Study of Factor Analysis on Game-Based Learning for Scaffolding Installation Activities in Education and Training for Indonesian State Electricity Company Employees

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***Abstract*—One of the appropriate ways to improve learning is to create innovations to attract students' interest in learning. To support this, UPDL-Semarang introduced the concept of learning through game-based learning in the practice of assembling and disassembling scaffolding or called GS-PVE. The purpose of this study is to analyze the factors that influence the interest in the application of GS-PVE. To achieve these goals, there are several factors, i.e., Authenticity, Engagement, Learning Motivation. This study uses quantitative research with a sample of 53 respondents which aims to collect data through Structural Equation Modeling (SEM). Validity and reliability tests were also applied to measure the validity and reliability of the data collected, the results obtained showed that all items were valid and reliable. The results of the proposed hypothesis that learning motivation has a positive and significant effect on interest in using the GS-PVE application with a p-value of 0.004 and the highest coefficient value of 0.514. This is in accordance with the hypothesis proposed, students like the concept of game-based learning in the GS-PVE application, students also operate the application for a long time. This research model shows that Authenticity, Engagement, and Learning Motivation that explain the variable Interest in Using the GS-PVE Application is 55.0\%, based on the value of R-Square 0.550, the rest can be influenced by other factors outside the variables studied.**

***Index Terms*—Game-based learning, authenticity, engagement, learning motivation, interest of using.**

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I. Introduction

The concept of learning using technology is increasing along with the limitations that cannot be solved by humans such as limited time, place, safety, and tools. From these limitations emerge innovations that aim to be able to continuethe learning process. One of the innovations in learning techniques is by utilizing game-based learning technology. Game-based learning technology can be applied to learning activities because it can be adapted into future educational curriculum and has little risk for users on the safety side [1]. The use of game-based learning methods in the field of education shows increase in the output of learning activities, and it is felt by students and teachers [2], [3].

Game-based learning is introduced to students to provide an immersive and interactive motivational experience. The implementation of game-based learning is applied to the assembling and disassembling of scaffolding or called Game-based learning of Scaffolding Practices in Virtual Education (GS-PVE). The development of game-based learning follows the rules that have been provided based on the applicable curriculum and follows work safety standards.

The usual obstacle the students face when using a game-based learning application is the will to use the application [4]. To find out the Interest of Using the GS-PVE application that has been built, it is tested on students. Several known factors need to be measured so that a conclusion can be drawn with the resulting level of influence. In this study, the factors considered to have an influence on Interest in Using GS-PVE applications are authenticity, engagement, and learning motivation [5]. A review of the factors that influence the interest in using the application is described in detail based on the data obtained through the questionnaire.

II. Related Works

Several interactive learning methods have been implemented, i.e., learning using Augmented Reality or Virtual Reality immersive technology. Research conducted by Ilham Achmad Al Hafidz *et al.* [6] is building a virtual clinical practicum learning module, which consists of normal delivery care, human anatomy collaboration, and childbirth surgery for medical students using virtual reality technology presented on WebXR which is a novelty to help the field

practical on medical learning.. However, in this study the users need to have an expensive equipment such as VR Headset, therefore not all education institution can use this application. And there is no measurement of the level of satisfaction from users, so the impact of using virtual reality technology on the medical field is not known and the study also did not measure the user experience when using the developed application.

The application of immersive technology was also carried out by Evianita Dewi Fajrianti *et al.*, [7], [8] by building a human anatomy learning platform for medical students by utilizing Augmented Reality and Augmented Intelligence technology. The content displayed in this study is part of the human body which is composed of many systems i.e., skeletal, muscles, respiratory, nervous, and other systems. The other content of the study is human body tracking system to place the rigged 3D asset to human body through camera in real-time. The platform can be executed on iOS and Android operating systems. This study also tested the level of satisfaction and importance of the platform to users through a questionnaire. The measurement of satisfaction and importance is based on the PIECES framework and Likert scale which is tested on medical students. The results obtained are that students are satisfied with the performance, information, and data security when running the platform. However, the metrics used to measure the user's response is meant to measure the performance of the software not the other way.

Research conducted by Yulita Ayu Rengganis *et al.* [9] is to build a virtual laboratory to conduct practical work in the virtual world by displaying scenarios built on a head-mounted display device and controlled using hand motion gestures. This study was tested on junior high school and high school students for a chemistry practicum scenario. The use of hand motion gesture as the hand controller is considered novelty when the new VR headset and controller hasn't hit the market just yet. However, the data obtained from the questionnaire was only shown in the form of a pie chart, and no further processing was carried out to obtain the relationship between responses and research objectives.

The same research was also conducted by Sritrusta Sukaridhoto *et al.* [10] designed 3D virtual chemistry which was implemented in chemistry learning through a 3D VR headset. This study has not fully discussed the impact of using the proposed immersive technology, so it is not possible to know the level of motivation to use this platform to support virtual learning. And the lack of metrics to measure the accuracy of hand movement from the sensor used to the VR environment thus creating a shallow conclusion.

A game-based learning witch takes advantages of the growth of smartphone and the limitations created from the COVID19 pandemic is conducted by Akrivi Krouska et al. [11]. The MGbL or Mobile Game-based Learning is designed to help the students in higher education to learn the C# programming language. Choosing a smartphone as a learning platform for the MGbL is a great move considering the number of students that use smartphone every day. And the relationships between each variables used to measure the outcome of the study is explicitly described. However, the scenario of the MGbL is not explained and creates confusion about whether the experiment took place or not. While MGbL is a game-based learning the personalized learning variables which is meant to be tailored and specifically designed to accommodate students to better understanding specific materials did not have a significant effect on MGbL.

