Developing Module of the Inventive Problem Solving Theory in Problem-Based Learning

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*Abstract***:** *Problem-solving is an important aspect to be applied to students in preparation for challenges in learning or everyday life. Therefore, the appropriate approach that needs to be exposed to students is problem-based learning (PBM). PBM is a learning tool that exposes real problems using systematic problem-solving. In this regard, to enhance the students' knowledge to be more creative and innovative, there is a theory that can help students to solve problems in PBM. This theory is known as the Theory of Inventive Problem Solving (TRIZ), which can be integrated into PBM as a guide to problem-solving more effectively. The purpose of this study is to develop the integration of TRIZ in PBM module by analyzing the feedback of format, content and usability of the module from lecturers and students. This study uses a quantitative approach involving five lecturers and 15 students. The data were analyzed descriptively and presented in the form of frequency and percentages. The findings show that five lecturers are 100%, and 15 students are 98.17% agreed with the module format. While 97.14% of lecturers and 91.8% of students agreed with the contents of the module developed. For module usability, there are 100% lecturers, and 96.2% agreed that the developed module could be used. In conclusion, this module is suitable for students to solve inventive problems in PBM which provided by lecturers.*

Keywords **:** *Theory of Inventive Problem Solving (TRIZ), Problem Based Learning*

I. INTRODUCTION

In an effort towards the nation development, the changes made in the educational pattern provide students with diverse skills and knowledge. Ref [1] stated include skills in problem-solving in learning. Problem solving skill is one the important elements and skills required in the 21st Century Skills (Educational Technology Division, 2012). Problem solving skill is an essential aspect required by students for preparing themselves in facing challenging life. Problem solving skill helps students to generate creative thinking and innovative thinking skills too students can develop creative thinking and innovative thinking skills to generate thoughtful ideas.

Nowadays, the government and industrial requires employess with fully prepared with employability skills included problem solving skills. (Noriah, 2006). Therefore, students should be exposed with the appropriate approaching problem-based learning (PBM). According to Ref [2], PBM is a learning tool that use systematics problem solving process by using real problems. With the problem-solving skills in this PBM, it can encourage students to participate in the classroom actively. Furthermore, students can apply their knowledge to solve problems in finding solutions to their learning problems [3]. Burden and Byrd (1994) have stated that PBM is student-centred learning approach included discussion, collaboration and even more interactive problem-solving.

In this regard, to further enhance the students' knowledge to be more creative and innovative, a theory that can help students to solve problems in PBM. Theory is can be used in PBM as a troubleshooting guide is known as Theory of Inventive Problem Solving (TRIZ) or creative problem-solving theory that introduced by. Russian engineer, Genrich Altshuller. TRIZ is a theory that uses structured, and systematic problem-solving approaches and ideas can be generated more creatively and innovatively[4]. TRIZ is a more systematic and -problem solving process, TRIZ has been integrated into PBMTRIZ can bridging the gap in the steps implemented in PBM, so that students can solve more specific problems. Therefore, the integration of TRIZ in PBM is a new thing in learning and has the advantage for students to learn it, the appropriate method of use is through the use of learning modules. Through this module, users can help students to identify and solve problems in PBM by using TRIZ so problems can be resolved more systematically. According to Bahaman (2014), the module is also complementary to the curriculum that guides students as reference material for teaching and learning.

