DEVELOPMENT OF PROJECT-BASED LEARNING E-MODULE BY UTILIZING THE ARDUINO FOR THE TOPIC OF IMPULSE AND ITS USABILITY

BERNET PARANTIS@FRANCIS

SULTAN IDRIS EDUCATION UNIVERSITY

2024

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THIS FINAL YEAR PROJECT REPORT IS PRESENTED TO QUALIFY FOR BACHELOR OF EDUCATION (PHYSICS) WITH HONOURS

FACULTY OF SCIENCE AND MATHEMATICS

SULTAN IDRIS EDUCATION UNIVERSITY

2024

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DECLARATION OF WORK ORIGINALITY

Student's Declaration:

I, Bernet Parantis@Francis, matric number of D20201093684, from the Faculty of Science and Mathematics declare that the work entitled Development of Project-Based Learning E-Module by Utilizing the Arduino for the Topic of Impulse and Its Usability is my original work. I have not copied from any other students' work, or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

Student's signature

7th February 2024

Supervisor's Declaration:

I, Wan Zul Adli Wan Mokhtar, hereby certify that the student's work entitled Development of Project-Based Learning E-Module by Utilizing the Arduino for the Topic of Impulse and Its Usability was produced by the student whose name appears above to fulfill part of the requirements for obtaining a Bachelor of Education (Physics) degree with Honours

Supervisor's signature

7/3/2024

Date

ACKNOWLEDGEMENT

I extend my heartfelt gratitude to the Almighty, whose divine guidance and unwavering support have been instrumental throughout the completion of this thesis. His infinite wisdom has illuminated my path, providing strength and perseverance during challenging times. I am deeply thankful for the blessings, inspiration, and clarity of mind bestowed upon me, allowing me to navigate through this academic journey.

I am profoundly grateful to my supervisor, Wan Zul Adli Wan Mokhtar, whose invaluable guidance, expertise, and unwavering support have been pivotal in the completion of this thesis. His dedication, patience, and encouragement have inspired and empowered me to strive for excellence throughout this academic endeavor. His insightful feedback, constructive criticism, and mentorship have significantly enriched my understanding and enhanced the quality of this work. I am truly fortunate to have had the privilege of working under his mentorship.

Finally, I would like to thank Encik Noor Mazlan bin Mohamed, Encik Bisyr Asfar bin Ahmad Bakhtiar and all individuals who played a role in helping me to make this research possible. Their contributions, whether big or small, have been invaluable in shaping the outcome of this research. I am deeply appreciative of their help, which has made this achievement possible.

ABSTRACT

This study aims to develop a Project-Based Learning E-Module by utilizing the Arduino for the topic of impulse and examine its validity and usability among trainee physics teachers. ADDIE model was followed in the development of the PjBL e-module where the problem was analysed, the e-module was designed, and then developed using Canva. Constructivism learning theory, Inquiry-Based learning, Experiential Learning Theory and Cognitive Load Theory was implemented into the e-module to make the e-module meet the learning style of 21st-century learning. After that, the e-module then goes to implementation phase before finally getting its usability evaluated. The PjBL e-module has been read and evaluated by 56 Semester 7 physics students selected via convenience sampling. The mean value of the usability obtained is 3.67, which proves that the e-module has achieved a high usability level among trainee physics teachers. The PjBL e-module surely will help trainee physics teachers to teach the topic of impulse for Form 4 Physics since the e-module is useful for them, easy to use and satisfy their need for teaching the topic.

