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Teaching aids innovation: spur gear system model kit

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ABSTRACT

This research describes the innovation produced to help the effectiveness of teaching and learning related to the topic gear found in DJJ5133 Engineering Design course. Previously students only saw pictures and video of the gear system. Instructors unable to bring real gear to class because it is heavy and dirty. Despite, this innovation of teaching aids is developed to help students to clearly understand the spur gear system and also power train system. The spur gear in this innovation is designed using CATIA V5 R20 software and been produced using a 3D printer. As a portable teaching and learning aid, Polylactic Acid (PLA) plastic is chosen as the main materials and the frame uses an aluminum profile. Apart from being used as a teaching aids, it is also suitable to be used as a gear ratio laboratory apparatus. Questionnaires were conducted on students and it was found that after using this teaching aids, mostly 100% student support this innovation produced and agree with the statement these teaching aids can help student understand more clearly about the basics of gear system.



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Introduction

The use of teaching aids contributes greatly to improving the quality of teaching and learning among teachers and students. These teaching aids can also solve various problems in the teaching methods of teachers that are constantly changing according to the passage of time (Omarin Ashaari, 1999).

Teaching aids is very necessary in helping instructors deliver teaching and learning sessions more easily and effectively, moreover the tools used are appropriate to the topic presented at the session. However, the teaching aids need to be innovated according to current technological developments and also the suitability of their use to make the delivery of R & D effective. According to the 1989 Dictionary of the House: 455 explains that innovation means introducing something new or renewing something that already exists by giving it a new look. This need is intended to further enhance the effectiveness of teaching with creative and interesting teaching aids.

DJJ5133 Engineering Design is a compulsory course that must be taken by fourth semester students of the Diploma in Mechanical Engineering of the Malaysian Polytechnic. In this course there is a topic of gear where students need to learn about the type of gear, spur gear features, mating spur gear teeth, velocity ratio and gear trains. Previously, students only saw the gear diagram in the notes and also the video only. Students are less clear on how the gear system works in transmitting power from input to output. As well as function in reality

driver gear and also guided function in increasing or decreasing velocity. To bring real metal gear to the lecture room is quite difficult and heavy. When it comes to gear train analysis there are many concepts that may be difficult to understand without seeing real-world examples. This is especially true when it comes to interpreting a diagram displaying a complex gear train (Bartholomew, 2017).

The objective of this teaching aids innovation is produced as a spur gear system model that can be used for teaching and learning of DJJ5133 Engineering Design course in gear's topic. According to research conducted by experts on hearing aids, the concept of understanding and knowledge acquired by humans, 75% is obtained through the sense of sight, 13% from the sense of hearing, 6% from the sense of touch, 3% from the sense of taste, 3% from the sense of smell (Mok Soon Sang, Lee Shok Mee: 1986). Therefore, teaching aids, especially audio-visual aids, play an important role in the teaching and learning process.

Gears are very common systems, and practically impossible to replace in various applications where mechanical power must be transferred (Litak & Friswell, 2005). The gearing is the best mechanism to transmit rotational motions and couple which has been offered numerous advantages: it ensures a mechanical reliability and efficiency (Guerine et al., 2015).

Gear systems are widely used in various power transmission applications such as automobiles, machinery, turbines, ships, mining, aircrafts and other industries due to their distinguished merits of accurate transmission ratio, large power range, high transmission efficiency and stable operation quality (Liu et al., 2016; Yi et al., 2019). Figure 1 shows the example of system gear in machinery.