III. Methodology

A. System Overview

Game-based learning in education has become a recent issue. Game-based learning is widely used to support learning, both practical and theoretical, packaged in interesting and interactive games [12]. The use of game-based learning in education has a positive impact, one of which is as an alternative to support virtual learning when direct learning cannot be implemented [13]. Learning to use game techniques becomes interesting because there is no compulsion in playing it. Like a game that gives players the opportunity to repeat and correct mistakes when they fail. One of the uses of game-based learning can be applied to the installation of scaffolding. Game-based learning is applied to the practice of assembly and disassembly with various considerations, i.e., practice in the field that requires a large space, good team coordination, and strict supervision of occupational safety and health standards, as shown in Fig. 1.

Fig. 1. Physical practice of scaffolding assembly and disassembly.

The existence of problems in physical practice such as the limitations of the modules used can reduce time efficiency, namely, students only see and wait their turn, nor does it guarantee that students are able to follow the rules and steps in accordance with the applicable rules due to time constraints. This is certainly a special concern in physical exercise to increase the success rate by updating teaching techniques [14]. Based on these problems, the GS-PVE application was built as a support module before the physical practice was implemented to minimize conflicts. GS-PVE has been adapted to the learning objectives by transferring the scenario and design of learning activities [15].

Game-based learning for scaffolding installation was developed by game application developers from Politeknik Elektronika Negeri Surabaya (PENS). The developer has understood the practical steps of the scaffolding installation based on the modules obtained from the authorized parties to be built in the virtual world. This application has gone through the inspection phase of the relevant agencies and is appropriate to operate. The following Algorithm 1 is pseudocode for the operation of GS-PVE.

```
Begin MainMenuScene
   Switch
      TrainingModeSelection do
      Case 0 do
         default;
      Case 1 do ChooseAssembly
         Bool AsssemblyChosen = true;
      Case 2 do ChooseDisassembly
         Bool DisassemblyChosen = true;

   If AsssemblyChosen or DisassemblyChosen
      Switch
         Do PlayModeSelection
         Case 0 do
            Default;
         Case 1 do SinglePlayerMode;
            Bool SinglePlayer == true;
         Case 2 do MultiPlayerMode;
            Bool MultiPlayer == true;
```

Algorithm 1: Operation of GS-PVE

While using the application, students must be under the supervision of the teacher to provide instructions to students who are operating. Communication in the application is done through audio to make it easier for users to coordinate when the practice is carried out. This application is designed with two player options namely single player and multiplayer, as shown in Fig. 2.

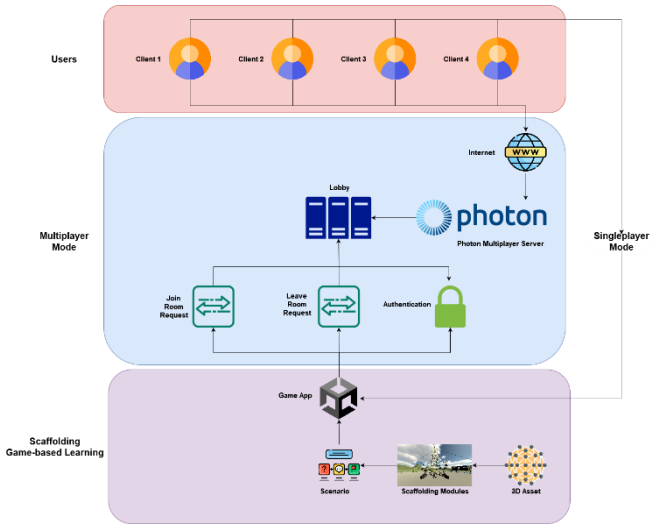


Fig. 2. Game-based learning architecture of scaffolding installation.

The single player scenario has the same scenario as the multiplayer scenario, but in the single player scenario all the practicum steps are carried out individually. Also, there is no assessment of each success. The single player is intended as a readiness exercise for students before entering a virtual class based on a predetermined schedule. Then for the multiplayer scenario, each class is set to a maximum of 20 players with different identities based on the names that have been entered at login phase. Multiplayer is intended to assess the cohesiveness of students in working together to install and dismantle scaffolding. There are several scenarios that can hone student's motor skills by collaborating, such as arranging scaffolding with different height rules, pulling the guy rope to hold the scaffolding, coordinating to measure the balance of the scaffolding using a water pass and sending information to students who are responsible for installing scaffolding at a certain height.

