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The Frontier Areas' Student Acceptance of Physics Fun-based Mobile Application: Incorporating the Process-Oriented Guided-Inquiry Learning (POGIL) Strategy

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The acceptability of technology is an essential factor to consider, particularly in frontier areas that encounter challenges related to availability and limited educational resources. This study aims to evaluate the acceptance of physics learning tools in a virtual laboratory (V-Lab) platform, utilizing the POGIL strategy, referred to as the Physics Fun-based mobile application. Mobile learning refers to the learning process carried out through mobile devices such as smartphones. The implementation took place at a senior high school located in West Papua Province, one of Indonesia's frontier areas, with 136 students participating. The Technology Acceptance Model (TAM) and Theory of Reasoned Action (TRA) were employed in this quantitative study. Structural Equation Modeling (SEM) was implemented for data analysis. The findings indicated that Attitude (ATT) and Behavioral Intention (BI) were significantly influenced by Perceived Ease of Use (PEU) and Subjective Norm (SN), respectively, while Perceived Usefulness (PU) did not have a direct effect on ATT. As a result, to enhance the acceptance of technology, teachers and technology developers should prioritize enhancing ease of use and reinforcing social factors. This should be done with a particular emphasis on the social benefits and simple accessibility of technology in the learning process, particularly in frontier areas.

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Introduction

Physics learning faces significant challenges related to the availability and quality of learning facilities, especially in frontier areas that have not been widely studied. West Papua Province, located in the eastern part of Indonesia, is included in the category of frontier areas. Eastern Indonesia frequently faces obstacles due to inadequate infrastructure and facilities that hinder practical activities, particularly in physics education (Cempaka et al., 2018; Karoror et al., 2020; Kurniawan et al., 2019). On the other hand, the western region of Indonesia, which is generally identified as an urban area, has better and more adequate learning facilities so that the implementation of learning can be carried out more optimally. Implementing online learning in frontier areas also experiences obstacles, such as not all students having access to computers and internet networks at home. This condition widens the learning quality gap between urban areas in the western region and frontier areas in eastern Indonesia.

Teachers must continue to innovate and optimize the learning process by utilizing appropriate technology to overcome learning challenges (Setyosari et al., 2023) according to the conditions experienced in their regions. Although most students already have smartphones, these devices have not been utilized optimally to access learning content individually or collaboratively (Ulfa et al., 2020), including by students in frontier areas. Thus, to surmount this obstruction, adaptive learning media must be implemented with innovation. Mobile devices are employed as interactive and engaging tools to enhance student learning, which is a progressive and innovative approach (Alfalah, 2023; Voicu & Muntean, 2023; Youssef et al., 2020). The utilization of mobile applications in the context of education is undergoing accelerated advancement (Jurayev, 2023; Voicu & Muntean, 2023) and has been proven effective in facilitating the learning process (Navarro et al., 2023). The use of mobile applications as a learning tool can no longer be avoided (Maritasari et al., 2022) because these applications offer high flexibility and accessibility, making the learning process more interactive and easily accessible anytime and anywhere.

In this context, researchers use mobile applications that integrate various learning devices in the form of virtual laboratory media (V-Lab). V-Lab allows the simulation of physics experiments not limited by space and time constraints. However, studies on the effectiveness and acceptance of using V-Lab remain scarce, particularly in frontier areas that face distinctive challenges like limited access to technological resources.

Numerous platforms provide V-Lab programs that are both free and easily accessible. The Kodular and PhET platforms were employed to develop the mobile application in this study. Kodular is a mobile application development platform that allows users to develop mobile-based applications that can be output as either web-based solutions or apps. On the other hand, PhET is a compilation of virtual experiment simulations that were created by the University of Colorado Boulder. The Physics Fun application, which is a mobile application that is outfitted with V-Lab facilities, is the objective of these two platforms. The purpose of this application is to offer students a more interactive and comprehensive learning experience. Consequently, this innovation can be implemented in the field of physics education by employing suitable methodologies.

Process-Oriented Guided-Inquiry Learning (POGIL) is a guided inquiry approach that is frequently employed in scientific investigations, particularly in the field of physics. This approach can be implemented through practical exercises (Purkayastha et al., 2019) using V-Lab in this study. The POGIL strategy has proven effective in enhancing students' conceptual understanding and critical thinking skills by promoting collaborative and inquiry-based learning (DeMatteo, 2019; Tang et al., 2020). The great potential of using V-Lab and POGIL strategies in physics learning has been recognized. However, there is still a lack of empirical data on the acceptance and effectiveness of the combination of the two, especially its use in frontier areas. Research on the use of V-Lab has not specifically explored how this learning medium is received by teachers and students in very diverse contexts, such as in underserved areas (Husnaini & Chen, 2019; Poo et al., 2023; Santos & Prudente, 2022). The assessment of student perspectives in these schools has also not been a widely researched topic (Rivas et al., 2023). This study evaluates the adoption of physics learning tools in the V-Lab platform, which is implemented through the POGIL strategy in frontier areas, to address the disparity.

This study offers new perspectives on adapting learning technologies in environments with limited access and resources. Additionally, it proposes recommendations for modifying and enhancing V-Lab and POGIL strategies to meet the unique needs of frontier areas, thus contributing both practically and theoretically to physics education in underserved regions. By doing so, this research adds to academic literature and educational practice by providing data and analysis that can guide policymakers and educators in designing and implementing more effective and inclusive educational technology solutions.