ABSTRAK

Kajian ini bertujuan untuk membangunkan E-Modul Pembelajaran Berasaskan Projek dengan penggunaan Arduino untuk topik impuls dan menguji kesahan dan kebolehgunaan dalam kalangan guru pelatih fizik. Model ADDIE telah digunakan dalam pembangunan e-modul tersebut di mana analisis masalah telah dilakukan, reka bentuk e-modul tersebut juga telah dilakukan dan e-modul dibangunkan menggunakan aplikasi Canva. Teori-teori yang diadaptasikan ke dalam e-modul tersebut adalah teori pembelajaran Konstruktivisme, Pembelajaran Berasaskan Inkuiri, Pembelajaran Berasaskan Pengalaman dan Teori Beban Kognitif. Selepas itu, e-modul tersebut memasuki fasa pelaksanaan sebelum memasuki fasa terakhir iaitu fasa penilaian. E-modul ini telah dibaca dan dinilai oleh 56 pelajar fizik Semester 7 yang telah dipilih melalui kaedah persampelan mudah. Nilai min kebolehgunaan yang diperoleh adalah 3.67 dan nilai min ini membuktikan bahawa e-modul ini telah memperoleh tahap kebolehgunaan yang tinggi di kalangan guru pelatih fizik. E-modul PjBL ini sudah pasti akan membantu guru pelatih fizik untuk mengajar topik impuls dalam Fizik Tingkatan 4 kerana e-modul ini berguna untuk mereka, mudah digunakan dan memenuhi keperluan mengajar mereka.

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LIST OF ABBREVIATION

ADDIE	Analysis, Design, Develop, Implementation, and Evaluation
CVI	Content Validity Index
DSKP	*Dokumen Standard Kurikulum Pentaksiran*
SPSS	Statistical Package for Social Science
PAK-21	*Pembelajaran Abad Ke-21*
PjBL	Project-Based Learning

APPENDIX LIST

CHAPTER 1

INTRODUCTION

1.1 Introduction

Implementation of the 21st century learning which known as *Pembelajaran Abad ke-21* (PAK-21) in Malaysia has changed the teaching method in class, from traditional teaching method to modern teaching method. To have a better understanding, traditional teaching refers to teacher-centred learning where teachers act as primary sources of information while textbooks are the center of activities (Hamdi Serin, 2018). In contrast, modern teaching methods are about student-centred learning where students play an active role in

the learning process as teachers do not transfer knowledge directly to them (Hamdi Serin, 2018). Students are now responsible for their own learning since teachers no longer provide them with everything as in traditional teaching method (Yunus, 2018). Additionally, the core of 21st-century learning consists of several elements which are communication, collaboration, critical thinking, creativity, and values and ethics (4C1V) (Mohd Idriki & Tan, 2022).

Student-centred learning should be applied to most of the subjects taught in school, especially science subjects such as physics. With the implementation of PAK-21, physics Curriculum and Assessment Standards Document (DSKP) highlighted the student-centred learning approaches to train their 21st century skills. For instance, inquiry-based learning is one of the approaches where students are presented with questions or problems to trigger their sense of curiosity which causes them to seek for the answer in many ways (Gholam, 2019). This learning approach helps to develop students' critical thinking and problem-solving skills. Next is the simulation approach where the activity imitates real world situations. Simulations approach can be carried out through games, role-play or using a model. Simulations approach enables students to visualize the real situation which allows them to understand the concepts they are learning.

Another important learning approach highlighted in the physics DSKP is the use of technology in teaching and learning. Using technology in teaching and learning can be more effective and exciting since there are varieties of technology that can be used. Integrating technology in teaching and learning can be a game changer in education nowadays as there are lot of new and improved technology which can be used as teaching aids. Teaching using video games, simulations, interactive whiteboards and even watching

educational videos on YouTube is considered as technology-based teaching. However, integrating technology into hands-on activities is a great combination for students. According to Ghavifekr and Rosdy (2015), technology-based hands-on activities is an effective, creative, and interesting approach which stimulate students understanding on the subject. As there are various ways of using technology in education, this means that technology is suitable to be adopted in different student-centred learning approaches such as inquiry-based learning, simulations approach and others as stated in the physics DSKP. For inquiry-based learning, students can be presented with a few questions before using the hands-on activity to allow them to look for the answers on their own. For simulations, the technology-based hands-on tool can act as a model which can be used to simulate the real-world situation too.

With various learning approaches available, it is possible to combine them into one learning module, creating a great educational tool for teachers, and giving students a solid experience when learning physics. A learning module is useful for student-centred learning as it contains a set of instructions for students to follow, allowing them to learn on their own while being facilitated by their teacher. By having a good module in hand, PAK-21 might be more achievable, especially in terms of student-centred education.

