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The impacts of integrated stem education on students' learning motivation

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Abstract. The purpose of this study was to determine the effect of STEM (Science, Technology, Engineering, Math) activities on learning motivation of the first-year students and the students' view on STEM. A mixed research method was used. In the quantitative section of the study, the pre-test and post-test experimental single group design were used, whereas the qualitative research was conducted with the interview. The survey questionnaire and interview form were used as data collection instruments. Forty-first-year students attending at Cao thang Technical College participated in this study. A 6-week program was conducted with STEM education through an industrial project. The paired sample T-test was used to determine the significant difference between pre-test and post-test motivation scores of students participating in STEM activities. The students' view on STEM education demonstrated that STEM improved their learning motivation. Furthermore, the students also consolidate students' careers before entering the job market.

Keywords. STEM education, motivation, industrial project

Introduction

Learning motivation is one of the determining factors for student academic success. Once students have short of learning motivation, they will duck out of receiving an assigned task, and their learning task is usually not completed. This failed learning outcome (Viau, 1998).

In the context of engineer training, the first-year students are asked to attend physics, advanced mathematics, and basic engineering courses at Cao Thang Technical College in Ho Chi Minh City, Vietnam. We saw that students studied declarative knowledge, then apply them to solve exercises that were not associated with real situations. Moreover, these courses were taught separately, students couldn't integrate them to solve an engineering problem related to their future career. This made students not interested in the learning process. In addition, by interviewing with a group of four students in Electrical and Electronic faculty, results revealed that students did not clearly understand the purpose of studying general physics knowledge, they also did not understand why they have to learn general physics and how to apply them to the field of careers.

Therefore, building a learning method to enhance learning motivation for students when studying science subjects and applying them in the engineering context is essential.

We assume that teaching general physics and mathematic by integrating technological et engineering through an industrial project is a solution to enhance students' learning

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motivation in the context of engineering training. This study is therefore to investigate the impact of integrated STEM education on students' learning motivation.

Framework

Motivation in learning

According to Viau (1998), several factors influence motivation in learning such as factors related to student life, social environment, school, and classroom environment. He also pointed out that there were three main components of a factor related to classroom environment impact on students' learning motivation directly, namely, students' perception of the value of the assigned task, students' perception of the task difficulty level, and students' perception of the cause of success or failure in carrying assigned task. From these three components, the author also builds four indicators of motivation in learning i.e., the choice of the learning task, cognitive engagement in the learning process, persistence in learning activities, and their academic achievement. The learning motivation model is presented as follows.

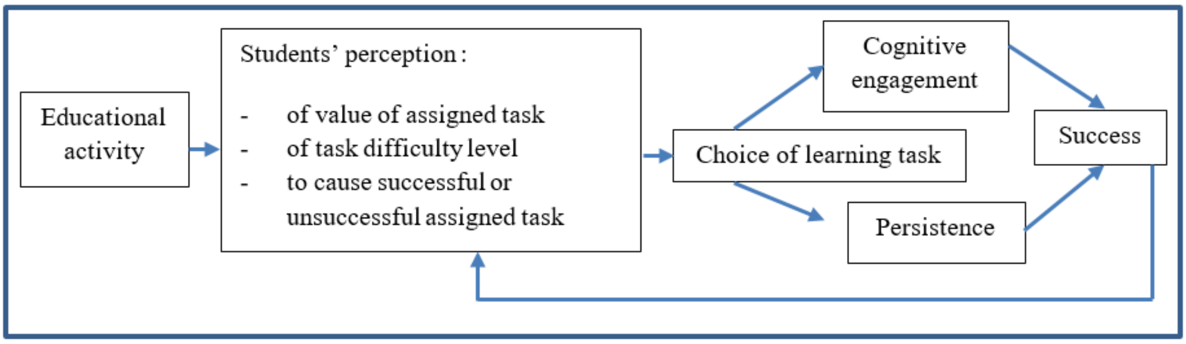

Figure 1: Motivational model

Integration STEM education

Research shows that when learning is fragmented, students fail to how various subject areas are integrated. Thus, STEM facilitates the integration of the content knowledge from several subjects to solve a complex problem (Capraro & Jones, 2013). STEM education is considered an educational approach that would contribute to the development of skills that 21 St century individuals that should acquire and support economic growth (National Research Council, 2014). Bybee (2010) mentioned that this approach aims to instruct science and math by integrating technology and engineering from kindergarten to 12th grade. The implementation of STEM education aims to engage students in building new knowledge or creating a product through solving an engineering problem. As a result, STEM education affected students' learning motivation (Vennix et al., 2018). Research indicated that integrated STEM improved students' problem solving skills. This approach also fostered students' learning motivation (Capraro & Jones, 2013).

