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Development of Teaching Aids- Interactive Inventive Principle Drawers for Form 2 RBT Subjects

(Pembangunan Bahan Bantu Mengajar- Pelukis Prinsip Inventif Interaktif untuk Mata Pelajaran RBT Tingkatan 2)

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Abstract

Design and Technology (RBT) for Form 2 introduced the subject of Inventive Principles, which encompassed 14 proposed inventive principles under two primary methods: the spatial separation method and the temporal separation method. The Theory of Inventive Problem Solving (TRIZ) is a methodology that is designed to enhance the efficiency of problem-solving by implementing these innovative principles. Nevertheless, the absence of tangible materials to elucidate the practical application of TRIZ principles in the classroom creates challenges. Consequently, the project's objective is to create an interactive inventive principle drawer as a teaching aid for the Form 2 Design and Technology subject. From the viewpoint of experts, the primary objective of this investigation is to develop and assess the efficacy of the Teaching Aid for Inventive Principles. The specific objectives are to determine the necessity of the teaching aid, develop it, and evaluate its usability from the perspective of experts. The ADDIE model is adhered to in the study design. This investigation employs a qualitative methodology, with semi-structured interviews that prioritize purposeful sampling strategies and concentrate on individuals who have been instructed on inventive principles. The usability of the developed teaching aid was assessed through interviews with three expert informants: Two secondary school teachers and one lecturer from a public university. The interviews with the expert informants yielded the following results: the teaching aid developed satisfies the specified objectives, and the experts concur that it is appropriate for use as a teaching aid during teaching and learning sessions. Interview sessions with experts were conducted to solicit suggestions and enhancements to improve the quality and added value of the teaching aid in the future.

Keywords: TRIZ, The principle of inventive, Education, Design and Technology (RBT), Reka Bentuk dan Teknologi (RBT).

INTRODUCTION

The current educational policies serve as a framework for schools to adapt to the requirements of contemporary industries. It is a continuation of life for those who will eventually require employment. For a country's economy to compete on a global scale, the education sector must be in harmony with the industrial sector (Mokhtar & Noordin, 2019). This is the reason why Malaysia has prioritized the development of an education system that is designed to facilitate digitalization by emphasizing skills in Science, Technology, Engineering, and Mathematics (STEM) and Technical and Vocational Education and Training (TVET) (Rahim & Iqbal, 2020). Nevertheless, student interest in these programs is low, as many perceive them as challenging to master, as explained by Arenawati and Zalina (2023) and Zhi and Atan (2021). Other factors that contribute to the lack of student interest in TVET fields, as identified by Zhi and Atan (2021), include parental influence, teachers, peers, grading systems, future careers, and potential job prospects. As a result of these factors, TVET's reputation is low and not highly regarded by society, leading to a decrease in academic focus in comparison to other fields (Arenawati & Zalina, 2023).

In Malaysia, each educational institution functions as a central hub for the development of the nation's future human capital through the facilitation of teaching and learning. The Integrated Secondary School Curriculum (KBSM) was replaced by the Secondary School Standard Curriculum (KSSM) in 2017. In 2018, Form 2 students started learning Design and Technology (RBT), one of the new subjects under KSSM. A major focus of RBT is creative problem-solving abilities (Kiong et al., 2018). The rapid technological advancements in a variety of sectors, including education, have rendered problem-based learning highly relevant in the present day, as per Kiong et al. (2018). Given these developments, it is imperative to investigate more efficient educational systems to confront the escalating pace of modernization. Innovative and creative thinking can be encouraged through systematic and proactive research and development (R&D) management, particularly in the fields of information technology and product development. The fields of science, technology, engineering, and vocational studies have been empowered by the national emphasis on creativity and innovation. This initiative is a component of the government's initiatives, including the implementation of the School Transformation Programme (TS25) in 2019, which prioritizes the integration of cooperative learning and e-learning in all Malaysian schools (Subban et al., 2022).

