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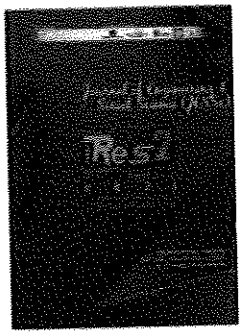

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Development of Hydraulic Landing Gear Training Kit as a Teaching Aid for Aviation Courses

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Abstract: Hydraulic Landing Gear Training Kit (HLGTK) is a teaching aid that is used for aircraft maintenance engineering students for simulation and education purposes. The HLGTK has been developed as a solution for interesting learning and teaching process especially in practical sessions for the Aircraft Standard Practices course as well as the theory course in Aircraft Structures and Systems. The main idea of the HLGTK development is to enhance students understanding of aircraft complex systems such as hydraulic systems and landing gear systems. A survey was conducted on 80 students from Diploma Engineering in Aircraft Maintenance (DAM) at Politeknik Banting Selangor (PBS) shows that 97.5% of students experienced confusion in understanding the landing gear systems. The ADDIE development model is used to develop HLGTK. As the result of the development of HLGTK as a teaching aid, it increases the understanding and knowledge among the students about the hydraulic system in the landing gear as one of the complex and overcomplicated aircraft systems. This is proven from a survey that shows 71.3% of the students strongly agreed that HLGTK attracts their attention and interest in the teaching and learning process. 68.8% of the students strongly agreed that the HLGTK enhance their understanding of landing gear systems. Lastly, this product will transform the traditional and old-fashioned learning and teaching process to the new technology-based teaching using HLGTK especially for aircraft maintenance engineering students at PBS.

Keywords: Education, Aviation Institutes, Hydraulic, Landing Gear.

1. INTRODUCTION

Training is defined as the action of teaching a person a particular skill and behavior while aid is defined as help or support someone in the achievement of something (Nachiappan et al., 2012). This means that training aid can be defined as a tool such as diagram, chart, videos, models or prototype intended to enhance the effectiveness of training by student or a trainee (Manthra et al., 2018). Training kit is very important nowadays and has been used widely in developed countries for example Japan, South Korea, United States, German and others (Jamian and Baharom, 2012). They start to use training kit or teaching aid for education industry which can help the students to enhance their understanding in any subjects. In Politeknik Banting Selangor (PBS), the Ministry of Education has provided the students with 3D printing machine and training aids such as aircraft hydraulic system, aircraft air conditioning system and others. PBS also has received a Boeing 737-400 aircraft from Malaysia Airlines Berhad (MAS) in 2014 to be used for teaching simulation.

Aircraft maintenance activities deals with many complex system especially hydraulic system which need the students to visualize or learn the system at the real aircraft. Lecturers usually provide notes and slides presentation as their teaching material in class. In this case, the students tend to lose their focus cause by the unattractive of teaching and learning process in classroom. This problem will result to the achievement of the student learning process because it is hard for

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them to understand the aircraft system especially hydraulic landing gear system because the system is very complex. This argument is supported by Che Kob et al. (2019) that states the conventional methods practiced by teachers of learning, will limit the ability of students to get a lot of knowledge (Che Kob et al., 2019). Lecturers or trainers must carry out their responsibilities as educators by educating the students using the best method to ensure the students are being able to understand and master the learning of what the lecturer has taught (Hamdan and Mohd Yasin, 2010). In fact, the use of the learning aid is expected to impact interest, fun and enthusiastic including improving student achievement in academics (Hassan, 2004).

Aircraft Structures and Systems and Aircraft Standard Practices are courses which are offered to aircraft maintenance engineering students at PBS. This module involves theory and practical activities. Lecturer usually used images as teaching aids for learning and teaching activities in the classroom. Teaching aid or training kit may help to improve learning and teaching practices by using HLGTK to show the concept on how landing gear works when landing or take-off. Therefore, HLGTK is strongly encouraged to be used for education purpose especially in aviation industry because it is not only will attract the students to learn but it will also make the learning and teaching process become more interesting, creative and innovative in accordance with the current era.

Hanif et al. (2017) in their research found learning aid whether in electronic or non-electronic form is important to increase students understanding while maintaining student interest (Hanif et al., 2017). The use of HLGTK for the hydraulic system not only attracts students but it can also improve students' engagement. Without it, students would not be able to understand the system of aircraft landing gear in details.