In addition, Langdon et al. (2011) indicated that STEM professionals improve economic growth, global competitiveness. Students who attended STEM programs are easy to apply for a job (National Research Council, 2014).

Implementing integrated STEM education through an industrial project

In general, implementing STEM education is conducted with a project which is divided into four phases. Basing on work of NGO (2014), an industrial project consist of six phases including need analysis, preliminary conception, detailed conception, implementation, testing and explementation, and evaluation as following Figure 2.

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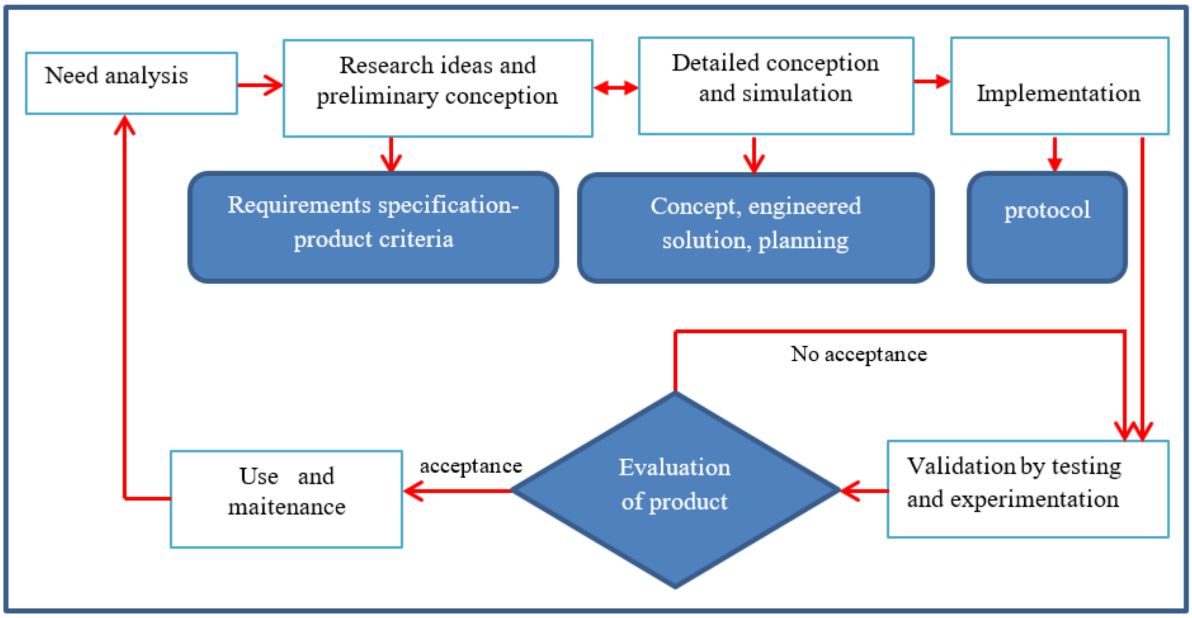

Figure 2: Cycle of an industrial project

The aim of the study

The present study aimed to observe the effects of integrated STEM activities on learning motivation of first years students and to determine the students' views on STEM education.

Research problem

The research problem was analyzed using the sub-problem listed below:

Q1: Is there a significant difference between pretest and posttest related to the students' perception of the value of the assigned task towards integrated STEM education of first year students in the vocational training program?

Q2: Is there a significant difference between pretest and posttest related to the persistence in the learning process towards the integrated STEM education of first-year students in the vocational training program?

Q3: Is there a significant difference between pre-test and posttest related to the engagement in the learning process towards the integrated STEM education of first-year students in the vocational training program?

Q4: Is there a significant difference between pre-test and posttest related to the perception of learning outcome towards integrated STEM education of the first-year students in the vocational training program?

Q5: What was the view of students on STEM education?

