THE DEVELOPMENT AND USABILITY OF GRAVITATION SIMULATION INTERACTIVE MODULE VIA WEB APPLICATION (WEBGSIM) AMONG FORM 4 PHYSICS STUDENTS IN JELUTONG DISTRICT

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DECLARATION OF ORIGINAL WORKS

I, Quah Kah Chun (D20191088390) from Faculty Science and Mathematics hereby declare that the thesis for Bachelor of Education in Physics with Honors titled "The Development and Usability of Gravitation Simulation Interactive Module Via Web Application (WebGSIM) Among Form 4 Physics Students in Jelutong District" is my original work. I have not plagiarised from any other scholar's work and any sources that contains copyright had been cited properly for the permitted meanings. Any quotations, excerpt, reference, or re-publication from or any works that has copyright had been clearly and well cited.

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(QUAH KAH CHUN)

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ABSTRACT

This study aims to develop an educational web application 'WebGSIM' for the topic of Gravitation and evaluate its usability among form 4 physics students in Jelutong District. This is a developmental research design study and WebGSIM was developed based on ADDIE instructional design model. ADDIE model has five phases which are analysis, design, development, implementation, and evaluation. After development, WebGSIM was validated by two experts. The research sample consisted of 67 form 4 physics students that was selected through cluster random sampling from all the students in Jelutong district. This research used a usability questionnaire of 20 items that was adapted from Technology Acceptance Model (TAM) to evaluate the usability of WebGSIM. The data was analysed using descriptive statistics of mean and standard deviation. The data from two experts showed that the newly developed WebGSIM had a good validity with 100% of agreement. The mean for the constructs of perceived ease of use (M=4.43, SD=0.664), perceived usefulness (M=4.64, SD=0.532), attitude (M=4.69, SD=0.535), behavioural intention (M=4.62, SD=0.682) and self-efficacy (M=4.45, SD=0.622). An average mean score of 4.57 was obtained from the result which showed that WebGSIM had a good usability. In conclusion, WebGSIM is valid and reliable, with a good level of usability. For implication, WebGSIM is suitable to be implemented into classroom because WebGSIM can help students to visualize abstract concept in Gravitation topic by using 3D simulation.

ABSTRAK

Kajian ini bertujuan untuk membangunkan aplikasi web pendidikan "WebGSIM" untuk topik Graviti dan menilai kebolehgunaannya di kalangan pelajar fizik tingkatan 4 di daerah Jelutong. Ini adalah rekabentuk kajian pembangunan dan WebGSIM dibangunkan berdasarkan model reka bentuk instruksional ADDIE. Model ADDIE terdiri daripada lima fasa iaitu analisis, reka bentuk, pembangunan, pelaksanaan dan penilaian. Selepas pembangunan, WebGSIM telah disahkan oleh dua pakar. Sampel kajian ini terdiri daripada 67 pelajar fizik tingkatan 4 yang dipilih melalui pensampelan rawak berkelompok daripada semua pelajar di daerah Jelutong. Kajian ini menggunakan soal selidik kebolehgunaan 20 item yang disesuaikan daripada Model Penerimaan Teknologi (TAM) untuk menilai kebolehgunaan WebGSIM. Data dianalisis menggunakan statistik deskriptif min dan sisihan piawai. Data daripada dua pakar menunjukkan bahawa WebGSIM yang baru dibangunkan mempunyai kevalidan yang baik dengan persetujuan 100%. Min bagi konstruk mudah guna (M=4.43, SD=0.664), kebermanfaatan (M=4.64, SD=0.532), sikap (M=4.69, SD=0.535), niat perilaku penggunaan (M=4.62, SD=0.682) dan keupayaan diri (M=4.45, SD=0.622). Min purata 4.57 diperoleh daripada keputusan yang menunjukkan bahawa WebGSIM mempunyai kebolehgunaan yang baik. Kesimpulannya, WebGSIM adalah sah dan boleh dipercayai, dengan tahap kebolehgunaan yang baik. Sebagai implikasi, WebGSIM sesuai diimplementasikan ke dalam bilik darjah kerana WebGSIM boleh membantu pelajar menggambarkan konsep abstrak dalam topik Graviti dengan menggunakan simulasi 3D.

