THE DEVELOPMENT AND USABILITY OF ONLINE INTERACTIVE LEARNING PLATFORM (E-ASTR) IN ASTRONOMY TOPICS AMONG HIGH SCHOOL PHYSICS STUDENTS

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DECLARATION OF ORIGINAL WORKS

I, LI JIAHUAN (D20202097359) from the Faculty of Science and Mathematics at this moment declare that the thesis for Bachelor of Education in Physics with Honors titled "The Development and Usability of Online Interactive Learning Platform (E-ASTR) in Astronomy Topics Among High School Physics Students" is my original work. I have not plagiarised from any other scholar's work and any sources that contains copyright have been cited properly for the permitted meanings. Any quotations, excerpts, references, or re-publication from any works that have copyright had been clearly and well cited.

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ABSTRACT

The purpose of this study is to develop an online interactive learning platform (E-ASTR) for the topic of astronomy and evaluate its usability among second-year high school physics students in Xihe District. E-ASTR was created using the ADDIE instructional design model, and this study employed a developmental research design. There are five stages in the ADDIE model: analysis, design, development, implementation, and evaluation. Two experts validated E-ASTR after it was developed. Forty-three physics students who did not participate in this study conducted a pilot test. Using cluster random sampling, 58 second-year high school physics students were chosen from among all the students in the Xihe District to make up the research sample. The usability of E-ASTR was assessed in this study using a 20-item usability questionnaire that was modified from the Technology Acceptance Model (TAM). The mean (M) and standard deviation (SD) of descriptive statistics were used to analyze the data. The newly developed E-ASTR had good validity with 100% agreement, according to the data from two experts. The mean scores for the constructs of perceived ease of use (M=4.28, SD=0.654), perceived usefulness (M=4.30, SD=0.774), attitude (M=4.38, SD=0.674), behavioral intention (M=4.36, SD=0.713), and self-efficacy (M=4.60, SD=0.676) were high. An average mean score of 4.38 was obtained from the results, which showed that E-ASTR had good usability. In conclusion, E-ASTR is valid and reliable, with a good level of usability. For implications, E-ASTR is suitable to be implemented in the classroom because it can help students understand complex astronomical concepts.

ABSTRAK

Tujuan kajian ini adalah untuk membangunkan platform pembelajaran interaktif dalam talian (E-ASTR) untuk topik astronomi dan menilai kebolehgunaannya di kalangan pelajar fizik tingkatan dua sekolah menengah di Daerah Xihe. E-ASTR dicipta menggunakan model reka bentuk pengajaran ADDIE, dan kajian ini menggunakan reka bentuk penyelidikan pembangunan. Terdapat lima peringkat dalam model ADDIE: analisis, reka bentuk, pembangunan, pelaksanaan, dan penilaian. Dua pakar telah mengesahkan E-ASTR selepas ia dibangunkan. Empat puluh tiga pelajar fizik yang tidak mengambil bahagian dalam kajian ini menjalankan ujian perintis. Menggunakan pensampelan rawak kelompok, 58 pelajar fizik tingkatan dua sekolah menengah telah dipilih daripada semua pelajar di Daerah Xihe untuk menjadi sampel kajian. Kebolehgunaan E-ASTR dinilai dalam kajian ini menggunakan soal selidik kebolehgunaan 20 item yang diubah suai daripada Model Penerimaan Teknologi (TAM). Min (M) dan sisihan piawai (SD) statistik deskriptif digunakan untuk menganalisis data. E-ASTR yang baru dibangunkan mempunyai kesahihan yang baik dengan 100% persetujuan, menurut data daripada dua pakar. Skor min bagi konstruk kebolehgunaan yang dirasakan (M=4.28, SD=0.654), kegunaan yang dirasakan (M=4.30, SD=0.774), sikap (M=4.38, SD=0.674), niat tingkah laku (M=4.36, SD=0.713), dan efikasi diri (M=4.60, SD=0.676) adalah tinggi. Skor min purata 4.38 diperoleh daripada hasil yang menunjukkan bahawa E-ASTR mempunyai kebolehgunaan yang baik. Kesimpulannya, E-ASTR adalah sah dan boleh dipercayai, dengan tahap kebolehgunaan yang baik. Dari segi implikasi, E-ASTR sesuai untuk dilaksanakan di dalam bilik darjah kerana ia boleh membantu pelajar memahami konsep astronomi yang kompleks.

