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Effective Science Teaching Approaches to Teaching STEM Career Orientation of Upper Secondary School Teachers: A Case Study in Vietnam

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Abstract

Teaching science subject at the upper secondary school is considered as the most important base to develop students' interest in science which is highly associated with their STEM career. This study investigated science teachers' teaching approaches in Vietnamese upper secondary schools to examine which teaching approaches will actively support the teaching of STEM occupational orientation and recommend for science teachers using teaching approaches and teaching methods to promote the effectiveness of STEM-oriented teaching in their lectures. A survey questionnaire measuring four teaching approach's effectiveness in teaching STEM career orientation was distributed to 235 science teachers at upper secondary schools in Hanoi and some northern provinces of Vietnam such as Nam Dinh, Vinh Phuc, Lao Cai, Hoa Binh province. The results indicated that teaching the "applications of science" (conveying the wider applications and/or relevance of science to students' lives) and "hands-on/practical activities" were measured teaching approaches to consistently and positively associated with teachers' teaching of STEM career orientation for upper secondary school students, accounting for other teaching approaches. Additionally, in this study, the "student-led investigation" negatively associated with teachers' science-related career orientation teaching. The implication of the study is helpful for science teachers when they choose and use teaching approaches to promote the effectiveness of STEM-oriented teaching in their science lectures.

Keywords: *Science teaching, STEM career orientation teaching, Teaching approach*

1. Introduction

Upper secondary school is a key moment for young people in science and affects their future career decisions (Subotnik, R.F., 2010). However, students lack clear and timely guidance in planning their careers. Teaching science at high school (such as physics, chemistry, biology) is a necessary base for further study in term of science in the university which is essential for having a career in the field of science and STEM (Science, Technology, Engineering, Mathematics). Therefore, experience activities at a school play a particularly important role in enabling students to choose or not to choose future careers in the field of science (Richard Sheldrake, 2017). Secondary education is indeed an important time to develop students' interest in science (Maltese, Melki, & Wiebke, 2014) and the interest of students in science and applied science. The science of students is believed to be associated with their academic aspirations and career orientation (Regan & DeWitt, 2015). The attitudes and aspirations of students in science courses in high school actually predicted whether they would have earned a degree related to science at university (Malta & Tai, 2011; Gelbgiser, & Weeden, 2013; Tai, Qi Liu, Maltese, & Fan, 2006). Therefore, teachers' teaching strategies are designed to promote student attitudes such as interest in science and thereby promote science-related career aspirations. It is especially important to use specific teaching methods such as using real work experience or classroom debate...

Background of the Study

Science teachers play an increasingly important role in encouraging students to explore the links between science and the professional field (Cohen & Patterson, 2012). Although students do not have access to career educators, every upper secondary school student is exposed to at least one science teacher such as biology teacher, chemistry teacher or physics teacher. Providing career information and connecting students with career opportunities related to science will be important to students. The definition of occupation in STEM field is growing rapidly, especially with the integration of informatics into occupational science, making it necessary for teachers to regularly update future career descriptions and the new skills needed to enter these areas.

Various measures have been taken to promote student attitudes towards science (Rosenzweig & Wig, 2016). Many approaches have been adopted to enhance student interest in science, such as highlighting the link between scientific knowledge and explaining the experience and work of scientists (Bernacki, Nokes-Malach, Richey, & Belenky, 2016; Hong & Lin-Siegler, 2012; Hulleman & Harackiewicz, 2009). Similarly, promoting the relevance and practical application of science to students and parents has been linked to excitement, improved student performance (Harackiewicz, Rozek, Hulleman, & Hyde, 2012; Rozek, Hyde, Svoboda, Hulleman and Harackiewicz, 2015). Overall, teachers can explain broader scientific or scientific occupations in a variety of ways, using the methods of active teaching.

Hands-on activities teaching

Hands-on activities and practical work which often take part in the laboratory, are still valuable in teaching science. For example, through practical work simulated to reaffirm the experimental nature of science are possible (Abrahams & Reiss, 2012; Hodson, 1993; Millar, 1998). Behavioural assessment data have hypothesized that students have a more positive attitude toward science when the teacher regularly emphasizes laboratory practices and as the student progresses. Hands-on activities and practical work have created a more positive attitude for students. This is claimed to be effective when students are given the opportunity to create independent hypotheses and draw their own conclusions (Ornstein, 2006).