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LIST OF ABBREVIATIONS

ADDIE	Analysis, Development, Design, Implementation and Evaluation
BI	Behavioural Intention
ICT	Information Communication Technology
JRE	Java Runtime Environment
PE	Perceived Ease of Use
PhET	Physics Education Technology
PU	Perceived Usefulness
SD	Standard Deviation
SE	Self-Efficacy
TAM	Technology Acceptance Model
TEL	Technology Enhanced Learning
UPSI	Sultan Idris Education University (Universiti Pendidikan Sultan Idris)
WebGSIM	Web Gravitation Simulation Interactive Module

CHAPTER 1

INTRODUCTION

1.1 Research Background

Physics is one of the subjects in high school where student's interest is significantly less because it is very abstract and complex (Yunzal & Casinillo, 2020). As reported, the status of the physics education in the Malaysia is facing challenges. According to the present data, students' interest in STEM has faded, with only 44% of students taking STEM in 2017 compared to 49% in 2012, a decline of nearly 6,000 students per year (MOE, 2019).

Fortunately, the widespread use of information and communication technology (ICT) is on the rise nowadays (Prestridge, 2012). When computers were first employed in education and schooling, the term "computer-based education" was introduced (Guven & Sulun, 2012). Specifically in physics education, Physics 2000 provides computer-based simulation video for students to have a better learning experience (Reviews, 2004). Later, a better computer-based simulation also known as Physics

Education Technology (PhET) Interactive Simulations was developed to advance science and math literacy (Maki, 2010). In contrast to Physics 2000 where their simulations are just simulation videos, PhET simulations provide high level of interactivity in terms of user control, dynamic feedback, and various representations (Adams et al., 2008). Study showed that students' academic performance in Physics improved significantly when they learned electromagnetism using PhET simulation (Batuyong & Antonio, 2018).

At the same time, several studies were conducted to develop learning module and its effectiveness was determined (Hamid et al., 2021; Lee & Osman, 2014). Learning module is a tool that provides course materials in a logical and sequential order to guide students through the content and assessments by the instructor. Instructors can insert formatted text, files, weblinks, discussion topics, assignments, tests & quizzes, assessments and so on (University of Florida e-Learning, 2013). However, most of the learning modules are soft copies of the print modules with little interactivity which are not effective in online learning (Makokha & Mutisya, 2016). Therefore, some interactive modules were introduced whose design and purpose is to actively engage learners to search for knowledge independently (Mwaniki et al., 2016). High level of interactivity allow learners to become engaged and involved in the learning process. This shows the combination of interactive simulation and interactive learning module are important to student's learning. For these reasons, a study was carried out to develop a web-based simulation interactive module for topic gravitation (also known as WebGSIM) and to determine its usability.

1.2 Rationale of the Study

Firstly, research topic is chosen as developing a web-based simulation interactive module is to propose a better approach which allows students to learn physics independently and actively by introducing high level of interactivity into WebGSIM. WebGSIM is a new and innovative educational technology for physics education in Malaysia. Second, it is essential to determine the usability of WebGSIM to ensure that WebGSIM is easy to use and useful to physics students in the future. Finally, most of the knowledge involved in other educational physics simulations such as PhET simulations are different from the physics curriculum in Malaysia. Therefore, WebGSIM was developed fully based on physics curriculum in Malaysia.

1.3 Problem Statement

Physics is the branch of science to describe the dynamic real world. However, Physics pedagogy frequently uses static representations such as text and drawing to illustrate real-world dynamic processes. This teaching method changes dynamic reality to static representation unavoidably loses something in the learning experience for physics students (Saudelli et al., 2021). This situation becomes obvious during the teaching or learning of gravitation topic. In fact, gravitation is one of the topics in physics which is abstract and difficult to demonstrate which may cause misconceptions (Chmiel, 2012). For example, several studies showed that both students and teachers have misconceptions about the concept of gravity and motion (Desstya et al., 2021;

Khandagale & Chavan, 2017). Therefore, a computer-based simulation is important to learn or teach this abstract gravity concept.