Figure 1 <Machinery Gear System>

The gear ratio is the ratio of the number of teeth in the gear to the number of teeth in the pinion, the pinion being the smaller of the two gears in mesh (Colin et al., 2012). Equation 1 is the formula to determine the gear ratio.

$$GR = \frac{N_{out}}{N_{in}} = \frac{d_{out}}{d_{in}} = \frac{\omega_{in}}{\omega_{out}} = \frac{\tau_{out}}{\tau_{in}} \quad \dots\dots\dots(1)$$

GR = gear ratio
 ω_{in} = angular velocity - driver
 ω_{out} = angular velocity - driven
 N_{in} = number of teeth - driver
 N_{out} = number of teeth - driven
 d_{in} = diameter - driver
 d_{out} = diameter - driven
 τ_{in} = torque - driver
 τ_{out} = torque - driven

A gear train is a mechanical system formed by mounting gears on a frame so the teeth of the gears engage. Gear teeth are designed to ensure the pitch circles of engaging gears roll on each other without slipping, providing a smooth transmission of rotation from one gear to the next. Gear trains are complex technical systems. It's transmit the energy from driving machine (driver/input) to working machine (driven/output) and in that, they adjust torque and number of revolutions of driving machine shaft to the torque and number of revolutions that the working machine needs (Marjanovic et al., 2012). Gear ratio formula as shown in equation 2.

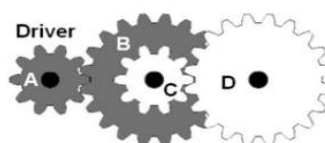


Figure 2 <Gear Train>

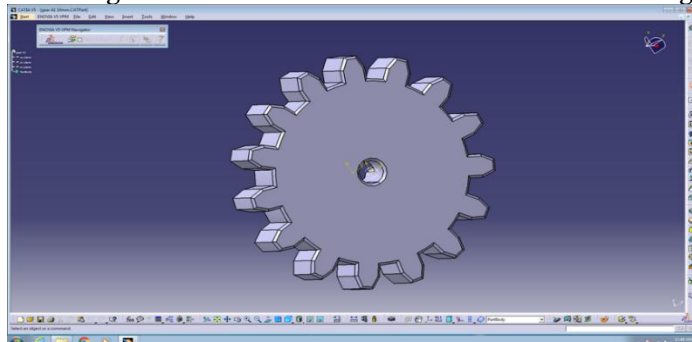
$$GR_{TOTAL} = \left(\frac{B}{A}\right) \left(\frac{D}{C}\right) \dots\dots\dots(2)$$

Method

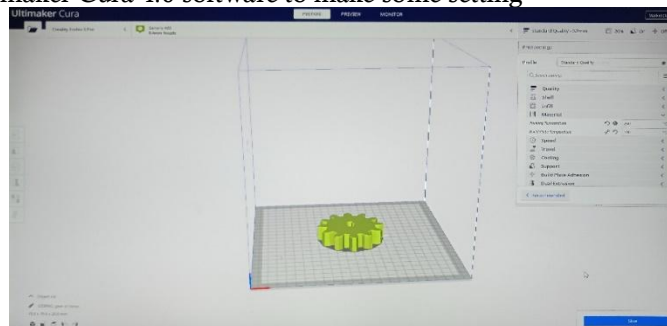
The methods described in this paper are divided into two section, (1) the development of Teaching Aids Innovation: Spur Gear System Model Kit and (2) the study of the effectiveness of the use of Spur Gear System Model Kit as teaching aids in teaching and learning session.

Development Of Teaching Aids Innovation: Spur Gear System Model Kit

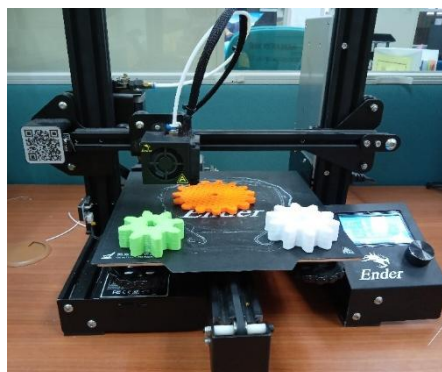
1. Spur gear design is provided using CATIA V5R20 software with various number of gear teeth.

