Integration of Inventive Problem Solving in Project Based Learning for Building Construction Program through Module Development

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Abstract. Cooperative learning and hands-on techniques are important dimensions for Building Construction students to build skills and gain knowledge. Therefore, the appropriate approach that needs to be given to Building Construction students is Project-Based Learning (PBL). PBL is meaningful question-based learning, encourages Building Construction students to think deeply and increase their curiosity. The problems that need to be solved are close to the real-world context. Accordingly, to increase students' knowledge to think more creatively and innovatively, a theory can help Building Construction students solve problems that is the Theory of Inventive Problem Solving (TRIZ) has been integrated into PBL. This study aims to develop the TRIZ Integration module in PBL by analyzing the format appropriateness feedback, content, and usability of the module from lecturers and students. This study uses a quantitative approach involving five lecturers and 30 students from the field of Building Construction. Data were analyzed descriptively and presented in terms of frequency and percentage. The study's findings show that 100% of Building Construction lecturers, and students agree with this module format's suitability. Besides, 97.3% of lecturers and 100% of students also agreed with the suitability of the content of this module developed. As for the module's usability, 90% of lecturers and 100% of students agree that Building Construction students can use this developed module. In conclusion, this module successfully helps Building Construction lecturers and students solve inventive problems in PBL effectively.

INTRODUCTION

For the country's progress in the 21st century, Malaysia has faced various challenges, especially globalization and technological development [1]. Thus, education plays a significant role and prepares a student who can compete in a large, competent group and is ready to face the obstacles of the Industrial Revolution 4.0. According to the Malaysian Education Development Plan 2013 - 2025, education aims to produce knowledgeable and skilled people to succeed in life [2]. Technical Education and Vocational Training (TVET) is an effort and process to produce graduates who have

high quality and are also an engine in developing the country [3]. Besides, industry and employers' involvement are also essential to provide knowledge in the country's economic development. Problem-solving skills are an indispensable element that includes analyzing, interpreting, predicting, and evaluating. With problem-solving skills, graduates in the technical field can quickly identify and solve a problem in the industry [4].

The project-based learning approach (PBL) is an effective method to improve students' problem-solving skills . This PBL approach can shape students' thinking more creatively because, through PBL, students can formulate thoughtful ideas for a project to be implemented [5]. A theory can help students solve problems in PBL, immensely improving the quality of projects or products that students will create. Students can use the approach to solve various issues known as the Theory of Inventive Problem Solving (TRIZ) or inventive problem-solving theory.

TRIZ is used widely in high-branded industries in the production of highly competitive products. TRIZ is also a method of generating good ideas and can solve problems during consumer products' design [6]. In the current 21st century, students should be more innovative in thinking of an idea with TRIZ theory's help [7]. TRIZ needs to practice because it can solve a creative problem systematically [8]. This method is suitable to be applied through the PBL approach [9]. TRIZ provides various advantages, so TRIZ is ideal for use through the use of modules.

Based on the discussion in the background of the study's problem, the researcher found that most students are comfortable using traditional teacher-centered methods. Most technical students give priority to theoretical academic achievement over project-based assignments. Besides, technical students also do not have exposure to problem-solving skills, which causes them to be unable to perform project-based tasks systematically. This is because most technical students do not have a reference source for completing a project. Furthermore, preliminary studies have shown that 80% of technical students are not proficient in using PBL methods and do not have specific skills to solve problems in project-based assignments. The majority of students are not proficient in using the PBL method to complete assignments, study in groups, or independently.

Students also do not have the specific skills to solve problems in project-based assignments given by lecturers. This is because students do not have reference sources as a guide to solve problems inventively. Indirectly, students become unmotivated to develop an innovative project without the guidance of a lecturer. As a result, technical students cannot complete a project-based task well [10]. Student assignment results are at a low-quality level [11]. Directly, students find it difficult to achieve excellent achievement in project-based assignments. This has been supported by [7] study, which shows that around 60 to 80% of new products created fail due to unsystematic project planning. As a result, technical students face difficulties in developing a project. Therefore, researchers want to develop a TRIZ integration module in PBL, which is expected to help technical students especially the building construction to solve problems in PBL.