An ideal web-based physics simulation application should allow students to achieve learning outcomes safely, efficiently, and effectively while enjoying the learning experience. However, several studies reported that PhET simulation had some usability issues which affected the student's learning experience and eventually the technology usage (Adams et.al., 2008; Almeida & Bastos, 2018; Chong et al., 2012; Kriek & Stols, 2010; Khoiriyah, et al, 2015; Taibu et al., 2021).

For the aspect of perceived ease of use, there is a study reported that there were some technical problems needed to be solved before usage because some of the PhET simulation files are written in the format ".jar" which requires the installation of Java Runtime Environment (JRE) (Khoiriyah, et al, 2015). Also, there is a study showed that some students feel difficulty to perfom a task given at PhET interface (Almeida & Bastos, 2018). Therefore, the technical issues in PhET simulation demotivate students.

For the aspect of perceived usefulness, there is a study showed that students believed PhET simulation is not helpful to their academic performance because no further explanation for the results shown in the simulation (Chong et.al., 2012). As a result, perceived ease of use and usefulness will affect attitudes toward the usage of PhET simulation. To illustrate, there is a study reported that some of the students were

frustrated to learn electricity concept by using PhET simulation (Adams et.al., 2008). Hence, elaboration or explanation should be included in simulation.

When students have negative attitude's toward PhET simulation, they are unlikely to use PhET simulation for learning in the future. For example, study showed that some of the students discouraged their professors to teach using PhET simulation due to their negative behavioural intention (Taibu et.al., 2021). As a result, students' attitude will affect the use of PhET simulation in their learning.

For the aspect of self-efficacy, teacher's general technology proficiency will influence the actual use of PhET simulation in the classroom. For instance, a study showed that some of the teachers did not use PhET simulation in the classroom due to their low general technology proficiency (Kriek & Stols, 2010). Besides, a study from Ummi and Tho (2021) found that teacher's self-efficacy is lower than student's self-efficacy which might affect the usability and actual usage of the technology in classroom. Eventhough there is actual usage of PhET simulation in classroom, unfortunately, based on the database in PhET website, most of the teachers are still using heavily guided simulation activities which negatively influenced student's engagement in learning (Chamberlain et al., 2014). These situations indicate that teaching using PhET simulation is still a teacher-centered pedagogy. As a result, the usability issue of physics simulation is one of the challenging issues need to be solved.

An ideal learning module not only need to enhance student's conceptual understanding on certain topic, but also increase interest, engagement, and motivation of students during the learning process. However, most of activities or worksheets provided by PhET are text-based and less interactive which will influence the students'attitude and motivation towards learning (PhET, 2014; Rockinson- Szapkiw et al., 2013). For example, a study reported that some of the students were frustrated with the worksheets provided and feeling demotivated to use PhET simulation in the future learning (Taibu et al., 2021). As a result, the interactivity issue of learning module is one of the challenging issues need to be solved.

To solve both usability issue of physics simulation and interactivity issue of learning module, WebGSIM was developed to unify both physics simulation and interactive module in a single web application. WebGSIM was consisted of highly interactive problem-based activities, game-based assessments, and physics simulation to motivate students to learn physics. Furthermore, WebGSIM implemented student-centered learning approach which allows students to control over learning method and pace of learning.

Currently, there is less 3D physics simulation for educational purposes. Some students from a study claimed that PhET simulation is not attractive to them because most of the simulations are based on 2D animation (Chong et al., 2012). The importance of 3D physics simulation in education is shown by a study where students learnt better by using 3D simulation compared to 2D simulation in Newtonian Mechanics (Koops et al., 2016). This is because scientific data or information will be lost, distorted, or

misinterpreted in 2D animation when learning physics (Mengistu & Kahsay, 2015). Therefore, WebGSIM's simulation engine used Glowscript libraries to render 3D animation which further enhance physics student's interest and motivation when learning physics.

