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Advancing Logistics Training with Virtual Reality: A Case Study of PT XYZ's Innovative Approach in Indonesia

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Abstract: PT XYZ is an Indonesian pharmaceutical company that provides domestic and international health services. PT XYZ established an apprenticeship program to design and develop virtual reality (VR)-based logistics practice training modules in the past. On December 28, 2022, PT XYZ logistics employees evaluated the newly developed training module for logistics in order to provide feedback. The development of logistics training modules is predicated on issues regarding motion sickness and assessment criteria. One of the training assessment features was created using the Fisher– Yates Shuffle algorithm, which was implemented in a training module application that had been previously developed using the Unity game engine. As part of the developments, the training flow is being redesigned, practice assessment features and exams are being added, and a warehouse environment is being created. On June 8, 2023, the logistics training module was effectively revised and retested. On the basis of the trial's evaluation, it was determined that efforts to prevent motion sickness had varying effects on trial participants. It was also discovered that participants viewed the assessment feature as beneficial, but that it remained difficult to access. On the basis of the assessment of the technology acceptance model (TAM), which was attended by six participants, an acceptance rate of 67.5% was obtained for the perceived simplicity of use and 78.33% was obtained for the perceived usefulness.

Keywords: *Fisher Yates Shuffle, logistics, technology acceptance model, Unity, virtual reality*

1. Introduction

VR lets consumers enter a virtual environment. VR gadgets enable virtual reality access. VR technology can create virtual work training [1]. VR training can be an alternative to traditional training because both provide similar performance. Several VR applications for practical instruction have been studied. VR training increases user commitment and memory [2], [3]. VR is used in education, industry, and entertainment, according to research on VR-based work practices [4]. Innovative tech businesses help VR technology advance daily [5], [6]. Companies may use VR technology due to its rapid development and industrial benefits.

PT XYZ began an XR Module Developer internship in July 2022. The XR Module Developer students created VR training modules for several PT XYZ divisions. The internship program starts with worksite observations, SOP training, and administrative papers including training analysis tables and storyboards. Training module design and development starts after analysis.

The XR Module Developer internship produced a VR-based logistics training module for PT XYZ. Unity designed the logistics training module. The Meta Quest 2 VR device installs the training app. Participants can connect up using an employee account and do a VR instruction and object interaction tutorial. After that, participants can change the app settings, run the training, or quit. If they run the course, they'll enter a 3D warehouse and use the UI to learn logistical activities. This logistics training module's VR gadget is unique. The logistics training module for PT XYZ uses portable VR devices without cords, unlike previous VR training, which used Oculus Rift. Participants have more training location options.

PT XYZ logistics staff tested the logistics training module on December 28, 2022. The testers and staff representatives identified two issues: VR headsets causing motion sickness and a lack of a means to evaluate training.

Training module trial participants complained about motion sickness. VR headsets' low FPS display screens and long use might create motion sickness. Motion sickness caused dizziness and nausea during the study. Logistics training programs should prioritize participant comfort to reduce motion sickness [7], [8]. Logistics training courses to prevent motion sickness reduce VR application duration and boost VR headset FPS. Changing the training flow so trainees can instantly start training will shorten application use. Optimizing the 3D model and rendering can boost FPS.

The logistics training module does not allow trainees to access activity-based assessments. Learning requires a new mode. Thus, participants can score the learning activity after learning it. Activity practice assessment and Fisher-Yates Shuffle multi-ple-choice quizzes are two types of assessment.

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Fisher-Yates Shuffle randomizes line members [9]. Logistics training modules can randomize multiple-choice quiz questions using the Fisher-Yates Shuffle algorithm. The assessment component uses Richard Durstenfeld's computer-based Fisher-Yates Shuffle method [10], [11]. Fisher Yates is employed due to its On time complexity. The Durstenfeld approach has linear time complexity since the number of operations is proportionate to the number of elements in the row to be randomized. Sattolo is a Fisher-Yates Shuffle variant. Sattolo's algorithm allows more permutations than Fisher Yates'. Sattolo's approach always randomizes a sequence element. Unlike the Durstenfeld method, an element can stay in the lineup. Thus, the Durstenfeld algorithm was chosen for its higher randomization probability than the Sattolo algorithm [12].