This research objectives are:

i. Identify the format design appropriateness of TRIZ integration module in PBL for Building Construction Program.
ii. Identify the content appropriateness of TRIZ integration module in PBL for Building Construction Program.
iii. Determine the usability of TRIZ integration module in PBL for Building Construction Program.

METHODS

The methodology section describes the methods that the researcher used to collect procedural data to develop learning and teaching module. Several aspects are emphasized, such as study design, study sample, study instruments, research procedures, and data analysis methods to achieve the objectives. The study's design is to develop the TRIZ integration module in PBL based on the Sidek model. The Sidek model has a proper and orderly module production work step. There are two stages in using this model, namely, draft stage and trial and evaluation stage. This study's design is also a survey study that uses a quantitative approach for data collection in obtaining user feedback on the TRIZ module in PBL for technical students in terms of format design, content and usability.

In this study, there are 35 samples consist of 5 lecturers and 30 students. The lecturers and students are from the Building Construction program at the Faculty of Technical and Vocational Education, UTHM. The selection of samples research as the respondents in this study is using a purposive sampling method.

The study used a quantitative approach by using a questionnaire form. The questionnaire contained four parts that were leveled as part A, B, C, and D. There are three items in part A and 30 items in part B, C, and D for lecturers and 28 items in part B, C, and D for students. Part A is about demography; part B is about the module's format in terms of design, part C is about the module's content, and part D is about its usability. The four-points Likert scale was used to

answer the questionnaire to measure the extent to which this study's objectives can be achieved. Three experts had validated the questionnaire. Based on the experts' reviews, the researcher had modified and removed a few terms used in the questionnaire items.

The data will be analyzed using Microsoft Excel 2019 by using frequency, percentage (%) and average. In order to facilitate the researcher to analyze and process the data for part B, C and D, the four-points Likert scale will be classified in two levels as shown in Table 1.

TABLE 1. Likert Four-Point Scale Range Interpretation

POINT	SCALE RANGE	EXPLANATION
4	4.00 – 3.00	Strongly Agree
3	2.99 – 2.00	Agree
2	1.99 – 1.00	Disagree
1	1.00 – 0.99	Strongly Disagree

RESULTS AND DISCUSSION

Findings explain the results obtained through the questionnaire form based on feedback from experts and students. The data obtained were analyzed using Microsoft Excel 2019 to get the frequency (f), percentage (%), and total average. The purpose of analyzing the data is to get feedback from lecturers and students about the module's format design, content, and usability.

The findings in part B are to test format design appropriateness of the module. Table 2 and Table 3 shows the descriptive analysis from lecturers and students' group. Based on Table 2, showed that 100% of the lecturers agreed with the format design appropriateness of the module.

TABLE 2. Format design appropriateness of module based on lecturers' perception feedback

	Item	Disagree		Agree	
		Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
B1	Each learning activity is divided into several small sections.	0	0	5	100
B2	All visual elements have been integrated into each learning activity.	0	0	5	100
B3	The sub units on each learning unit are organized in an orderly and systematic manner.	0	0	5	100
B4	This module has continuity from one topic to another.	0	0	5	100
B5	The latest and most interesting module interface design.	0	0	5	100
B6	The type of writing in the module is easy to read.	0	0	5	100
B7	The writing size in the module is appropriate.	0	0	5	100
B8	All diagrams in the module are clear.	0	0	5	100
B9	All diagrams in the module are appropriate	0	0	5	100
B10	The diagram / photo in the module is placed in the appropriate place for reference.	0	0	5	100
B11	The table in the module is easy to refer to.	0	0	5	100
B12	The order of the text in the module is easy to follow.	0	0	5	100
	TOTAL AVERAGE	**0**	**0**	**5**	**100**

Table 3, showed that 100% of the students agreed on the format design of the module.