1.1 Problem Statement

Aircraft maintenance engineering students have to undertake Aircraft Structure and System and Aircraft Standard Practices courses which the students will learn about aircraft systems which includes ATA Chapter 32 - Landing Gear and ATA Chapter 29 - Hydraulic Power. A survey has been done among PBS students to get their feedback on problems they faced in teaching and learning activities especially in hydraulic and landing gear systems. From the survey 100% of the students responded 'yes' that they tend to lose focus in class because of the traditional way of teaching method conduct in class. This shows that lecturers and instructors need to have interesting teaching aid or learning materials used in class in order to attract student attention.

From the same survey, 97.5% of the students' experience confusion in understanding the operation of landing gear especially the flow of hydraulic in landing gear system. This shows that aircraft systems are much more complicated and complex which make the student hard to understand the operation of the landing gear system. Students find it difficult to understand if visual aids are not provided. Students also find it hard to imagine the learning if there is no visual aids for example animation or videos. As the result, it is crucial to build a training kit as a teaching aid to help students to enhance their understanding in learning of the aircraft systems especially the landing gear system. Thus, when the training kit such as HLGTK is being use in aviation educational institute especially PBS as an Approved Training Organisation (ATO) under Civil Aviation Authority of Malaysia (CAAM), it will make the learning environment become more interesting and engaging.

1.2 Research Objective

This project is aimed to:

a) To design the complex hydraulic landing gear system as a training kit to enhance the understanding for the student
b) To demonstrate the function of the hydraulic landing gear training kit.
c) To apply the hydraulic landing gear training kit in teaching and learning activities.

2. METHODOLOGY

To ensure a systematic collection of data and information, and to increase the accuracy of analysis to achieve the aims and objectives of the project development HLGTK, this research study will conduct in five stages. Table 1 illustrates the five stages of research flow activities referred to ADDIE model which developed by (Dick and Carey,1996).

Table 1- Five stages of research flow shows the activities involved in the research

Stage	Activities
1	Analysis
2	Design
3	Development
4	Implementation
5	Evaluation

3. DATA ANALYSIS AND DISCUSSION

3.1 Analysis of HLGTK

A survey has been done to 80 DAM students in PBS to attain the problem statement of the research that will show the problems faced by the aircraft maintenance engineering student in their learning and teaching activities for Aircraft Structure and System and Aircraft Standard Practices courses especially for topics related to ATA Chapter 32 - Landing Gear and ATA Chapter 29 - Hydraulic Power. Based on survey, 97.5% of the students responded 'yes' that show their difficulties in understanding the concept and the function of landing gear. On the other hand, 100% of the students tend to lose focus in class due to the traditional way of teaching method. Result from the survey show there is a need to design a teaching aid that can help the students to enhance their understanding in aircraft system especially related to landing gear systems. Other than that, the teaching aid can capture students' attention in class rather than chalk and talk traditional way of teaching method. As the result, HLGTK is developed to overcome the problems faced by the students.

Another survey has been conducted to the same respondent after the development of the HLGTK. A demonstration of the HLGTK was conducted by the lecturer of Aircraft Structure and System and Aircraft Standard Practices courses to the students to get their feedback on the applicability as well as the effectiveness of the product. The students also get the chance to operate the HLGTK by themselves in a group. Result from the survey by the demonstration session show that 71.3% of the students strongly agreed while another 26.3% agreed that the HLGTK attract their attention and interest in the teaching and learning process. This results show that HLGTK helps to overcome their problems of losing their focus in class. Another result shows that 68.8% of the students strongly agreed while 28.7% agreed that HLGTK helps them to enhance their understanding on the landing gear system. This shows that the students may overcome their problems in confusion in understanding the operation of the landing gear system by using the HLGTK.

3.2 Design of HLGTK

The first product modelling has been sketched and designed carefully by using Paint Software that has been shown in Figure 1. After a few discussions, the design of HLGTK has been modified and designed by using SolidWorks Software. Isometric view of the latest model of HLGTK has been shown in Figure 2. Furthermore, the orthographic view consisted of three different view which are plan view, front view and side view respectively shown in Figure 3. All the measurements in the drawing were in the scale factor of 1:10 (centimeter, cm).