Review of the literature

Virtual laboratory and POGIL *strategy*

Virtual laboratory (V-Lab) is an innovation in learning media, especially in science. V-Lab allows students to run computer simulation-based experiments that can be accessed at any time, regardless of the availability of a physical laboratory (Elmoazen et al., 2023; Yusuf & Widyaningsih, 2020). V-Lab significantly increases accessibility and allows students to learn independently (Durkaya, 2023). The use of V-Lab also promotes the development of critical thinking skills and fosters a deeper understanding of scientific concepts (Kolil & Achuthan, 2024). The use of V-Lab helps address the limitations of physical resources in schools while maintaining the quality of science education (Poo et al., 2023). Process-Oriented Guided-Inquiry Learning (POGIL) is a science learning strategy well-suited to the characteristics of physics. POGIL is a student-centered approach that involves students working collaboratively to understand concepts through guided investigations. It enables students to directly observe phenomena and understand concepts through visual experiences (Tang et al., 2020). POGIL effectively improves students' critical thinking and collaboration skills, essential in science learning, especially when using V-Lab (Donnelly et al., 2013). This strategy directs students to find solutions independently, with the instructor acting as a facilitator.

The integration of V-Lab with POGIL learning strategies provides an excellent approach to improving student engagement and learning outcomes. Integration of appropriate learning strategies not only provides a more interactive learning experience but strengthens students' understanding and motivation to learn, especially for more complex scientific concepts (Diwakar et al., 2023). The combination of V-Lab and POGIL offers a relevant solution for enhancing the quality of physics education in frontier areas of Indonesia (Yusuf et al., 2024). V-Lab provides flexibility in learning and allows students from remote areas to continue to follow interactive laboratory practices (Durkaya, 2023). The physics learning tool in this study, which is integrated with V-Lab media, offers resources, content, and features that align with the POGIL learning model. This media serves as a useful tool to enhance the learning process based on student needs. The learning stages can be tailored to fit the use of the media. For instance, when group learning is involved, students can utilize worksheet features or engage in collaborative virtual experiments. The theoretical framework of this study integrates multiple learning approaches to enhance physics education using the media. The theoretical framework is shown in Figure 1.

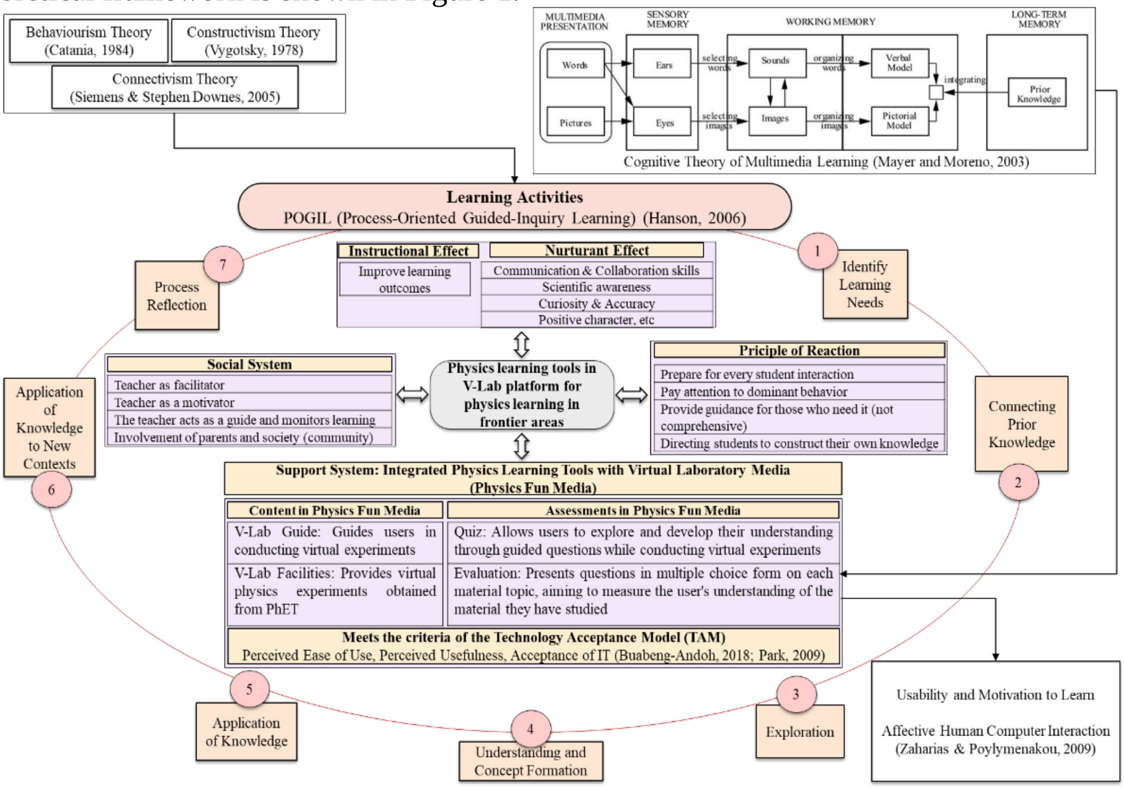


Figure 1. Theoretical framework that utilizes the V-Lab and POGIL in the frontier area of Indonesia (Yusuf et al., 2024)

The theoretical framework's application, as illustrated in Figure 1, also considers technology acceptance, which encompasses metrics such as perceived utility and simplicity of use. This is particularly critical in the frontier area of Indonesia, where physical infrastructure is scarce. Nevertheless, the utilization of technology, such as V-Lab, has the potential to expand the scope of learning opportunities and improve student engagement in the field of physics education. This framework incorporates the POGIL learning models. It is designed to provide a learning experience that is both meaningful and adaptive, and that is specifically tailored to the requirements of all students.