B. Game-Based Learning Scenario

In the GS-PVE scenario using game-based learning technology in the virtual world, there is movement control that is adjusted to the user's comfort to make it easier for users to operate. The motion control consists of grabs, releases, and points to manipulate the position of objects. Then for activity control consists of forward, backward, run, up, and down. All movements in the GS-PVE scenario are controlled using the keyboard. Every step that students take can be observed directly by the teacher, there are also reports on every transition of experimental steps that require a confirmation from participants, such as confirmation of having used Personal Protective Equipment, and confirmation of scaffolding height. After students carry out virtual practicum by utilizing a GS-PVE application that is operated using a computer, students are asked to submit responses through questionnaires with predetermined items. The students need to choose between single player or multiplayer mode before using the GS-PVE and some feature will need and internet connection for multiplayer and storing data to server as shown in Algorithm 2.

```
Begin TrainingScene
   If AsssemblyChosen and SinglePlayer
      Do AssemblyOfflineTraining;
   If AsssemblyChosen and MultiPlayer
      Do AssemblyOnineTraining;
   If DisassemblyChosen and SinglePlayer
      Do DisassemblyOfflineTraining;
   If DisassemblyChosen and MultiPlayer
      Do DisassemblyOnlineTraining;

Function AssemblyOfflineTraining
   Do NeedInternet
   Bool UseInternet = false;
   For sequence Assemblytask1 to Assemblytask(n)
      If taskFinished == Assemblytask(n)
         Bool AssemblyFinished = true;

Function AssemblyOnlineTraining
   Do NeedInternet
   Bool UseInternet = true;
   For sequence Assemblytask1 to Assemblytask(n)
      If taskFinished == Assemblytask(n)
         Bool AssemblyFinished = true;

Function DisassemblyOfflineTraining
   Do NeedInternet
   Bool UseInternet = false;
   For sequence Disassemblytask1 to Disassemblytask(n)
      If taskFinished == Assemblytask(n)
         Bool DisassemblyFinished = true;

Function DisassemblyOnlineTraining
   Do NeedInternet
   Bool UseInternet = true;
   For sequence Disassemblytask1 to Disassemblytask(n)
      If taskFinished == Assemblytask(n)
         Bool DisassemblyFinished = true;

Function NeedInternet
   Do MultiPlayerManager
   Do StoreData

Function MultiPlayerManager
   Do ConnectToMultiPlayerServer

Funtion StoreData
   Do ParseParticipantData;
   Do ParseParticipantScore;
```

Algorithm 2: Operation of GS-PVE training selection

C. Game-Based Learning Mehcanic

The need to add a game like mechanics is essential for a game-based learning system [5]. The mechanics used in GS-PVE such as task sequence or quests in game terms, scores, or reward and lastly notification sound to represents the completion of tasks. To ease the users learning experience the tasks that designed have a guidance such as highlighted object destination as shown in Fig. 3.

The purpose of this mechanics is to ease the use for beginners when completing the training in GS-PVE. Upon completing one task a sound of completion, such as "cling", will appear to notify the user that the task is complete and need to move to the next task. To fully recreated the activity, we need more than 160+ tasks that is developed using Unity Game Engine as shown in Fig. 4. The task is sequence list therefore the next task will not be assigned if the current task is not finished.

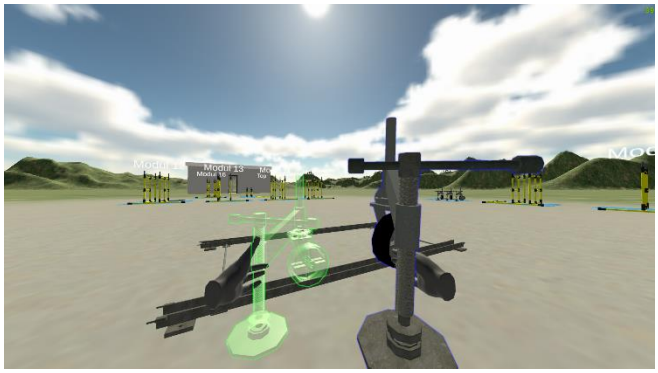


Fig. 3. Object highlight in destination.

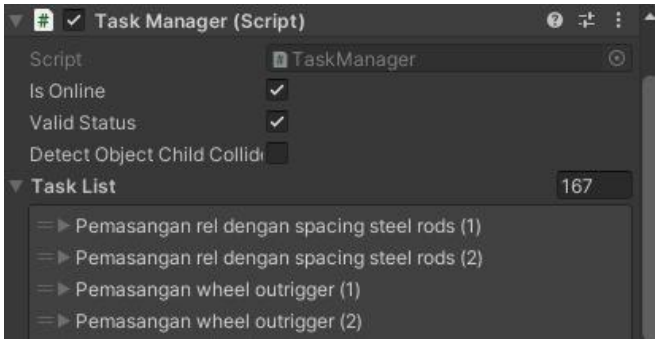


Fig. 4. Task list of GS-PVE.

The tasks given are accumulatively adds the score up to 100, and if the user makes mistake the score will naturally decrease. The score is sent to the server for evaluation by the instructor. The details sent to the server after a session of training can be seen in Fig. 5.

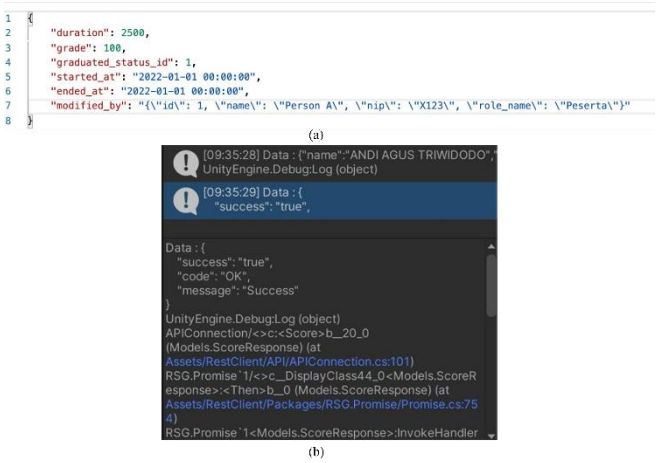


Fig. 5. (a) Postman-side score log (b) Unity-side score log.