TAM was used to evaluate the logistics training module development. TAM assessed logistics training module acceptance. TAM assesses how user-friendly and useful an information system technology is [13]. Since it has been utilized in numerous research, the TAM measurement approach is used to assess logistics training module acceptance. TAM can measure how easy it is for participants to use VR devices to interact in the logistics training module and how valuable its features are [13], [14].

This research develops a VR-based work practice training program for PT XYZ logistics employees. Fisher-Yates Shuffle is used in training module development. This research aims to solve the problems from previous training module trials, gain acceptance from logistics department employees through TAM, and raise awareness of VR technology's benefits in education and work so that PT XYZ can fully utilize it.

2. Materials & Methods

2.1. Visually Induced Motion Sickness (VIMS)

Visually induced motion sickness (VIMS) is a subcategory of motion sickness as-sociated with nausea and disorientation caused by the perception of motion at rest [15]. VIMS can be experienced by VR users when navigating in a virtual world. The main symptoms that can result from VIMS are nausea, headache, dizziness, fatigue, and eye fatigue [16]. Nausea and fatigue are symptoms that can be caused by motion sick-ness in general, while headache, dizziness, and tired eyes are more commonly caused by subcategories of VIMS. There are several ways that can be used to reduce VIMS during the training module [8], [17], namely:

- Shorten the duration of using VR applications and simplify the move-ments that can be performed by users [9].
- Increasing the screen FPS of a VR headset. VR [9]. Low FPS results in a screen that cannot accurately show the motion input from the partici-pant, resulting in motion sickness.
- Maintain the immersiveness that participants experience from the begin-ning to the end of the training module [10]. Every input made by the par-ticipant should be able to generate an appropriate response from the VR application.
- Adding a fixed image reference that is always visible to the trainee's view of the training module [10]. The image reference can connect the partici-pant to the virtual world.
- Reducing the movement of participants' limbs [11]. One solution that can be used to reduce limb movement is to provide a remote object capture feature. That way, participants who want to pick up objects in hard-to-reach places do not need to bend down and reach for the object with their hands.
- Play music during the training module [12]. Music has an influence on participants' comfort during VR activities. The effect felt by participants is influenced by the type of music and personal preferences.

2.2. Fisher-Yates Shuffle

Fisher-Yates Shuffle is an algorithm that performs random permutations on a fi-nite sequence. The Fisher-Yates Shuffle algorithm was originally proposed by Ronald Fisher and Frank Yates in the book Statistical Tables for Biological, Agricultural and Medical Research, then updated by Richard Durstenfeld for computer use [18], [19].

Before the algorithm is executed, a starting line of length N and an ending line that has no contents yet are prepared. After that, a number is selected from one to N. The number selected is considered as k. In the starting row, the kth member is crossed out and then written back in the ending row. Each time the result row increases by one member, N is reduced by one. This algorithm is run continuously until all the mem-bers in the starting row have been crossed out. The result will be at the end of the row. A noticeable difference between the original algorithm and Fisher Yates algorithm is the use of a single row. The selected row member of number k is swapped in position with a member of N. Table 1. shows an example of Richard Fisher Yates use of the Fisher-Yates Shuffle algorithm for computer use [12], [20].

Table 1. Fisher-Yates Shuffle algorithm

Range	Random Number	Sequence
		F I S H E R
1 – 6	3	F I **R** H E / S
1 – 5	4	F I R **E** / **H** S
1 – 4	4	F I R / **E** H R
1 - 3	1	**R** I / **F** E H S
1 - 2	2	R / **I** F E H S
		R I F E H S

3. Methodology

3.1. Problem Identification

Prior to the commencement of the development process for research, a pilot test of the logistics training module was conducted for several representatives of logistics employees first. The trial was conducted on Friday, December 28, 2022 at the PT XYZ building. The trial used the training module build created during the internship program. Each test participant was given a brief direction on how to operate Meta Quest 2 before being given access to the training module. After being given directions to open and implement the training module, the test participants tried the training module and found out if there were problems with the training module. The pilot test was conducted to identify and ascertain the problems experienced by the pilot participants. The problems that have been obtained are used as a basis for developing logistics training modules.