In the context of Industry 4.0, teachers must confront the challenge of preparing students with industrial skills (Mokhtar & Noordin, 2019). Ismail et al. (2015) claim that students who possess 21st-century skills, including critical, creative, and innovative thinking, are more prepared to compete on a global scale. Consequently, textbooks are insufficient to guarantee student success in the present day. Teachers must implement teaching aids in every lesson to ensure students understand the subjects they are teaching. This is consistent with the Malaysian Ministry of Education's recommendations for the integration of technology into school learning environments, as outlined in the Malaysia Education Blueprint 2013-2025 (Jalaludin & Said, 2021). Hussain et al. (2024) emphasized the necessity for educators to address the challenges posed by the rapid growth of knowledge, ideas, and information technology to enhance the quality of education. This emphasis guarantees that the instructional materials employed are of an adequate quality to facilitate classroom performance.



Figure 1. Development of Inventive Principle Interactive Drawer Teaching Aid

In the present day, the classroom must prioritize the development of higher-order thinking skills, problem-solving abilities, and innovative and creative thinking (Jalaluddin & Said, 2021). This is closely associated with the escalating prevalence of technology in daily life, which facilitates the resolution of a wide range of issues, from the straightforward to the intricate. As a result, the necessity for proficiency and comprehension in a variety of disciplines has become more pressing (Kiong et al., 2018). The Theory of Inventive Problem Solving (TRIZ) is one of the current approaches or applications that are widely used across a variety of industries, including engineering, management, and business (Kiong et al., 2018). TRIZ has the potential to resolve future issues and resolve potential contradictions, as per Heong et al. (2020). Consequently, it is unsurprising that the subject of inventive principles is difficult for students to comprehend, particularly in light of their limited exposure to technology and its applications in their environments.

The teaching of TRIZ applications in the RBT subject reflects the government's initiative to emphasize the acquisition of complex problem-solving skills (Rahim & Iqbal, 2022). TRIZ is a problem-solving approach that generates innovative and creative concepts for product development (Jalaluddin & Said, 2021; Heong et al., 2020). However, research has shown that, based on their attitudes and behaviors in the classroom, not all students can comprehend and resolve issues in a timely and effective manner using the taught skills. This may be attributable to psychological barriers, limitations in knowledge, expertise, and other uncontrollable factors (Abidin et al., 2016). As a result, numerous researchers have taken measures to further investigate the applications of TRIZ to assist students in comprehending and applying inventive principles. Understanding logical, creative, lateral, analytical, critical, and intuitive thinking skills can facilitate the idea-generation process. This methodology has prompted researchers to create teaching aids that emphasize innovative principles as an integral component of the educational curriculum (refer to Figure 1).

The development of the Inventive Principle Interactive Drawer Teaching Aid is based on the following objectives set by the researcher:

- Identifying the need for the Teaching Aid: Inventive Principle Interactive Drawer for Form 2 RBT Subjects.
- Developing the Teaching Aid: Inventive Principle Interactive Drawer for Form 2 RBT Subjects.

- Assessing the usability of the Teaching Aid: Inventive Principle Interactive Drawer for Form 2 RBT Subjects, from the expert's perspective.

METHODOLOGY

To reinforce the necessity and novelty of research on existing products in Inventive Problem Solving (TRIZ), this study was conducted to develop and evaluate the effectiveness of the Inventive Principle Interactive Drawer Teaching Aid. The study design is based on the ADDIE model, which comprises five phases: analysis, design, development, implementation, and evaluation. Expert informants with experience teaching RBT and expertise in the TRIZ field provided the information through a qualitative method using a semi-structured interview approach.