The frame and structure of the design has been made by using mild steel hollow square bar (2'x2'). Mild steel plate 2mm is used to hold the landing gear on top of the project frame. It is also used to build the door of the landing gear. Furthermore, zinc plated loose pin *durasmooth* butt hinge has been used in this project. The hinge is located at the doors of the landing gear. The Polyvinyl Chloride (PVC) has been used to build the holder of landing gear lever that has been shown in Figure 4. Poly-lactic Acid (PLA) filament is used to print all component and parts of the landing gear by using 3D printer and the acrylic frame 5mm is used as a frame to cover the parts and components as well as the wiring inside the frame.

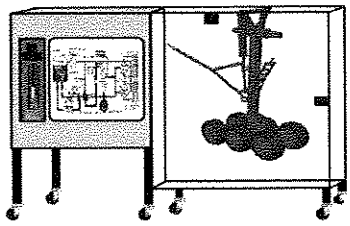

Figure 1- Isometric View of First HLGTK Model

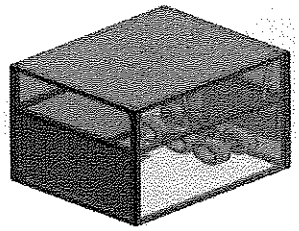

Figure 2 - Isometric View of Latest HLGTK Model

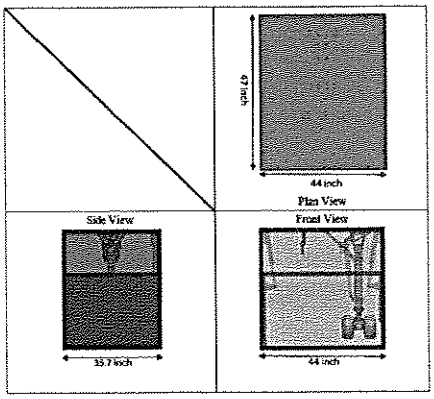

Figure 3 - Orthographic view of HLGTK

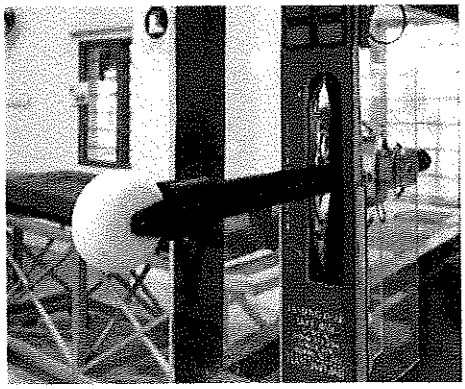

Figure 4 - Landing Gear Lever

In this project, LOUIE 24Volt linear actuator has been used as shown in Figure 5. A linear actuator is a mechanical device that converts energy to create motion in a straight line. It can also be used to apply force. Type of motion including blocking, clamping, lifting, pushing or pulling. It is used and connected to the landing gear so that the landing gear can perform extract and retract movements. The bottom of the design, there are the caster wheels to support the structure of the design and to make it mobile. The final design of the HLGTK as shown in Figure 6.

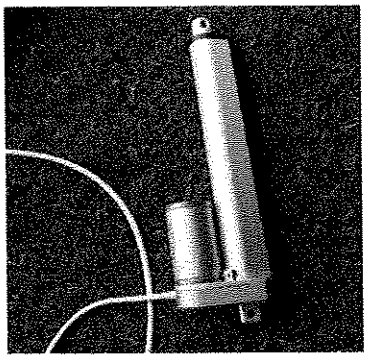

Figure 5 - 24Volt Linear Actuator

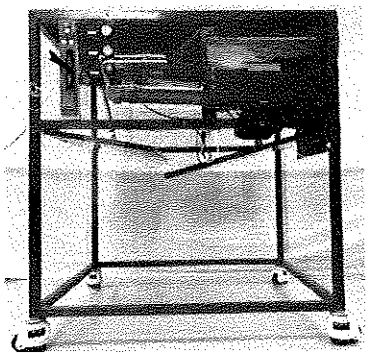

Figure 6 - Final Design of HLGTK

3.3 Development of HLGTK

Department of Aircraft Maintenance, PBS has provided facilities that support the completion of the HLGTK. The facilities are such as workshops, machines and tools. Nevertheless, before utilise all the facilities, an approval is needed in order to make sure there is no issues related to safety occurs. In order to complete the project, collaboration with other companies are needed due to the lack of components and facilities in PBS. In order to complete the HLGTK, collaboration has been done with My Conceptual Robotics Sdn. Bhd, (MyCRO) located at University Malaya is a company that

with to complete our project. MyCRO Company provides facilities for 3D printings services and programming. There are THREE (3) parts in development of HLGTK.