Research method

Research design

The study was conducted in two successive stages. Quantitative data were collected and analyzed in the first stage, and qualitative data were collected and analyzed in the second stage. In the first stage, the pre-test, posttest single group experimental design was used in this research. This experimental design based on the work of Creswell & Creswell (2017). In the second phase of the study, the case study was used to investigate in deep.

Sample

The sample size was conducted in two successive stages. In the first stage, the sample was randomly selected from one of four Electrical Engineering classes, the school year of 2018-2019. The experimental class was assigned a code as EC with 40 students. These forty students were divided into eight groups in the second. Each student group, we randomly selected one. Thus, the number of students that were composed sample size was eight participating in semi-structured interviews. Eight students were assigned codes such as “S1, S2,..S8” for ethical purposes.

Data collection tools

The tool used in this study is a questionnaire using the Likert scale of 5 levels (1= strongly disagree, 5 = strongly agree) to measure students' perception of learning motivation according to the STEM integrated education approach. This tool is used based on the work of Viau (1998), including five factors: "Students’ perception of the value of the assigned task", "students’ perception of task difficulty level", " students’ perception of the cause of success or fail assigned task", “ students’ perception of engagement”, “students’ perception of persistence”, and “students’perception of resulting of learning outcome”. Four out of these six factors were selected to construct the survey questionnaire.

This questionnaire was validated by two experts in science education. The reliability of the questionnaire was first tested and confirmed in a pilot study with more than 100 students from different engineering disciplines. Then these students’ responses were collected, processed by using SPSS 22 to obtain the Cronbach’s Alpha. Due to items with low Cronbach’s Alpha were deleted, and 11 items remained in this questionnaire as Shown in Table 1. All four groups represent excellent internal consistency as evidenced by high Cronbach’s alpha statistic, as seen in Table 2.

Table 1: Questionnaire items

Factor	Items	Numer of Item
Students’ perception of the value of the assigned task	1. I recognize learning interest activities 2. I recognize learning activities are useful 3. I recognize learning the background knowledge meaningful	3
Students’perception of engagement (PE)	1. I put a lot of effort in preparing materials and planning for my learning process 2. I always controlled the progress on my learning process 3. I always involve in learning process	3
Students’perception of persistence	1. I devote all my effort to find out a solution to the problem 2. I invested much time in carrying out the assigned task 3. I never gave up on the assigned task.	3
Resulting from the learning process (RLP)	1. I have got the perfect results of learning 2. The learning process allows me to integrate science, technology, engineering, and mathematic to solve a real problem	2

Table 2: Cronbach’s alpha statistic

Factor	Code of Items	Cronbach Alpha
Perception of the value of the assigned task	PVAT1, PVAT2, PVAT3	0.762

Students' perception of engagement	PE1,PE2, PE3	0.783
Students' perception of persistence	PP1, PP2, PP3	0.967
Resulting from the learning process	RLP1, RLP2	0.777

For the internal validity of the qualitative dimension of the study, data were diversified with the use interview. The interview form was developed by the researcher, an expert in qualitative data analysis was consulted. This interview form was read, evaluated by two students for comprehensibility. Based on expert opinion, and student assessment, the interview form was reorganized to comply with the view on the suitability and comprehensibility of the question.

- **Data collection stage**

Before the implementation of integrated STEM education, we observed the teaching and learning process in the classroom. For the first time, we observed the interaction between teachers and students; between students and students, as well as student interaction with the learning environment. This observation aims to monitor students' attitudes towards the subject. For the second time, we distributed a questionnaire about students' learning motivation in studying General Physics.

In the teaching process, integrated STEM education was applied through the implementation of an industrial project. The implementation of the project took place in 6 weeks as flowing.

Table 3: Time schedule for an industrial project

Week	STEM activities through an industrial project
Week 1	- Choosing of the project's topic, - Receiving the driving question to explore physics knowledge to conduct a project.
Week 2	- Presenting explored knowledge according to the driving questions
Week 3	- Finding out a technical solution
Week 4	- General conception
Week 5	- Detailed conception
Week 6	- Testing project

After the teaching process, a questionnaire et structured interviews was adopted to investigate students' learning motivation through an integrated STEM education by using an industrial project**.**

Data analysis

Data were collected before and after the intervention of STEM activities. Shapiro Wilk test was used to evaluate the normal distribution of the data, in which the confidence interval percentage is 95%. The fact that the p-value was over 0,05 considered as the evidence of normal distribution of the data, as seen in Table 4.

