

Effectiveness of Root Cause of Inventive Problems Module Based on Function Analysis on the Achievement of Invention Students

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Invention, Function Analysis, Root Cause, Inventive.

ABSTRACT

Understanding invention fundamentally involves developing inventive problem identification skills (IPIS). This study investigates the impact of the Root Cause of Inventive Problem-Solving Identification module (MP), utilizing Function Analysis from the Theory of Inventive Problem-Solving Skills (TRIZ), on Form Four secondary school students' ability to identify the root cause of a problem in an invention subject. Employing a quantitative research approach with a quasi-experimental design, pre- and post-test instruments were administered to both a treatment group (TG) and a control group (CG). Descriptive analysis and inferential methods (ANCOVA and T-test) were employed for data analysis. A total of 124 students from four national secondary schools in the State of Johor participated, with two schools assigned to each group (TG and CG). The study reveals a significant difference in students' IPIS achievement before and after implementing the MP module based on Function Analysis. The pre-test analysis for CG yielded a mean value of 37.66, indicating a failing level of IPIS, while TG scored a mean value of 39.73. The ANCOVA test ($F(1,124) = 21736.62, p = 0.00, (p < 0.05)$) revealed post-test results of 39.32 for CG and 65.15 for TG, significantly demonstrating the treatment's effectiveness. The study suggests that implementing the MP module, grounded in Function Analysis, aids teachers in providing effective teaching aids for the topic of invention and offers students a robust foundation for mastering IPIS. In summary, Form Four Invention students benefit from the Function Analysis-based MP module as a tool for mastering IPIS.

1. Introduction

Malaysia is one of the industrialized countries that has a relatively recent Technical and Vocational Education (TVET) system [1]. However, Malaysian society is now more open to debating this topic because of its importance in helping the country develop more positively. This is because, according to [2], high employability, personal maturity, and the ability to demonstrate technical abilities are all important factors in the success of TVET graduates. According to [3], TVET is the foundation of an education program that can focus on the production of quality workforce skills in driving the national economy. In other words, TVET is the basis for the preparation space for graduates who will meet the job market in the future. However, the marketability of graduates after graduation is an issue that is often discussed. In line with that, various previous studies such as [4]–[7] have stated the reasons why Malaysian graduates find it difficult to find a place in the job market. More disappointingly, the study shows the weakness of graduates in the skills of identifying the cause of the problem and then solving the problem, which is the main reason why graduates find it difficult to be employed. This skill is also listed as the third highest attribute skill that is taken seriously in the career world. According to [8] most Malaysian organizations prefer to recruit individuals with talent rather than qualifications such as schooling or experience.

The invention is one of the TVET branches that has an elective pattern, and it is offered in upper secondary schools [9]. This subject was also introduced to emphasize the integration of technology in learning Invention to continue moving toward the development of student's potential in a comprehensive, balanced, and integrated manner [10]. The Invention process does not run away from

facing these constraints. Among the main constraints that occur is, according to [11], this subject requires a student to act on his own, or simply put, learning is only student-centered. Through the results of the preliminary study, most of the students failed to find out the cause of the problem because the learning method did not apply comprehensively. The teachers also complained that most students of Form Four Invention are still not proficient in applying the skills of identifying the source of inventive problems. This makes the students becoming passive because they do not know the cause of a problem [12]. As a result, the learning that takes place becomes less effective. Furthermore, the study of [13] also supported by [14] stated that teachers need to master and have rigid skills in expanding the knowledge of Invention. Therefore, teachers need to have alternatives or new methods to ensure that the implementation of assessment is carried out well and thus saves time [15].

Therefore, the skill of identifying the root cause of inventive problems needs to be highlighted to help Invention students to be able to facilitate the teaching staff in identifying the root of the problem and to be able to solve inventive problems in a systematic and orderly manner. Therefore, the teaching module helps to identify the root cause of the inventive problem to be able to translate their ideas in the production of a product that works well. This point is also supported by [16–19] that the use of Teaching Modules can improve the quality of student achievement. Modules also become an alternative learning system in the new millennium.