For the score and various data such as duration, time start and end, user's name, user's ID, and user's role such as in Fig. 5. Those data above are used to examine the user's competence after the users receive training whether in class or by using GS-PVE. On the Fig. 5a. is the log postman-side of the data received from Unity Side and will be forwarded to the central server and the Fig. 5b. is the log Unity-side of the data after user's training.

IV. Research Model and Hypotheses

In this study, hypotheses were developed in accordance with the determinants of the study. Interest in using GS-PVE applications has increased since the emergence of learning from home innovations due to the pandemic, limited time, limited modules, to work safety considerations during bad weather. From this condition, it is possible to innovate learning techniques using game-based learning which can be operated at any time as an exercise tool before doing physical practice. The authenticity of the application of GS-PVE cases is considered new, so it can attract student's interest to use it. Game-based learning-based learning is considered authentic because activities in the physical world can be applied to the virtual world as if imitating the real situation. From this case, the proposed hypothesis is:

H1: Authenticity directly has a positive and significant effect on Interest in Using the GS-PVE application.

As a result of the physical limitations of the practicum, it can reduce the interaction of students with one another. To maintain student interaction, the scaffolding application is equipped with a multiuser system that can be operated between students. From this case, the proposed hypothesis is:

H2: Engagement directly has a positive and significant effect on Interest in Using the GS-PVE application.

Learning Motivation is the main factor for learning success. Learning must continue to provide innovation to increase learning motivation in students. To increase learning motivation, learning using game-based learning techniques is applied to present a learning atmosphere such as playing games without coercion, so that students feel unburdened to get satisfactory results. Students can repeat the practical steps for a long time without any restrictions and disadvantages. Based on this case, the proposed hypothesis is:

H3: Learning Motivation directly has a positive and significant effect on Interest in Using the GS-PVE application.

This study tested three hypotheses (H1, H2, H3) with the research model using the Structural Equation Modeling (SEM) method shown in Fig. 6.

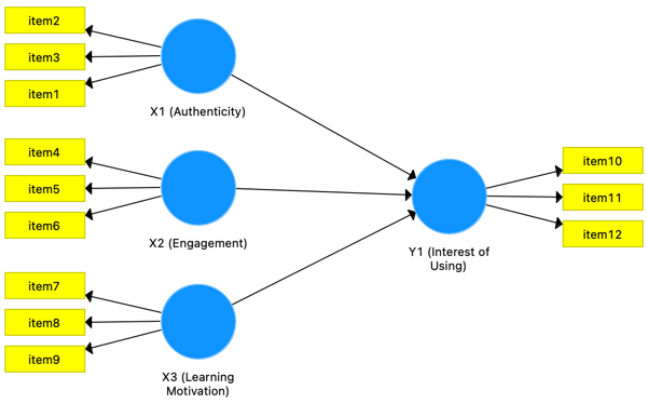


Fig. 6. SEM Research models and hypotheses.

The research model used has two latent variables, namely exogenous variables (Authenticity, Engagement, Learning Motivation) which are symbolized by X1, X2, and X3. While the endogenous variable in this model is Interest in Using which is symbolized by Y1, Fig. 6 shows that endogenous variables are affected by exogenous variables.

A. Instrument

Questionnaires are used as an alternative to data collection involving components of questions and written statements given to respondents to be answered. The questionnaire given

is divided into two components, namely the demographic component of the respondents consisting of gender, age, and education, as well as a question instrument component based on a five-level *Likert* scale. It is used to measure authenticity of interest when using the GS-PVE application [16]. Engagement to use the application and learning motivation to use the application based on interest to use. Questionnaires were given to participants who have operated GS-PVE in a multiuser room with an adequate internet connection, at least with a speed of 20 Mbps to maintain real-time collaboration and user convenience, as well as minimum computer specifications as shown in Table I. Operation of GS-PVE with supervisor's guidance to guide practical steps.

TABLE I: GAME-BASED LEARNING DEVICE AND CONNECTION RECOMMENDATION

CPU	4 Core 2.5GHz i5 gen 7 codename Kaby Lake
RAM	4GB
GPU	GTX1050 VRAM 2GB
Shader Model	1.5
Connection Speed	20Mbps

The items used to measure user experience refer to the research of Chang *et al.*. [17].Which has been modified to be applicable to the implementation of scaffolding installation practices [18]. The respondents were students who did virtual scaffolding practicum at UPDL-Semarang, Indonesia. To get respondents, it is necessary to use a sampling technique. The sample is part of the number and characteristics inherent in a population to be studied. in this study using the *Taro Yamane* technique to represent the number of students who must fill out so that the respondent's data can be said to be valid and can be used. From a total of 97 students, the number of samples was 49 respondents.

B. Variable

The research variables in this study were used to obtain information and draw conclusions. This research uses latent variable and measured variable. Latent variable is a variable that is influenced indirectly by the measured variable. The endogenous latent variable in this study is Interest in Using (Y1). Exogenous latent variables in this study are Authenticity (X1), Engagement (X2), and Learning Motivation (X3). Measured variables represent indicators that function to measure latent variables. Each variable has an item that can be used as a question to the respondent. Table II are questions and statement items presented in the questionnaire.