1.2 Research Background

With the shift from the traditional method of teaching and learning to 21st-century learning, the implementation of various learning approaches backed with various learning theories has become doable, especially in Physics. Previously, teachers only learnt about learning

theories and the characteristics of different learning approaches but when it comes to teaching, it goes back to the same practice where teachers stand and teach while students sit and learn. However, pedagogy now has shifted to meet the need of 21st-century learning where it is no longer teacher-centred learning but student-centred learning. Various learning approaches are now able to be implemented in Physics classrooms to allow the engagement of the students so that they can become active learners.

To be able to conduct great teaching in a 21st-century learning environment, teachers nowadays must possess a great understanding of diverse learning approaches as well as learning theories. Not only those teachers in school, but university students pursuing education degree also need to learn it to be prepared for the day when they finally become a teacher. One example of diverse learning approaches is the use of technology in teaching and learning. With so many available modern technologies nowadays, it is an advantage for Physics teachers as they can use it as their teaching aid. According to Conger, Krauss and Simuja (2017), technology-based pedagogical approaches increase student motivation and they become more participative, showing that teachers gain benefits by using technology in their teaching method. Learning theory is important too as it is interconnected with learning approaches. It serves as the foundation for learning approaches taken by the teachers. For example, constructivism learning theory, which state that learners construct their own knowledge through experiences, serve as the foundation for learning approach such as project-based learning, collaborative learning, interactive simulations and many more that gives a wonderful experience for each of the students.

Since there are a lot of learning approaches available, it is possible to create a combination of several learning approaches together, giving students a more unique

learning experience. When doing so, it is better to turn it into a learning module. Learning module is a great tool for teachers as it contains a well-organized learning content with multiple learning approaches in it. The learning module also contains a detailed instruction which guides students going through the module. This indeed suits student-centred learning where students can learn on their own when using the module and teachers only facilitate their learning. For instance, using a Physics learning module, students can explore the physics concept on their own and only seek guidance if they face any difficulties. Learning through module would give students an experience of learning on their own or together with their friend which differs from receiving everything from their teacher. From this experience, students will be able to develop several valuable skills including critical thinking skills, problem-solving skills, and scientific research skills.

To sum up, using a learning module in teaching and learning can be a great method for nowadays education, particularly in physics education. Learning modules' adaptability and versatility give teachers a strong tool for successfully engaging their students and giving them a new experience in the classroom. By combining several learning approaches within the module, Physics learning should be able to meet the criteria of 21st-century learning and successfully shift from traditional learning method to this modern approach.

1.3 Problem Statement

To meet the elements of 21st-century learning, the characteristics of learning in nowadays education should be interactive, holistic, integrative, scientific, contextual, thematic, effective, collaborative, and learner-centred learning process (Kalalo, Katuuk,

Lengkong & Rotty, 2023). In terms of physics education, these are the characteristics that should be applied during teaching and learning sessions. When learning the topic of impulse and impulsive force, a lesson planned well to meet the characteristics of 21st-century learning can help students understand the topic more enjoyably since it can make them active learners and provide them with a unique learning experience. Lessons or e-modules that can provide such lessons can be an excellent tool for teachers to help them improve their teaching.

However, most e-modules on the topic of impulse and impulsive force found online mostly consist of questions and experiments derived from traditional textbooks only. This kind of module does not fully meet all the characteristics stated by Kalalo et al. (2023). Figures below show some of the results when searching for impulse and impulsive force e-module on Google search.