Mobile learning

Mobile learning that is applied in a fun way is the basis for using this application. Physics Fun is a jargon used in this study to describe fun physics learning. The Physics Fun application provides a viable solution for promoting physics education, particularly in areas with inadequate infrastructure, by integrating V-Lab media and the POGIL strategy, which still allows for the use of digital technology. The media is based on behaviorism, constructivism, and connectivism, which collectively aid students in grasping physics concepts within a digital learning environment. Mobile learning, with its accessibility across devices and the ability to learn without restrictions of time and location, plays a crucial role in this process (Abidin et al., 2023; Yosiana et al., 2021). A structured instructional system is essential for implementing mobile learning, allowing educators to deliver lesson materials in a cohesive and integrated way (Suartama et al., 2019). Applying learning methods based on learners' material and characteristics is necessary to create a conducive learning atmosphere and improve learner achievement (Iksan & Saufian, 2017). Mobile learning technology enables the incorporation of various learning models, effectively engaging learners in actively constructing their knowledge (Criollo et al., 2021). To ensure success, comprehensive learning theories must be integrated into mobile learning while taking into account factors such as the learner's age, the learning approach, subject area, user roles, and cultural values (Dong et al., 2023). Consequently, applying suitable learning strategies is crucial for the effective implementation of mobile learning.

One learning strategy suitable for applying mobile learning in science learning is POGIL. The POGIL strategy focuses on guided learning through inquiry activities, where students work in teams to understand concepts through experiments directed by the teacher as a facilitator. POGIL has improved learning outcomes, critical thinking skills, and student collaboration (Alatas & Fachrunisa, 2018; Tang et al., 2020). This approach allows students to learn more actively and build their scientific understanding through direct experience.

***Technology Acceptance Model* (TAM) *and Theory of Reasoned Action* (TRA)**

TAM and TRA are two theories that help explain the factors that influence technology acceptance by individuals. TRA, developed by Fishbein and Ajzen in 1975, states that a person's behavior is largely influenced by their intention to act, which is influenced by two main factors: attitude toward the behavior and subjective norms. Attitude refers to an individual's positive or negative evaluation of a particular behavior, while subjective norms reflect an individual's perception of the social pressures from the environment that encourage or discourage the behavior. When a person has a positive attitude toward an action and feels supported by social norms, they are more likely to have the intention to perform it (Ajzen & Fishbein, 1980). TAM, developed by Davis in 1989, adapted TRA to focus more on technology acceptance by introducing two main constructs, namely perceived usefulness and perceived ease of use. Perceived usefulness is the extent to which a person believes that using a particular technology will improve his or her performance, while perceived ease is the perception that the technology is not difficult to use. These two factors influence users' attitudes toward technology and ultimately shape their intentions to use it (Davis, 1989). The following elements of TAM and TRA as shown in Figure 2.

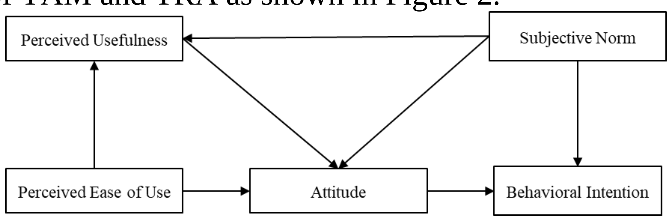


Figure 2. TAM and TRA (Andoh, 2018; Park, 2009)

Figure 2 shows the elements of TAM and TRA to illustrate the factors that influence the intention and behavior of technology use. Perceived Usefulness (PU) and Perceived Ease of Use (PEU) are two main components in TAM that describe the perceived benefits and convenience of technology (Park, 2009). These two components play a role in shaping the user's Attitude (ATT) towards the technology. In addition, PEU also has a direct influence on PU because the easier it is to use, the greater the perceived benefits (Baki et al., 2018). Subjective Norm (SN) from TRA represents social pressure or an individual's perception of the expectations of important people around him, which directly influences Behavioral Intention (BI) (Vlachy et al., 2018; Voicu & Muntean, 2023). ATT and SN together influence BI to use technology (Andoh, 2018). This BI ultimately determines whether the user will actually use the technology or not. This diagram illustrates how perception, attitude, and social norms play a role in shaping the user's intention and decision to accept or reject new technology.

Research model and hypotheses

A questionnaire was administered in this investigation in accordance with the TAM and TRA (Andoh, 2018; Park, 2009). The questionnaire was designed to evaluate the degree of user adoption of the Physics Fun app, which is a mobile application. Figure 3 illustrates the research model and hypothetical frameworks.