1.4 Research Objectives

i. To develop Web Gravitation Simulation Interactive Module (WebGSIM) among Form 4 Physics Students in Jelutong District.

ii. To determine the usability of the developed Web Gravitation Simulation Interactive Module (WebGSIM) among Form 4 Physics Students in Jelutong District.

1.5 Research Questions

i. Are the newly developed Web Gravitation Simulation Interactive Module (WebGSIM) valid and reliable?

ii. Are the newly developed Web Gravitation Simulation Interactive Module (WebGSIM) usable among Form 4 Physics Students in Jelutong District?

1.6 Research Scope and Significance

This study is limited to topic gravitation which is one of the topics in form 4 physics and only involves form 4 physics students because form 5 physics students have examination (SPM).

The findings of this study significantly impacted physics students, physics educators, and researchers. For physics students, this study helped them to have immersive learning environment which further motivate them to learn physics. Besides, this study also helped physics students to visualize an abstract concept in physics, specifically topic gravitation. For physics educators, this study allowed them to implement new and innovative educational technology in classroom. Furthermore, this study allowed physics educators to improve students' attitude towards learning physics. For researchers, this study helped them to uncover a new educational technology and its effectiveness can be further studies.

1.7 Conceptual framework

The focus of this study is to develop the content for WebGSIM. ADDIE model was chosen as the instructional design model for the development of WebGSIM. During the analysis phase, only one topic were selected as the content of this WebGSIM, namely Gravitation. Learning theories were studied and applied when the content of the WebGSIM is being designed. The theories involved are Cognitivism, Connectivism

and Constructivism. During the implementation phase, the WebGSIM were introduced to experts and training teachers to check WebGSIM's validity and reliability. Finally, perceptions of students on WebGSIM's usability were studied during the evaluation phase. Conceptual framework of the study is represented in Figure 1.1.

