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The Development of Teaching Aid for Design and Technology Learning

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Abstract: The subject of mechanical design is a topic that needs to be studied by daily secondary school students for Form 2 students in all daily secondary schools in Malaysia. Through this subject, students need to understand the basics of mechanical systems. Knowledge for each student in topics or learning at school is very important for producing quality students.The subject of design and technology has been introduced to replace life skills subjects and is aimed at providing students and educators with a variety of new topics. The diversity of new topics requires teachers to prepare various Teaching Aids to facilitate a more effective teaching and learning process.This study aims to develop a Gear Teaching Aid for use in teaching the topic of mechanical design, specifically within the subject of Design and Technology at form 2. Specifically, the objectives of this study are to identify the essential elements for creating a Gear Teaching Aid system and to develop the teaching aid for the gear system related to the mechanical design topic in subject Design and Technology at form 2. Additionally, it aims to determine the usability of the gear teaching aid within the mechanical design topic. The study will employ cognitive learning theory and be developed based on the Waterfall model. It involves three experts: one high school Design and Technology subject teacher and two lecturers from Sultan Idris Education University specialising in mechanical engineering for interviews and insights into the development of the Gear Teaching Aid system. As for the research instrument, the study will utilize interview protocol inventories with the appointed experts. The study findings indicate that the developed teaching aid is positive and requires minimal improvements. With the presence of this teaching aid, it is hoped to enhance students' achievements, understanding, and serve as an additional reference for them.

Keywords: Technical and Vocational Education (TVET), Cognitivism, Teaching Aids, waterfall model, mechanical design, gear system, design & technology

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INTRODUCTION

In the subject of Design and Technology, the focus is on four main aspects: design appreciation, technology application, product manufacturing, and assessment of product design. This aligns with the objectives of implementing D&T, which is to provide students with knowledge of technology usage and cultivate students who can repair, upgrade, and even create new technologies (Ministry of Education Malaysia, 2018). Moreover, students are exposed to content standards, including technology application, product development, and business design, particularly in introducing design and technology, project management, design processes, sketching, and inventive problem-solving. Within the technology

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application content standards, subjects include fertigation system design, fashion design, manufacturing technology, mechanical design, electrical design, electronic design, aquaponic system design, food design, and mechatronic design. Additionally, teachers need to ensure students comprehend and apply the taught content, echoing a study by Zamri & Nurfaradilla (2020), where Design and Technology teachers expressed moderate readiness in terms of materials and teaching aids. Tailored teaching methods can assist students in solving or facing challenges.

Furthermore, Alizah Lambri & Zamri Mahamood (2019) highlighted that the best teaching method involves the use of teaching aids to stimulate students' senses while ensuring their understanding of the taught content. As known, the design and technology subject has been introduced to replace life skills subjects, offering a variety of new topics to both students and educators. The diversity of these new topics requires educators to provide various teaching aid to facilitate more effective teaching and learning processes. However, the mechanical design topic poses a challenge for educators due to the lack of teaching aids related to gear systems, resulting in unclear explanations often delivered in a traditional lecture style (Albine Moser & Irene Korstjens, 2018). Hence, the effective implementation of concepts and theories in practical applications can be more successful when using teaching aid compared to oral explanations.

Research Problem

Teaching and learning methods solely reliant on textbooks and lectures are perceived as dull and insufficient for clarifying gear system concepts. On another note, the provision of equipment and teaching aids by schools is said to be unsatisfactory and inadequate (Zamri & Nurfaradilla, 2020). This perception stems from the fact that the subject of design and technology is relatively new, resulting in a lack of satisfactory teaching aids related to this subject. Findings from Noorazman Abd Samad et al.'s study (2018) also indicate that teachers believe schools still lack complete equipment to produce teaching aid tools for use in teaching and limit the use of teaching aid by teachers for specific topics.

Similarly, the teaching techniques selected by teachers during teaching and learning processes are deemed unsuitable for meeting students' learning needs (Cathrine & Sabariah, 2019). Although technology-based teaching aids like PowerPoint slides are used, the teaching approach is characterised as traditional because teachers emphasise a teacher-centred approach over student-centred learning. For instance, student-focused activities in teaching and learning involve group discussions, presentations, and the creation of functional mechanical models.