RESEARCH MODEL

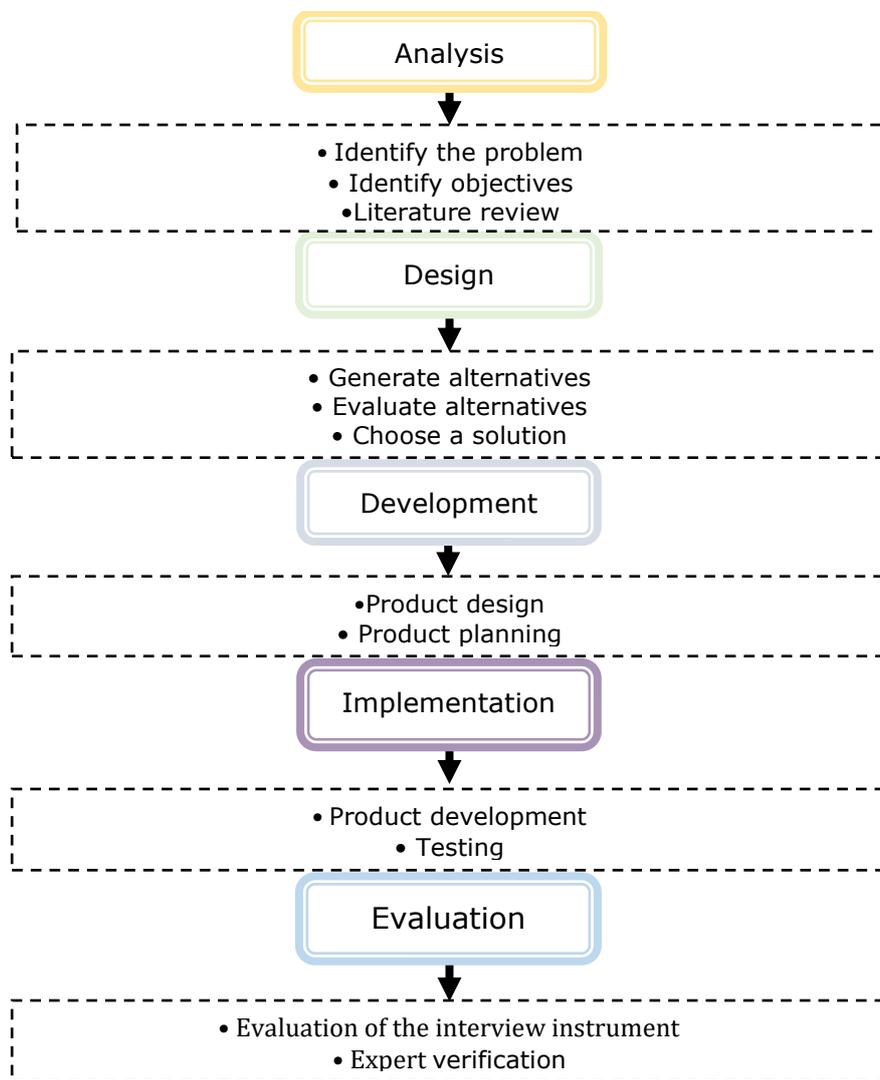


Figure 2. Five phases in the ADDIE model

This study uses the ADDIE model as a framework for developing the Inventive Principle Interactive Drawer Teaching Aid. Each phase plays a unique role and establishes connections with the others.

The analysis phase focuses on identifying problems and setting study objectives through a literature review. During this phase, the researcher also observes schools to understand the problems students face when learning about inventive principles. The design phase involves generating and evaluating alternatives for suitable problem solutions. In this study, the design of the Inventive Principle Interactive Drawer Teaching Aid includes creating 2D sketches, 3D renderings, and 3D models to visualize the appearance of the teaching aid (Figure 3).