3.3.1 Fabrication of 3D Printing Parts of Landing Gear

The HLGTK provides movement of extend and retract of the landing gear. The first procedure of its fabrication is modelling and designing. The layout of landing gear assembly is designed using SolidWorks shown in Figure 7. SolidWorks is a software that allow the user to design for product development. Thus, SolidWorks is one of the easiest software to be use compared to other software. All the parts, joints and even tires are 3D printed. After all the drawing parts are well drawn, all the files are being copied and moved into a software called Ultimaker Cura. The software converts the drawing into coding before it can print out. This software allows the user to change the diameter, size, ratio and infill of the drawing parts. 3D printing machine has been used to perform printing parts. The main parts of #D printing are landing gear parts including tires. Several 3D printing machine has been used throughout the printing process of all the parts to save time and ensure the parts are all printed out within the time given. All parts are well printed out. If there is any damage or defect on printed parts, the printing process will be done again until the parts are printed perfectly. Any defects and damage will not be tolerating to avoid any malfunction during the operation of HLGTK.

Cementing process is one of the most important process when dealing with printed parts. In order to cover some gaps on the printed parts, cements have been applied. After cementing, sanding process using sandpaper is applied to the surface of the printed parts to ensure are the surface are smooth. Sandpaper with 200 grit has been used to avoid from damaging the surface parts. Spraying process with primer coating had been applied to enhance the actual color to the surface of the printed parts. Finally assemble all printed parts to make a landing gear as per drawing as shown in Figure 8. Screw and nuts are required to ensure the tires are well placed.

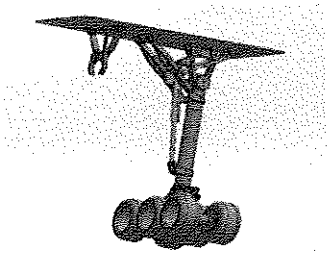

Figure 7 - Drawing of Landing Gear using SolidWorks

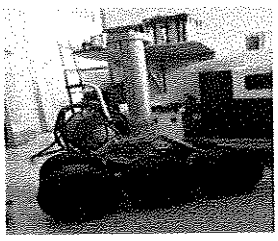

Figure 8 - Assembled landing gear

3.3.2 Fabrication of Programming and Animation

In this project, the source code of programming is set up used Raspberry Pi to ensure the programming instruction either it input or output. Initialization process are doing using Pause Width Modulation (PWM) to limiting the voltage to prevent circuit from over limit. PWM is often used to control motors including servo motors used in robots and automation, lights and other electronic devices. PWM, is a technique for getting analog results with digital means. Digital control is used to create a square wave, a signal switched between on and off. This on-off pattern can simulate voltages in between full on (5 Volts) and off (0 Volts) by changing the portion of the time the signal spends on versus the time that the signal spends off. The duration of "on time" is called the pulse width (Bakaoukas et al., 2014). The duty cycle of PWM is shown if Figure 9. An interrupt code is programed by run min loop, whenever pin get signal it will interrupt min loop and jump to call back function. It trigged the motor for 10 seconds and then it will turn off the motor. Open Source Computer Vision (OpenCV) coding programming are used to control two separated webcams. OpenCV coding are programed to focus the images and videos. OpenCV is a library of programming functions mainly aimed at real-time computer vision. It is mainly used to do all the operation related to Images (Kulkarni and Singh, 2018) and link to the webcam which are used in this project shown in Figure 10. This webcam is place near at the landing gear to produce a close

up view of the up-lock operation. WaitKey coding are programmed in to determine how many milliseconds to update an images. 20 miliseconds are put as a waitkey. Clean up coding are programmed to clean up the pins to tell the computer to make all base input, in case the output accidentally damage. Hence, it will not affect the circuit. The "kill all motion" need to key-in to reset the settings.