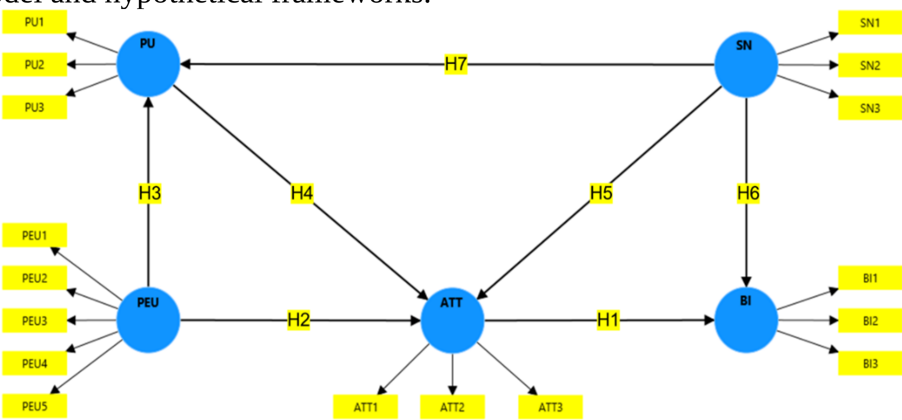


Figure 3. Research model and hypothetical frameworks

A total of seven hypotheses were tested in this study. The specific research hypotheses are outlined in detail in Table 1.

Table 1. Research hypotheses

Hypotheses code	Hypothetical statement
H1 (ATT→BI)	ATT significantly and positively impacts BI
H2 (PEU→ATT)	PEU significantly and positively impacts ATT
H3 (PEU→PU)	PEU significantly and positively impacts PU
H4 (PU→ATT)	PU significantly and positively impacts ATT
H5 (SN→ATT)	SN significantly and positively impacts ATT
H6 (SN→BI)	SN significantly and positively impacts BI
H7 (SN→PU)	SN significantly and positively impacts PU

Methodology

This study employs quantitative methods, specifically using questionnaires for data collection. The analysis of questionnaire data has been conceptualized, validated, and analyzed through SEM software, specifically SmartPLS 4.

Research participants

The Physics Fun application was implemented in one of the senior high schools in West Papua Province. The number of students who studied using the Physics Fun application was 136 people, 57.4% female and 42.6% male. Figure 4 shows students' learning activities using the Physics Fun application as a learning medium.

Figure 4. Student learning activities using the Physics Fun application

Learning with the Physics Fun application can occur both in the classroom and outside of it. Students have the ability to access a range of features within the application, enabling them to collaborate on virtual practicums or review the available materials.

Data collection and research procedure

Data were collected through a structured questionnaire distributed in November 2023 after students participated in learning using the Physics Fun application. The research procedure carried out is explained in Figure 5.

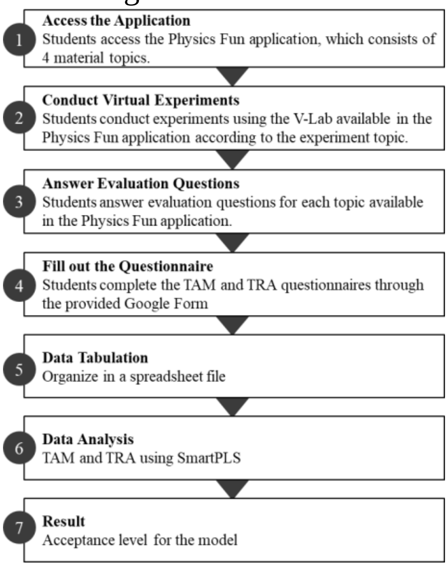


Figure 5. Research procedures carried out

This study began with students accessing the Physics Fun application, which contains four topics of physics material. In this first stage, students are introduced to the application to learn the available materials. After that, students conduct virtual experiments using the V-Lab in the application. Experiments are carried out according to the topics that have been studied to deepen students' understanding. After completing the experiment, students are asked to answer evaluation questions related to each subject in the Physics Fun application. These questions are designed to measure their understanding of the material studied. The next stage is to fill out a questionnaire that includes the TAM and TRA models. This questionnaire is given via Google Forms and aims to obtain data on students' perceptions and level of acceptance of using the Physics Fun application. The data collected from the questionnaire are then tabulated in a spreadsheet file to facilitate the analysis process. Data analysis was conducted using SmartPLS 4 software to evaluate the TAM and TRA models used in this study. The analysis results show the level of student acceptance of the model, which will provide an overview of the extent to which the Physics Fun application is accepted and utilized by students in learning physics.

Instruments

The instruments utilized in this study were the TAM and TRA questionnaires, which were completed by students after engaging with the Physics Fun application (https://bit.ly/surveiphysicsfun-TAM-CRA). The introductory section of the survey included guidelines for filling out the TAM and TRA questionnaires. A 7-point Likert scale was utilized for the conceptual framework. Table 2 displays the indicators and statements related to the instruments employed in this study.