II. PROBLEM STATEMENT

In previous study, Hasliza (2002) found that most graduates were less likely to get a job because they did not have the skills to solve the problem Graduates cannot apply what they have learned in class to real-world work [5]. Their skills are only on a theoretical basis but are less capable of adjusting when in the realm of work. The unemployment problem is commonly caused by lecturers are still using a traditional learning approach that discourages students from thinking critically in problem-solving Harison's learning (2008). The findings show that lecturers lack the proper methods and to convey knowledge to students about learning that can improve their skills in

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identifying and solving the given problems. The weak students have exceptional skills in identifying problems and solving problems in PBM assignments provided by lecturers. The effect is, therefore, less motivated in the student. Besides, fewer students are given the right and systematic steps to also analyze the information to identify the root cause of the problem and solve the problem more systematically. This is because students have fewer resources to guide them to identify and solve problems. Therefore, this study was aimed to develop a problem-solving learning module in PBM by using TRIZ. The following are the research questions that support the purpose of this study; (i) is the format design suitable for the theory of integration of inventive problem-solving theory in problem-based learning?, (ii) is the content appropriate to the theory of integrating the theory of inventive problem-solving in problem-based learning accordingly? , and (iii) is the module integrating the theory of inventive problem-solving in problem-based learning possible?

III. METHODOLOGY

According to Ref [6], survey study is one of the data collection approaches that can directly performed to obtain the information. The primary purpose of the survey method was to find the answer. In this study, a questionnaire was distributed to obtain the information A descriptive analysis was conducted to analyze the survey questionnaire... A total of 15 students and five lectures were selected as the respondents from Faculty Technical and Vocational Education, FPTV.

A. Instrument

Two types of instruments were used to collect data which feedback forms given to lecturers and students. The feedback instrument given to students and lecturers were adopted from by Ref [7] and UTHM book manuscript evaluation forms [5].

The validation form was given to the selected students and lecturers aimed to determine the suitability of the module design and content modules. Besides, this feedback form is also available for information on the usability of the TRIZ integration module in PBM. The number of items for student feedback form and lecturer varies.

According to Ref [6], respondents choose the answer on the item whether to agree or disagree with the use of this even number scale despite being hesitant and uncertain about the statements are given in the feedback form. In this context of study, Likert scale with ranging from 1(strongly disagree) – 4 (strongly agree) was used.

B. Students

A survey questionniare prepared students consist of four main sections; . The questionnaire was designed in Bahasa Melayu. Students were asked to answer each given item based on even numbered Likert Scale. Table 1 shows the items for each sections.

Table 1 Part of the student feedback form

Section	Details	Number of items for students	Number of items for lecturer
Section A	Respondent's demographic	3	3
Section B	Format design suitability for TRIZ integration module in PBM	11	5
Section C	The suitability of TRIZ integration module content in PBM	13	14
Section D	Usability of TRIZ integration module in PBM	7	6

C. Lecturers

A survey questionnaire prepared for lecturer is also consist of four main sections and designed in Bahasa Melayu. The lecturer were asked to the questionnaire with after go throught the module. Table 2 shows the total items prepared for each sections.

Table 2 Part of the lecturer feedback form

Section	Details	Number of items
Section A	Respondent's demographic	3
Section B	Format design suitability for TRIZ integration module in PBM	5
Section C	The suitability of TRIZ integration module content in PBM	14
Section D	Usability of TRIZ integration module in PBM	6

IV. MODULE DESIGN

The development process of the module was based on the Model ASSURE Generally, the ASSURE model consisted of six phased of process, , however, in this current study, only four phases was adopted. The next two phases will be discussed in the following subsequent publication.. In the first of analysis phase, learning objectives, was analyzed.Each phase of the ASSURE model for the researcher to produce the module is to analyze the development of the module, the phase of the learning objective, the method selection phase and the material source and module development phase. In the third phase of selecting methods, media and materials modified to source selection and designing modules. In the fourth phase, using media and materials was modified to module development. Each phase stated is all-encompassing, including the objectives of module, contents, order and materials used for the development of the module.

V. RESULT AND DISCUSSION

In this section, frequency and percentage of disagree and agree responses were recorded by using Microsoft Excel 2016 software.. There are three sections of validation; (i) Design suitability, (ii) Contents, and (iii) Usability of TRIZ

A. Format design suitability for TRIZ Integration module in PBM

Table 3 shows an analysis of the learning module format for lecturers. Based on the findings of the lecturers' feedback, it has been shown that 100% of the lecturers agree on the suitability of this module format.