3.2. Literature Study

At the literature study stage, data collection and learning from written sources related to the development of logistics training modules are carried out. This stage aims to find information that supports the development of logistics training modules and expands research references.

3.3. New Feature Design

To overcome the problems of the research, new features were designed for the training module. The purpose of the new features designed is to overcome the problems that arise during problem identification. After the literature study, the updated flowchart and features for the training module were designed. The new features developed for the logistics training module are a new main menu feature, a practical assessment feature, and a training quiz. The design was made in the form of a flowchart and continued with a mockup design for the user interface (UI). 3D asset optimization and sound asset search were also conducted.

Training Module Flow Update

During the trial, it was found that some participants needed to take a break because they could not use the VR device for too long. Based on the observations made, participants can ask to take a break even before starting the training activity. This happens because there are several activities that need to be done by participants before accessing training activities. Therefore, the training module flow needs to be modified so that participants can directly access the training activities.

In the developed training module, participants directly enter the scene that provides access to training activities. Initially, participants are immediately placed in the warehouse scene. Guidance on how to operate VR devices is placed in the Main Menu so that it does not interfere with participant activities. There are several parts that are omitted from the flow, namely the participant account login and the Main Menu space. The participant account login is removed because it is not the focus of the research, while the Main Menu space is removed because participants no longer need to access the Main Menu scene as a bridge to access other features.

3.3.1. Main Menu

The difference between the new main menu features and the old ones is the way they are accessed. The new main menu can be accessed anytime and anywhere by participants, while the old main menu could only be accessed in a special scene. The contents of the main menu are access to the list of training activities that have been done and have not been done, training quizzes, training guides, and settings. **Error! Reference source not found.** shows a mockup view of the main menu UI.

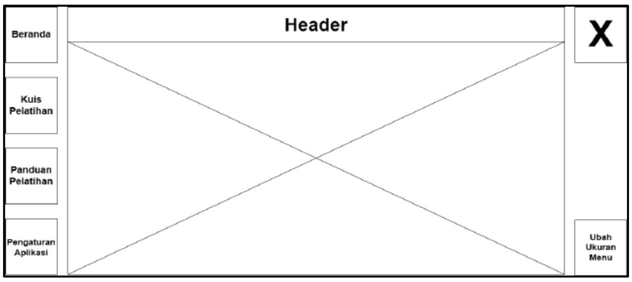

Fig. 1. Main menu UI mockup

3.3.2. Assessment Features Model

All activities carried out by participants have also been given an assessment in the form of a numerical score from zero to one hundred. Each time a participant com-pletes a training activity, the scoring system will indicate the completed activity and give the participant a score. The list of training activities accessible in the main menu will also be updated to reflect activity completion.

The training quiz covers questions related to logistics activities. Fisher-Yates Shuf-fle is a randomization algorithm that will be used in the training quiz feature to randomize the order of quiz questions. In the Fisher-Yates Shuffle algorithm, an array named T with a number of n becomes the input of the algorithm. An integer named i is initialized with the value of n minus one. After that, an operation is performed that will keep repeating as long as the value of i is greater than zero. In the operation, an integer named k is initialized with a randomly obtained value between zero and i. When the value of k is obtained, the value of the integer at the i-th index of T is ex-changed with the value of the integer at the k-th index of T. The operation is complet-ed by subtracting the value of i by one. When the value of i is less than zero, the array T becomes the output of the algorithm. Fig. 2 shows the flowchart of the Fisher-Yates Shuffle algorithm.