Table 2. TAM and TRA questionnaire grid for the use of the Physics Fun application

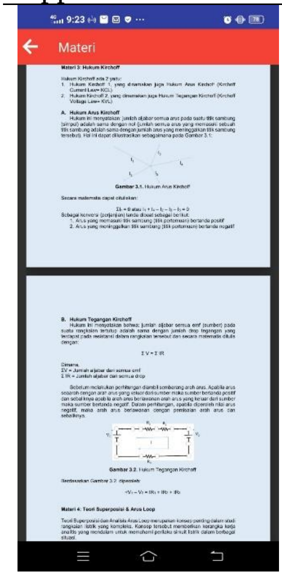
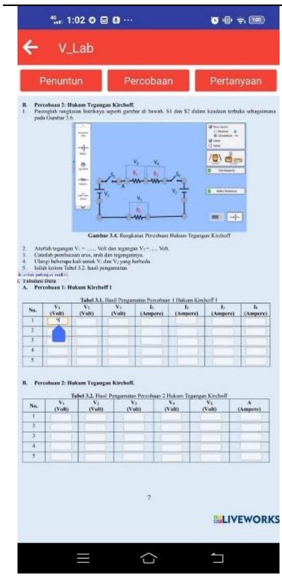
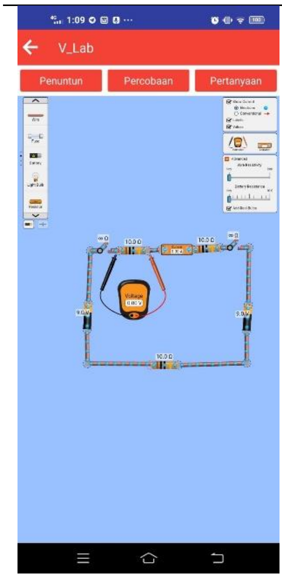
No.	Indicator	Item Code	Statement
1	Perceived Usefulness (PU)	PU1	Using the Physics Fun Mobile App allows me to complete tasks faster
		PU2	Using the Physics Fun Mobile App improves my performance
		PU3	Using the Physics Fun Mobile App will improve my productivity
2	Perceived Ease of Use (PEU)	PEU1	The Physics Fun Mobile App is user-friendly and facilitates my objectives
		PEU2	My interactions with the Physics Fun Mobile App do not require much effort
		PEU3	I have no difficulty acquiring the necessary skills to operate the Physics Fun Mobile App
		PEU4	I am in charge of the Physics Fun Mobile App
		PEU5	I am aware that it is imperative to utilize the Physics Fun Mobile App
3	Attitude (ATT)	ATT1	I look forward to aspects of assignments that require me to use the Physics Fun Mobile App
		ATT2	I enjoy learning to use the Physics Fun Mobile App
		ATT3	I am enthusiastic about utilizing the Physics Fun Mobile App
4	Subjective Norm (SN)	SN1	The Physics Fun Mobile App is recommended by individuals who have an impact on my behavior
		SN2	Individuals who are significant to me will lend their assistance in utilizing the Physics Fun Mobile App
		SN3	Individuals whom I hold in high regard will endorse the utilization of the Physics Fun Mobile App
5	Behavioral Intention (BI)	BI1	I plan to continue utilizing the Physics Fun Mobile App in the future
		BI2	I anticipate that I will utilize the Physics Fun Mobile App in the future
		BI3	In the future, I intend to utilize the Physics Fun Mobile App

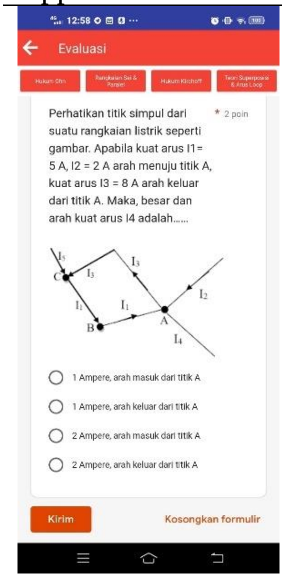
Source: (Andoh, 2018; Mulyanto et al., 2020; Park, 2009)

TAM and TRA questionnaires were administered at the conclusion of the learning process following the use of the Physics Fun application. Access to the Physics Fun application is available at the following link: https://bit.ly/PhysicsFun1. The appearance and function of the Physics Fun application are as in Table 3.

Table 3. Appearance and function of the Physics Fun application

Appearance	Description
	The initial display is designed with essential elements that interest users to learn physics interactively and have fun. The Splash Screen displays the title and a logo representing the Physics Fun concept, which is expected to encourage user curiosity. There is also a button to start the application. When the user clicks the button, they will enter the main menu. The main display also includes icons of the programs used to develop the application. This is an appreciation that this application is a product developed using Kodular, PhET, Canva, G-Form, and Liveworkshet.
	The menu page is designed with user convenience and ease of navigation in mind and displays the various features available. The menu display is designed to provide quick and direct access to different learning materials available in the application and provide information about the application's profile and purpose. Users can easily access the content they want by giving precise and direct buttons for essential materials or by returning to the application's main display.

