science subjects significantly contributed to their STEM career aspirations. This positive influence was supported by a standardized coefficient of 0.443 and a p-value below the 0.05 threshold.

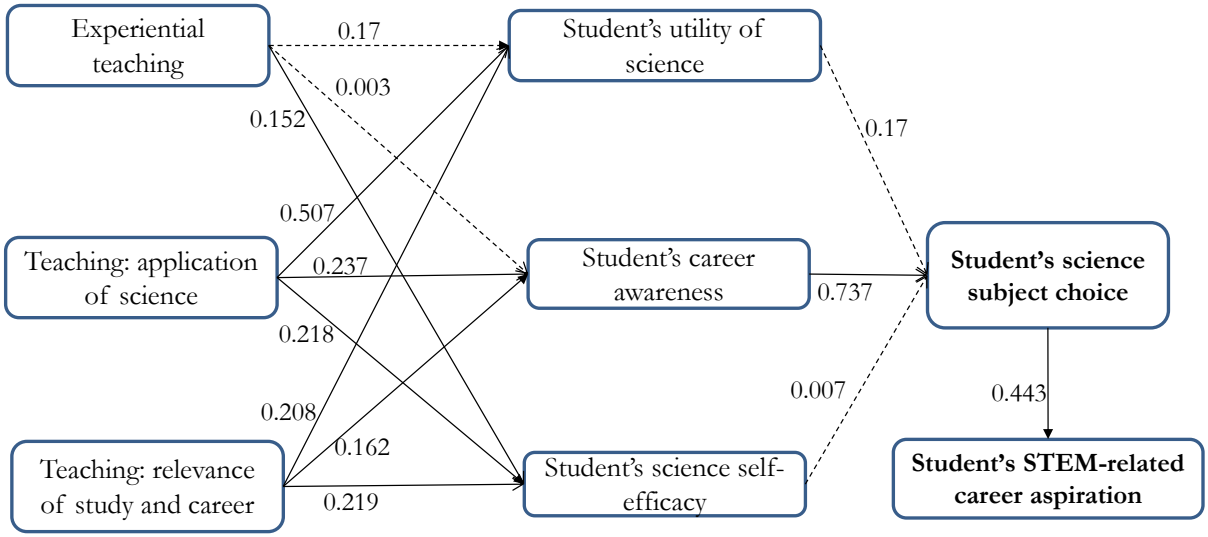

Figure 2. Linear correlation findings for the research model.

A teacher's science-related career orientation teaching was predicted by a logistic regression statistic, with an overall percentage of 83.5% (Table 5). The model of predictors showed that only 'teaching relevance of studying and careers" was the factor to consistently and positively associate with the students' subject choice, with an R square of 0.575 and a p-value < 0.05. Moreover, the students' STEM career aspiration and career awareness were factors that were significantly associated with the students' science subject choice. However, other teaching approaches, such as experiential teaching and science application teaching, had no affect on the students' science subject choices.

Table 5. Summary of logistic regression of independent variables with students' science subject choice.

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	1. Experiential teaching	0.275	0.173	2.519	1	0.112	1.316
	2. Science application teaching	-0.333	0.179	3.439	1	0.064	0.717
	3. Teaching relevance of study and career	**0.427**	**0.112**	**14.517**	**1**	**0.000**	**0.652**
	4. Students' STEM career aspiration	**0.735**	**0.129**	**32.653**	**1**	**0.000**	**2.086**
	5. Students' science self-efficacy	-0.168	0.135	1.541	1	0.214	0.845
	6. Students' utility of science	-0.080	0.190	.179	1	0.672	0.923
	7. Students' career awareness	**3.144**	**0.168**	**350.318**	**1**	**0.000**	**23.199**
	Constant	-7.659	0.614	155.471	1	0.000	.000
Nagelkerke R Square : 0.575							

Note: Significant coefficients ($p < 0.05$) are highlighted in bold.

7. Discussion

The obtained data highlighted the effects of teaching approaches in teaching science-related subjects for upper secondary students. A linear regression analysis of different science teachings revealed that emphasizing how science applies to teaching and highlighting the relevance of studying and careers consistently and positively influenced the students' subject choices and their aspirations for STEM careers, even when considering other teaching methods.

The study's findings strongly suggest that when students see how science is used in the real world, they are more likely to want a career in STEM. This aligns with what other research have already indicated [30,31]. However, the results did not clearly support the hypothesis that experiential teaching would be associated with a high efficiency.

Although experiential teaching was directly associated with a students' self-efficacy of science, there was no positive contribution associated with the students' science subject choice. This finding was appropriate with real context in Vietnamese schools. The results of the direct interviews with the students showed that science teachers in Vietnamese schools have not frequently and effectively used the experiential activities to orient STEM careers for students and support a students' science subject choice. The study examined different teaching methods used in science education, some of which have been researched and implemented in various ways. It's often been thought that emphasizing how science relates to real-world studies and future careers shows the practical, evidence-based nature of science [32]. Practical work in science was part of an inquiry-based learning model, which was intended to echo the way scientific inquiries are actually performed [33]. Alternatively, illustrating the 'applications of science' does not inherently necessitate the premise that student learning must mirror the activities of scientists. This approach to conveying the 'applications of science' can be effectively integrated with diverse pedagogical strategies, thus enabling students to

acquire scientific competencies and concepts specifically by examining the applied contexts, without necessarily requiring or implying a direct engagement in the scientific methodologies [34]. Illustrating the practical applications of science has the potential to strengthen all teaching methodologies, including those that are hands-on.