TABLE II: QUESTION ITEMS AND STATEMENTS FOR RESPONDENTS

Laten Variable	Item
X1(Authenticity)	
	I feel what I see in the virtual world is the same as the real world when I control the movement using the keyboard.
	I feel that the digital learning materials of GS-PVE lessons are authentic.
	Practical steps in the game-based learning of GS-PVE related to physical practice situations.
X2 (Engagement)	
	I fully concentrate on GS-PVE activities.
	I am involved in the GS-PVE because there are practical steps to collaborate with friends in the virtual world.
	Virtual characters and scenes on the GS-PVE make it easier for me to face physical practice readiness.
X3 (Learning Motivation)	
	I like learning how to install scaffolding using the game-like concept of game-based learning.
	I will use GS-PVE app to learn good installation steps for a long time.
	I want to use GS-PVE app to learn installation again.
Y1 (Interest of Using)	
	I intend to use a game-based learning-based GS-PVE application
	I will refer a game-based learning-based GS-PVE application to friends
	I will look for information about the goodness of game-based learning-based GS-PVE applications

C. Data Processing and Data Analysis Technique

The research model used is SEM with the consideration that 1) can make more models 2) SEM can test measurement error on observed variables 3) produce a more systematic and comprehensive analysis set 4) can be used as an alternative to path analysis and time analysis series [19], [20]. There are several stages of data processing, namely descriptive analysis to describe and analyze the results of each variable, then testing the model through hypothesis testing, reliability and validity testing, and model suitability test [21]. The design diagram for the stages of data processing and analysis can be seen in Fig. 7. The questionnaire was carried out with an initial test, namely validity and reliability tests to obtain the most suitable SEM model.

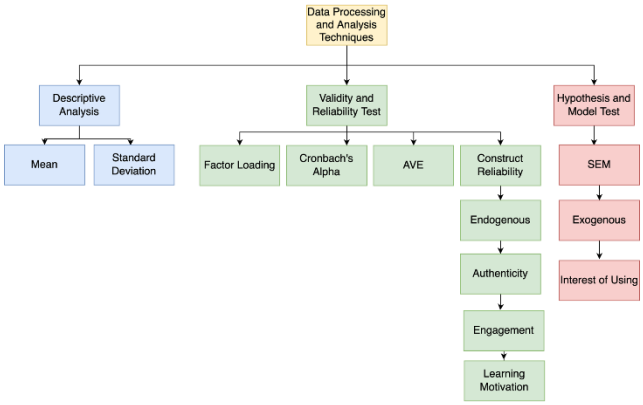


Fig. 7. Data processing and analysis techniques.

Prior to data processing and analysis, the main thing to do is to determine the variables that affect the use of GS-PVE applications. In this study, the proposed variables are Authenticity, Engagement, Learning Motivation, and Interest of Using. Subsequently, the hypothesis H1, H2, and H3 were drawn. The subjects in this study were students from UPDL-Semarang who operated a game-based learning-based GS-PVE application, as shown in Fig. 8.

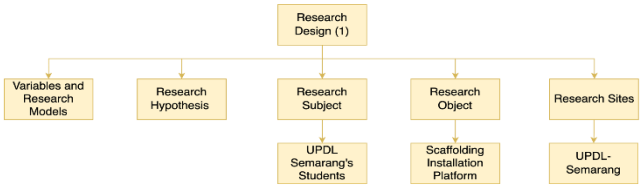


Fig. 8. Research design of game-based learning data processing.

After the variables and hypotheses are determined, the next step is collecting data through a questionnaire using a 5-level Likert scale to do a measurement scale. Data collection was carried out through an online process to UPDL-Semarang students with a minimum number of 49 respondents so that the study was said to be valid. In this study, 53 respondents were obtained from the minimum number and had met the target Fig. 9.

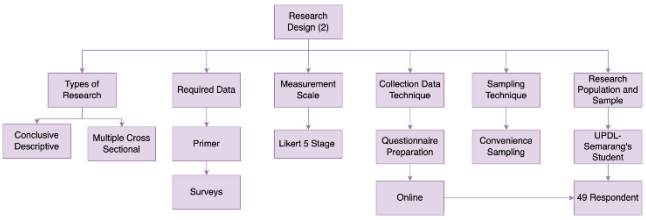


Fig. 9. Research design of game-based learning questionnaire structure.

V. Results and Discussion

A. Game-Based learning Demonstration of GS-PVE

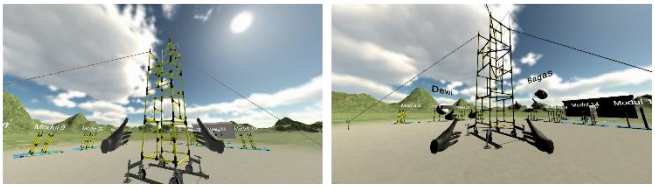
In the GS-PVE application for State Electricity Company UPDL-Semarang which applies the concept of game-based learning, participants follow the steps that have been determined previously by the educators at UPDL-Semarang, it can be seen in Fig. 10.

Fig. 10. Student's actual operation of GS-PVE.

Fig. 11. GS-PVE application mode selection menu display.

The first step that participants need to take before running the game-based learning of the GS-PVE is to choose a learning mode. It can be seen in Fig. 11 that the application that was built provides 2 choices of single player and multi-player learning modes. And, GS-PVE has 2 stages of practice namely the assembly and disassembly of the scaffolding.