Hence, teaching methods utilising simulation-based teaching aid and teaching modules in one of the sub-topics of Design and Technology at form 2 are considered more effective than conventional teaching methods (Fatihah Anis & Tee, 2018). The use of appropriate teaching aids in the mechanical design topic helps teachers enhance students' understanding of the taught sub-topics.

Research Objectives

This study aims to develop teaching aid for the gear system specifically for the use of form 2 Design and Technology students in learning the topic of mechanical design. Specifically, the study aims to:

i. Identify the essential elements necessary for creating gear system teaching aids.
ii. Develop gear system teaching aids within the mechanical design topic, focusing on Subject of Design and Technology at form 2.
iii. Determine the validity of the gear system teaching aids within the mechanical design topic

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SIGNIFICANCE OF THE STUDY

This study is conducted to contribute to the learning performance of form 2 students by enhancing their learning experience in the subject of mechanical design while preventing boredom. Teaching through teaching aid is not only crucial but also significantly assists students in optimising their learning time effectively. For instance, students can utilise existing time for discussions, contemplation, and imagination related to their learning. This approach promotes more active learning, fostering creative thinking among students (Fatihah Anis & Tee, 2018).

According to Amir Hasan (2002) as cited in Rahim Hamdan and Hayazi Yasin (2010), every individual possesses unique psychological and intellectual abilities. Hence, this study serves as a guide for teachers to plan tailored teaching methods aligned with students' abilities, supported by teaching aids. The aim is to stimulate the maximum potential development of each individual. Therefore, technical teachers should wisely and creatively increase the use of teaching aid in their teaching practices.

As Rahim Hamdan and Hayazi Yasin (2010) suggest, the use of teaching aid in the teaching and learning process is highly necessary in technical secondary schools due to the incorporation of scientific and technological elements in their curriculum. Difficulties in understanding specific terms often render students passive due to a lack of comprehension. Providing teaching aid to technical teachers assists in explaining subject matters and learning content concepts more accurately. Furthermore, this implementation can enhance the image of schools involved as institutions meeting the government's aspirations of producing excellent students.

LITERATURE REVIEW

Teaching aid, also known as instructional media, are defined as visual aids and related materials used in the implementation of teaching. Fundamentally, teaching aid is used to prevent students from feeling bored and losing focus. A study conducted by Nashir, Irdayanti Yaqeen Sulaiman & Aishah (2021) states that teaching aids are divided into two categories: electronic and non-electronic materials. With the advancement of technology, the use of electronic materials such as projectors, teaching slides, animated videos, and simulation models has become a necessity for teachers to prepare learning content. This is because the use of Information and Communication Technology (ICT) is said to enhance teaching and learning outcomes in the classroom, fostering curiosity and willingness to explore new things (Norhanim, 2022).

The application of teaching aid in the sub-topic of gear systems can increase students' interest in the teaching and learning process while developing understanding and thinking patterns, in addition to enhancing the teacher's presentation style. Findings from a study conducted by Fatihah Anis & Tee (2018) also discovered that the performance of students in the treatment group was better than that of the control group after learning using teaching modules and teaching aid provided to the treatment group. Implementing teaching aid in this sub-topic in the form of models allows students to learn about the primary functions of gear systems, such as lifting an object. Alongside using teaching aid, incorporating additional activities during teaching and learning sessions becomes an alternative for teachers to reinforce students' understanding of the learned topic. For instance, students can rotate gears and observe how they function. Therefore, the teaching aid provided by teachers can maximize learning time effectively, aid in building self-directed learning abilities in students, and reduce dependence on teachers.

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Cognitivism Theory and Application in Gear System

Teaching aid in the realm of mechanical design, specific theories are employed, namely cognitive and psychomotor theories. The selection of these theories stems from their ability to generate more effective teaching methods, significantly influencing the field of educational psychology for decades, providing guidelines for instructional design (Anesman Buangraya & Azlan Hussain, 2021). Specifically, cognitive theory is used to evaluate and understand every form of material presented by educators to students. This concept aligns with the six levels applied in this theory: knowledge, comprehension, application, analysis, synthesis, and evaluation. Moreover, it can be used as an approach to teaching gear systems in terms of collaborative, cooperative, and active learning.

Cognitivism theory emphasizes that a student's behavior is determined by their understanding of the relationship between the situation and what is being learned. According to this theory, changes in knowledge and understanding occur that are not perceptible to the senses. Additionally, the theory focuses on students receiving and processing learning content by organising, storing, and then associating new learning content with existing knowledge. This highlights the significance of this theory in the ongoing learning process. The theory comprises four stages of thought patterns: sensorimotor, pre-operational, concrete operational, and formal operational. Furthermore, Piaget enhanced this theory concerning an individual's knowledge reconstruction process involving assimilation, accommodation, and equilibrium.