Inquiry-based teaching

Science teaching focuses on student-led activities rather than teacher-led activities (but with some guidance and support from teachers), usually is through observation and experimentation (and may be similar to actual work) and this is an opportunity for students to apply more scientific methods (Furtak, Seidel, Iverson, & Briggs, 2012; Minner, Levy, & Century, 2010; Schroeder, Scott, Tolson, Huang, & Lee, 2007).

Context-based approaches

These are the approaches applied in teaching science when the context of teaching science is used as the starting point for the development of scientific ideas (Bennet, 2006). This is in contrast to traditional approaches in the formulation of scientific ideas before, then new applications. Context-based teaching methodology focuses more on enhancing the interest, interest in the subject, and the relevance of subject knowledge to the application of life, through the use of contexts that apply scientific skills and ideas (Bennett, Lubben, & Hogarth, 2007).

Science application teaching

Teaching science application is teaching the broader application of the lesson knowledge and the relevance of scientific knowledge in the lesson to the life of the student) is the only teaching method that is measured consistently and positively compared to other teaching methods (R. Sheldrake et al., 2017).

In Vietnam, the experience of solving a practical work in STEM careers has not been elucidated yet.

2. Research Objectives

The action study aims (1) to investigate which teaching approaches in science teaching will actively support the teaching of STEM occupational orientation in upper secondary schools in Hanoi and some Northern provinces of Vietnam and (2) recommend for science teachers use in their teaching strategies and teaching methods to promote the effectiveness of STEM career orientation teaching in their lectures.

The research question is: What science teachers use in their teaching strategies and teaching methods to promote the effectiveness of STEM career orientation teaching in their lectures?

Additionally, this study tested the following hypotheses to address the research question (Figure 1):

H1: Hands-on/practical activities contribute to STEM career orientation teaching.

H2: Student-led investigations contribute to STEM career orientation teaching.

H3: Context-based approaches contribute to STEM career orientation teaching.

H4: Teaching application of science contributes to STEM career orientation teaching.

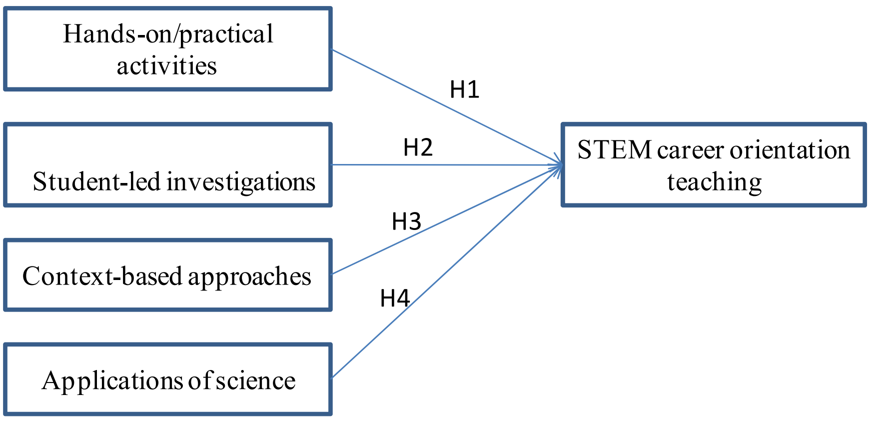

Figure1. Research framework

3. Research Methodology

3.1. Research Instruments

Questionnaires are manipulated from previous research (Novodvorsky, 1993; Stake, J.E., & Mares, K.R., 2001; Ornstein, 2005; OECD, 2015) and adapted to the context of the study. Then, the understandability of the questions was evaluated by the accession and suggestion of the 15 teachers who teach sciences in the upper secondary schools. After the pilot test, the questionnaire was evaluated and had the necessary reliability and understandability for using in the study.

The items/factors of the questionnaire were scaled by using Likert-scales. Specifically, the frequency of using different teaching approaches of the science teachers was from (1) 'Never or hardly ever', (2) 'In some lessons', (3) 'In most lessons', to (4) 'In all lessons'. Some examples of items/factors in the questionnaires are described in Table 1.