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LIST OF ABBREVIATIONS

ADDIE	Analysis, Development, Design, Implementation and Evaluation
E-learning	Electronic Learning
M-learning	Moblie Learning
BI	Behavioural Intention
ICT	Information Communication Technology
PE	Perceived Ease of Use
PhET	Physics Education Technology
PU	Perceived Usefulness
SD	Standard Deviation
SE	Self-Efficacy
TAM	Technology Acceptance Model
UPSI	Sultan Idris Education University (Universiti Pendidikan Sultan Idris)
E-ASTR	Online interactive astronomy learning platform
PWA	Progressive Web Application
M	Mean
UI	User Interface
UX	User Experience
GBL	Game-based Learning
VR	Virtual Reality
HTML	HyperText Markup Language
AR	Augmented Reality
GIF	Graphics Interchange Format
CSS3	Cascading Style Sheets 3
AJAX	Asynchronous JavaScript and XML

API	Application Programming Interface
HD	High Definition
SVG	Scalable Vector Graphics
PNG	Portable Network Graphics
JPEG	Joint Photographic Experts Group
ELT	Experiential Learning Theory
CAI	Computer-Assisted Instruction

CHAPTER 1

INTRODUCTION

1.1 Research Background

In modern education, traditional physics teaching techniques are being scrutinized for their ability to engage students and deepen their comprehension. The mathematization of information and inadequately active teaching methods sometimes lead to student disengagement (José De Carvalho Sousa & Rangel De Moura Sousa, 2022). Students majoring in science may find the material unrelatable and the teaching techniques uninteresting (Kalender et al., 2020). Traditional teaching techniques, which emphasize lecture and rote learning, have been criticized for not actively engaging students, resulting in low physics understanding and enjoyment (Good et al., 2019). These strategies may not engage students or provide a solid foundation in basic physics courses (May et al., 2020). Physics is perceived as a difficult subject, influenced by instruction, teacher variables, curriculum, and evaluation techniques, making it even

harder (Bao & Koenig, 2019). As a result, there is an increasing desire for physics education to be more entertaining, relevant, and accessible to more students (Forndran & Zacharias, 2019).

In environments without hands-on activities, students find it hard to learn physical astronomy, a branch of the physical sciences, because its material is abstract and remote (Gozzard & Zadnik, 2021). Astronomical concepts and themes may seem unrelated or paradoxical to students' observational experiences, making them hard to understand (Ladd et al., 2019). Teaching non-science majors presents challenges in identifying scientific tasks (Chimonidou et al., 2021). The physics profession's emphasis on experimental and quantitative research over explanatory attempts makes physics, a crucial aspect of physical astronomy, seem challenging (A. Yang et al., 2019). These issues make teaching and studying physical astronomy difficult.

Rapid progress in information and communication technology (ICT) is revolutionizing teaching and learning. ICT tools like digital platforms and online materials have transformed education. They offer both synchronous and asynchronous learning, and accommodate different learning styles and needs (Tikam, 2021). Technology has made instructional content more interactive and engaging, potentially boosting student motivation and learning (Higgins et al., 2019). ICT has also promoted student-centered learning, cooperation, critical thinking, and problem-solving (Dunn & Kennedy, 2019).

Web applications and online platforms have improved the teaching of physics. By improving exam preparation and time management, adaptive online learning solutions like Wiley Plus ORION enhance physics course success (Darmaji et al., 2019). Web 2.0 applications have inspired secondary physics students by encouraging creativity, cooperation, and active learning. User engagement, collaboration, and content production have dramatically improved in Web 2.0. Web 2.0, the second phase of web development, emphasizes peer-to-peer social interaction, collective intelligence, and increased opportunities to engage users (Azlan et al., 2020).

Proteus, a web platform designed for generating and sharing computer models, has significantly improved the process of teaching and understanding intricate physical systems. Astro Concepts also develops browser-based software modules for entry-level conceptual astronomy courses to help students comprehend basic physical principles (Tan & Cheah, 2021). These novel strategies demonstrate how digital platforms can revolutionize conventional instructional techniques, enhancing accessibility and engagement for students in complex topics like physics and astronomy. However, most e-learning applications lack adequate engagement mechanisms, resulting in students becoming disengaged and passively absorbing information from the instructor for prolonged periods (Delgado, 2021). Due to a lack of online social interactions and tools and knowledge for educators, online learning and teaching platforms are not as engaging as they could be. Online educational platforms are advancing beyond their original purpose of delivering information by integrating interactive and captivating features to address student apathy and lack of interest. Gamification and increased

interactivity in the classroom foster a more enjoyable and concentrated environment for students while also promoting a more relaxed atmosphere (O'Brien, 2021). Research produced E-ASTR, an astronomy-focused online interactive learning platform. The study sought to determine the platform's practicality.