**Figure 3 <Spur Gear Design in CATIA V5R20 Display>**

2. The designed spur gear file is saved in stl format
3. stl file is included in Ultimaker Cura 4.0 software to make some setting

**Figure 4 <Ultimaker Cura 4.0 Software Display>**

4. Spear gear is produced using a 3 dimensional printer Creality Ender 3 Pro

**Figure 5 <3D Printer Produce A Spur Gear>**

5. Provides frame structure of Spur Gear System Model Kit using aluminum profile 20mm x 20mm cross section and other required components
6. Installation of frame structures



Figure 6 <Frame structure of of Spur Gear System Model Kit>

7. Wiring motor and gears installation

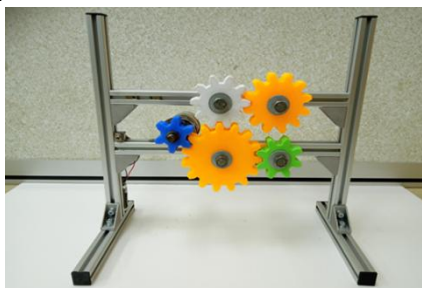


Figure 7 <Installation of Spur Gear System Model Kit>

8. Spur Gear System Model Kit testing



Figure 8 <Testing and Measure RPM by Using Tachometer>

9. Improvements and updates the Spur Gear System Model Kit

The Study Of The Effectiveness Of The Use Of Spur Gear System Model Kit

1. Using this Spur Gear System Model Kit in DJJ5133 teaching sessions



Figure 9 Student use Spur Gear System Model Kit

2. Conduct a questionnaire on 70 of Engineering Design students on December 2019 session.

3. Analysis of questionnaires findings by using Microsoft excell

Results and Discussion

Innovation of teaching aid Spur Gear System Model Kit is successfully developed. Then from the questionnaire study conducted the result was found that before this teaching aid used percentage of knowledge

and understanding of the four questionnaire item regarding gear is at a moderate level as shown in Figure 10. Student also need teaching aids to better understand and understand the topic of gear.

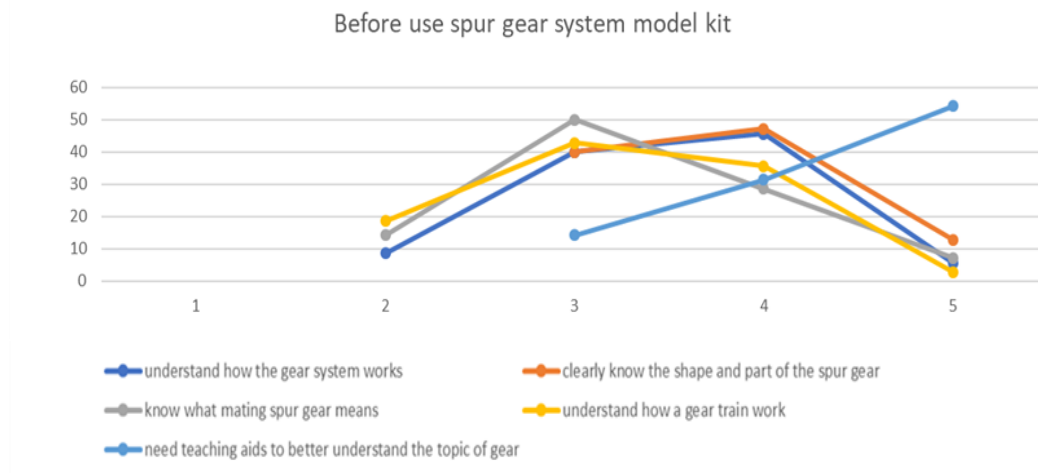


Figure 10 <Analysis Result before Use Spur Gear System Model Kit>

Meanwhile after using these teaching aids the result shown, a student knowledge and understanding regarding gears is increasing as in Figure 11. Meanwhile the level of teaching aids needed for gear topics is declining.