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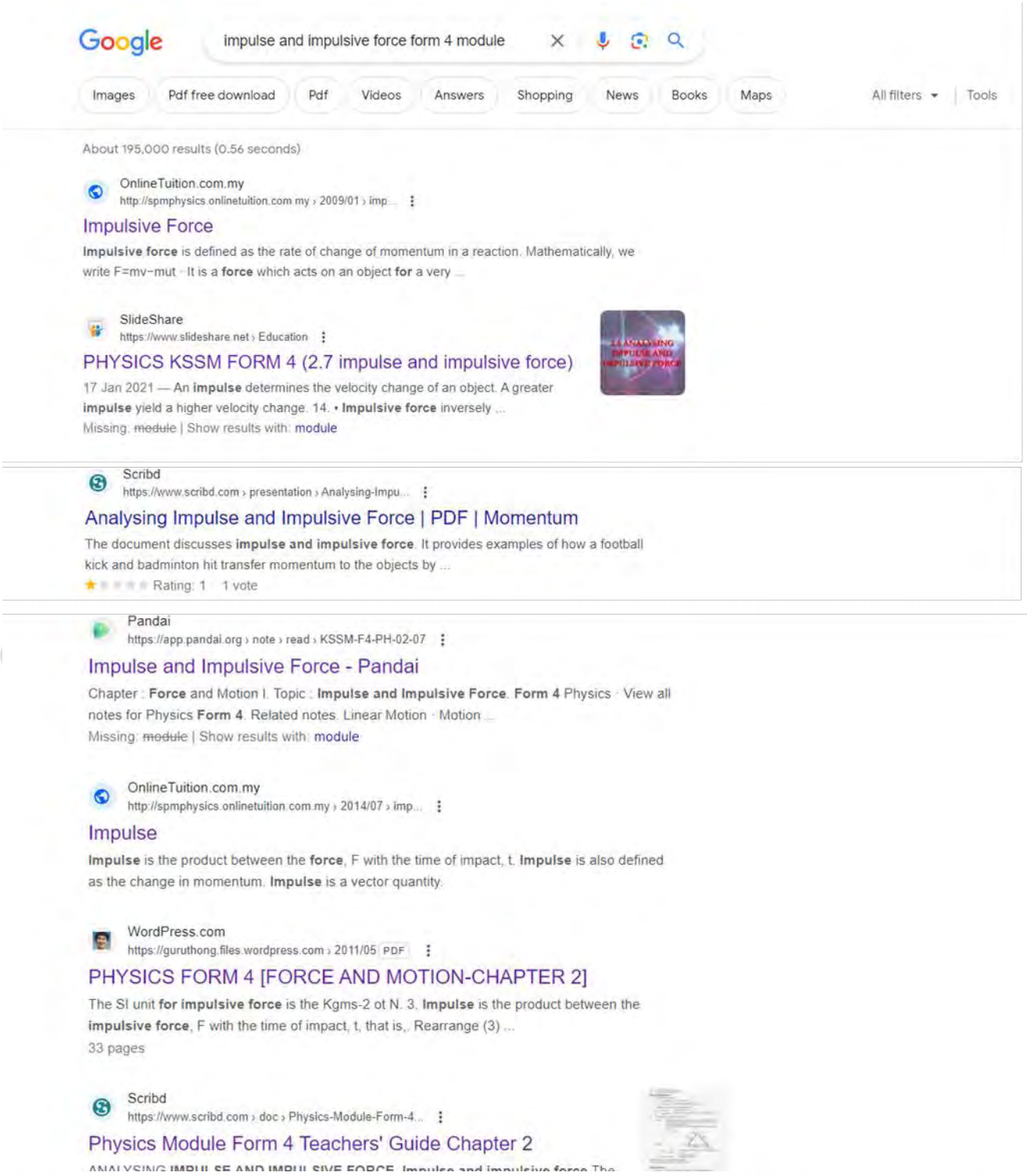