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

Item/factor	Example item
STEM career orientation teaching	'Students learn about professions related to subject area"
Teaching: hands-on/practical activities	'Students are asked to draw conclusions from an experiment they have taken
Teaching: applications of science	'I discuss questions of practical relevance"
Teaching: student-led investigations	'Students are given opportunities to explain their ideas"

3.2. Data collection

The survey was conducted with 235 teachers. Investigation is conducted by direct investigation. Direct surveys use contact methods and teacher interviews at high schools in Hanoi and some northern provinces of Vietnam such as Nam Dinh, Vinh Phuc, Lao Cai, Hoa Binh province. We distributed 235 questionnaires directly collected 230 validated questionnaires. The total number of questionnaires for the official analysis is 230, which is greater than 200 according to the study of Comrey and Lee (1992) (Table 2).

Firstly, the validated questionnaires were analyzed and showed the characteristics of surveyed subjects including age, gender, qualification and teaching experience (Table 2). The subjects are almost from the age of 30 to 49 (88.3%), abundantly female gender (94.8%), and all graduated or post graduated. Additionally, it seems likely that the surveyed subjects have high teaching experiences as shown in teaching years almost being from 10 to over 20 (71.3%). These data may support the viabilities of late analysis.

Table 2. Characteristics of the surveyed subjects

Group	Classify	Number of people (rate)
Age	<=30	25 (10.9%)
	30 - 39	137 (59.6%)
	40 - 49	66 (28.7%)
	>=50	2 (0.8%)
Gender	Male	12 (5.2%)
	Female	218 (94.8%)
Qualification	Graduate	212 (92.2%)
	Post graduate	18 (7.8%)
Teaching years	< 5 years	14 (6.1%)
	5 – 10 years	52 (22.6%)
	10 – 15 years	75 (32.6%)
	15 – 20 years	58 (25.2%)
	> 20 years	31 (13.5)

3.3. Data Analysis

Data were collected through a questionnaire and analyzed by using the descriptive and regression analysis. Factors and dependent variables in the model were tested for reliability of the scale by Cronbach's α coefficient and coefficient of correlation. To see the questionnaire in the current study, Cronbac's α was used and the questionnaire was tested on other participants outside the real participants. One criterion for ensuring the reliability of the scale is the minimum Cronbach α coefficient of 0.6 and a minimum total correlation coefficient of 0.3. Following factors will be tested for convergence by using Exploratory Factor Analysis (EFA) The appropriate standards for EFA are the minimum Kaiser-Meyer-Olkin (KMO) coefficient of 0.5, Bartlett's test with a p-value less than 0.05, minimum explanation of 50%, minimum Eigenvalue of 1. Furthermore, to test the hypothesis, contribution of H1, H2, H3 and H4, the regression analysis was used by looking at the magnitude number of R Square (Percentage of R Square). We used a linear regression analysis to analyze the correlation between pairs of variables and used a logistic regression analysis to estimate the presence or absence of teaching activities in career orientation for students. Data were analyzed by using a Statistical Package for Social Science (SPSS) software.

4. Results and Discussion

4.1 The reliability of research Model

Analysis the reliability of the questionnaires' scales showed that Cronbach's α is higher than 0.6 (from 0.647 to 0.876), corrected item-total Correlation is higher than 0.3 (from 0.372 to 0.71), and cumulative of total variance explained is higher than 50%. These data support the idea that the factors-measuring items are highly reliable to use.

4.2. Statistical analysis of studied samples

As shown in Table 3, the descriptive analysis of the findings in this study indicated that teachers used the student-led investigations in the highest frequency with a mean value of 3.09. And the next ones are teaching differentiation with a mean value of 3.08, teaching applications of science with a mean value of 2.9, context-based approach with a mean value of 2.89, respectively, in all science teaching approaches.