The paired-Sample T-test was used to understand the change of student attitudes to integration in interdisciplinary STEM before and after the learning process.

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Table 4: Normality Test finding

	Stastic	df	p
PAVT	0,872	40	0,371
PE	0,853	40	0,524
PP	0,865	40	0,275
RLP	0,835	40	0,621

The qualitative data conducted with participating were processed with the content analysis method. In this study, interview transcripts were analyzed by three researchers. The interview transcripts were analyzed separately by the researcher and a faculty member in the educational field who was expert in qualitative research. The reliability of content analyses was determined by using the agreement rate formula of Miles and Huberman (1994). This formula was taken as [agreement /(agreement + disagreement) x100]. According to Miles & Huberman (1994), at least 70% agreement between the coders were required to establish reliability. Since the coefficient of agreement between the coders was over 70%, the coding conducted in this study was considered reliable.

Results

Q1: Students' perception of the value of the assigned task towards integrated STEM

The paired sample T-test finding, applied to determine the students' perceived value of the assigned task, is presented in Table 5.

Table 5: Students'perceived value of the assigned tasks

	N	Mean	Std.Deviation	t	p
Pretest	40	3,059	0,3119	6,288	,00
Posttest	40	3,733	0,5241		

*p < 0,05

Table 5 demonstrates that there was a statistically significant difference between pretest and posttest scores ($p < 0,05$). Thus, it was determined that integration STEM education gave students' perceived toward the value of learning tasks. In paired sample T-test, the effect size was calculated by the ratio of t value to the square root of the sample size. The test result effect size was calculated as 6,288. The fact that the effect size was greater critical value ($t_{0,025,\ 39} = 1,96$) indicated that the difference between the groups was quite high (Green & Salkind, 2005)

Q2: Students' perception of persistance in the learning process

The paired sample T-test, applied to determine the students'persistance in the learning process, is presented in Table 6.

Table 6:Students'persistance in the learning process

	N	Mean	Std.Deviation	t	p
Pretest	40	2,888	0,5603	5,476	,00
Posttest	40	3,700	0,6961		

*p <0,05

Table 6 demonstrates that there was a statistically significant difference between pretest and posttest scores ($p < 0,05$). Thus, it was determined that the integration of STEM education enhanced students'perseverance through the learning process. In paired sample In paired sample T-test, the effect size was calculated by the ratio of t value to the square root of the sample size. The test result effect size was calculated as 5,476. The fact that the effect size was greater critical value ($t_{0,025, 39} = 1,96$) indicated that the difference between the groups was quite high (Green & Salkind, 2005).

Q3: Students' perception of engagement in the learning process

The paired sample T-test, applied to determine the students' engagement in the learning process, is presented in Table 7.

Table 7:students'engagement in the learning process

	N	Mean	Std.Deviation	t	p
Pretest	40	3,013	0,5125	2,756	,00
Posttest	40	3,375	0,6176		

*p < 0,05

Table 7 demonstrates that there was a statistically significant difference between pretest and posttest scores ($p < 0,05$). This was determined that the integrated STEM through the implementation of an industrial project triggers students' curiosity, interest, and involvement, an attraction in working on the project. In paired sample T-test, the effect size was calculated by the ratio of t value to the square root of the sample size. The test result effect size was calculated as 2,756. The fact that the effect size was greater critical value ($t_{0,025, 39} = 1,96$) indicated that the difference between the groups was quite high (Green & Salkind, 2005)

Q4: Students'perception of desired learning outcome

The paired sample T-test, applied to determine the students' perception toward the desired learning outcome, is presented in Table 8.