In single player mode, it is designed as a place for participants to learn the interaction of participants with scaffolding so that participants can smoothly build scaffolding. In single player mode, participants can practice the assembly and disassembly stages of scaffolding freely without using an internet connection. Then in multiplayer mode, participants are required to fill in the participant id in the form of a name as identification. After that, participants can collaborate with other participants to build and dismantle the scaffolding Fig. 12. In multi-player mode, educators can also follow the scaffolding installation process to monitor the scaffolding installation and disassembly process.



(a) (b)

Fig. 12. (a) Single player (b) Multiplayer GS-PVE.

To control the movement and interaction of participants is done using the keyboard. For forward movement can be done by pressing the keypad W, backward S, walk to the left A, to the right D. The keypad function is adjusted according to the user's ergonomics. Keypad input which can be seen in Fig. 13.

Fig. 13. GS-PVE application movement and interaction Keyboard control.

The keyboard control used in the scaffolding application; namely key binding commonly used in RPG (Role-playing games) makes it easier for participants who have previously played games with similar controls. Furthermore, participants are expected to choose PPE (Personal Protective Equipment) and equipment including wear pack, full-body harness, lanyard, safety helmet, safety shoes, safety gloves, safety goggles, K3 signs, first aid kit in accordance with the instructions of educators before entering the installation area. The PPE selection process can be seen in Fig. 14.

When participants select the equipment of PPE it has voice feedback as an indicator of wrong and right choices. After the participants have succeeded in choosing the appropriate PPE and equipment, the participants can continue the scaffolding installation process by moving to a field outside the PPE selection area.

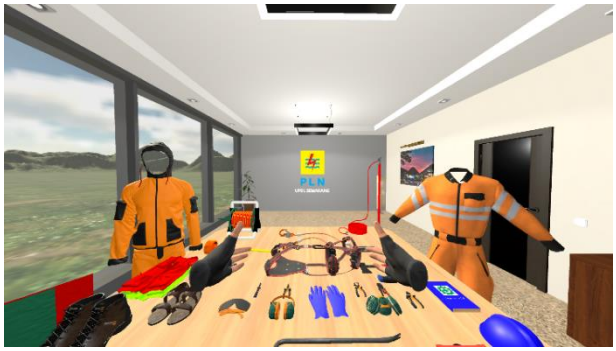


Fig. 14. Selection of PPE and equipment.

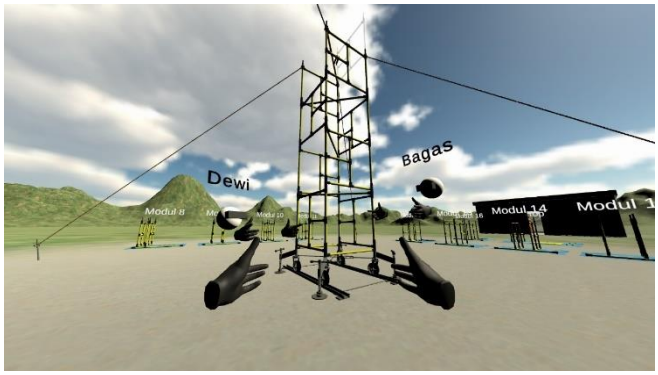


Fig. 15. GS-PVE practicum field.

The field for scaffolding can be seen in Fig. 15. In the field outside the selection of PPE and equipment, each 3D module of the assets needed to build the scaffolding has been arranged in a structured manner. The installation steps are designed to follow the scaffolding installation steps in the real world. In this installation process, participants are facilitated to build scaffolding by giving hints in the form of color highlights on the edges of the 3D assets that need to be installed first and the position where the 3D assets need to be placed.

B. Results of Data Collection and Processing

In this study, data collection was obtained through the distribution of online questionnaires through the Google Forms platform. From the distribution of the questionnaires obtained as many as 53 respondents who have sent answers based on the specified time. The data obtained is primary data for processing using Partial Least Square - Structure Equation Modeling (SEM) with the aim of knowing the measurement model, structural model, hypothesis testing using SmartPLS software. The test is divided into two models i.e., outer models and inner models. In the outer model, a validity test is carried out by considering the values Average Variance Extracted (AVE) and loading factor, also a reliability test is carried out by considering the values of AVE, composite reliability, and Cronbach's alpha on the construct model. In this study, to obtain valid and reliable data, it is necessary to test the validity and reliability of each instrument. Instruments can be said to be valid if the instrument measures something that should be measured. The validity of the instrument can be determined by connecting the scores obtained from each item with the total score. This test uses Confirmatory Factor Analysis (CFA) for each variable. An item is said to be valid if the significance value is < 0.05 [22]. While the reliability test was tested to obtain consistent data. Table III shows the validity test of the SEM model of convergent and discriminant.

TABLE III: VALIDITY TESTING OF CONVERGENT TEST

Laten Variable	Observed Variable	Factor Loading	AVE	Description
X1 (Authenticity)	Item X1.1	0.908	0.739	VALID
	Item X1.2	0.879		VALID
	Item X1.3	0.788		VALID
X2 (Engagement)	Item X2.1	0.925	0.714	VALID
	Item X2.2	0.864		VALID
	Item X2.3	0.735		VALID
X3 (Learning Motivation)	Item X3.1	0.876	0.790	VALID
	Item X3.2	0.882		VALID
	Item X3.3	0.906		VALID
Y1 (Interest of Using)	Item Y1.1	0.911	0.791	VALID
	Item Y1.2	0.918		VALID
	Item Y1.3	0.837		VALID

The test results of the outer convergent model test in Table IV, show that 12 items have passed the test, this is evidenced by the AVE value of all variables that meet the standard value, namely AVE > 0.50. Based on these results, this study did not eliminate items and no re-validity test was performed, so that it can be continued on the Discriminant Fornell-Lackker Criterium Validity test by correcting each relationship between the observed variables in Table V.