2. Methodology

This study employed a quasi-experimental research design. It was selected to address how well the IP Module aids in students' learning of invention and develops their capacity to identify and address the root causes of creative difficulties. The study was conducted in a typical classroom environment, just like what students would experience. The quasi-experimental approach allows the researcher to undertake systematic analysis to verify the efficiency of the module while observing the effects of the IP module on identifying and resolving the root cause of inventive problem solving without strict control circumstances. The 124 participants in this study were split into two groups: 62 students from Classes A and B were in the treatment group, and 62 students from Classes C and D were in the control group. The participants, who were all between the ages of 16, were chosen from four distinct SMK schools in Johor with comparable demographics and educational backgrounds. Students were randomized at random into the treatment and control groups as part of the sampling procedure. Following the conclusion of the teaching and learning phase, the experiment's outcomes were assessed using post-tests for the treatment (TG) and control (CG) groups, and statistical analytic techniques were employed to examine the data. Reviews and expert conversations were used to demonstrate the research instruments' content validity, proving that the items on the instruments were complete, meaningful, and useful in assessing the targeted constructs. Furthermore, a reliability analysis revealed a high degree of internal consistency in the research instrument, with a Cronbach's alpha coefficient of 0.851 for the pre-test and 0.874 for the post-test. Because of its great internal consistency, the study tool produced consistent and dependable results when applied to the participants.

3. Data Analysis and Discussion

In this study, the analysis of frequency, mean, and difference for the data obtained was used to answer the research questions. The research questions for this study are as follows:

Is there an effectiveness of IP module on the RCIP of Invention students?

- a. Is there a difference in post-test achievement between TG and CG?
- b. Is there a difference in pre and post-test performance for TG?
- c. Is there a difference in pre and post-test achievement for CG?

A. Overall Differences in post-test Achievement CG and TG

Table 1 shows the analysis of the ANCOVA test of the mean difference in post-test scores between CG and TG. The results of the ANCOVA test data analysis stated that there was a significant difference in mean post-test scores between CG and TG ($p < .05$). ANCOVA analysis showed that the CG and TG groups through post-test was a significant difference: $F(1,124) = 21736.62$, $p = 0.00$, ($p < 0.05$). While the CG and TG groups went through the pre-test there was no statistically significant difference at all: $F(1,124) = 0.324$, $p = 0.97$, ($p > 0.05$). This means that the regression slopes for the groups did not differ between pre-tests. Here it clearly shows that the students' root cause inventive problems (RCIP) level for the initial pre-test is the same.

Table I. RCIP post-test level for CG and TG

Dependent Variable: Post					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	21743.582a	2	10871.791	39.488	.000
Bypass	16888.021	1	16888.021	61.340	.000
Pre	.324	1	.324	.001	.973
Group	21736.624	1	21736.624	78.951	.000
Error	33313.256	121	275.316		
Amount	376358.000	124			
a. R Squared = .395 (R Squared equally = .385)					

The pre-test of the RCIP level of this respondent covers four aspects, (i) the identification of components; (ii) Inventive problem-solving strategies; (iii) identification of the inventive problem cause; (iv) the effect of problem-solving. Table 2 shows that the level of RCIP test of CG is weak for the aspect of inventive problem-solving strategy and the aspect of identifying the cause of inventive problems. While the component identification aspect is at a good level. Next, the effect of inventive problem-solving is at a satisfactory level. On the other hand, TG has a good level for the aspect of component identification and inventive problem-solving strategies. The problem identification aspect of inventiveness is at an excellent level. However, it is still at a satisfactory level for the aspect of inventive problem-solving effects.

Table 2. RCIP levels for CG and TG according to the aspect for assessment

Group	Mean Score	Group			
		CG		TG	
		Pre (Level)	Post (Level)	Pre (Level)	Post (level)
Aspect i					
Identification of Components		1.76 (M)	1.94 (G)	1.59 (M)	2.11 (G)
Aspect ii					
Inventive Problem-Solving Strategies		3.57 (W)	3.77 (W)	3.96 (W)	6.89 (G)
Aspect iii					
Identification of Inventive Problem Causes		1.34 (W)	1.37 (W)	1.38 (W)	4.73 (E)

Group	Mean Score	Group			
		CG		TG	
		Pre (Level)	Post (Level)	Pre (Level)	Post (level)
Aspect iv Effects of Inventive Problem-Solving	0.79 (M)	0.85 (M)	1.00 (M)	1.17 (M)	
Overall	7.55 (W)	8.84 (M)	7.93 (W)	14.9 (E)	

Note:

W-Week, M-Moderate, G-Good, E-Excellent

CG-Control Group, TG-Treatment Group

The results of the pre-test study as a whole show the same level which is weak for CG and TG. The aspect of the effect of inventive problem-solving strategies, CG and TG are at a satisfactory level. When comparing the answers between these two groups, TG is better able to express the effect of the solution even if only partially. Most CG students find it difficult to express the real effect. For the aspect of identifying the source of inventive problems, both groups were found to be at a weak level in the pre-test. However, for the test, there were three levels of improvement for TG and no level increase for CG. Respondents are not able to identify the root of the inventive problem nor solve the inventive problem well. Invention students also seem to be less able to come up with Inventive and innovative ideas in solving inventive problems and at the same time find it difficult to deliver effective proposals in terms of cost, energy, and time.

