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Gear Simulation Kit as a Learning Tool

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Abstract: Technical students often faced an understanding problem especially in terms of the learning process in theory only. The development of the Gear Simulation Kit as a learning tool is intended to assist educators in basic gear learning. Preliminary studies have found that there is no use and preparation for interactive learning tools where students can explore and experience simulations on their learning topic. Therefore, a study was conducted to design, develop and test the functionality of the Gear Simulation Kit as a Learning Tool. This is to help the educators in varying the delivery method especially for gear topics to students. The Gear Simulation Kit as a Learning Tool was developed using the ADDIE development model. The use of this model is to help researchers in analyzing consumer needs phase, designing the kit, developing kit, experimenting, and engaging theoretically to also perform expert evaluations. Based on the analysis data, it can be concluded that the project was successfully developed and achieved the objectives and research questions. However, some weaknesses need to be improved such as make these kits user-friendly. The development of the Gear Simulation Kit as a Learning tool can help educators in basic gear calculation learning.

Keywords: Gear, Simulation Kits, Learning Tools

1. Introduction

Education is an important part of developing a good generation. Technical institutions especially will become one of the backbones of this country in the face of Industry 4.0 because the objective of the institution is to produce a skilled workforce in the young (Nasir, 2012). There are many different psychological backgrounds and intellectual abilities in a classroom. Therefore, lesson plans need to be arranged and structured according to student level and supported by teaching aids to stimulate students' maximum potential (Jonid & Hashim, 2010). Learning tools are one of the solutions that captivate students and stimulates their thinking which indirectly captures students' attention and helps the teaching and learning process in the classroom, especially in theory class become smooth (Biden & Kamin, 2013).

Learning tools are not only focused on the use of a whiteboard, screen display, or related display but something that can be heard, felt, referenced, and viewed. As long as the purpose of using the

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learning tools during the teaching and learning process is to assist students in facilitating understanding of the content delivered by the lecturers. Besides, learning that involves practical work in the workshop requires proper and effective guidance and resources. Learning should be conducted hands-on so that students can apply it theoretically to practicalities correctly. This can also provide students with real-life experiences in the context of their learning (Mohamad, 2012). Technical students often face problems in understanding learning if they are based solely on theory because they cannot imagine the system operating (Hamdan, & Mohd Yasin, 2010). This study offers a simulation kit as a learning tool especially in basic gear learning since there is no preparation for the teaching and learning process according to early research.

According to Mohd Yasin et al., (2013), factors of lack of support materials to conduct teaching and learning sessions in the classroom such as equipment, learning materials, financial resources and inadequate skills in building self-teaching aids have the disadvantages of providing learning tools for effective learning. In addition, one of the problems faced by some students is that they have difficulty in understanding the input given during the teaching and learning process. According to Buntat & Ahamad (2012), lecturers should understand and have an idea by carefully devising strategies to ensure changes are made well during the learning and teaching process.

Some students are having trouble calculating gear. This may be because students have difficulty visualizing the gear in the machine. In support of Mok (2000), students will fully grasp their learning topics as they experience practical and simulated learning to enhance their learning experience. In addition, technical students often face problems in their understanding of learning if they are based solely on theory because they cannot imagine the system operating (Hamdan & Mohd Yasin, 2010). Based on the questionnaire provided through the Google Form application, the researcher has received two sets of answers answered by a lecturer in faculty in Mechanical Engineering at FPTV and a lecturer in Diploma Study (PPD), UTHM. According to the results of the survey, no use and preparation of a learning tool were made during the teaching and learning process for the gear-related subject. Learning is done orally, using video or slideshow. Thus, the researcher chose to develop a gear simulation kit as a learning tool for the use of FPTV and PPD lecturers in the Mechanical field to show students the true picture of gear movement and facilitate the calculation of gear speed. The objective of this study is to:

i. To design Gear Simulation Kit as a Learning Tool for the use of mechanical students.
ii. To develop Gear Simulation Kit as the effectiveness for the teaching and learning.gptl5o6ll
iii. To test the functionality of Gear Simulation Kit as a Learning Tool.