TABLE 3. Format design appropriateness of module based on students' perception feedback

	Item	Disagree		Agree	
		Frequency (f)	**Percentage (%)**	**Frequency (f)**	**Percentage (%)**
B1	The design of the module is the latest and interesting	0	0	30	100
B2	The type of writing in the module is easy to read.	0	0	30	100
B3	Module writing style is appropriate.	0	0	30	100
B4	All diagrams in the module are clear.	0	0	30	100
B5	All diagrams in the module are appropriate	0	0	30	100
B6	The diagram / photo in the module is placed in the appropriate place for reference.	0	0	30	100
B7	The table in the module is easy to refer to.	0	0	30	100
B8	The order of the text in the module is easy to follow.	0	0	30	100
	TOTAL AVERAGE	0	0	30	100

Lecturers and students agreed with the format design suitability because each visual element has been integrated into each interesting learning unit. All units in the module have specific sub-units. The continuity of learning has also been identified with the presence of a link in each part of learning because the layout is well organized and systematic. Therefore, this module can increase each learning unit's understanding more systematically and effectively to students and lecturers.

Table 4 and 5 shows the results of the lecturers and student feedback on the content appropriateness of the modules. Based on table 5, 97.3% lecturers agreed with the content appropriateness of the module. However, there are 40% of lecturers who do not agreed with the layout of each page of the module neatly arranged.

TABLE 4. Content appropriateness of module based on lecturers' perception feedback

	Item	Disagree		Agree	
		Frequency (F)	Percentage (%)	Frequency (F)	Percentage (%)
C1	This module is in line with the needs of users.	0	0	5	100
C2	The purpose of the module is clearly explained to all users.	0	0	5	100
C3	The introduction of this module gives a clear picture of the scope of this module.	0	0	5	100
C4	Learning outcomes are clearly stated at the beginning of the module.	0	0	5	100
C5	The learning objectives of each unit achieve the objectives of this module.	0	0	5	100
C6	Module content is in line with learning outcomes.	0	0	5	100
C7	Modules are arranged in a learning sequence that is easy to difficult.	0	0	5	100
C8	Each unit in the module is determined by category.	0	0	5	100

TABLE 4. Content appropriateness of module based on lecturers' perception feedback (Continued…)

	Item	Disagree		Agree	
		Frequency (F)	Percentage (%)	Frequency (F)	Percentage (%)
C9	The activities provided in the module are in line with the content of the module.	0	0	5	100
C10	The activities provided in the module are in line with the learning outcomes.	0	0	5	100
C11	All instructions are clear and easy to understand.	0	0	5	100
C12	All instructions are easy to follow.	0	0	5	100
C13	The layout of each module page is neatly arranged.	2	40	3	60
C14	The layout of each page of the module is attractive.	0	0	5	100
C15	The layout of the module pages makes learning easier to learn.	0	0	5	100
	TOTAL AVERAGE	**0.1**	**2.7**	**4.9**	**97.3**

Based on Table 5, 100% of students agreed with the content appropriateness of the module.

TABLE 5. Content appropriateness of module based on students' perception feedback

No.	**Item**	**Disagree**		**Agree**	
		Frequency (F)	**Percentage (%)**	**Frequency (F)**	**Percentage (%)**
C1	I can understand the objectives of the module clearly.	0	0	30	100
C2	I easily understand what I need to do in the module	0	0	30	100
C3	I was able to learn the contents of the module without much trouble.	0	0	30	100
C4	I understand the ideas written in the module.	0	0	30	100
C5	I was able to do all the things directed in the module well.	0	0	30	100
C6	The ideas featured in the module are interesting.	0	0	30	100
C7	The words used in the module are easy to understand	0	0	30	100
C8	I understand all the meanings of the sentences in the module.	0	0	30	100
C9	This module helps me learn each topic more easily.	0	0	30	100
C10	I enjoy learning by using this module.	0	0	30	100
C11	The grammar used is easy to understand.	0	0	30	100
C12	The terms used are accurate and appropriate to the relevant topic.	0	0	30	100
C13	The questions and answer schemes provided in the exercise are easy to understand.	0	0	30	100
	TOTAL AVERAGE	**0**	**0**	**30**	100

Lecturers and students agreed with the content suitability because this module were developed based on the need analysis conducted in the earlier stage of research. The module was developed based on the needs of the users for this module. 40% of the lecturers disagreed with the module layout is because the usage of infographic style for the development of this module. Therefore, the information layout on each page is caused it untidy and needs to be

improved. This is supported by Corcega, where the essential element of a module is the page layout.