Furthermore, this paper has highlighted the significance of 'science application teaching' and 'teaching the relevance of studying and careers' in the relationship with a students' career awareness. Individuals will gain access to practical methods and opportunities through this support, thus enabling them to strengthen their science skills [35]. In addition, B. Aechlimann [10] suggested that both the inherent worth students found in STEM subjects and their actual achievement in those subjects positively impacted their STEM study choices. Furthermore, the positive influence mentioned is consistent with the findings of Sheldrake's study [19]. The research results also indicated that 'science applied teaching' in Vietnamese schools contributed to raising awareness of practical applications of the subject, thereby making students interested in STEM-related subjects. According to the result of logistic regression statistical analysis that predicted a students' subject choice in Vietnam, the result confirmed the 'teaching relevance of studying and careers' critical role in positively and consistently influencing the students' science subject choice and STEM career aspiration ($\beta = 0.427$). Additionally, the study demonstrated the significant role of 'students' career awareness' support in the students' subject choice ($\beta = 3.144$). Specifically, 'science application teaching' had a negative effect on the relationship to the students' science subject choice ($\beta = -0.333$). To foster a students' interest in science subjects and STEM careers, science teachers should implement practical activities and real-world applications in their teaching. These methods have been proven to correlate with an increased career interest [36].

The research findings strongly suggest that science educators should emphasize the practical uses of science and its connection to various studies and careers. This approach is crucial to help students select science subjects and consider STEM pathways, as these teaching methods have been shown to boost their career awareness. While students possess some understanding of workplace skills, their perceptions are often limited by stereotypes [37].

8. Conclusions

The study introduced a framework to investigate a students' science subject choice and their STEM career aspiration by exploring various science teaching approaches. This research contributes to supporting upper secondary school students' science subject choices and their STEM career orientation by analyzing science teaching approaches in Vietnam. The study highlighted that teaching the 'applications of science' and teaching 'the relevance of studying and careers' were measured teaching approaches to associate with the high school students' science subject choosing and their STEM career aspiration, thereby accounting for other teaching approaches. The study found that when high school science teachers focused on real-world uses of science and how the subject relates to future careers, it strongly encouraged students to choose more science courses and aspire to pursue STEM careers, even when compared to other ways of teaching. We found that regularly and positively demonstrating the real-world and career applications of science strongly encourages students to select science subjects. This suggests that teaching the relevance of studying and careers can promote a students' career awareness and career interest. Furthermore, the study also demonstrated that the significant effect of the 'experiential teaching' was not obviously associated

with a students' science subject choice by affecting the students' career awareness and self-efficacy of science. The study suggests that science teachers in Vietnamese schools have not frequently and effectively used the experiential activities to orient STEM careers for students and support a students' science subject choice. The findings imply that making science relevant to the students' lives and demonstrating its broader impact can cultivate their interest in STEM careers.

The implications of this study in education are that science educators can become better at guiding students toward future careers by incorporating two key teaching strategies into their lessons. First, teachers should actively demonstrate how scientific concepts are used in real-world situations ('applications of science'). Second, they should clearly highlight the connections between what students are learning and various study paths and potential STEM-related careers ('the relevance of studying and careers'). By focusing on these approaches, teachers may be able to spark a greater interest in science and encourage more students to consider careers in STEM.

The limitations of this study are partly evident in the empirical results we have reported. The study specifically investigated the impact of "experiential teaching," "teaching the application of science," and "teaching the relevance of studying and careers." Other potentially influential teaching approaches or pedagogical factors in science education were not examined. Therefore, the findings offer a focused but not necessarily comprehensive view of the factors that influence STEM choices.

Future research should meticulously examine the various aspects of the educational setting that plays a role in shaping how well teachers can integrate STEM career guidance into their instruction for upper secondary students. A more profound understanding of these influential factors will be essential to design targeted interventions and pedagogical approaches. These interventions aim to not only strengthen a students' awareness of and inclination towards STEM career paths, but also cultivate a more profound and lasting interest in science disciplines.

Author contributions

Van Thi Hong Ho: Conceptualization, Methodology, Formal analysis, Writing – Original Draft, Results analysis; Hanh Thi Thuy Doan: Results analysis, Writing – Review & Editing, Survey creation and distribution; Ha Thanh Vo: Survey creation, Results analysis; Duc Trong Nguyen: Investigation, Resources, Results analysis; Thanh Thi Nguyen: Results analysis; Chi Thi Nguyen: Validation, Visualization, Survey creation; Chinh Ngoc Dao: Software, Validation, Visualization, Survey creation; Results analysis; Dzung Trung Le: Writing – Review & Editing, Survey creation and distribution; Trang Gia Hoang: Writing – Review & Editing, Survey creation and distribution; Nga Thi Hang Nguyen: Writing – Review & Editing; Ngoc Hoan Le: Writing – Review & Editing, Survey creation and distribution; Gai Thi Tran: Writing – Review & Editing, Survey creation and distribution.

Use of Generative-AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The authors declare that there is no conflict of interest in this paper.

Ethics declaration

The research related to human use has been complied with all the relevant national regulations and institutional policies and has been approved by the Vietnam National Institute of Educational Sciences review board. We have obtained informed consent from all individuals included in this study. The data supporting the findings of this study are available within the paper.

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