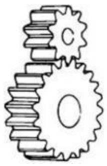
1.1 Literature Review

According to Prastowo and Jatmiko (2013), the learning model that is considered effective is a cooperative learning model (MPK) which has two strategies which are applying the elements of the preparation of the model or strategy and the learning medium. In addition to them, the advantage of using the simulation kit as a learning tool is to encourage the student psychomotor as well as to enable the student to try using the simulation kit provided.

1.1. Type of gear

The gear is used to transfer power and movement through the shaft which also rotates through the gear teeth. The gear operates in a pairing condition known as the drive gear and the driven gear. Table 1 shows the summary of types of gear reported by previous studies. Spur gear was selected for the development of the simulation kit because the gear concept is simpler and more suitable for basic gear learning and calculation.

Table 1: Summary of type of gear

Type of Gear	Description
 Spur gear	A spur gear is used to reduce, increase and double the torque. The gear teeth act in parallel to the gear axis and act only to move the movement between the axis and the gear set. (Budynas & Nisbett, 2011).
 Helix gear	The advantage of helical gear can transmit energy between parallel or angular axes using helical teeth. The helices are designed to move the pressure gradually throughout the entire tooth movement. (Budynas & Nisbett, 2011).
 Diagonal gear	The use of diagonal gear when changing the direction of shaft rotation. The gear is mounted on a 90° angular shaft and can be designed for other angular operations. The diagonal gear teeth can be in a straight, spiral, or hypoid state. (Budynas & Nisbett, 2011).
 Worm gear	Worm gear is usually used during the large gear reduction process. This worm gear has a specialty that can rotate the gear but the worm remains, not rotated. (Budynas & Nisbett, 2011).

1.2. Tachometer

A tachometer (RPM gauge) is an instrument used to measure the speed of rotation of a shaft, disk, or gear such as in a motor or other machine. These devices typically display rotations per minute (rpm) on a synchronized analog dial. Commonly used for tachometers today is the digital type. Table 2 shows the type of tachometer with its description. In this research, researchers chose a digital tachometer because it is easy to use and included reflective strips. Reflective strips were flexible because we can stick it on our gear according to the needs.

Table 2: Types of tachometer

Type of tachometer	Description
 Analog tachometer	Comprise a needle and dial-type of the interface. They do not have a provision for storage of readings and cannot compute details such as average and deviation.
 Digital tachometer	Comprise LCD or LED readout and storage memory. These can perform statistical operations and are very suitable for precision measurement and monitoring of any kind of time-based quantities. Digital tachometers are more common these days because of numerical data.
 Contact and non-contact tachometers	The contact type is in contact with the rotating shaft. The non-contact type is ideal for mobile applications and uses a laser or optical disk. In the contact type, an optical encoder or magnetic sensor is used. Both these types are data acquisition methods.
 Time and frequency measuring tachometers	The time measurement device calculates speed by measuring the time interval between the incoming pulses. Whereas the frequency measurement device calculates speed by measuring the frequency of the incoming pulses. Time measuring tachometers are ideal for low speed measurements and frequency measuring tachometers are ideal for high-speed measurements.

2. Methodology

In this section, the methodology of this study is described with the help of a flowchart built on the ADDIE development model. ADDIE model is used as a guideline for developing the gear simulation kits as a learning tool. This model has five elements which are for analysis, design, development, implementation, and evaluation and these elements can help the development process easier.

2.1. Phase of analysis

At this stage, the preliminary studies were conducted by doing an initial review with two lecturers in the Mechanical field using the Google Form application. In my initial review, the problem was identified and there are a few things that need to be analyzed including determining the scope of a study, determining the problem statement, designing the suitability and making the data analysis. Researchers use SPSS to analyze data because the values analyzed will facilitate the process of obtaining the mean score, frequency, and percentage.

2.2. The phase of design product

This phase covered the design of the gear simulation kit using Solidwork software. Solidwork software is used to redesign the final sketching after a discussion with lecturers in designing the simulation kit. By discussion, design improvement can be made from the early sketch and some additional suggestions to make the gear simulation kit more flexible and able to accommodate multiple sets of gear (Figure 1).