Tables 6 and 7 show an analysis of the usability of the module based on lecturers and students' feedback. Based on table 6, showed that 90% of the lecturers agreed that the TRIZ integration module in PBL is suitable for use. However, a lecturer disagreed with the appropriateness of learning activities encourages active involvement and feedback, and the use of modules can integrate high-level thinking skills well.

TABLE 6. Usability of module based on lecturers' perception feedback

No.	Item	Disagree		Agree	
		Frequency (F)	Percentage (%)	Frequency (F)	Percentage (%)
D1	All learning activities encourage active involvement and feedback.	1	20	4	80
D2	Overall, this module can motivate students to perform PBL assignments well.	0	0	5	100
D3	The use of modules can integrate high-level thinking skills well.	1	20	3	80
D4	All aspects in the module can be used as a good reference source for a successful learning.	0	0	5	100
	TOTAL AVERAGE	**0.5**	**10**	**4.25**	**90**

Based on Table 7, showed that 100% of students have agreed with the usability of the module developed. Therefore, as a whole, it can be concluded that the TRIZ Integration module in PBL is suitable for use thus helping students to solve problems in a project systematically.

TABLE 7. Usability of module based on students' perception feedback

No.	Item	Disagree		Agree	
		Frequency (F)	Percentage (%)	Frequency (F)	Percentage (%)
D1	This module can be used as the main reference to solve problems in PBL by using TRIZ.	0	0	30	100
D2	I can use this module for self-learning.	0	0	30	100
D3	I was able to use this module throughout the PBL process in class.	0	0	30	100
D4	The information in the module helped me master the solution of inventive problems in PBL using TRIZ.	0	0	30	100
D5	This module helps me to carry out the assigned PBL tasks well.	0	0	30	100
D6	The "Glossary" section in this module helps me to find the meaning of a term easily.	0	0	30	100
D7	The use of modules can integrate high-level thinking skills well.	0	0	30	100
	TOTAL AVERAGE	**0**	**0**	**30**	**100**

The majority of lecturers and students agreed with the usability because the developed modules can help students use self-learning. Learning by using this module can allow students to create their learning style and test the understanding of each individual's knowledge. The index and glossary sections of the module make it easy to understand grammar and find terms easily. 40% of lecturers disagreed with the learning activities encourages active involvement and feedback and the use of modules can integrate high-level thinking skills well. This is because respondents find it difficult to identify the part of high thinking integration as the researcher did not point it.

CONCLUSION

The development of an integral module of inventive problem-solving theory in project-based learning is essential to solving problems in developing a project in daily life and at work. The development of this module is very suitable to be carried out in individual learning. Besides, it enhances high-level and creative and innovative thinking among

students. The analysis results were five lecturers, and 30 students of Building Construction agreed with the research questions conducted. The conclusion that can be drawn in this chapter is to enhance the effective value of the learning module. Simultaneously, comments from expert confirmations and samples can be used as an improvement in the future. Finally, suggestions are made to improve and enhance this module's quality to assist lecturers and students in the teaching and learning process. The production of the module has been fully developed for use by lecturers and students. The module developed aims to assist lecturers and students in the problem-solving process in project development. Therefore, there are some implications from lecturers and students based on the findings of the study conducted. This module enables lecturers to plan and implement the TRIZ solution process in project- based learning activities to expose students to TRIZ. In addition, lecturers can give project assignments developed using the TRIZ solution process and guide students in using inventive problem-solving theory in the development of a project systematically. This module enables students to know and understand the solution of TRIZ in PBL. Next, students can perform the exercises given in the module to understand more deeply and able to apply problem-solving in the project using the TRIZ solution process. Based on the study's findings, the researcher's opinion is that TRIZ is new learning that needs to be applied to solve PBL problems and the world of work later. Students can also apply this TRIZ solution in their daily lives when they have the solution's basics. Therefore, there are some recommendations needed in further study. Firstly, the number of samples should be increased and conduct a study of TRIZ problem-solving process in PBP for the entire field of study in the Faculty of Technical and Vocational Education. Next, this module should be developed in bilingual with KBAT question training and a test should be conducted to identify the effectiveness of the learning modules that have been developed.

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