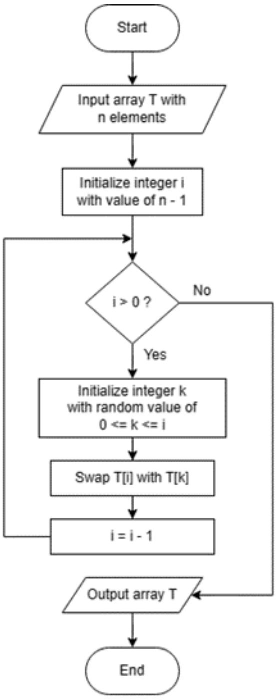

Fig.2 Fisher-Yates Shuffle algorithm

3.4. New Feature Implementation

The newly designed features were implemented in the logistics training module Unity project. Implementation is done in the form of UI laying, 3D and audio asset laying, and code writing.

3.4.1. Main Menu

Fig. 3 shows the implementation result of the main menu UI. In the main menu UI, a main screen is displayed that can be changed by pressing one of the buttons on the left side of the main screen. The content that can be accessed on the main screen is the home menu, training guide, training quiz, and settings. The button on the right of the main screen can be used to close the UI or resize the UI.

Fig. 3. Main menu UI view

3.4.2. Assessment Features Result

Fig. 4 shows the training quiz that can be accessed by participants in the main menu UI. Each question is multiple-choice with four answer options. The question types are divided based on the training procedures that participants can perform in the training module. The questions that appear on the training quiz were previously randomized using the Fisher-Yates Shuffle algorithm.

Fig. 4. Training quiz UI view

Error! Reference source not found. shows the training q uiz that can be accessed by participants in the main menu UI. Each question is multiple-choice with four answer options. The question types are divided based on the training procedures that participants can perform in the training module. The questions that appear on the training quiz were previously randomized using the Fisher-Yates Shuffle algorithm.

```
private List<T> Shuffle<T>(List<T> listToShuffle)
{
    List<T> list = listToShuffle;

    int n = list.Count;

    for (int I = n – 1; I > 0; i--)
    {
        int k = Random.Range(0, i);
        (list[i], list[k]) = (list[k], list[i]);
    }   return list;
```

The code displays a randomization method that accepts input data of type list containing objects of a common type and outputs a list of input that has been randomized by the position of each object in it. The algorithm used is the modern Fisher-Yates Shuffle algorithm developed by Richard Durstenfeld.

When the method is called, a list variable with the name *list* is declared. The value of *list* is taken from the input list. After that, a variable *n* is declared with a value as many as the number of objects in the list. After the list and *n* variables have been declared, the loop process is done in the form of a for loop. Before starting the loop, variable *i* is declared with the value of *n* minus one. When the loop is performed, a variable *k* is declared with a random value between zero and *i*. Randomization uses the Random.Range method that has been provided in Unity in the UnityEngine.Random namespace. After the value of *k* is obtained, the value of the *i*-th object and the *k*-th object in the list are exchanged. Each time a loop completes, the value of *i* is decremented by one. The loop process continues until the value of *i* is equal to zero. After the loop process is complete, the randomization method produces a list that has been randomized.

3.4.3. Motion Sickness Prevention

One of the ways to minimize the effect of motion sickness is to create movement inputs that can be done by participants, namely teleportation and toggle for snap turn. With the teleportation feature, participants can now move to the desired area without using the left thumbstick to walk. The toggle for snap turn can be used by participants to turn off and on the body movement feature using the right thumbstick. The function of the toggle for snap turn is to avoid accidental movement by the participant.

Efforts are made to increase and stabilize frames per second (FPS) by optimizing 3D assets. High FPS can provide comfort to participants when doing training activities. The basis set for the minimum FPS value that the application needs to obtain is 60 FPS, according to the list of needs and guidelines that have been given on the official Meta Quest 2 documentation site **Error! Reference source not found.**, w hile the optimal FPS value is 72 FPS. **Error! Reference source not found.** displays the FPS generated by the logistics training module application at the time of the screenshot frame, which is 71 FPS. Based on the profiler results, the application can have a stable FPS in the range of 60 to 72 FPS.