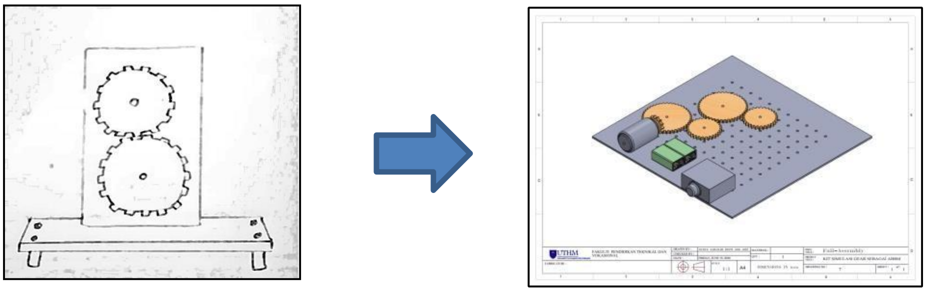


Figure 1: An early sketch to the final design of the gear simulation kit.

2.3. Phase of development product

The process in this phase involves technical works such as measuring, cutting, and drilling to form a simulation kit. Among the processes involved in this phase, the construction of the kit base, the installation of wires for electrical components, the installation of components, and the finalization of the simulation kit. Several considerations have been made in selecting materials and components in producing gear simulation kits as a learning tool. The goal is to meet the specifications stated.

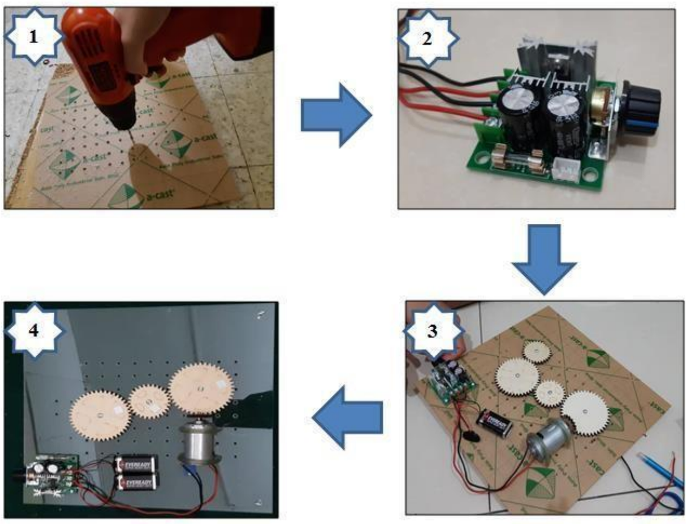


Figure 2: Processes in developing gear simulation kit.

Based on Figure 2, picture 1 shows the drilling process for making the base of the gear simulation kit. The gap between the holes was measured 20mm x 200mm and the diameter of the holes is 4mm. Picture 2 shows making some wiring on electrical components such as motor and controller. While picture 3 shows the assembly of all the parts is done. The placement of the parts is arranged to avoid the components using space provided in the gear area. Lastly, the finishing process was done by sticking reflective strips.

2.4. Phase of implementation product

This phase started when the development of the simulation kit was completed. The process involved in the implementation phase includes testing the functionality of this simulation kit. Whereas the evaluation phase is a process of determining whether or not the stated objectives have been achieved. A test will be conducted to make sure this simulation kit works. The results of the testing obtained will be evaluated by selected experts. Evaluation is conducted for expert feedback or views on this kit.

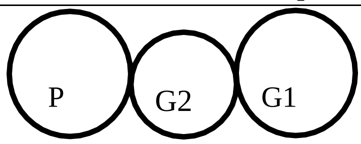
2.5. Phase of evaluation

Expert evaluation is one of the important aspects of validating the product that researchers have done. Expert evaluation is done using an expert verification form and questionnaire form. The expert verification form is intended to know the recommendations and improvements suggested by the expert on gear simulation kits as a learning tool. The questionnaire is to obtain confirmation that the simulation kit produced can work well and achieve the objectives of the research study.

3. Results and Conclusion

This section discussed the analysis of the result of the data collected from the Gear Simulation Kit as a Learning Tool. Testing the functionality of the product is to run a test on the simulation kit. The test aims to take the driven gear speed readings (rpm). The drive gear acts as a manipulated variable whose speed (rpm) is set to three different readings during the simulation kit testing process.