Figure 1. The First Page of Google Search

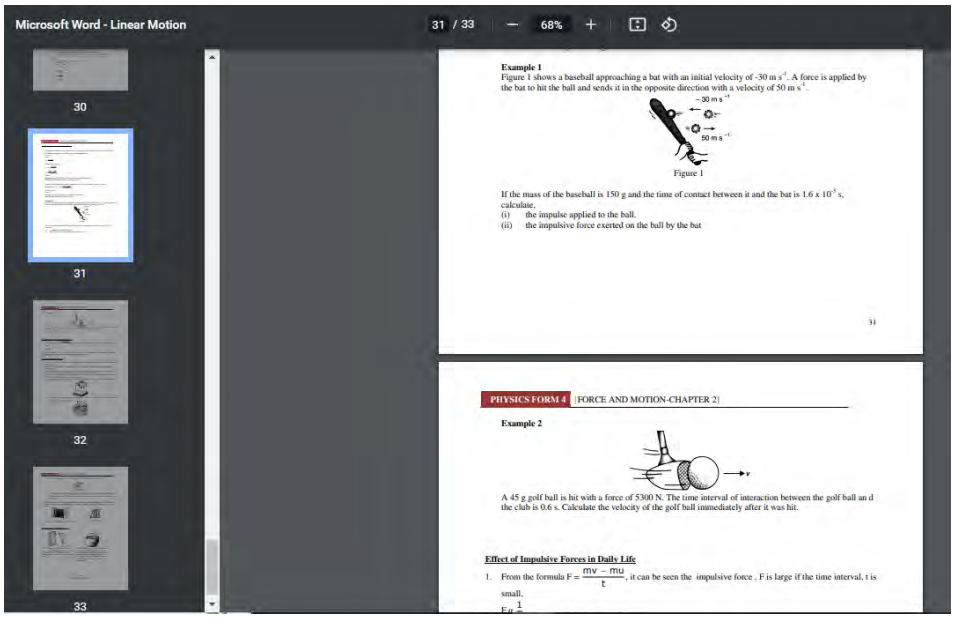
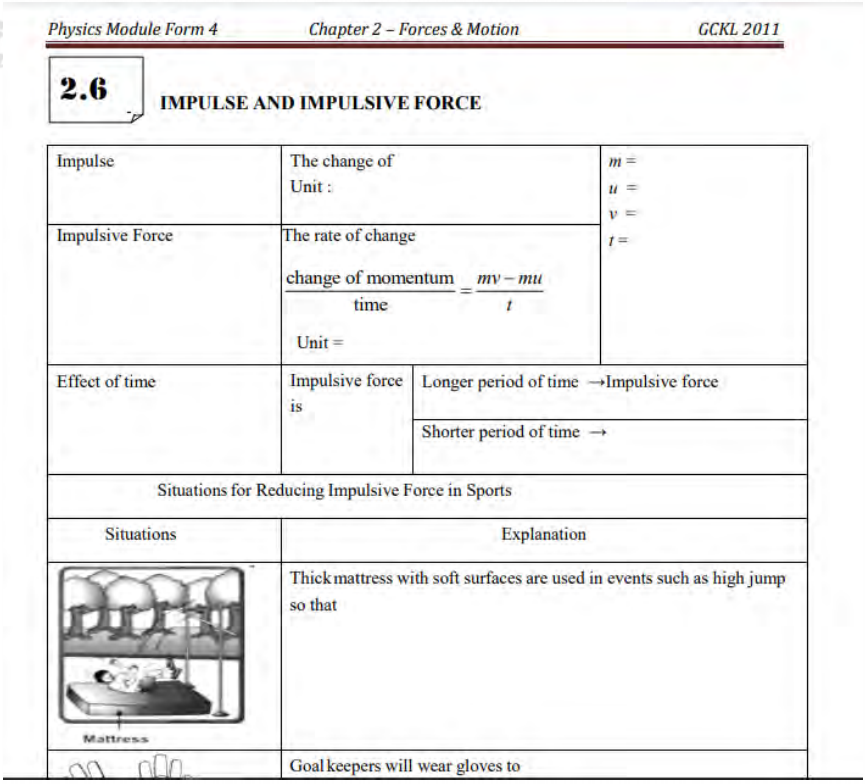


Figure 2. Example 1 of Impulse and Impulsive Force Module on https://guruthong.files.wordpress.com/2011/05/linear_motion1.pdf



Physics Module Form 4 *Chapter 2 – Forces & Motion* *GCKL 2011*

2.6 **IMPULSE AND IMPULSIVE FORCE**

Impulse	The change of Unit :	m = u = v = t =
Impulsive Force	The rate of change $\frac{\text{change of momentum}}{\text{time}} = \frac{mv - mu}{t}$ Unit =	
Effect of time	Impulsive force is	Longer period of time →Impulsive force
		Shorter period of time →

Situations for Reducing Impulsive Force in Sports	
Situations	Explanation
Mattress	Thick mattress with soft surfaces are used in events such as high jump so that
	Goal keepers will wear gloves to

Figure 3. Example 2 of Impulse and Impulsive Force Module on https://www.slideshare.net/deanamin/20-forces-and-motion-18825095

These e-modules may pose limitations in the learning approach, as students' interaction is primarily restricted to discussions among themselves and later with their teacher to share their answers. Besides, not all students might be interested in the learning and will not actively participate in the discussion. Trainee teachers may encounter challenges when trying to learn and implement modern teaching methods because they might struggle to find modules that align with the demands of 21st-century education.