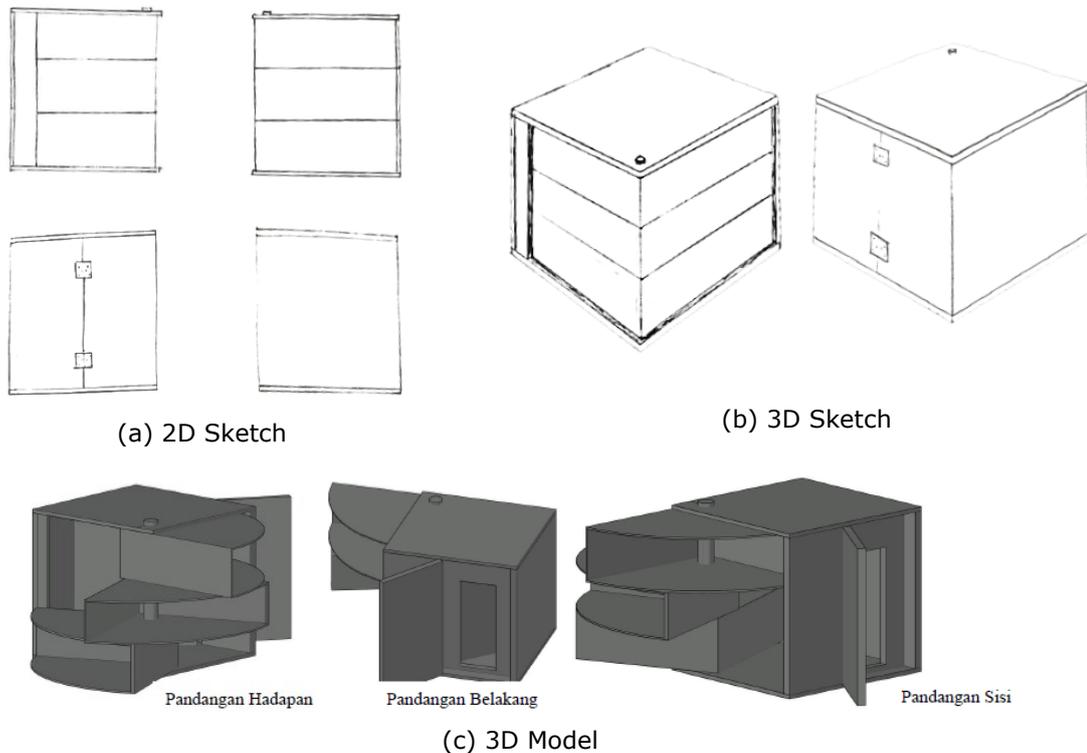


Figure 3. Sketch of the Inventive Principle Interactive Drawer Teaching Aid

The development phase entails product design and planning. Using tools and easily cuttable wooden materials, the researcher creates the teaching aid. This phase also includes material selection, preparation of materials and equipment, measuring materials, cutting materials, assembling materials, and finishing. The implementation phase involves testing the teaching aid with three expert informants before evaluation. During this phase, the expert informants use the teaching aid during teaching and learning sessions. The evaluation phase is the final stage, which involves interviewing the expert informants to gather feedback, suggestions, and improvements needed for the teaching aid. Afterwards, the researcher will analyze the collected data and develop specific themes based on the questions and answers from the expert informants.

POPULATIONS AND SAMPLES

In this study, the research sample consists of expert informants who are teachers and university lecturers teaching the RBT subject with more than five years of teaching experience. During the evaluation phase, these expert informants will assess the usability of the developed teaching aid. Furthermore, the researcher highlights that they select the expert informants through purposive sampling, focusing on specific criteria to obtain reliable information.

Table 1. Demographic data of respondents.

Respondent	1	2	3
Designation	Lecturer in the Engineering Technology Department Technical and Vocational Faculty.	Teacher of RBT Subjects.	Teacher of RBT Subjects.
No experience years in TRIZ	14 Years	12 Years	15 Years
Job	Teaching Industrial Design subjects.	Teaching RBT Subjects from Form 1 to 3.	Teaching RBT Subjects from Form 1 to 3.

RESEARCH INSTRUMENT

During the interview sessions, the expert informants will complete an interview protocol form, which serves as the research instrument. Table 2 serves as a reference to the five primary sections of the developed interview protocol form: Introduction questions, transition questions, key questions, and closing questions.

Table 2. Interview Protocol Inventory

Section	Details
A	Introduction Questions (Respondent Background) <ol style="list-style-type: none"> 1. Could you please provide a brief overview of your background, including your work experience and educational status? 2. Could you share the duration of your teaching experience and your experience related to the topic of Inventive Problem Solving?
B	Transition Questions <ol style="list-style-type: none"> 1. In your opinion, is a teaching aid for the topic of Inventive Problem Solving a necessity for the Design and Technology subject for Form Two? 2. In your view, is this teaching aid relevant for use in the implementation of Teaching and Learning (PdPc) for the Inventive Principles topic in Design and Technology for Form Two? 3. Does the developed teaching aid, the Interactive Drawer for Inventive Principles, align with the textbook's syllabus and the Curriculum and Assessment Standard Document (DSKP) for Form Two's Design and Technology subject? 4. Do you believe that using this teaching aid can help reduce students' misunderstandings of innovative principles? Please provide reasons.
C	Key Questions <ol style="list-style-type: none"> 1. Does the design of this teaching aid provide a clear representation of the examples of inventive principles? Please explain why. 2. How do you feel about the "Interactive Drawer for Inventive Principles"? <ol style="list-style-type: none"> a. Size. b. Materials and components used. c. Ergonomic suitability. d. Added value for users. 3. In your opinion, do the elements of the inventive principle included in this teaching aid assist educators in designing more creative Teaching and Learning (PdPc) activities? Please explain. 4. Please share your overall thoughts on the developed "Interactive Drawer for Inventive Principles" design.
D	<ol style="list-style-type: none"> 1. Could you please share your thoughts on the "Interactive Drawer for Inventive Principles" teaching aid's functionality? 2. Does the "Interactive Drawer for Inventive Principles" offer benefits to users in terms of: <ol style="list-style-type: none"> a. Appropriateness for the learning level. b. Enhancement of user understanding?
E	Closing Question <ol style="list-style-type: none"> 1. What is your overall review and suggestions for improvement for this teaching aid?