Appearance	Description
	The Material Display consists of a complete and structured explanation. This explanation includes laws, basic principles, formulas, or theories related to dynamic electricity. Using supporting images, graphs, or diagrams to explain complex concepts. This illustration helps students better visualize the concept of dynamic electricity. Application of the idea of dynamic electricity in the context of real-world or everyday technology. This comprehensive Material Display aims to provide in-depth explanations and trigger critical thinking to help better understand and apply the concepts of dynamic electricity.
	The worksheets in the application consist of explanations of virtual experiments. The worksheets also consist of detailed steps on how students should complete the task or activity. The worksheets consist of illustrations in images or fill-in tables to help students understand the functions or concepts being studied. Students can input the results of their observations directly through the available live worksheets so that the worksheets do not need to be printed but can also be printed according to their needs.
	The virtual experiment in the Physics Fun application has components, namely a visualization or simulation area, to display experiments that represent processes or phenomena related to dynamic electricity, such as electrical circuits, measurements of electrical quantities, and others. The virtual experiment display in this application aims to provide an interactive experience that supports understanding the concepts of dynamic electricity. By presenting attractive and interactive visualizations, this virtual experiment allows students to observe and understand phenomena related to dynamic electricity like a real laboratory experiment.

Appearance	Description
	The evaluation view includes multiple-choice questions of varying difficulty levels to test students' understanding. After answering each question, students receive feedback on the correct answers. This feedback helps students improve their knowledge. The scoring system provides an overview of how well students have completed the exercises. This evaluation supports effective learning by presenting a variety of questions and providing appropriate feedback.
	About App provides information about the app, including the developer, resources, or contact information. This feature also provides a guide or instructions for new users if they have technical questions about using the app. This feature also gives users access to more information or help if needed.

Data analysis

A total of 136 questionnaire forms have been filled out by students via Google Forms. The analysis used 136 sets of completed questionnaires. The amount of data has met the testing requirements using SEM PLS.

Research findings

Overall model assessment

The validity and reliability of the measurement model were assessed in this investigation. Assessments of Convergent Validity and Discriminant Validity comprised the validity tests. The Composite Reliability (CR) and Cronbach's Alpha (CA) values were computed to assess reliability. The testing was conducted in two stages: the first stage evaluated the Outer Loading or Loading Factor, and the second stage examined the Average Variance Extracted (AVE). The Fornell-Larcker Criterion value was determined, which represents the average Cross Loading value for a latent variable construct, following the interpretation of SEM. Table 4 presents the findings regarding Fornell-Larcker Criterion values, Cross Loading, CA, CR, and AVE.

Table 4. Cross loading and fornell larcker criterion values, CA, CR, and AVE

	Cross Loading					CA	CR	AVE
	ATT	BI	PEU	PU	SN			
ATT1	0.841	0.621	0.689	0.571	0.708	0.845	0.907	0.764
ATT2	0.906	0.678	0.687	0.611	0.710			
ATT3	0.874	0.670	0.672	0.579	0.642			
ATT	0.874							
BI1	0.725	0.908	0.719	0.712	0.753	0.905	0.940	0.840
BI2	0.674	0.924	0.602	0.681	0.711			
BI3	0.663	0.917	0.615	0.595	0.660			
BI	0.751	0.916						
PEU1	0.712	0.669	0.797	0.647	0.683	0.883	0.914	0.681
PEU2	0.615	0.521	0.825	0.463	0.593			
PEU3	0.730	0.683	0.860	0.716	0.726			
PEU4	0.531	0.519	0.832	0.529	0.658			
PEU5	0.589	0.470	0.810	0.508	0.566			
PEU	0.781	0.706	0.825					
PU1	0.641	0.671	0.654	0.939	0.687	0.920	0.949	0.862
PU2	0.597	0.640	0.585	0.918	0.644			
PU3	0.632	0.707	0.726	0.928	0.677			
PU	0.672	0.726	0.708	0.928				
SN1	0.655	0.619	0.741	0.639	0.893	0.887	0.930	0.815
SN2	0.722	0.721	0.731	0.634	0.910			
SN3	0.746	0.750	0.669	0.679	0.905			
SN	0.786	0.775	0.789	0.721	0.903			

According to Table 4, the Loading Factor values for all valid items exceed 0.7 (Götz et al., 2010) or fall between 0.4 and 0.7 (Henseler et al., 2009), thereby allowing for the direct fulfillment of bootstrapping and Q prediction. Discriminant Validity assesses how distinct a construct is from other constructs, with validity indicated by cross-loading values greater than 0.70. As shown in Table 4, each variable demonstrates strong correlations, as their correlation values are higher than those of other variables. The AVE values for the constructs are as follows: ATT at 0.764, BI at 0.840, PEU at 0.681, PU at 0.862, and SN at 0.815, all meeting the criterion of ≥ 0.5. A construct is considered reliable when both CA and CR values exceed 0.70 (Hair et al., 2021). Table 4 shows that all variables have values greater than 0.70, indicating their reliability.

Structural model analysis evaluates hypotheses regarding the relationships between variables outlined in the model. Several stages must be completed as prerequisites for this analysis; the first involves assessing the Outer Model Collinearity Statistic (VIF), and the second focuses on the Determination Coefficients (R^2). VIF is utilized to detect collinearity, ensuring that no variable exhibits a correlation that exceeds the acceptable threshold for model constructs. The analysis results indicated that all variables had appropriate VIF values, specifically greater than 0.2 and less than 5 (Hair et al., 2021), indicating that the constructs in this research are valid across all variables.