Table 3: Formatting finding by lecturers

	Items	Disagree (F)	Disagree (%)	Agree (F)	Agree (%)
1	All units have explanations of logical steps in every learning	0	0	5	100
2	Each learning activity is divided into small steps.	0	0	5	100
3	All visual elements have been integrated into every learning.	0	0	5	100
4	All units form steps are organized according to each learning unit	0	0	5	100
5	Continuity of learning has been identified with the connectivity of each section.	0	0	5	100
	TOTAL AVERAGE	**0**	**0**	**5**	**100**

Table 4 shows the analysis of learning module format for students. The findings for student feedback have shown that 98.17% of students agree on the suitability of this module format. However, there are 6.7% students who disagree with that interesting page

design, tables in easy-to-read modules and writing in easy-to-read modules.

Table 4: Formatting findings by students

	Items	Disagree		Agree	
		(F)	(%)	(F)	(%)
1	Easy to carry module size.	0	0	15	100
2	Attractive module page design.	1	6.7	14	93.3
3	The articles in the modules are easy to read.	1	6.7	14	93.3
4	The number of diagrams in the module is sufficient.	0	0	15	100
5	The diagram in the module is placed in the appropriate place to refer.	0	0	15	100
6	The photos in the module are placed in the appropriate place to refer.	0	0	15	100
7	The table in the easy-to-read module.	1	6.7	14	93.3
8	The composition of the text in the module is easy to follow.	0	0	15	100
9	Instructions in the module are clear.	0	0	15	100
10	Correct use of spelling.	0	0	15	100
11	Clear use of punctuation.	0	0	15	100
	TOTAL AVERAGE	0.3	1.83	14.7	98.17

Based on the findings of the analysis of lecturers and students agree that the format in the module is likely appropriate. The reason contribute to the positive finding is because each module was designed with graphics, interactive visuals that offers interesting learning. All units from the learning steps of each unit and the continuity of learning can also be identified with the connectors in each part of the learning as the layout is well organized and systematically. Indirectly increase and disseminate knowledge widely and systematically and effectively to students and teachers [8].

The size of the developed module is easy to carry as it is B5 size and flexible to be carried anywhere. The use of pictures and also graphics are placed in the right place with the learning content to attract students. The instructions given in the module are clear to facilitate the student to perform strengthening exercises as well as games that can relieve the student's mind. It is supported by Siddiqi (2002) which says that useful module features are complete content, taking into account individual differences, objective statements, self-referrals, using various media methods and materials and exciting and clear graphic presentations.

Besides, composing text in the module makes respondents easy to follow every learning in the module. Correct use of spelling and precise punctuation can help respondents to understand the contents of the module. Systematic compilation of learning content can help students to learn more easily and quickly. This is supported by [9] which stated that the achievement of a student can be improved if the modules are designed that meet the students' needs.

However, respondents disagree with the design of the module pages. This is because researchers are using the module design designated by UTHM Publisher. Besides, respondents also disagree that writing in the modules is easy to read. Researchers admit that there are some blurring writings because the writing is in the picture. This is because the pixel level in the image is low, causing the writing to be challenging to read.

B. *Content suitability for TRIZ Integration module in PBM*

Table 5 shows the lecturer feedback analysis for the suitability of the contents of the module. Based on the findings of the lecturer feedback analysis, 97.14% have agreed upon the suitability of the content of this module. However, there are 20% of lecturers disagree with the requirement that this module meets a clear layout and layout is well organized.