Table 3. Descriptive analysis

Item/factor (scale)	Mean	SD
Teaching science-related career orientation (1=Y)	0.599	0.49
Teaching: hands-on/practical activities (1 – 4)	2.42	0.51
Teaching: teacher-led activities (1 – 4)	2.79	0.49
Teaching: student-led investigations (1 – 4)	3.09	0.46
Teaching: context-based approach (1 –5)	2.89	0.93
Teaching applications of science (1 – 4)	2.90	0.63
Teaching differentiation (1 – 4)	3.08	0.58
Teaching: collaboration (1 – 4)	2.78	0.56
ICT (1 – 4)	2.55	0.55
Group evaluation (1 – 4)	2.84	0.53
Assessment (1 – 4)	2.27	0.64
Valid N (listwise) 230		

In Vietnam (Table 3), 59.9% of teachers in this study taught STEM career orientation. Teachers most frequently reported using science teaching that highlighted the 'application of science', then 'hands-on/practical activities', and then 'student-led investigations' and 'context-based approach'.

4.3. Modeling teacher's career orientation teaching

Table 4. Correlation summary

		1	2	3	4	5	6	7	8	9	10
1.Teaching: STEM career orientation	Pearson Correlation	1									
	Sig. (2-tailed)										
2.Teaching: hands-on /practical activities	Pearson Correlation	**0.540**	1								
	Sig. (2-tailed)	**<0.001**									
3.Teaching: teacher_led activities	Pearson Correlation	**0.465**	**.430**	1							
	Sig. (2-tailed)	**<0.001**	**<0.001**								
4. Teaching: student-led investigations	Pearson Correlation	**0.342**	**.434**	**.389**	1						
	Sig. (2-tailed)	**<0.001**	**<0.001**	**<0.001**							
5. ICT	Pearson Correlation	**0.405**	**0.374**	**0.366**	**0.343**	1					
	Sig. (2-tailed)	**<0.001**	**<0.001**	**<0.001**	**<0.001**						
6. Teaching: differential	Pearson Correlation	**0.404**	**0.336**	**0.328**	**0.320**	**0.340**	1				
	Sig. (2-tailed)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**					
7.Teaching: Context-based approach	Pearson Correlation	**0.412**	**0.457**	**0.401**	**0.344**	**0.375**	**0.420**	1			
	Sig. (2-tailed)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**				
8. Group evaluation	Pearson Correlation	**0.337**	**0.445**	**0.334**	**0.206**	**0.253**	**0.487**	**0.448**	1		
	Sig. (2-tailed)	**<0.001**	**<0.001**	**<0.001**	**0.014**	**0.002**	**<0.001**	**<0.001**			
9. Teaching: collaboration	Pearson Correlation	**0.255**	**0.411**	**0.298**	**0.171**	**0.270**	**0.385**	**0.392**	**0.540**	1	
	Sig. (2-tailed)	**0.002**	**<0.001**	**<0.001**	**0.042**	**<0.001**	**<0.001**	**<0.001**	**<0.001**		
10. Assessment	Pearson Correlation	**0.188**	**0.340**	**0.323**	**0.323**	**0.327**	**0.316**	**0.366**	**0.355**	**0.308**	1
	Sig. (2-tailed)	**0.025**	**<0.001**	**<0.001**	**<0.001**	**0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	
11. Teaching applications of science	Pearson Correlation	**0.440**	**0.315**	**0.373**	**0.297**	**0.348**	**0.297**	**0.298**	**0.203**	0.129	**0.293**
	Sig. (2-tailed)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.015**	0.127	**<0.001**

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

The result shown that, there were correlative associations between the various teaching approaches (science-related career orientation, 'hands-on/practical activities', 'applications of science', and 'student-led investigations', teacher-led activities, context-based approach, context-based approach) and which were considered for Pearson correlation from 0.203 to 0.54 (Table 4). Moreover, STEM-related career orientation teaching strongly associated with hands-on/practical activities, teacher-led investigations, context-based activities and applications of science teaching (table 4) compared with learning assessment which affected negatively to STEM career orientation teaching. However, the results also indicated that teaching approaches such as student-led investigations had no effect on teachers' teaching of career orientation.

The results of the regression analysis were shown in table 6 which indicated that hands-on/practical activities, teacher-led activities and teaching applications of science affected on the teachers' performance of STEM career orientation teaching variable. It was shown by the number of R Square was 0.42 and p-value < 0.05.