In Piaget's study, the assimilation process involves receiving and organising new information or knowledge into an individual's existing cognitive structure (Halim Simatupang & Purnama, 2019). This can be observed in children learning letters, where they may experience confusion between letters like "b" and "d". However, this issue can be resolved through guidance from teachers and experience. As a result, they attempt to distinguish between "b" and "d" and come to understand that both letters are different. Next, the accommodation process involves restructuring cognitive structures during new learning. For instance, the children have learned to differentiate between "b" and "d". The equilibrium process involves adjusting between the processes of assimilation and accommodation. It also involves balancing the environment with an individual's cognitive structure.

Waterfall Model and Its Application in Developing Gear System Teaching Aid

According to Akmal Hidayat, Qirani Ridhaihi, Fiqral Shiddiq, Andi Ashilla (2023), the Waterfall Model is frequently used in developing applications or products and is considered a conventional or classic life cycle model. In the Waterfall model, it is divided into 5 stages: analysis, design, implementation, verification, and lastly, maintenance. This model is also seen as one of the approaches in the linear sequential model category from the initial stage of product development, which is the planning stage (analysis), through to the final stage, which is maintenance.

i. Analysis Stage

The analysis stage is a fundamental process involving the formulation of learning objectives and identifying what needs to be learned to ensure these objectives are achieved. To identify relevant problems, researchers need to conduct various analyses of the mechanical components involved. Firstly, the analysis of the teaching aids required in the subject is essential. Secondly, analysing goals and learning objectives. However, the analysis process must be conducted in the correct sequence, starting from analysing students to subsequent stages and the final stage (Yopi Nugraha, 2020). Findings and decisions in this stage become inputs and references for the design stage and beyond.

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ii. Design Stage

In the design stage, the aim is to determine the instructional and technological components used to develop teaching aid for the mechanical gear system. For instance, the topic of mechanical design is intended for 14-year-old form 2 students in the subject of Design and Technology. The importance of students learning this topic is to provide knowledge, skills, values, aesthetics, and technology in the world of design. Students can develop communication skills and generate ideas to create new products, fostering critical, creative, innovative, inventive, and entrepreneurial thinking (KSSM Reka Bentuk Dan Teknologi tingkatan 2, 2016). To ensure learning objectives are achieved, students need to master and meet the established learning standards. The researcher has selected 2 learning standards from the Design and Technology Curriculum Standard Document (DSKP) for form 2, namely students' ability to identify mechanical components and their ability to explain how the mechanical system functions

iii. Implementation Stage

The development of this gear system teaching aid must adhere to the established design through the design phase. Before this stage is carried out, the purpose and teaching objectives of the mechanical design topic in the Design and Technology subject need to be identified. In this section, development must refer to the development process, such as the materials used, facts related to the gear system topic, and the involved components.

iv. Verification Stage

The verification stage will take place once the gear system teaching aid is fully completed. At this stage, an assessment will be conducted by organizing an interview session with appointed experts to obtain and identify external opinions, perspectives, and evaluations regarding the gear system teaching aid to ensure it aligns with the objectives of form 2 Design and Technology teaching and learning.

v. Maintenance Stage

The maintenance stage involves enhancing the developed product based on the opinions, views, and assessments of the experts conducted during the verification stage. This stage will be implemented if there are deficiencies in terms of functionality and design applied in the development of this gear system teaching aid.

METHODOLOGY

Research Design

The purpose of this study is to develop a gear system teaching aid on the topic of mechanical design, a subject in form 2 Design and Technology in a daily national secondary school. Hence, the appropriate research design employed is the product development study. The design of this study involves the development of a teaching aid, and a qualitative approach will be used for data collection. This method is highly effective when researchers can thoroughly analyze qualitative data to identify patterns within a phenomenon and explain to what extent a phenomenon occurs through the researcher's perspective (Susanto & Andriana, 2016).

Study Sample

This study involves observations within a small group. The researcher has selected 3 respondents as the study sample, comprising 1 teacher specialising in the subject of Design and Technology in a daily secondary school with experience in teaching the subject and 2 experts,

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namely lecturers from Sultan Idris Education University specialising in mechanical engineering, for interviews to gather perspectives on the development of the gear system teaching aid for the topic of mechanical design, form 2 Design and Technology. The study also utilises purposive sampling techniques to ensure the selected sample provides accurate data (Noorajamsha & Azizan Morshidi, 2018).