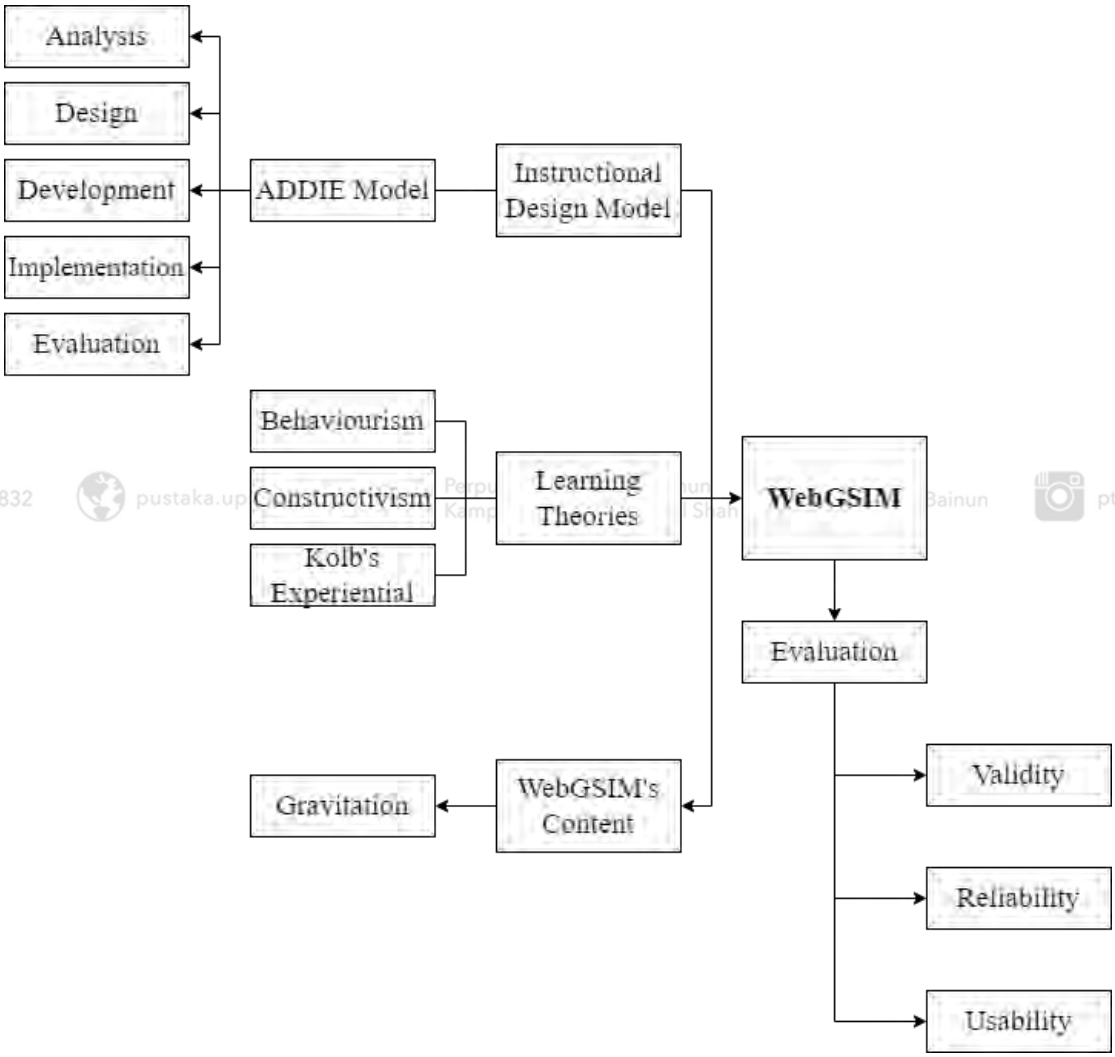

Figure 1.1: Conceptual Framework of WebGSIM

1.8 Operational Definitions

i) Development

Development in research is the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet criteria of internal consistency and effectiveness (Richey, 1994). WebGSIM was developed using ADDIE (Analyze, Design, Develop, Implement, Evaluate) model (Branch, 2009). WebGSIM was validated by providing a video about operating procedure of the web application to the experts. The reliability of WebGSIM was measured by form 4 physics students who are not involved in this study during pilot test.

ii) Usability

Usability is the capacity of a system to provide a condition for its users to perform the tasks safely, effectively, and efficiently while enjoying the experience (Lee et al., 2019). To evaluate the usability of WebGSIM, 20 items from Technology Acceptance Model (TAM) was adapated in the questionnaire. The five constructs involved are perceived ease of use (PE), perceived usefulness (PU), attitude (AT), behavioural intention (BI), and self-efficacy (SE) (Park, 2009). PE refers to the degree to which physics student believes that using WebGSIM will be free of effort. PU refers to the degree to which physics student believes that using a WebGSIM will enhance his or her job performance. AT refers to physics student's attitude toward the use of WebGSIM. BI refers to physics student's intention or motivation to use WebGSIM in future learning. SE, which is an

external variable, refers to physics student's confidence level on their capabilities to use WebGSIM.

1.9 Limitations

One of the limitations of this study is lack of prior research studies on the topic. The simulation engine in WebGSIM uses Glowscript libraries to render 3D animation. However, there is less prior research study on the comparison between Glowscript and PhET simulation. The second limitation is WebGSIM requires active internet connection, it might affect the implementation or actual use of WebGSIM in the classroom.

1.10 Summary

This chapter begins with a general introduction of WebGSIM. The research background includes the use of learning modules and computer simulation in physics education. Next, the problem statement discusses the interactivity and usability issues of learning modules and computer simulation (specifically PhET simulation) in physics education. Following the problem, 2 research objectives and research questions are clearly stated. This is followed by research scope which discusses about the delimitation in this study.

Next, the importance to conduct this study is discussed in research significance section. Following that, conceptual framework of WebGSIM is shown which specifies ideas used in this study. Next, operational definition section defines the terms in this study. Lastly, limitations of the study are discussed to highlight the weakness in this study.