The results of the hypothesis test 1 (H1) indicated that there was a contribution of hands-on/practical activities to teachers' performance of STEM career orientation teaching. It was shown by Standardized Coefficients was 0.322 and p-value was under 0.001 (<0.05). Another interesting finding was that the results of hypothesis test 4(H4) indicated that there were contributions of teaching applications of science to teachers' performance at the research sites, shown by the Standardized Coefficients was 0.205 and p-value was 0.006 (<0.05) (Table 5).

However, the result of hypothesis test 2 (H2) and test 3 (H3) revealed that there were not contributions of student-led investigations and a context-based approach to teachers' performance of STEM career orientation teaching. They were shown by the Standardized Coefficients were 0.007 and 0.85, p-value were 0.923 and 0.300 (>0.05) respectively.

A further finding showed that there was a contribution of teacher-led activities to teachers' performance of STEM career orientation teaching. It was shown by Standardized Coefficients was 0.174 and p-value was 0.02 (<0.05).

Table 5. Regression linear summary

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	0.248	0.275		0.902	0.368		
1. Teaching: hands-on/practical activities	**0.300**	**0.078**	**0.322**	**3.851**	**<0.001**	0.588	1.701
2. Teaching: teacher-led activities	**0.168**	**0.076**	**0.174**	**2.220**	**0.028**	0.669	1.494
3. Teaching: student-led investigations	0.008	0.079	0.007	0.097	0.923	0.696	1.436
4. ICT	0.103	0.066	0.119	1.569	0.119	0.714	1.400
5.Teaching: Context-based approach	0.043	0.041	0.085	1.040	0.300	0.622	1.609
6. Group evaluation	0.029	0.076	0.032	0.376	0.708	0.555	1.803
7. Teaching: collaboration	-0.043	0.068	-0.050	-.624	0.533	0.635	1.576
8. Assessment	**-0.115**	**0.056**	**-0.155**	**-2.075**	**0.040**	0.739	1.352
9. **Teaching applications of science**	**0.155**	**0.056**	**0.205**	**2.781**	**0.006**	0.758	1.319

Adjusted R Square: .**420**

a. Dependent Variable: Teaching: science-related career orientation

Note: Significant coefficients ($p < 0.05$) are highlighted in bold. Explained variance shows Nagelkerke R2.

Moreover, the result of predicting teachers' STEM career orientation teaching by using logistic regression statistic was indicated in table 6. The model of predictor shown that only 'hands-on/practical activities", "teacher-led activities", "teaching applications of science" were the teaching factor to consistently and positively associated with STEM career orientation teaching. It was shown by the number of R Square was 0.434 and p-value < 0.05.

However, other teaching approaches such as student-led activities, differential teaching, context-based approach, group evaluation, ICT and collaboration teaching had no effect on teachers' career orientation teaching. The assessment was the only factor which associated negatively with science-related career orientation teaching.

Table 6. Summary of the model predicting science-related career orientation teaching (logistic regression)

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	**1. Teaching: hands-on/practical activities**	**1.991**	**0.655**	**9.228**	**1**	**0.002**	**7.323**
	2. Teaching: teacher-led activities	**1.626**	**0.555**	**8.585**	**1**	**0.003**	**5.081**
	3. Teaching: student-led investigations	-.418	0.546	.586	1	0.444	0.658
	4. ICT	.256	0.447	.327	1	0.568	1.291
	5.Teaching: Context-based activities	.858	0.462	3.447	1	0.063	2.359
	5.Teaching: Context-based approach	.268	0.296	.821	1	0.365	1.308
	6. Group evaluation	-.590	0.516	1.305	1	0.253	0.554
	7. Teaching: collaboration	-.160	0.469	.117	1	0.732	0.852
	8. Assessment	**-.917**	**0.400**	**5.245**	**1**	**0.022**	**0.400**
	9. Teaching applications of science	**.818**	**0.400**	**4.176**	**1**	**0.041**	**2.265**
	Constant	-8.685	2.251	14.887	1	<0.001	<0.001

Nagelkerke R Square: **0.434**

Note: Logistic modelling was used to predict science-related career teaching; exponential coefficients ('Exp.') and significance ('Sig.';p-values) are reported. Exponential coefficients are 'odds ratios'; Significant coefficients ($p < 0.05$) are highlighted in bold.