To overcome the problems, the researcher decided to create a project-based learning e-module for the topic of impulse. This e-module focuses on student-centred learning by integrating various learning approaches including cooperative learning, inquiry-based learning, experiential learning, simulation learning and the use of technology in teaching and learning by utilizing the Arduino microcontroller. This e-module will be developed based on the constructivism learning theory and cognitive load theory. This e-module will provide activities that go beyond the traditional teaching methods or a basic physics module, sparking students' interest in learning physics, especially on the topic of impulse and impulsive force.

1.4 Research Objectives

1.4.1 Development

- To develop a Project-Based Learning E-Module by Utilizing the Arduino for the Topic of Impulse for trainee physics teachers.

- To determine the level of usability of the Project-Based Learning E-Module by Utilizing the Arduino for the Topic of Impulse among trainee physics teachers.

1.5 Research Question

1.5.1 Development

- Does the Project-Based Learning E-Module by Utilizing the Arduino for the Topic of Impulse have a good level of validity?
- What is the level of usability of the Project-Based Learning E-Module by Utilizing the Arduino for the Topic of Impulse among trainee physics teachers?

1.6 Framework of Research

Figure 4 depicts how the researcher structured the study utilizing the conceptual framework of the research.

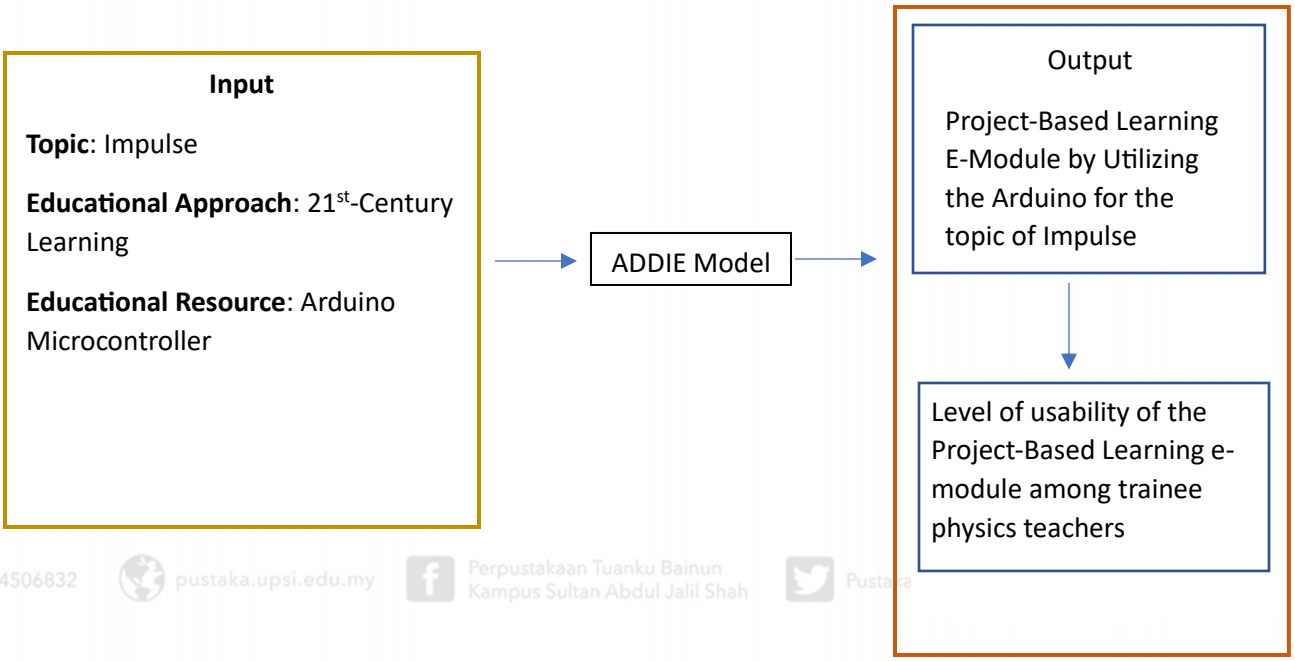


Figure 4. Conceptual Research Framework of the Study

The researcher has developed a conceptual framework for the research using the ADDIE Model. During the analysis phase, the researcher analyses whether the learning module found online for the topic of impulse adopt the 21st-century learning or not. The result shows that it still uses the traditional method, hence the researcher decided to develop a project-based learning e-module by utilizing the Arduino for the topic of impulse. The output of this study would be the production of the project-based learning e-module and the level of usability of the e-module.

1.7 Research Limitation

This study was only done for the topic impulse and impulsive force and the respondent is only the physics students at Sultan Idris Education University that already completed Teaching Practicum 1 and will undergo Teaching Practicum 2 after that, which is students of Semester 7. The research design for the project involves a single-group design, where the experimental group uses the Project-Based Learning e-module. However, the absence of a control group receiving traditional instruction alone limits the ability to directly compare the effectiveness of the Project-Based Learning e-module with a non-intervention group. Hence, this study can only be generalized to a study which has the same characteristics or scope.

1.8 Significance of Research

1.8.1 Students