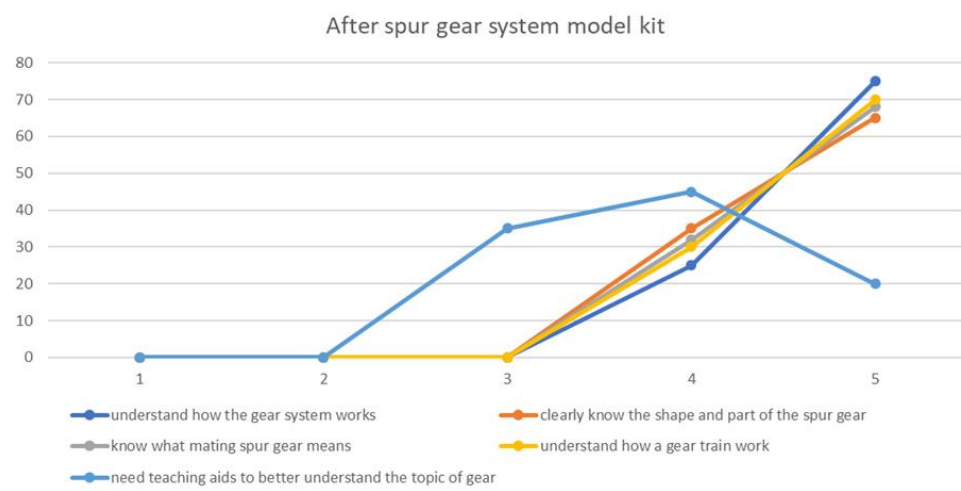


Figure 12 <Analysis Result After Use Spur Gear System Model Kit>

The results prove that the innovation of teaching aids Spur gear system model kit is effective in improving students' knowledge and understanding of the topic of gear in the engineering design course. This tool can continue to be used to improve the teaching and learning outcomes of students in the future.

Four additional questions related to the comments on the spur gear system model kit produced were also given to the students after the tool was used in the lecture. The results shown in figure 13 found that almost 100% of them strongly agreed with the statement given that this tool helps in understanding the topic of gear, easy to use, light and easy to carry and supports this tool is used as a teaching aid.

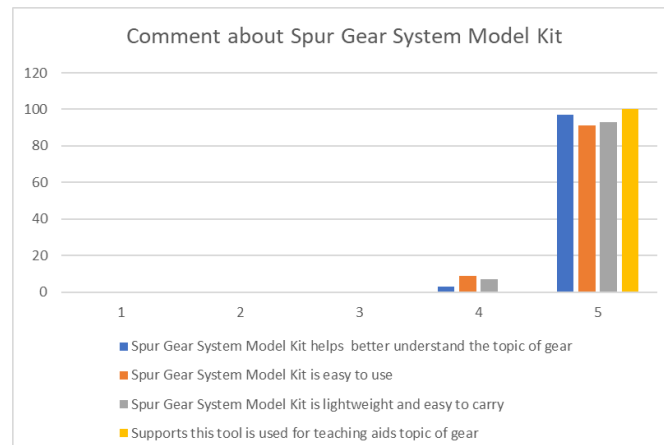


Figure 13 <Result comment about Spur Gear System Model Kit>

Conclusions

The conclusion of this study is from the results of the survey questionnaire conducted found that Teaching Aids Innovation Spur Gear System Model Kit able to increase the level of understanding and knowledge of Engineering Design students on the topic of gear. Students support such teaching aids are used to increase students' interest and understanding in the lecture room.

The advantages of this innovation is this tool can be disassembled and reassembled as well as very easy to use. It's allows instructors and students to change the size of the gear they want to use as well as measure the gear rotation speed (rpm) using the tachometer provided with this tool. This allows students to make comparisons between values from calculations and values from measurements in practice. Its light mass allows the lecturer to take it to class easily. Gear is produced in a variety of colors, attracting students to focus in the lecture session. It also allows instructors to show or name the parts directly to this Spur Gear System Model Kit teaching aid.

Finally, this tool is also suitable for other courses that have topics related to gear such as Automotive Technology, Mechanical Component and Maintenance and others. As well as suitable for use as a practical tool of the gear system.

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