TABLE IV: FORNELL-LACKER CRITERIUM DISCRIMINANT VALIDITY TESTING

	X1 (Authenticity)	X2 (Engagement)	X3 (Learning Motivation)	Y1 (Interest of Using)
X1 (Authenticity)	**0.860**			
X2 (Engagement)	0.759	**0.845**		
X3 (Learning Motivation)	0.726	0.647	**0.889**	
Y1 (Interest of Using)	0.640	0.581	0.718	**0.889**

TABLE V: MEASUREMENT MODEL RELIABILITY TEST RESULTS

Laten Variable	Cronbach's Alpha	rho_A	Composite Reliability	Description
X1 (Authenticity)	0.824	0.854	0.894	RELIABLE
X2 (Engagement)	0.797	0.831	0.881	RELIABLE
X3 (Learning Motivation)	0.867	0.871	0.918	RELIABLE
Y1 (Interest of Using)	0.867	0.867	0.919	RELIABLE

Based on Table V, the results of the discriminant validity test show that the root value of the construct (number in bold) is greater than the root value of other constructs, namely the Authenticity, Engagement, Motivation Learning, and Interest of Using variables. So, it can be implied that the model has met the discriminant requirements and is considered valid. Furthermore, the reliability of the model was tested by

measuring Cronbach's Alpha and Composite Reliability

Based on Table V, it explains that the four latent variables in this study can be accepted with the values Cronbach's Alpha and Composite Reliability on each variable > 0.70. After testing the outer model, the inner model test can be applied by identifying the coefficients (R^2) and effects (f^2) which are used to test the predictive power of the latent variables and observed variables.

TABLE VI: COEFFICIENT OF DETERMINATION (R^2) TEST RESULTS

	R Square	R Square Adjusted	Description
Y1 (Interest of Using)	0.550	0.523	**STRONG**

Based on Table VI. In testing the inner model, the value is 0.550. Chin gave criteria for R Square values of 0.67, 0.33 and 0.19 as strong, moderate, and weak [23], [24]. From the results of the (R^2) test, we get a moderate model on Interest of Using. The value of (R^2) indicates that the variable Authenticity, Engagement, and Learning Motivation is sufficient to explain the latent variable Interest of Using of 55.0% of the overall model and the value is considered to have a moderate significant effect on the model. Effect size test is also needed to identify the relationship between latent variables.

TABLE VII: f^2 TEST RESULTS

	X1 (Authenticity)	X2 (Engagement)	X3 (Learning Motivation)
X1 (Authenticity)			
X2 (Engagement)			
X3 (Learning Motivation)			
Y1 (Interest of Using)	0.025	0.010	0.265
Description	SMALL EFFECT	NO EFFECT	MODERATE EFFECT

Based on Table VII The f square value of 0.02 is interpreted as small, 0.15 as medium, and the value of 0.35 as large. Values less than 0.02 can be ignored or considered to have no effect [25]. The results obtained indicate that the Authenticity variable has a small effect on Interest of Using as evidenced by the f-square value of 0.025, Engagement on Interest of Using is considered not to have a significant effect because the f-square value is < 0.02, while Learning Motivation has an influence. moderate to Interest of Using with an f-square value of 0.265.

According to the hypothesis testing with path coefficient that has been done, the next step is to test the hypothesis based on statistical values and p-value. Hypothesis testing is used to determine whether the previously proposed hypothesis is accepted or rejected. Hypothesis test results can be seen in Table VIII.

TABLE VIII: HYPOTHESIS TESTING THE RELATIONSHIP BETWEEN VARIABLES

Hypothesis	H1	H2	H3
Variables Relationship	X1 (Authenticity) → Y1 (Interest of Using)	X2 (Engagement) → Y1 (Interest of Using)	X3 (Learning Motivation) → Y1 (Interest of Using)
Original Sample (O)	0.185	0.108	0.514
Standard Deviation (STDEV)	0.217	0.165	0.177
T Static (|O/STDEV|)	0.851	0.653	2.991
P Values	0.395	0.514	0.004

According to the results of bootstrapping, the variable Authenticity and Engagement have a value of *t statistic* < 1.96 then both hypotheses are rejected so that both variables have no significant effect on interest in using GS-PVE applications. However, the Authenticity and Engagement variables in the original sample are positive, so they have a positive influence on Interest of Using. While Learning Motivation has a value of *t statistic* > 1.96 and a value of *p-value* < 0.05, then this hypothesis is accepted so that the variable Learning Motivation has a significant and positive effect on Interest of Using the use of GS-PVE applications. The *t statistic* (1.96) is the standard deviation of the mean in the upper quartile of 97.5% in the normal distribution, so it is used to determine the significant condition of the variables used. Therefore, the relationship between the Authenticity and Engagement variables with the Interest in Using variable has no significant effect but is still supportive. While the variable Learning Motivation has a significant influence because it has a *t statistic* value that exceeds the value of 1.96