Table 3: Data collected experimentally



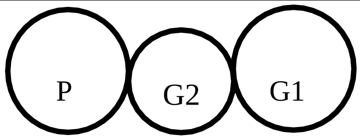
Speed of P (rpm)	Gear reading for G2 every 10 seconds (rpm)				Gear readings for G1 every 10 seconds (rpm)			
	1	2	3	Average	1	2	3	Average
100	150.7	150.0	150.9	150.5	100.2	99.2	98.3	99.2
150	226.7	226.0	225.3	226.0	150.0	150.6	149.3	149.9
200	302.9	298.1	302.4	301.1	199.3	200.9	202.1	200.7

Based on Table 3 P functions as the drive gear. Whereas the G2 and G1 act as driven gear. The sizes P and G1 are the same. In this run, three readings were taken for each P speed using a digital tachometer on each gear that involved two different gear sizes each having 28 and 42 teeth. The three readings are calculated to get the average value for every P speed.

The average G1 shows a reading value very similar to the speed value of P. This means that although not placed next to each other, the speed (rpm) for two gears of the same size still has similar gear speed.

While for G2 the reading value is different because of its smaller size and has higher speed rotation compared to G1. The time interval every 10 seconds for reading values is given to see the stability and to reinforce the experimental reading value.

Table 4: Data obtained theoretically



Speed of P (rpm)	The calculated value for G2 (rpm)	The calculated value for G1 (rpm)
100	150	100
150	225	150
200	300	200

Table 4 shows the results of gear calculations obtained using the basic gear formulas. The formula is N1T1 = N2T2 = N3T3. For 'N' means the gear revolution speed (rpm) which is the element observed in this simulation kit test. Whereas for 'T' is the number of teeth for each gear. For drive gear P and driven gear G1, they have the same size, and the number of teeth is 42. The driven gear G2 has 28 teeth and is smaller in size compared to the other two gears. The results show that smaller gear has a faster-gearing speed.

Based on Tables 3 and 4, it can be seen that the comparative value of the findings in both ways shows no significant differences. Both tables are also an example of a combination of a driven gear of the same size as the drive gear and for another gear-driven is smaller in size to see a comparison of speed values between the size of gears.

3.1. Expert evaluation

Expert evaluation is done by using a verification form and questionnaire which have four-section including demography, designing a product, development of the product, and functionality of the product.

The first section is designing and four items in this section received a high mean score, while one item received moderate. With the design and the size of this simulation kit. They also agree that this kit is suitable to be used in the teaching and learning process. The next section is development. All items in this section received a high mean score by agreeing about the selection of the materials and components used and the characteristics of this gear simulation kit. The last section is functionality and also received a high mean score for all items by three experts to agree that this kit is well functioning and effective for students and teachers to use learning sessions.

Besides that, all experts also gave their recommendations and comments to improve this kit to get better performance. Experts' recommendations for the kit are about the safety and some addition to ease students when using the simulation kit.

3.1 Discussions

All three experts agree to say that this gear simulation kit is suitable for use as a learning tool. Besides, experts also agree on the simple design and suitable size for users during learning and teaching sessions. According to Azman et al., (2014), the learning tools produced should emphasize simple, easy to use and not necessarily expensive features. It is best to do it by the teacher or the student with his or her guidance.

The flexibility element of this simulation kit also has expert approval with the ability of the kit to change the size of the gear provided and to shift the gear position according to the user's requirements. In support of Albakri, Idris, Ibrahium & Ibrahim (2001) state that learning will be more effective if learning is in a way or condition that suits students' needs. Experts have confirmed that these simulation kits work well because they prove the theoretical and experimental relevance of gear speed calculations. According to Ja'apar (2017), using ABBM can produce quality teaching with the latest methods and apply hands-on teaching techniques.

4. Conclusion

On the whole, it can be concluded that the gear simulation kit as a learning tool is successfully developed according to its stated objectives. This simulation kit can also serve as a guide not only in the formal classroom but can also be developed for early exposure to self-knowledge or home-like demonstrations. Thus, in line with the objectives and purpose of the development of this simulation kit in helping and can be used as a method of providing early exposure to the topic of gear speed calculation. Finally, all of the aspects discussed in this chapter are intended to serve as guidelines for researchers to build better gear simulation kits in the future.

Acknowledgement

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