Table 5: Content Module Analysis by Lecturers

	Item	Disagree		Agree	
		F	%	F	%
1	This module meets the obvious requirements	1	20	4	80
2	The purpose of the module has been explained to all users.	0	0	5	100
3	The introduction of this module gives a clear picture of the scope.	0	0	5	100
4	The general goal is clearly related to the purpose of the module.	0	0	5	100
5	All objectives tend to achieve the objectives of the module clearly.	0	0	5	100
6	All module contents are directly related to the objective	0	0	5	100
7	The contents of the module have been arranged logically in order of learning.	0	0	5	100
8	The whole of each module unit is divided by category clearly.	0	0	5	100
9	All the activities is related to the module content	0	0	5	100
10	All instructions are clear and understandable.	0	0	5	100
11	All directions are easy to follow.	0	0	5	100
12	Layout (layout) of the page is well organized.	1	20	4	80
13	Layout (layout) of the page causes interesting modules.	0	0	5	100
14	Layout (page layout) is easy to learn.	0	0	5	100
	TOTAL AVERAGE	0.14	2.86	4.86	97.14

Table 6 shows the student feedback feedback on the suitability of the content for the TRIZ Integration module in PBM. The findings of the student feedback analysis of 91.8% of students agree with the suitability of the module. However, there are three students (13.3%) who do not agree with the steps shown, understand the contents of the module and do all the things directed in the module.

Table 6: Content Module Analysis by Students

	Item	Frequency (F)	Percentage (%)	Frequency (F)	Percentage (%)
1	I understand the objective of the module clearly.	0	0	15	100
2	I'm easy to understand the steps I have shown.	2	13.3	13	86.7
3	I can understand the contents of the module.	2	13.3	13	86.7
4	Guide in interesting modules.	1	6.7	14	93.3
5	I can do all the things pointed out in the module.	2	13.3	13	86.67
6	Idea in interesting modules.	0	0	15	100
7	Words used in modules are easy to understand.	1	6.7	14	93.3
8	The writing style of the module is appropriate.	3	20	12	80
9	I understand all the texts in the module.	0	0	15	100
10	his module makes it easier for me to learn.	1	6.7	14	93.3
11	I enjoyed studying the modules.	0	0	15	100
12	The grammar used is easy to understand.	3	20	12	80
13	The accuracy of the terms used is appropriate.	1	6.7	14	93.3
	Total average	1.2	8.2	13.8	91.8

Based on the findings of the analysis of lecturers and students, it is agreed that the content in the module is appropriate. This is because, researchers have developed modules based on the module production requirements by UTHM Publishers who have three parts, the first part, the text and the end. Therefore, the module page layout is more systematic and easy to learn. Indirectly, the objectives stated in the module can be achieved.

As a result of the student feedback findings, all students understand the module's objectives clearly. Objective determination is an essential element that needs to be stated in each module. The stated objectives should be clear and achievable. According to Ref

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[9], objectives need to be designed based on the targeted user for the module.. Besides, respondents agreed that the ideas in this module were interesting. It is reaffirmed by Reid (2002), each individual needs to think creatively to gain a brilliant idea.

The colours used in the module was harmonious colours. Besides, researchers place an angle of info, motivational words, mind relax games and QR Code on the module to help sample to get additional information. According to S. Nasution (2003) explained that the definition of the module is a complete unit consisting of a range of student activities aimed at helping students learn more clearly and accurately.

However, some respondents argue that the words and terms used in this modules was difficult to be understand. Some terms and words used in this module was 'engineering term' which respondent will not familiar with that. This is supported by Ref[10], where new knowledge takes a long time to be implemented primarily at an individual level. Therefore, the respondents did not understand the contents of the module and could not do the subjects in the module.