DATA ANALYSIS

This study employs thematic analysis as its methodology, which involves identifying, analyzing, and generating distinct themes from the informants' interview sessions. The coding process will be conducted based on the insights provided by the expert informants and the order in which the responses were received. The researcher will analyze the data and categorize it into themes. The "Informant-sequence number" will be denoted as "I-1/2/3," and responses will be classified according to the section and question number (see Table 2). The findings section of the study will contain a discussion of the results obtained from this data analysis. The coding methodology makes it easier to identify the participants and their responses, which we will then condense and present as the study's findings.

STUDY RESULTS AND DISCUSSION

Based on the interviews with the three expert informants, the researcher concludes that the development of the Inventive Principle Interactive Drawer Teaching Aid was well-received by all three experts. Several themes emerged from the informants' responses, including the fact that the teaching aid provides a clear depiction of how inventive principles work.

"...it can engage students during learning... by providing clearer examples, being tangible, and stimulating their understanding..." (I-2, B4)

"...with comprehensive examples and applications that make it easier for teachers to explain the topic to students..." (I-3, B4)

The next theme is that the Inventive Principle Interactive Drawer Teaching Aid can improve students' creative and critical thinking after use. This is because the expert informants observed changes in students' behavior after using the teaching aid, noting that students were able to relate technology, products, and tools around them to the two categories of inventive principles: spatial separation and temporal separation. Students' mastery improved, and they found it easier to understand the 14 suggested principles included in the learning syllabus.

"Overall, this teaching aid helps students who have issues with imagination and visualization." (I-1, D1)

"...it benefits users (teachers and students)... students easily understand and can think, thereby increasing their creativity in the classroom..." (I-2, D1)

"...this teaching aid provides ideas for students to sharpen their thinking and create new concepts to understand inventive principles..." (I-3, D1)

The third theme explored by the researcher is the presence of bidirectional interaction between teachers and students through classroom activities. Bidirectional communication in the classroom not only allows students to ask questions about the topics under study but also allows them to share their own experiences or perspectives on the subject. Additionally, this type of communication makes it easier for teachers to create an interactive and informative classroom environment.

"...this teaching aid fosters bidirectional interaction between teachers and students... various activities can be carried out, and students are engaged with the activities." (I-3, C2)

"...students can think creatively, and some students who understand the concept of inventive principles can teach their peers..." (I-2, C2)

"...inventive principles are easier to understand when students teach their peers, as they will communicate at the same level of knowledge." (I-1, E1)

However, the developed teaching aid requires improvements based on the suggestions and feedback from the expert informants. The researcher concludes that future enhancements should include using different colours to stimulate students' interest, adding more examples to the teaching aid, and modifying the teaching aid to a disassemblable concept to enhance students' experience with the Inventive Principle Interactive Drawer Teaching Aid.

"...different colours could be used for each example of the principle to be explained... Additionally, an assembly concept for the teaching aid could be implemented during the explanation process." (I-1, E1)

"... colours could be improved to make it more engaging for students..." (I-2, E1)

"...provide more examples and illustrations of inventive principles... because a teaching aid like this is very helpful for students to understand due to its compact concept." (I-3, E1)

CONCLUSIONS

Overall, the development of the Inventive Principle Interactive Drawer Teaching Aid offers a successful method for introducing students to the functioning of TRIZ principles, specifically spatial separation and temporal separation. This physical substance serves as a potent strategy for students because it allows them to directly engage with it (through manipulation and observation), in contrast to learning methodologies that rely solely on textbooks. According to the study's findings from the expert informants, all three experts highly endorse the creation of the teaching aid because it enhances student learning and facilitates teachers in delivering the topic. Teachers must establish a favourable and dynamic classroom atmosphere to actively involve students and foster their curiosity in delving into the subject matter over some time. Furthermore, the expert informants have provided suggestions and improvements to enhance the effectiveness and informativeness of the teaching aid.

DECLARATION

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