1.2 Rationale of the Study

This research offers a new perspective on high school physics instruction by addressing major difficulties. Astronomy is essential to high school physics, but its abstract nature and complicated principles make it difficult for students to grasp. Many students lose interest in astronomy because its principles and theories are hard to understand and have few practical applications. Traditional techniques are often ineffective in introducing students to the fascinating and dynamic nature of astronomy. Textbooks and standard teaching methods fail to convey the vastness and complexity of the cosmos, limiting students' understanding and appreciation. Integrating the online interactive platform into students' daily lives to meet their needs and learning styles may customize education. Given how tech-dependent today's students are, this is especially true. Our platform aims to make astronomy entertaining, engaging, and accessible for students.

I am developing E-ASTR, a dynamic and interactive online astronomy classroom for high school sophomore physics students. The curriculum uses gamification and interaction to make astronomy more engaging and accessible. Active engagement enhances students' interest and understanding of astronomy. Given the

expanding relevance and accessibility of online educational materials, the research will evaluate the platform's usability based on its educational value, engagement, and convenience of use. Evaluation is essential to ensure that the platform meets student educational needs.

1.3 Problem Statement

Physics ideas and concepts underpin our knowledge of nature. Physics encompasses the study of nature, from subatomic particles to the universe (Rofendi & Amran Manalu, 2020). Physics is tough to learn and teach due to its nature and approaches. Teaching modern physics is challenging due to students' lack of interest and the absence of structured learning approaches (Stadermann, 2022). Traditional physics education faces several challenges in meeting the unique requirements of astronomy (Widayanti et al., 2019). The ability to visualize, mentally model, and rearrange concepts is crucial for students to succeed in astronomy (Fidan & Tuncel, 2019). Most students are not interested in, or do not learn much from, traditional transmission-based astronomy and physics classes (Kanim & Cid, 2020).

Web technologies and online platforms have improved physics and astronomy teaching in many ways. Astronomy education benefits from web-based computer infrastructure for visual integration, mining, and interactive navigation of large-scale observations. This approach enhances learning by helping students understand complex

astronomical events (Van De Heyde & Siebrits, 2019). Online software modules for astronomy and physics courses can achieve project-based learning objectives for education and outreach (Fidan & Tuncel, 2019). Astronomy may be taught in classrooms using web apps and platforms, enhancing comprehension and motivation. These innovations show how digital technology may simplify and engage students in complicated disciplines like physics and astronomy (Chen et al., 2024; Oktay et al., 2022).

However, current online astronomy instructional tools lack interaction and customization, therefore they do not fully exploit recent Web 2.0 technology (Efe et al., 2022). Although Web 2.0 capabilities offer a platform for interactive and collaborative learning, many online astronomy resources lack dynamism and fail to engage learners effectively. The absence of involvement can result in a passive learning experience, which is less effective in promoting a profound comprehension of intricate astronomical concepts (Hacer et al., 2022; Ünal, 2019). The use of Web 2.0 applications to revolutionize astronomy education through the facilitation of user control over professional instruments and collaboration with other users is largely unexplored in many existing resources (Acikgul Firat & Firat, 2020). Web 2.0 technologies have the potential to be flexible and efficient in locating and distributing digital resources. However, its application in astronomy education typically lacks a learner-centric strategy that could improve teaching and learning. Using student-centered Web 2.0 tools can make learning more dynamic, personalized, and engaging (Korhonen et al., 2019).

PhET simulations, commonly used in scientific education, offer interactive learning but have design and interaction limitations that may reduce their effectiveness and enjoyment. PhET was designed to enhance learning and requires continual development and assessment to ensure its usefulness across educational contexts (Inayah & Masruroh, 2021). PhET simulations enhance physics performance depending on how they are integrated into the learning process, indicating a need for better implementation methods (Najib et al., 2022). In one study, PhET interface activities challenged students. Another study found that students did not view the PhET simulation as beneficial to their academic achievement due to the lack of explanation of its consequences. These limitations suggest that improvements in PhET design are needed (Mahtari et al., 2020; Riantoni et al., 2019).

Although PhET simulations are widely utilized in educational environments, there are apprehensions surrounding their level of involvement. The introduction of situational interest at the start of a class greatly improves students' involvement, drive, and focus, thereby aligning learning goals more closely with students' interests (Shanholtzer et al., 2019). Nevertheless, most of the exercises or worksheets offered by PhET rely heavily on text and lack interactivity, which impacts students' attitudes and motivation toward the learning process (Salame & Makki, 2021). Additionally, although PhET simulations are utilized in educational experiments, they may not effectively involve students in active learning, potentially restricting the extent of comprehension and investigation in physics (Mallari, 2020). The significant impact of PhET Interactive Simulations in education highlights the need for more dynamic interactivity to fully optimize their educational value. PhET simulations possess

significant instructional value, and augmenting their interaction has the potential to foster more efficient and captivating learning encounters (Banda & Nzabahimana, 2023; Perkins, 2020).