Research Instruments

The research instruments employed by the researcher take the form of interview inventory protocols conducted by the researcher with the respondents. Interviews are carried out to obtain the experiences, perceptions, and feelings of the sample in a study (Albine Moser & Irene Korstjens, 2017). The researcher uses a mobile phone and notebooks to record and document the data and information obtained during the interviews.

STUDY ANALYSIS

Interview Findings on Needs

Results from the conducted needs assessment interviews revealed several elements essential for a teaching aid suitable for use in the mechanical design topic, specifically the gear subtopic. These elements include a teaching aid equipped with a system capable of demonstrating a particular function, such as lifting or pushing, allowing students to clearly visualise how the gear system operates. Additionally, the researcher favours a teaching aid of a manageable size, as a tool that is not overly large or heavy can be easily transported, whether to a classroom or workshop. Furthermore, the colour of the teaching aid to be developed should be engaging to students, encouraging their use (Nurulhuda, Sa'adiah & Azuana, 2019). These elements will be incorporated into the development of the teaching aid.

Product Development

The conducted development entails creating a teaching aid for the gear system within the mechanical design topic of form 2 Design and Technology. The teaching aid aims to assist both students and teachers in the teaching and facilitation processes.

Teaching Design in the Waterfall Model

i. Analysis Stage

In this phase, the researcher conducts an analysis of the learning content for the mechanical design topic to create a teaching aid that assists teachers in the teaching and facilitation processes. Referring to the form 2 Design and Technology textbook, relying solely on conventional teaching methods would result in students lacking a comprehensive understanding and less engagement during learning sessions. As a result of the analysis, a teaching aid that is present and usable by both teachers and students will be developed by the researcher. The focus on a teaching aid centred around the gear system is the researcher's choice, considering that the gear system is the initial subtopic within the mechanical design topic. This is to captivate students' interest in the classroom or workshop and enhance their understanding of how the gear system functions.

ii. Design Stage

In this phase, the design process is executed by gathering information related to the teaching aids to be developed. This involves a comprehensive design approach encompassing the selection of colours, materials, shapes, intended functions, and dimensions for each teaching

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aid. Initial planning has been carried out as a guide for the researcher to refine the teaching aids according to the set timeline.

The researcher has prepared sketches and 3D and 2D designs for the gear system teaching aids. The sketches include the quantity of materials and drawings of each part, including the gear. The primary part of this teaching aid uses wood, while the gears utilise filament. The production of gears involves using a 3D printer. Choosing wood as the main material for creating these teaching aids is preferable because it is readily available and cost-effective for production.

iii. Implementation Stage

Based on the textbook for Design and Technology at form 2, the topic of mechanical design requires students to identify types of gears and understand their functionality. The provision of a gear system teaching aid fulfils the researcher's requirements for addressing the identified issues.

The implementation and development of the gear system teaching aid have been divided into five (5) stages: the preparation of materials and equipment, the 3D gear printing process, the primary material cutting process, painting, packaging, and the assembly process for the components of the gear system teaching aid. These processes are crucial to ensuring that the implementation and development of this teaching aid align with the planned design and are completed within the specified timeframe. Below are the job descriptions related to each executing stage.

a) The first stage involves the preparation of materials and equipment. In this process, the researcher readies the materials and the equipment necessary for constructing this gear system teaching aid. Among the materials involved are platewood, threaded shafts, and screws used to connect each component.

b) The second stage involves the 3D printing process for the gears using a 3D printer. The printer's ink used is plastic filament suitable for producing the gears.

c) The third stage involves the primary material cutting process. Once the wood pieces are selected and marked according to the desired sizes, the cutting process is carried out using a wood cutting machine (Circular Saw). The researcher practices safety measures in the workshop, ensuring equipment safety when cutting wood to prevent accidents or damage to the wood used for making this teaching aid.

d) The fourth stage encompasses the painting and packaging. The wooden parts are fully painted as they will attract students' attention, and the paint enhances the lifespan of this teaching aid. The choice of brown colour is optimal as it adheres well to wood and is both clear and distinct.