The use of the PjBL e-module by utilizing the Arduino for the topic of impulse gives students an improved educational experience that goes beyond traditional classroom instruction. Through hands-on interactive activities, students can have a better understanding of the concepts of impulse and impulsive force. Analyzing current data and applying theoretical knowledge to real-world situations encourages critical thinking. The e-module also increases students' interest and engagement through the fun activities offered by e-module. Because it is hands-on and includes visual feedback, it grabs their interest and makes learning much more enjoyable. As a result, students are more interested in learning physics and are

motivated to explore the topic further. Moreover, this e-module helps students to have a deeper conceptual understanding of impulse and impulsive force. By visualizing the effects of force and time on momentum, students are able understand these abstract concepts. Improved understanding means improved performance in physics. Furthermore, the use of this e-module promotes problem-solving skills and develops critical thinking abilities which are important not only in physics, but other subjects as well. Overall, the PjBL e-module improves conceptual understanding, boosts student interest and engagement, and develops important skills which are useful for students.

1.8.2 Teacher

PjBL e-module by utilizing the Arduino for the topic of impulse also brings significant benefits for teachers. It helps teachers to adopt hands-on and technology-based learning tools in the physics classroom. This method enhances engagement, incorporates different learning preferences, and fosters a dynamic learning environment. Additionally, using the e-module offers teachers significant possibilities for professional growth. By exploring the use of technology in physics education, they can develop their pedagogical knowledge and skills and keep up with innovative approaches. Moreover, by fostering an engaged and dynamic environment, the e-module used in the classroom boosts the dynamics overall. It promotes a supportive classroom environment by encouraging student cooperation, discussion, and active engagement. In turn, this creates a positive learning environment and develops the relationship between teachers and students.

1.9 Operational Definition

1.9.1 Validity

According to Nur Izzati Binti Rozman (2018), validity determines the suitability and usefulness of the instrument used in research study. This definition will be used in the context of this study and the validity of the instrument will be determined by Cronbach's alpha from SPSS software.

1.9.2 Usability

According to Dubey and Rana (2010), usability can be viewed as usefulness and ease of use of the system. In the context of this study, usability refers to the effectiveness of the PjBL e-module towards the respondents. It is measured via the questionnaire given to the respondents and then this instrument will be analyzed using SPSS software.

1.10 Summary

This chapter has covered the problem existing in Malaysia education. The researcher has come up with the PjBL e-module by utilizing the Arduino for the topic of impulse to tackle the issues stated. Research objectives have been clearly stated. The chapter also discusses the conceptual framework, which outlines the theoretical foundations, variables, and data collection method guiding the investigation. Research limitations were acknowledged too and the significance of research to both students and teachers was also highlighted. This chapter serves as the base for the subsequent chapters.