The presence of technical concerns and the intricate nature of the user interface pose substantial obstacles in the realm of online learning resources currently. Online classes are prone to technical difficulties, shifts in communication styles, and misunderstandings between teachers and students (Adiyanto, 2021). Educational software utilization in underdeveloped areas is hindered by interface ambiguity and restricted sharing practices. Hence, there is a need for designs that are intuitive and user-friendly (J. Yang et al., 2019). Traditional online learning experiences significant dropout rates due to boredom and apathy. A lively interface may make students happier with their learning (Mutambara & Bayaga, 2021). To solve these issues, I created an interesting, informative, and easy-to-use online astronomy education platform.

This project aims to provide high school physics students with a fun and easy online tool to study the cosmos. Gamification and mobile learning should be utilized on the platform to engage and teach astronomy. This project will construct 'E-ASTR', an interactive, engaging, and easy-to-use astronomy study platform. Second year high school physics students will assess the platform's functioning and usefulness.

1.4 Research Objectives

i. To develop the online interactive learning platform (E-ASTR) in astronomy topics among second year high school physics students in Xihe District.

ii. To determine the usability of the developed online interactive learning platform (E-ASTR) in astronomy topics among second year high school physics students in Xihe District.

1.5 Research Questions

i. Is the newly developed astronomical knowledge online interactive learning platform (E-ASTR) valid and reliable?

ii. Is the newly developed astronomical knowledge online interactive learning platform (E-ASTR) usable among second year high school physics students in Xihe District?

1.6 Research Scope and Significance

This project will create and test an interactive, enjoyable astronomical learning platform

for second-year high school physics students. Using cutting-edge online and mobile technologies, along with digital instructional tools, the platform provides an entertaining and instructive learning environment. Gamified learning approaches are also utilized to enhance engagement. The study focuses on enhancing students' enthusiasm and understanding of astronomy using a unique teaching environment, focusing on fundamental ideas and theories.

Creating an online interactive and fun astronomical learning environment for second-year high school students is vital in education. First, interactive and gamified components on the website engage students and improve their astronomy knowledge. This novel way of learning can motivate and interest students by helping them comprehend difficult astronomical concepts. This platform gives physics teachers a new way to teach astronomy and boost students' interest in physics. This study also demonstrates to educational technology researchers how to integrate online, mobile, and gamified learning to improve learning outcomes. The project will boost educational technology research by assessing the platform's usability and educational efficacy.

1.7 Conceptual framework

The content for E-ASTR was developed using the ADDIE instructional design paradigm. The analysis of E-ASTR focused exclusively on high school physics astronomy. E-ASTR material was constructed using learning theories such as

constructivism, experimentalism, and connectivism. To ensure validity and reliability, experts and certified instructors reviewed E-ASTR throughout the development process. Ultimately, the evaluation phase focused on analyzing students' perspectives regarding the usability of E-ASTR. This analysis was conducted using the Technology Acceptance Model (TAM). Figure 1.1 displays the conceptual framework of the investigation.