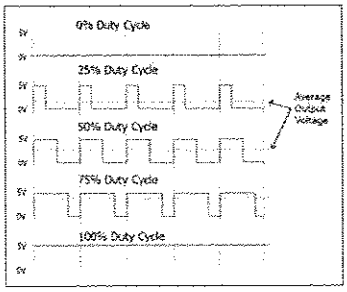

Figure 9 - PWM Duty Cycle

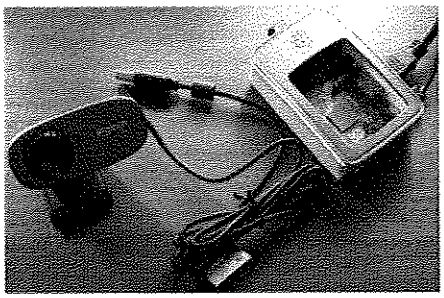

Figure 10 - OpenCV program link to the webcam

Meanwhile, Paint software are used to fabricate block diagram animation to shown the flow of hydraulic fluid in landing gear system shown in Figure 11. After finished created all the sequence block diagram of flow of fluid hydraulic landing gear for every positions, the animation is edited using movie maker software to make the completed flow of fluids. Then, the animations are installed in display to show the flow of fluids when landing gear operates.

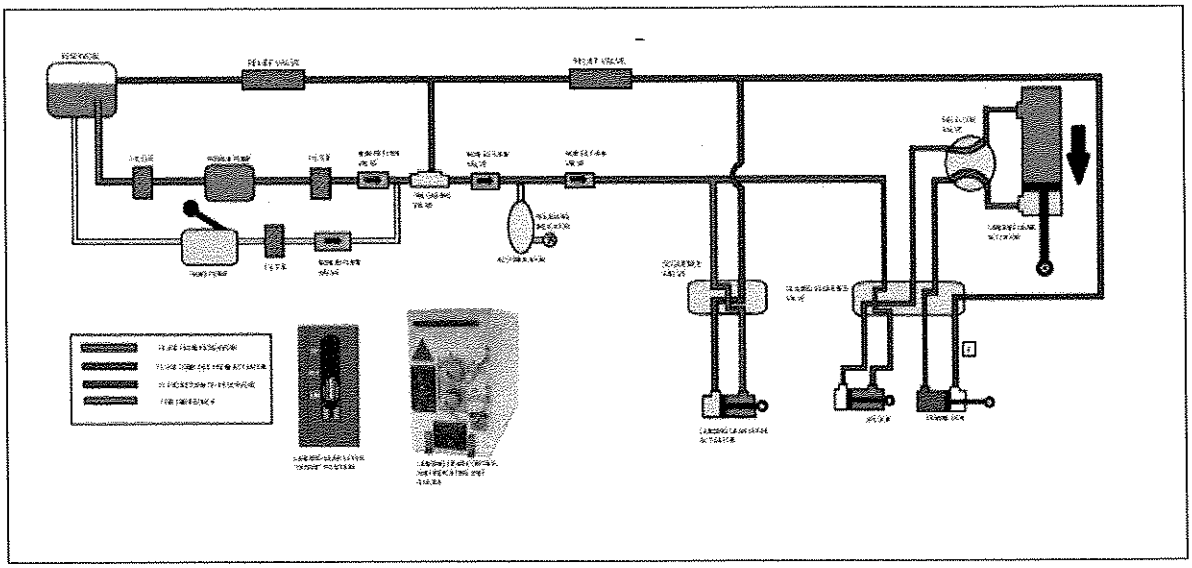

Figure 11 - Flow of fluid hydraulic landing gear block diagram animation

3.3.3 Electrical Fabrication

There are two actuators that attached on landing gear for extend and retract movement and also attached to doors for open and close movement. 24V DC are used to support weight until 1000N. The power sources come from power supply that converts power from AC to DC. Input: 110/220V, Output: 24V 5A. There is light indicator attached to the landing gear lever to inform the current position of the landing gear. When the red indication lightens up, its mean the landing gear are on transit either from retract to extend or extend to retract and the green indication will lighten up after the landing gear fully extend or retract. After a few seconds the green indication will turn off automatically. There are 3 button to change the LCD screen view. Top button (yellow) is for camera view, the middle (green) is for hydraulic flow when the landing gear extend and the bottom (blue) is for the hydraulic flow when the landing gear retract shown in Figure 12. LCD

screen also known as display are well attached inside the frame. The purpose of having this display is to show the hydraulic flow and close up view from webcam for up-lock operation.