Structural model testing

The p-value and t-statistic values can be analyzed to conduct hypothesis testing. A hypothesis is accepted if the p-value is less than 0.05 and the t-statistic is greater than 1.96 (Hair et al., 2021). Six of the seven hypotheses that were evaluated exhibited t-statistic values exceeding 1.96 and p-values below 0.05, which suggests that these hypotheses had a significant effect, as shown in Table 5. Additionally, Table 5 emphasizes that one hypothesis was rejected due to its failure to satisfy the specified criteria.

Table 5. Bootstrapping direct effect

H-Code	Path	Path Coefficients	t statistics	Decision	p Values	Decision
H1	ATT → BI	0.372	3.720	Accepted	0.000	Significant
H2	PEU → ATT	0.387	2.747	Accepted	0.006	Significant
H3	PEU → PU	0.367	2.162	Accepted	0.031	Significant
H4	PU → ATT	0.107	0.677	Rejected	0.499	Not Significant
H5	SN → ATT	0.403	3.898	Accepted	0.000	Significant
H6	SN → BI	0.483	5.412	Accepted	0.000	Significant
H7	SN → PU	0.432	3.249	Accepted	0.001	Significant

Figure 6 shows the tested model. This model explores the relationship between several latent variables, such as PU, PEU, SN, ATT, and BI. Each variable is represented by indicators shown with loading factor values and significance levels (p-values). The direction of the arrows indicates the hypothesis or relationship between variables, along with the path coefficients and their p-values.

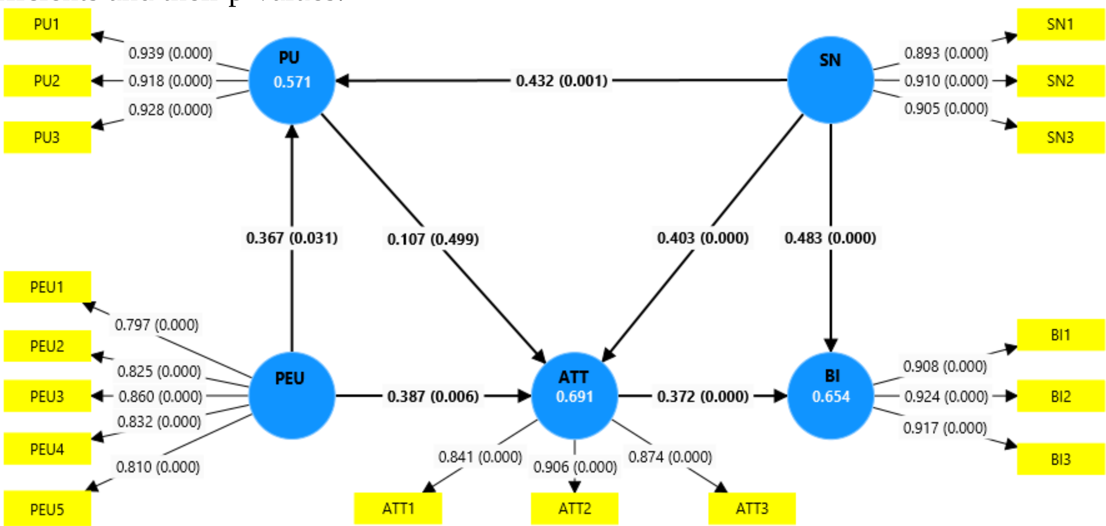


Figure 6. SEM PLS model tested

Figure 6 illustrates that each variable is assessed using loading factor value indicators. The loading factor values fall within the strong category, indicated by numbers that are close to or greater than 0.7, signifying the reliability of the measurement for each indicator.

Discussion

The results of this analysis indicate that ATT has a substantial impact on BI, with a path coefficient of 0.372 and a p-value of 0.000 (H1). The TAM, which asserts that a positive attitude toward technology is a critical factor in determining the intention to use it, is corroborated by this result (Davis, 1989). In the context of information systems, the adoption of new technologies is contingent upon the presence of positive attitudes (Ardıç, 2021; Venkatesh et al., 2016). These results suggest that individuals who have a more favorable perspective on technology are more likely to employ it (Turan et al., 2022). These positive attitudes are likely to be further bolstered by the Physics Fun application, which features a responsive and visually enticing design that is optimized for mobile devices. Its User Interface (UI) and User Experience (UX) designs are informed by a variety of technical factors to enhance learning outcomes and ensure a seamless user experience (Miya & Govender, 2022; Sunarto et al., 2020). Additionally, technical support is a critical external variable in the technology acceptability model (Caratiquit & Caratiquit, 2022). The Physics Fun application is responsive to user input and functions efficiently on a variety of devices with varying screen sizes. Therefore, it is essential to have a design that is both adaptive and responsive in order to foster positive attitudes toward technology.