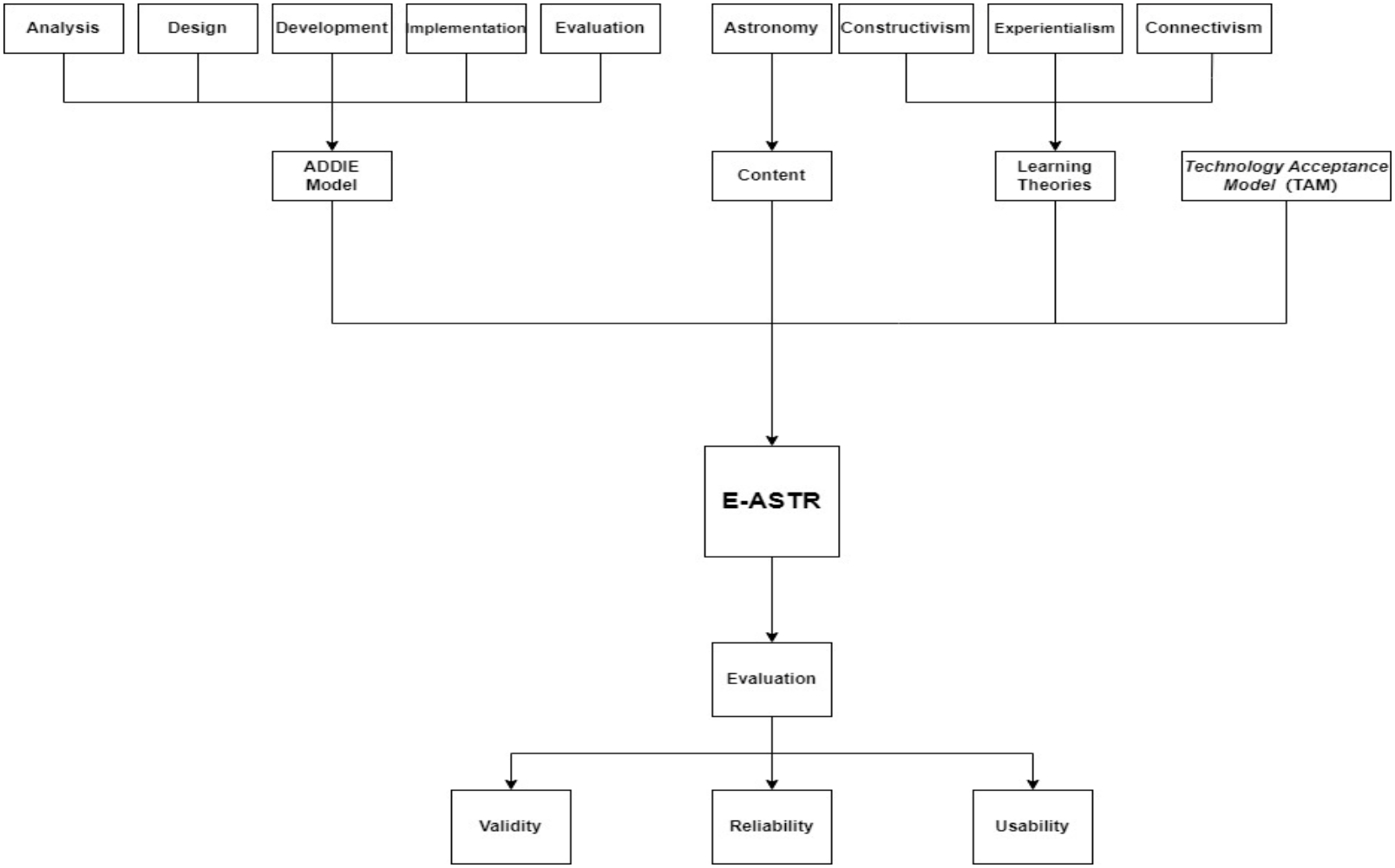

Figure 1.1: Conceptual Framework of E-ASTR

1.8 Operational Definitions

i) Development

In the domain of research development, a systematic technique is utilized for the design, advancement, and evaluation of instructional programs, methods, and products. These endeavors undergo thorough evaluation to ensure they conform to norms of internal consistency and effectiveness (Richey, 1994). The instructional design framework ADDIE (Analyze, Design, Develop, Implement, Evaluate) drove E-ASTR's creation (Branch, 2009). Experts were shown a video demonstration of the web application in operation to validate E-ASTR's functionality. A pilot test with second-year high school physics students, who were not involved in the main research, was conducted to examine E-ASTR's dependability. This method thoroughly assessed the app's functioning and instructional value.

ii) Usability

Usability influences digital interface, system design, and efficiency. Usability is the effectiveness, efficiency, and satisfaction users experience when achieving certain goals in practical and social circumstances. User experience is crucial for achieving desired results (Ågerfalk & Eriksson, 2006). Using 20 items from the Technology Acceptance Model (TAM), which assessed factors including perceived ease of use (PE), perceived usefulness (PU), attitude (AT), behavioural intention (BI), and self-efficacy (SE) (Park, 2009). PE measures the degree to which physics students believe that using

E-ASTR is effortless. PU refers to the perceived usefulness of E-ASTR in the classroom, as assessed by physics majors. AT is a student's overall opinion on E-ASTR. BI research explores students' interest in using E-ASTR in future curricula. SE, the model's exogenous variable, measures students' confidence in using E-ASTR. This comprehensive method evaluates the platform's usability based on students' perspectives and technical engagement.

1.9 Limitations

One of the limitations of this study is the restricted scope of the pedagogical content. In this research project, E-ASTR's main teaching content was designed only for physical astronomy for second-year high school students. However, it has very little curriculum relevance concerning other content. The second limitation concerns the target instructional population for E-ASTR, which in this study consisted of 58 second-year physics students at a high school in Xihe District.