Figure 12 - The Buttons to Change the LCD Screen View

3.4 Implementation and Product Testing of HLGTK

From the branding name itself, shows that the Hydraulic Power System (ATA 29) and Landing Gear System (ATA 32) has been combined to create the training kit or teaching aid for education purposes shown in Figure 13. This product is suitable and mainly design for aviation field especially for aircraft maintenance engineering students at PBS where the complex hydraulic system and landing gear system. Before this project are implement in teaching process, the product must be run for the testing. First, the landing gear lever was tested to operate the landing gear for extend and retract movement. Light indicator must be lighting up with their own command. Red light is for landing gear on transit and green light is when landing gear are fully extending or retract. The movement of landing gear and doors were completely operated by the linear actuator. The webcam shows the close up view for the up-lock operation must been clearly. Push the display button must be seen their preview on the LCD screen, which is yellow button for webcam view, green button for movement of hydraulic fluid when extend or blue button for movement of hydraulic fluid when retract. Finally make sure all that display was appeared on the LCD screen.

The position of landing gear is determined by moving the landing gear lever. To extend the landing gear, move the landing gear lever to the DOWN position. The landing gear door starts to open and the up-lock on the top of the landing gear will unlock and red indication will lighten up to show the transition of landing gear during extension and change to green indication after the landing gear is fully extend and locked by the down-lock. After that, there is no indication to eliminate the pilot from distraction. The movement of hydraulic flow in the animation will move synchronized with the landing gear.

The lever must be at a neutral position first before extend or retract to make sure the sequence valve blocks the fluid go through the up-lock or down-lock. To retract the landing gear, moves the landing gear lever to UP position, it will unlock the down-lock and the landing gear starts to retract while the light indicator will show red in color due to retraction transition of the landing gear. The landing gear door starts to close after the landing gear retracts slowly. The red indication will change to green light once the landing gear fully retracted and locked by the up-lock. After that, there is no indication to eliminate the pilot from distraction.

3.5 Evaluation of HLGTK

Throughout the experiment and evaluation that had been held, there are limitations that occur during research that affect the accuracy and consistency to achieve the aims and objective of product. Therefore, an improvement needs to do in future to make sure the product reliability will increase in next research. The improvement can be divided as follows:

a) It is important to acquire quality and reliable materials in order to minimize the risk of inadequate specimens and maximize the accuracy and reliability of the test results. For example, every parts of landing gear printed by using 3D printer. The material used for the filament is Poly-lactic acid (PLA). PLA have their own advantage and disadvantage. In this project, the PLA is not working as what we expect. There are a few parts which need to reprint because there a few cracks and even worst it is break into pieces.
b) Facilities and equipment are the most important things to make sure the project success. Lack of equipment or tools can lead to unsuccessful product. The facilities such as machine are really needed depends on the project. For example, to make the parts of landing gear, 3D printer is

really important to print each parts of landing gear. 3D printer also one of the sensitive machine that needs a right care. Each part takes a long time to finish the printing. Therefore, printer must more than one to reduce the time prints each parts. Moreover, to handle 3D printer everyone needs knowledge and skills to set up the code before start printing. The right handling needed to prevents the printing parts from damage. Hence, a third-party help was obtained from MyCRO Company.

c) Due to the unsuitable specification of the linear actuator, the landing gear cannot be extending and retract. This is because the linear actuator cannot support the landing gear weight. The movement of landing gear is relying on the power of linear actuator. After finished print all the components for the landing gear, there are some part that not strong enough to be use. These parts need to be reprinted to make it more durable. If these parts are not reprinted, it will affect the landing gear structure as it cannot stand on its own and need to be support by other structure.