In addition, the IP module used provides step-by-step instructions that suit the student's critical thinking approach. [20] acknowledge that to achieve educational success, students need to be introduced to step-by-step strategies. Even [21] also recognized that step-by-step teaching is a systematic and organized teaching method. In fact, they emphasize the need to follow the stages fairly to achieve the teaching objectives.

B. Overall Differences in pre-test and post-test Achievement CG

Table 3 shows that an independent sample t-test was conducted to compare the pre-test and post-test scores for the CG group. It was found that there was no significant difference pre-test and post-test for CG [$t(62) = 0.79$; $p=0.43$, ($p>0.05$)]. The investigation revealed that CG can only explain the components involved in the problem scenario, but it is difficult to come up with ideas with solution strategies and inventive problem identification techniques well. This is because the subject of Invention does not present any precise process or alternative invention concept. This is because the problem identification teaching approach recorded in DSKP Invention Form 4 is too general. It only involves the process of questionnaires, observations, media references, interviews, and own experiences. From there, students lack deeper knowledge of specific steps in the process of identifying the root cause of inventive problems. As a result, they find it difficult to answer the test questions well. Furthermore, various studies have highlighted the way teachers teach Invention, such as using two-way communication [22], providing high motivation [23], and brainstorming [24]. However, students are still unclear in the selection of learning techniques. As mentioned by [25], the techniques used still require knowledge and awareness by students. The invention should find the root of the problem, develop, and improve the Invention characteristics inherent in oneself. As a result, the scenario seems to repeat itself endlessly.

Table 3. T-test for pre-test and post-test of CG

		CG		
		var equality is assumed	var equality is not assumed	
Levene's Test for Equality of Variances	f	7.40		
	Sig	-.01		
T-Exam for Equivalence Min	t	.79	.79	
	df	122	90.56	
	Sig. (2-tailed)	.43	.43	
	Mean Diff	1.66	1.66	
	Std. Error Diff	2.10	2.10	
	95% Confidence Interval of the Difference	Lower	-2.50	5.82
		Upper	-2.51	5.84

C. Overall Differences in pre and post-test Achievement TG

Table 4 shows that an independent sample t-test was conducted to compare the pre-test and post-test scores for the TG group. It was found that there was a significant difference pre-test and post-test for TG [$t(62) = -9.10$; $p = 0.00$, ($p < 0.05$)]. The TG test found that there was an increase of one level for one aspect, which is the aspect of identifying the components studied. For the second aspect, which is the aspect of inventive problem-solving strategies, there are two levels of improvement. On the other hand, a three-level increase in the aspect of identifying the source of the inventive problem. Unfortunately, for the fourth aspect, the effect of problem-solving is still at the same level, which is weak. This clearly shows that the treatment carried out using the IP module shows an improvement compared to learning without the use of the module. This explains the increase in students being able to identify the source of inventive problems in the situations they face well.

The proliferation of unique ideas can also be seen through the results of tests done by students. Invention students' ideas also seem spontaneous even though some suggestions for inventive problem-solving strategies cannot be solved accurately. Furthermore, together with the idea, they can train them towards improving their inventive problem identification skills in line with the objective of the study to create the effectiveness of the IP module on students' RCIP skills. However, students still find it difficult to master the effects of inventive problem-solving. This is because the IP module does not focus too much on the effect of problem-solving. In addition, improvements from future studies should specify the effects of inventive problem-solving. Based on the explanation above, it is proven that the use of the IP module can help students improve their skills in identifying the source of inventive problems.