4.4. Discussion

The presented results highlighted the importance of teachers' teaching application of science, hands-on/practical activities and teacher-led activities in STEM career orientation teaching in classes. The new significant insight for science education was that conveying the 'applications of science' and hands-on/practical activities were the measured teaching approach to consistently and positively associate with teachers' performance of career orientation for students, accounting for the other teaching approaches.

Addressing the first research aim, from across the indicators of different frequencies of teaching approaches (organizing 'hands-on/practical activities', organizing teacher-led activities, organizing 'student-led investigations', and conveying the 'applications of science'), conveying the 'applications of science', 'hands-on/practical activities", "teacher-led activities" were approaches to consistently and positively associate with theorized antecedents when accounting for the other teaching approaches.

The results supported the hypothesis that explaining the wider context or applications of science would associate with teachers' STEM career orientation teachings, which accordingly coheres with implications from existing research (Savelsbergh et al., 2016; Straw and Macleod, 2015; Sheldrake, 2017). However, the results did not clearly support the hypothesis that context-based approaches (assumed to be identified through the 'hands-on/practical activities' and 'student-led investigations' indicators) would associate with high efficiency (Savelsbergh et al., 2016). When accounting for the other teaching approaches, 'hands-on/practical activities' and "teacher-led activities" approaches had positive associations with teachers' career orientation teaching. However, when accounting for the other factors, "context-based approach" and 'student-led investigations' had no significant association with teachers' career orientation teaching. These findings might explain the reality that science teachers in Vietnamese schools have not used the context-based approach and student-led investigation to orient STEM career for students yet.

The analysis considered indicators of teaching approaches that have variously been explored and applied within science education. Applying 'hands-on/practical activities' has often been assumed to reflect the empirical nature of science (Millar,1998). Practical work and 'student-led investigations' both occur within wider ideas of inquiry-based learning of science, which again aim to reflect overall processes of scientific inquiry (Furtak et al., 2012). Alternately, conveying the 'applications of science' does not necessarily require an underlying assumption that students must learn by doing what scientists do. Conveying the 'applications of science' may potentially link with wider teaching/learning approaches where students learn scientific skills and ideas specifically through considering applied contexts but do not necessarily imply or require this (Bennett et al., 2007). Conveying the 'applications of science' could supplement any other teaching approaches, practical or otherwise.

On a wider level, the presented results highlight the potential benefit of continuing to explore how teachers using their teaching/learning context, rather than focusing on applying theoretical or conceptual ideas of (or various other rationales for) how students could or should learn science. Assumptions that students must learn by doing what scientists do may appear reasonable, but may risk science education focusing only on professional development, and may inadvertently perpetuate an idealised or discouraging version of who or what a scientist is (Archer, Dawson, DeWitt, Seakin & Wong, 2015; Claussen & Osborne, 2013;).

According to the result of predicting teachers' STEM career orientation teaching by using logistic regression statistic in case of Vietnam, 'hands-on/practical activities", "teacher-led activities", "teaching applications of science" were the teaching factor to consistently and positively associated with STEM career orientation teaching. However, science teachers should organize hands-on/practical activities and teaching applications of science in order to teach STEM career orientation because these approaches were empirically verified to associate with career interest (Abrahams & Reiss, 2012; Furtak, Seidel, Iverson, & Briggs, 2012). We believe that the teaching approach of "teacher-led activities" should be used less and teachers should organize more student-led activities to improve STEM career orientation teaching and learning in Vietnam.

5. Conclusion

Analysis of science teaching in Vietnam highlighted that teaching the 'applications of science' (conveying the wider applications and/or relevance of science to students' lives) and hands-on/practical activities were measured teaching approaches to consistently and positively associate with teachers' teaching of STEM career orientation for high school students, accounting for other teaching approaches.

Overall, these patterns of results suggested that conveying the wider relevance of science to everyday life and to wider contexts may help teachers' performance in teaching science and career orientation, which may then help foster students' aspirations towards STEM careers.

The implications of this study in the education is that science teaching should use teaching approaches of the 'applications of science' and "hands-on/practical activities" in their lessons in order to improve their performances of career-orientation teaching which may enhance students' aspirations towards STEM careers.

For further studies, it is necessary to study more about the factors of educational condition affect to teacher's performance of STEM-career orientation teaching to promote career orientation for upper secondary students."

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