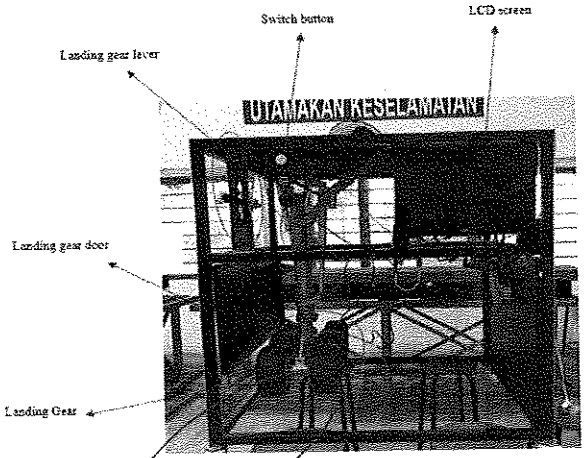

Figure 13 - Functional of HLGTK

4. CONCLUSION

HLGTK will give positive impact to the students in the teaching and learning process which can help them to be more focus in the class by attracting them using the new technology of training kit provided. Furthermore, this project will increase the understanding and knowledge among the students about the aircraft system which is the hydraulic system in landing gear as the system of the aircraft are much more complex and overcomplicated. Lastly, this product will upgrade the traditional and old-fashioned teaching and learning process to the new technology of teaching aids which is the HLGTK.

Hopefully, this project can be improving with full commitment and passion in order to achieve the aims and objective and increase the quality of product in future. Therefore, there are few suggestions that need to be considering in next research:

- The animation of hydraulic landing gear needs to be improved from the aspect of visualization, the movement of fluid and creativity.
- Furthermore, the door of landing gear needs to be improved to make it looks more real and operate like in the real aircraft.
- The positions of landing gear lever and display should be put at their own compartment to give more clearly images of landing gear operations.

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REFERENCES

Bakaoukas, A., Liu, S., & Petridis, P. (2014). *Pulse Width Modulation (PWM) Method For Power Components Estimation In Power Meters* (Vol. 60).

Bernama. (2019, Monday, 29 Jul 2019). Education Ministry planning new curriculum to meet IR4.0 needs. *The Star*. Retrieved from https://www.thestar.com.my/news/nation/2019/07/29/education-ministry-planning-new-curriculum-to-meet-ir40-needs-says-maszlee/

Che Kob, C. G., Abdullah, A. S., norizan, N., & Shamsuddin, H. (2019). Effects of Learning Aid (KIT) on Student Performance for Electric Circuits Topics. International Journal of Academic Research in Business and Social Science 2019, 9(1), 320-330. 22-6990.

Dick, W., & Carey, L. (1996). *The systematic design of instruction*. 4th ed. New York, NY: Harper Collin.

Hamdan, A. R., & Mohd Yasin, H. (2010). *Penggunaan Alat Bantu Mengajar (ABM) Di Kalangan Guru-Guru Teknikal Di Sekolah Menengah Teknik Daerah Johor Bahru, Johor.*

Hanif, A. S., Azman, M. N., Pratama, H., & Ma'arof, N. N. M. I. (2017). Kit pemantauan penyambungan litar elektrik: Satu kajian efikasi Alat Bantu Mengajar (Schematic circuit and circuit connectivity kits for Malaysian science students: An efficacy study of a teaching aid). *Geografia-Malaysian Journal of Society and Space, 12*(3).

Hassan, N. A. (2004). Kebolehgunaan Kit Pembelajaran Bagi Meningkatkan Prestasi Pelajar : Satu Tinjauan Di KUITTHO. *Maters Thesis, Kolej Universiti Tun Hussein Onn*.

Jamian, A. R., & Baharom, R. (2012). The application of teaching aids and school supportive factors in learning reading skill among the remedial students in under enrolment schools. *Procedia-Social and Behavioral Sciences, 35*, 187-194.

Kulkarni, S. N., & Singh, S. K. (2018). Object Sorting Automated System using Raspberry Pi *3rd International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India*, 217-220. doi:10.1109/CESYS.2018.8724056.

Manthra Prathoshni, S., Vishnu Priya, V., & Gayathri, R. (2018). Effect of teaching aids on student's academic performance in professional courses. *Drug Invention Today, 10*(12).

Nachiappan, S., Kamaruddin, K., Shukor, A. A. A., Jantan, R., & Mustapha. (2012). *Pembelajaran aan Perkembangan Pelajar Edisi Kedua*.