Table 4. TG pre-test and post-test of t-test

		TG	
		var equality is assumed	var equality is not assumed
Levene's Test for Equality of Variances	f	3.40	
	Sig	-.07	

		TG		
		var equality is assumed	var equality is not assumed	
T-Exam Equivalence Min	t	-9.10	-9.10	
	df	122	99.90	
	Sig. (2-tailed)	.00	.00	
	Mean Diff	-24.42	-24.42	
	Std. Error Diff	2.68	2.68	
	95% Confidence Interval of the Difference	Lower	-29.73	-29.75
		Upper	-19.11	-19.09

Achievement of pre and post-test CG and TG Overall

Overall, Table 5 shows the number of pre and post-test grades for the CG and TG groups. The table states that most Invention students in form four are at a very weak and weak level in the CG and TG pre-tests. 46 CG students and 44 TG students are at a very weak level. Meanwhile, 15 CG students and 12 TG students were at a weak level for the pre-test. Nevertheless, TG showed an increase in grades on the post-test, the majority of which were in a good position (24 students) and excellent (28 students). While the CG test was mostly at the very weak (43 students) and weak (18 students) level. However, there are still some TG students who are at a very weak (5 students) and weak (5 students) level. Thus, it can be concluded that the post-test for TG leads to an excellent and satisfactory level while CG is mostly at a weak and very weak level even though in the pre-test, CG and TG are at the same level. This clearly shows that the IPIS module can help students master the skills of identifying the source of inventive problems.

Table 5. Number of Pre and Post Test Grades for CG and TG groups

Group		Pre-test		Post-test		Level
		TG	CG	TG	CG	
Test Grade	G	30	34	5	23	Very weak
	E	14	12	0	20	
	D	6	10	1	10	Weak
	C	6	5	4	8	
	C+	5	1	8	1	Good
	B	1	0	3	0	
	B+	0	0	13	0	
	A-	0	0	22	0	Excellent
	A	0	0	6	0	
Total		62	62	62	62	

The use of the IP module in the context of this study aims to enable students to use their thinking skills in critical thinking. Critical thinking is efficient thinking and the ability to use the mind to evaluate the reasonableness of something [26]. Thus, the development of ideas shows an important aspect of following instructions step by step, students' critical abilities can be demonstrated when they choose and combine the steps well. In addition, Invention students thinking can also be seen through the identification of the root cause of the inventive problem followed by the statement of the solution strategy given by them. This can also be detected through the way they channel ideas through their imagination and extraordinary adaptability in producing unique solutions.

Overall, the level of mastery of RCIP among Invention students is low. [27]–[31] agree that the RCIP level of school students are still at a weak level. In this study, the researcher used the definition of the RCIP level to refer to students' problem-solving abilities. This is because there is currently a lack of research examining inventive problem-solving skills at the secondary school level. This is emphasized by [32] and [33], who claim that the ability to use identification skills to deal with challenges is important. Based on previous studies, students in low-performing secondary schools no longer can recognize the main cause of difficulty in inventive problems [34]–[37]. When focusing on Invention, it was found that students failed to identify the source of inventive problems when questioned by the teacher. Students need to generate new concepts while generating ideas. If they are given work steps or something organized to follow one by one all the time, the development of ideas will happen something outside the box.

To be something more original and distinctive in inventive problem solving, thinking outside the box requires fresh facts that can be related to current facts. Failure to generate ideas, according to [38], will not motivate students to deal with challenges. This is what happens when students do not know how to develop ideas and thus cannot produce inventive solutions to face challenges [39]. According to [40], the inability to generate ideas in inventive problem-solving is caused by the inability to use previous information in the future. Nevertheless, the lack of mastery of RCIP skills from the lack of guidance on how to generate good ideas, resulting in failure to identify the cause and solve inventive problems effectively. This is because idea development is an Invention style of thinking, while classroom learning focuses primarily on revealing important characteristics. Therefore, structural guidance should be given to students so that they can generate ideas correctly. As a result, for students to generate ideas correctly, structural guidance should be shown to them so that they have more data to answer the problem.

4. Conclusions

The study's conclusions show how innovative teaching materials that integrate Function Analysis in TRIZ Theory with critical and inventive thinking styles have led to the development of the IP Module, which integrates these thinking styles with a framework for effective usage by invention teachers. The IP module is methodically designed and organized using the Theory of Innovative Problem Solving (TRIZ), the study's implementation can enhance students' ability to recognize creative problems. The results of this study also have a positive effect on students' thought processes since they increase the likelihood that students will adhere to the IP module. Researchers have shown that the IP module has an effect and is useful in improving abilities. This is demonstrated by the positive effects of modules that are constructed in a planned and methodical manner by combining thinking styles in their content and teaching that is appropriate for the age and cognitive level on students' ability to solve problems. Students handle problems creatively.

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