e) The final stage involves assembling the cut and painted parts. The assembly of this entire project is done using screws. Each part is assembled according to the diagrams and drawings provided by the researcher. Once all the parts are perfectly assembled, the researcher conducts a test run of the product to ensure that all primary components function properly without any issues.

iv. Validation Stage

This stage involves discussions concerning the validation of the produced product. The validation process is conducted in collaboration with three (3) experts for the development of the gear system teaching aid. Validation is carried out to ensure that the study material aligns with and achieves the set objectives. In this study, the researcher seeks opinions regarding the

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development of the gear system teaching aid in terms of its characteristics, functionality, and design. Opinions on this development are obtained through interviews with three education experts, one being a design technology teacher and two engineering technology lecturers. This stage is crucial to ensuring that the developed gear system teaching aid is suitable for use in teaching and learning sessions. Furthermore, expert opinions on the developed teaching aid are essential to facilitate the improvement process for the gear system teaching aid.

v. Maintenance Stage

After receiving assessments and opinions from the experts, the researcher will proceed with a maintenance process aimed at improving the developed teaching aid based on the suggestions put forward by the experts. Expert feedback and the maintenance stage are crucial to ascertain whether the use of the gear system teaching aid in teaching and learning sessions should be continued. Among the suggestions obtained from the joint interview session with experts is the preparation of a user manual for the developed teaching aid. There are also potential improvements that can be implemented later, such as diversifying the gears on the teaching aid and changing the primary material from wood to transparent perspex.

FINDINGS ON VALIDITY

Question 1: What is Your View on the Development of the Gear System Teaching Aid in the Mechanical Design Topic, Subject of Design and Technology for Form 2?

According to respondent 1, the Teaching Aid for the mechanical design topic in Design and Technology for form 2 helps in teaching sessions by providing an illustration and allowing firsthand observation of the movement and function of the gear. This enables students to gain a deeper understanding of how the gear system is used in daily life, consequently fostering students' interest in delving into the topic of mechanical design. Respondent 2 stated that the developed teaching aid is at a good level and is capable of providing students with an understanding of the gear system. Finally, Respondent 3 opined that the development of the teaching aid utilized appropriate elements and is at a good stage, and the produced teaching aid functions effectively.

Question 2: What is Your Opinion on the Design of the Gear System Teaching Aid in the Mechanical Design Topic, Subject of Design and Technology for Form 2?

Findings from the interviews indicate that respondent 1 stated that the developed gear system Teaching Aid by the researcher aligns with the curriculum standard documents, assessments, and the form 2 Design and Technology textbook. Additionally, the respondent confirmed that the produced Teaching Aid is user-friendly and easy to carry. Moreover, the development of this Teaching Aid has the potential to pique students' interest in learning. Furthermore, Respondent 2 opined that the design produced for this teaching aid is good, and the first respondent suggested a slight improvement: the inclusion of a user manual with the Teaching Aid to ensure students know how to use it. Finally, Respondent 3 expressed that the overall design is at a good level but could be further improved. The design that has been created has met its goal of providing students with an understanding of how the gear system functions.

Question 3: What is Your Opinion on the Use of the Gear System Teaching Aid in the Mechanical Design Topic, Subject of Design and Technology for Form 2?

The results from the development of this gear system Teaching Aid indicate that respondent 1 stated that this Teaching Aid is highly suitable and functions well as students no longer need to imagine how the gear system operates. Moreover, this Teaching Aid can assist teachers during teaching sessions; teachers no longer need to rely solely on textbooks, and students no

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longer need to imagine how the gear system functions. Respondent 2, on the other hand, suggested that the developed teaching aid is useful during teaching and learning sessions. The use of this teaching aid reduces reliance solely on textbooks during teaching and learning sessions and is effective as students can physically interact with and visually understand the teaching aid. Respondent 3 expressed that the developed teaching aid greatly assists in teaching sessions as it is clearly visible to students, enabling them to easily comprehend the concept of gears and how they transfer power.

CONCLUSION

Overall, all three objectives and questions outlined in Chapter 1 have been achieved and addressed. The research questions were successfully answered based on the interview results conducted with 3 experts, comprising one high school Design and Technology teacher from Malaysia and 2 engineering technology department lecturers. Hence, it can be concluded that the conducted interview method is crucial in obtaining precise and substantial data from users regarding this gear system teaching aid. Ultimately, the main hope of this study is for the developed gear system teaching aid to be implemented and expanded over time with more creative and innovative improvements.

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