Table 8:Students' perception toward the desired learning outcome

	N	Mean	Std.Deviation	t	p
Pretest	40	3,059	0,3119	11,664	,00
Posttest	40	3,908	0,2823		

*p <0,05

Table 8 demonstrates that there was a statistically significant difference between pretest and posttest scores ($p < 0,05$). This was determined that the integrated STEM through the implementation of an industrial project enhanced students'learning outcome, allowed students to integrate Science, Technology, Engineering, and Mathematics into solving a real problem. In paired sample T-test, the effect size was calculated by the ratio of t value to the square root of the sample size. The test result effect size was calculated as 11,664. The fact that the effect size was greater critical value ($t_{0,025, 39} = 1,96$) indicated that the difference between the groups was quite high (Green & Salkind, 2005)

Q5: Students'view on STEM education

At the end of the experiment, an interview was conducted to determine the students' attitude to put their effort to learn. The interview was carried out with eight students as mentioned above in the session “sample size”. The interview lasted 30 minutes. The conversation from each student was recorded for a deeper study of students’learning motivation.

The results of the contents analyze conducted on the student responses to the question “What do you think about the value of the assigned task”. Analysis of interview transcripts was used to investigate both students’ perceptions of the value of learning activity and how the students applied STEM knowledge to create a product through the implementation of an industrial project activity. The results of the content analysis showed that all student interviews had the most significant changes in attitude towards the value of learning activity before and after the implementation of STEM education through an industrial project activity. Indeed, students have strong interests in learning physics, and they prefer to learn practically rather than theoretically. They also mentioned that science is beneficial and can be generally applied in engineering. They also indicated that they preferred to learn and apply science physics knowledge from practical experiments, and previous experience.

With regard to the question “What do you think about students’attitude towards engagement and persistence in the learning process”. Six out of eight students had changes in attitude towards spending time on learning activity before and after the implementation of STEM education through an industrial project activity. Students mentioned that they were always responsible for the assigned task. They also indicated that an industrial project facilitates the enhancement of learners’ autonomy, from choosing a technical solution through engineering process design to implementing their project so as to result in a product.

With respect to the question “What do you think about students’ learning outcome”. Three out of eight students mentioned that the industrial project not only helped them to learn essential knowledge, but also to integrate them to create a product related to the process of engineering production. It is important that they stated ‘‘the possession of professional science knowledge is beneficial to their future career”. The other indicated that “learning science physics through integrating engineering created favorable conditions for developing problem-solving competencies”.

Discussion

Teaching general physics and mathematic by integrating the technical and engineering field through implementing an industrial project revealed that the students’ learning motivation is improved. Indeed, after implementing an industrial project at the Cao Thang Technical College has enhanced students’ perception of the value of learning activities than using conventional lecture method ($p < 0,05$), as shown in Table 5. When students perceived the importance of the value of the assigned task, they engaged and persevered in their effort to achieve the desired learning outcome ($p < 0,00$), as seen in Tables 6 and 7. Thus, in order to optimize the students' proactive participation in the learning process, the STEM theme given to students must satisfy necessary and sufficient conditions. With regard to necessary conditions, STEM themes are in favor of connecting content knowledge related to STEM fields to solve an engineering problem with reference to students’ future careers. In connection with sufficient conditions, a STEM theme makes the students see meaningful learning. This finding result is completely consistent with the work of (Kennedy & Odell, 2014). They mentioned that curricula that engages students in STEM promote teaching approaches that challenge students to innovate and invent. This indicates students have to apply science and mathematics they learn to solve an engineering problem by using technology to find out a solution.

This teaching strategy improves students’ learning motivation in the context of technical and vocational education and training. The result aligned with those obtained by Beier et al., (2019), who found that engaging of project based learning affected on student perception of STEM skills, perceptions of the utility value of participating in STEM course, and STEM career aspirations.

Although this study has contributed to the modality of enhancing students' learning motivation by integrating STEM education through an industrial project, the study was not without flaws. The first limitation concerns the research design. This study was exploratory and lacked the control group, thus limiting the generalizations of results. The second limitation is rooted in the assessment method. Since most of the data were coded and analyzed from survey questionnaires and interviews, the results may reflect in part in which the data were gathered and analyzed.

Conclusion

Findings revealed that students' learning motivation enhanced by integrating STEM through implementing an industrial project. The integration of STEM education helped students to actively engage in the learning process, in which students persevere in completing their assigned tasks. It is of great importance that learning topics are considered under two aspects: one side is relevant to the student's future career, the other has to pay attention to the students'interesting in performing assigned tasks. As a result, students have strong interests in learning science by integrating engineering and technology to create a product.

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Conflict of Interest Statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Data availability statement

The data that support the finding of study are available from corresponding author, upon reasonable request.

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