C. Discussion of Implementation Results

Considering the safety of students when carrying out physical scaffolding installation practicums, innovations to improve learning methods are continuously being developed by utilizing game-based learning. The use of game-based learning in the field of education, especially scaffolding installations that have Authenticity value for users regarding Interest in Using because it is considered a new technique to understand practical procedures. However, in this study it was found that Authenticity had no significant effect on interest in using GS-PVE applications. This means that seeing the virtual world and the real world does not affect the decrease in the use of GS-PVE applications. To find out other factors that can influence interest in using applications such as the Engagement factor, there is no positive and significant influence. This means that engagement between students is not a reason to keep using the GS-PVE application. The learning motivation variable has a positive influence on the level of interest in use. This shows that students like to learn to use the concept of game-based learning to learn the steps from installation to dismantling of scaffolding over a long period of time, the structural model is obtained as shown in Fig. 16.

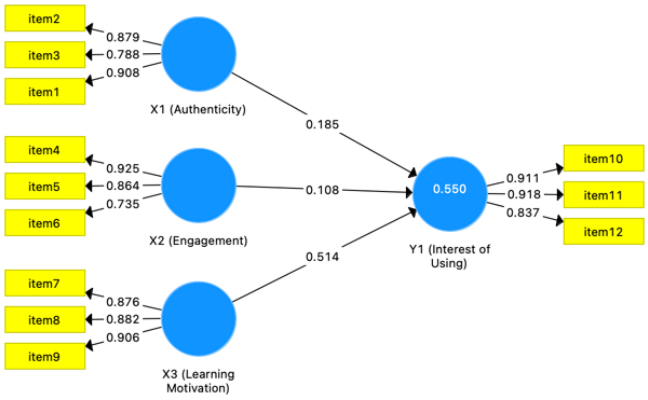


Fig. 16. Research structural model results.

Based on the results of the path coefficients, Fig. 16, there is an accepted hypothesis, namely Learning Motivation on Interest of Using, there are also two rejected hypotheses, namely Authenticity and Engagement. However, these three variables have a positive influence on Interest of Using. Authenticity and Engagement variables have no significant effect because the value of *t-statistic* < 1.96 and *p-value* > 0.05, while Learning Motivation has a significant effect.

VI. Conclusion

The application of game-based learning in the practice of scaffolding installation is the appropriate step as an innovation in learning techniques. Game-based learning which was built based on the rules from UPDL-Semarang has been successfully implemented and tested on students. The test is used to measure the factors that influence students' Interest of Using the application of GS-PVE.

Based on the research results obtained through questionnaires the level of Authenticity has positive relationships to the Interest of Using the GS-PVE application. Based on the questionaries the student agrees that what they see is the same as in the real world and they agree that scaffolding assembly practicum module is authentic from the real-world counterpart.

For the level of Engagement, it can be acquired that it also has positive relationships between Interest of Using the GS-PVE application. The students agrees that the GS-PVE application makes them easier to understand the content of Scaffolding assembly instruction and they also feel involved on each step of assembly because the limitations mentioned above is gone and the ability to collaborate with colleagues in the GS-PVE application.

On the variable Learning Motivation, the data acquired shows that it has positive relationships and significant effect on Interest of Using the GS-PVE application. Based on the questionaries the students agree that they like the concept of game-based learning that has been applied to Scaffolding installation scenario. And the student agree that they want to use the GS-PVE application for learning the scaffolding again.

This study also allows several players i.e., students or instructors to join at the same room thus creating a collaborative environment for them to works together. Based on the data presented above it can be concluded that the results of data processing and analysis using SEM that have been carried out are

1) The most dominant variable influence on Interest of Using GS-PVE application is Learning Motivation with a significant value of 0.004 and the highest coefficient value of 0.514 so that it has the highest influence compared to other variables.
2) This research model shows that Authenticity, Engagement, and Learning Motivation explain the Interest of Using GS-PVE application variable by 55.0%, this is indicated by the value of *R-Square* 0.550, the rest can be influenced by other factors outside the variable that researched.

This research focuses on UPDL-Semarang students who are interested in using game-based learning-based GS-PVE applications, factors outside of research can be developed for further research.

VII. Limitation and Further Investigation

The study discussed scaffolding assembly using game-based learning method on students in PLN UPDL Semarang. In this study, some limitations that the authors found are the impact of understanding after using and before using GS-PVE on real practical scenario. On the GS-PVE side some improvement can be done with using real VR technology to increase the user experience.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, S.S., U.H.A.R., R.P.N.B., U.Z., M.A.F., and M.A.F. ; methodology, A.L.H., E.D.F., S.S., I.A.A., N.A.S and L.H.I; software, I.A.A., A.L.H., N.A.S., and L.H.I.; validation, S.S., U.H.A.R., R.P.N.B., U.Z., and M.A.F.; formal analysis, E.D.F.; investigation, E.D.F., and R.P.N.B.; resources, S.S., and R.P.N.B.; data curation, E.D.F.; writing---original draft preparation, A.L.H., E.D.F., I.A.A., N.A.S., and L.H.I.; writing---review and editing, S.S., U.H.A.R., and R.P.N.B.; visualization, E.D.F.; supervision, S.S., U.H.A.R., U.Z., M.A.F., and M.A.F.; project administration, R.P.N.B., and N.S.P; funding acquisition, S.S., R.P.N.B.; All authors have read and agreed to the published version of the manuscript.

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