C. *Usability of TRIZ Integration module in PBM*

Table 7 shows an analysis of the usability of learning modules for lecturers' perspectives. Based on the findings, All the lecturers agreed that the usability TRIZ Integration module in PBM was appropriate to the targeted users

Table 7: Module's Usability Results from Lecturers

No	Item	Disagree		Agree	
		(F)	(%)	(F)	(%)
1	All learning activities encourage active engagement and feedback.	0	0	5	100
2	Diagrams, tables, charts and other graphs are used to provide clear explanations.	0	0	5	100
3	The strengthening exercises available at each learning unit are appropriate.	0	0	5	100
4	Overall, this module can motivate students.	0	0	5	100
5	High-level thinking skills can be well integrated in the module.	0	0	5	100
6	All aspects of the module can be used as a source of success for learning.	0	0	5	100
	Total average	0	0	5	100

Table 8 shows the result of usability from students' perspective. The findings of the findings show that 96.2% of students have agreed upon the usability of the module developed. However, there are two students with a 13.3% disagreement that this module can be used throughout the teaching and learning process in the classroom and can help to complete the PBM assignments provided by the lecturers.

Table 8: Module's Usability Results from Students

No	Item	Disagree		Agree	
		(F)	(%)	(F)	(%)
1	This module can be used as the main reference to solve PBM problem by using TRIZ.	0	0	15	100
2	This module can be used by me self-learning.	0	0	15	100
3	This module can be used throughout the teaching and learning process learning in the classroom.	2	13.3	13	86.7
4	The information contained in the module helps me master problem solving in PBM by using TRIZ.	0	0	15	100
5	This module helps me to carry out PBM assignments provided by lecturers.	2	13.3	13	86.7
6	The Glossary of this module helps me to search the meaning of a term with ease.	0	0	15	100
7	Index in this module helps me to search terms easily.	0	0	15	100
	Total Average	0.6	3.8	14.4	96.2

Based on the analysis of the findings of the lecturers' feedback and the students found that all agreed that this module can be implement with some recommendation of improvement. This module can be the main source of reference for problem-solving in PBM by using TRIZ. This is because with this module help the student to complete the assignment given by the lecturer. This statement is supported by Shaharudin & Fatimah (2011) which, this learning module is one of the sources of reference and guidance in the learning process of each student. Additionally, this module

also has a glossary section that can help find something less incomprehensible. So with the learning of TRIZ application in PBM students and lecturers, there is no problem while using this module because the glossary section can help to understand the grammar used. This is because the module is complementary to the curriculum, which is used as a guide to students as reference material for teaching and learning [2].

The module developed helps students to use self-learning. This is because, through learning using modules, it can allow students to create their learning styles and to give students the freedom to test the understanding of each individual's knowledge [11].The use of this module is also suitable for problem-based learning because of learning materials such as this module, and students can review self-learning without the help of lecturers. Furthermore, the index can help students and lecturers find the term easily on the pages provided.

Researchers have used infographics and diagrams, so students will not getting bored to use this module to learn. This is reaffirmed by Ref [12], without a diagram, a problem would be challenging to solve. Students are happy to learn by using this module as the guides in the module can attract users. However, some students disagree that this module can not be used throughout the teaching and learning process in the classroom and does not help in carrying out PBM assignments provided by the lecturers. This is because this module is for self-study and is only used as a reference source for the user. Overall, based on the highest percentage, this module can be used for problem-solving in learning.

VI. CONCLUSION

From the findings, studies have shown that the format, contents and usability of these modules have been accepted by lecturers and students as reference materials for them to solve the problem. This is because the researcher has obtained five validation experts in the field of PBM and TRIZ for the suitability of the module to be applicable to consumers. Therefore, the first objective of the research in developing the TRIZ Integration Module in PBM has succeeded in achieving the objectives and has answered all the questions of this study. based on the results of the findings, the researchers are of the opinion that TRIZ is a new learning that needs to be applied to students so that students are able and able to solve problems in PBM and also in the work world later. Students can also apply this TRIZ solution in their daily life when it has the basis of the solution. therefore, there are several aspects required in further studies are:

I. Prepare a picture of the real owner and does not use pictures on the internet because it hinders the process of selling the learning module later.

II. The number of samples should be increased if such a study is to be conducted.

III. Test the effectiveness of developed learning modules.

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