The second hypothesis (H2) indicates that PEU significantly influences ATT, with a path coefficient of 0.387 and a p-value of 0.006. This finding suggests that the easier a technology is to use, the more positive the user's attitude toward it. The Physics Fun application provides straightforward navigation and comprehensive features that enhance the learning experience, including access to materials, virtual experiments, and assessments without the need for login or a leveling system, as seen in many games. Students can review the evaluation results after completing a learning session, which is crucial for measuring performance and tracking learning progress (Ulfa et al., 2024). The Physics Fun application's structured content organization enables users to learn in a progressive manner, beginning with fundamental concepts and progressing to more intricate subjects (Nasrullah et al., 2024). Furthermore, the application is consistent with the POGIL learning model, which can be effectively implemented by utilizing available resources, including technological tools (Shea & Bidjerano, 2010). The Physics Fun application expands the learning experience beyond the classroom by providing learning opportunities that are not constrained by time or space and are accessible through mobile devices (Hamid et al., 2019). This accessibility enables students to capitalize on the Physics Fun application's extensive capabilities. It offers a variety of content, such as virtual experiments and physics-related inquiries, that enhances students' understanding of physics concepts through practical and interactive experiences. Users are capable of observing, manipulating, and evaluating these concepts in a practical context (Maulidah & Prima, 2018). The application accommodates a variety of learning requirements by presenting physics content in a variety of formats. In general, these findings underscore that users are more likely to employ technology that is readily accessible and navigable.

The third hypothesis test (H3) revealed that PEU had a substantial impact on PU, with a path coefficient of 0.367 and a p-value of 0.031. The argument that the perceived utility of technology is more excellent the simpler it is to use is substantiated by this discovery. PEU is a significant determinant of perceived utility, particularly in the context of complex technologies or newly introduced systems (Baki et al., 2018). In this investigation, the significance of guaranteeing that the technology introduced is user-friendly is underscored by the positive correlation between PEU and PU. This is done to enhance the perceived utility of the technology.

The fourth hypothesis test (H4) results, which indicated that PU had a substantial impact on ATT, were rejected with a path coefficient of 0.107 and a p-value of 0.499. This demonstrates that user attitudes toward technology are not significantly influenced by perceived utility in the context of this study. However, attitudes are not consistently determined by perceived efficacy; rather, user experience and other factors are more influential (Bancoro, 2024). The use of the Physics Fun application is something new for students, so the perception of use is initially less confident that it can improve their performance in learning. However, in the end, students can understand the use of the Physics Fun application. The Physics Fun application can overcome the limitations of existing equipment and resources, especially in frontier areas. This shows that the initial perception of using this application, which is not good, can facilitate more effective physics learning by accommodating various student learning needs.

The fifth (H5) and sixth (H6) hypotheses demonstrate that SN influences ATT and BI. The path coefficients for SN to ATT and SN to BI are 0.403 and 0.483, respectively, with a p-value of 0.000, respectively. These values suggest a highly significant relationship. This is consistent with the TRA theory, which posits that subjective norms, or individual perceptions of social pressure, significantly influence attitudes and intentions to act (Andoh, 2018). These findings bolster the hypothesis that social norms significantly influence the formation of individual attitudes and behavioral intentions, which is consistent with prior research findings that individuals tend to adhere to the prevailing norms in their environment in order to avoid social dissonance and achieve conformity (Park, 2009; Vlachy et al., 2018; Voicu & Muntean, 2023). In addition, the strong relationship between SN and BI also underlines the importance of considering social influence in designing interventions aimed at changing attitudes and behaviors because social support can be a significant motivating factor for individuals to take specific actions.

The results of the seventh hypothesis (H7) suggest that PU is substantially influenced by SN, as evidenced by a path coefficient of 0.432 and a p-value of 0.001. Perceptions of the utility of a technology are frequently influenced by social factors, particularly within digital communities or social networks (Vlachy et al., 2018). Users frequently evaluate the utility of technology by relying on the opinions or expectations of others, underscoring the influence of social factors on technological perceptions.

This is demonstrated in the Physics Fun application, which enables students to engage in virtual practicums or investigate preexisting materials. Furthermore, the Physics Fun application offers users valuable feedback upon completion of evaluations, virtual experiments, or attempts to answer physics queries. Students' motivation to engage with and study the materials can be improved by providing timely feedback in mobile-based learning (Crompton et al., 2016). Students are able to monitor their progress, develop a more profound comprehension of physics concepts, and enhance their knowledge by utilizing the assessments that are offered. Consequently, the Physics Fun application's capabilities can be instrumental in the integration of social factors that influence technology's perceptions.

This study demonstrates that combining TAM and TRA offers valuable insights into the factors influencing technology acceptance. Attitudes, subjective norms, perceived usefulness, and ease of use are critical in shaping users' intentions to adopt technology. Although some findings, such as the lack of influence of perceived usefulness on attitudes, differ from previous studies, the results still provide a comprehensive understanding of how social factors, attitudes, and ease of use contribute to technology adoption.

Conclusion

The results showed that ATT and SN were two main factors that influenced BI to adopt technology. Positive attitudes toward technology, driven by PEU and social influence, were shown to be significant in increasing one's intention to use technology. PEU not only influenced attitudes, but also PU, which reinforced the importance of creating easy-to-use technology to increase acceptance. However, contrary to the basic assumption of TAM, PU did not significantly influence user attitudes in this study, indicating that in some contexts, other factors such as user experience may be more important. SN derived from social pressure or expectations of others, was also shown to influence attitudes, behavioral intentions, and perceived usefulness. Social influence plays an important role in driving technology adoption, especially in the digital era where social networks and digital communities are becoming increasingly important. Overall, this study confirms the importance of psychological and social factors in technology acceptance. Therefore, teachers and technology developers should focus on improving ease of use and strengthening social factors to increase technology acceptance, as well as emphasizing social benefits and easy access in the learning process.

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