Fig. 5. Profiler view

4. Results & Discussion

On June 8, 2023, the improved logistics training module was tested at the PT XYZ building. The trial was attended by six participants. Four participants were PT XYZ employees from the logistics department, while two participants were PT XYZ em-ployees from the HR department. The trial was conducted from 2 pm until comple-tion. Five pieces of Meta Quest 2 were provided for the trial. One Meta Quest 2 dis-plays its screen through a projector using the Cast feature to facilitate observation of activities carried out by one of the participants. Participants are free to choose the VR device they want from the VR devices that have been provided. Before starting the trial, participants were given a brief guide on how to move and interact with objects. For the rest, participants were given the freedom to access each feature in the training module and the examiner made observations.

The evaluation was conducted using the technology acceptance model (TAM) in the form of filling out questionnaires by participants. Black box testing was also con-ducted and conclusions were drawn from participant interactions through observa-tion. In the questionnaire, each question is categorized into two aspects, namely per-ceived ease of use and perceived usefulness. In order to be an evaluation material, the results of the questionnaire are processed into a table consisting of statements and the number of participants' answers based on a Likert scale.

Table 2. Data on perceived ease of use statement values

Statement	1	2	3	4	5	Average (%)
The movement input is easy to learn and suits my preferences.	0	1	1	4	0	70
The warehouse layout is very clear and easy to navigate.	0	1	2	1	2	73.4
Training activities are clear and can be passed smoothly.	0	1	1	4	0	70
I did not experience any motion sickness symptoms that interfered too much with the training session.	2	0	2	1	1	56.6

Error! Reference source not found.displays a collection o f statements from the questionnaire results related to the perceived ease of use aspect. The data displayed is the ease of participants in inputting movements, clarity of warehouse layout, clarity in performing training activities, and the effect of motion sickness on the implementation of training sessions. It was found that the majority of the trial participants found it quite easy to move their bodies. The majority of the trial participants also felt comfortable navigating the warehouse area. Two of the four logistics employees who participated in the pilot test had neutral answers regarding the ease of navigating the warehouse area. One possible reason for this neutral answer is that the warehouse environment is similar to the real one, but has some differences in the layout. Due to the scope of the training procedure, the warehouse area environment underwent changes in room layout and size, so there may be some parts of the warehouse area where logistics employees feel confused.

There was a question that provided information on the effect of motion sickness experienced by participants. It was found that four participants experienced motion sickness symptoms that interfered with their training sessions, while the other two participants did not experience motion sickness symptoms. Therefore, it was concluded that motion sickness prevention efforts still produce mixed reactions for participants.

From the overall average that has been obtained, it is known that the value of the logistics training module in the aspect of perceived ease of use is 67.5% with a fairly good predicate.

Table 3. Data on perceived usefulness statement values

Statement	1	2	3	4	5	Average (%)
Training quizzes are a good complement to training modules.	0	0	0	1	0	80
The training guide is useful.	0	0	2	1	1	75
The scoring system is useful.	0	0	1	1	4	90
The 3D environment is faithful to the original.	0	0	0	4	0	80

Error! Reference source not found.displays a collection o f statements from the questionnaire results related to the perceived usefulness aspect. The data displayed is the level of suitability of the training quiz as a complement to the training module, the level of usefulness of the training guide, the level of usefulness of the scoring system, the likeness of the 3D environment to the original warehouse, the likeness of the sound effects to the atmosphere of the original warehouse, and the suitability of the training activities to the original interaction. From the questionnaire results, it was found that there was only one participant who tried the training quiz and four participants who tried the training guide. The reason for the low usage of these two features may be related to the problems participants encountered in opening the main menu during observation during the trial. The one participant who did try the training quiz found it to be a suitable complement to the logistics training module. The training manual received mixed responses from the four participants who tried the training manual. Two participants found the training guide useful in the training activities, while the other two participants rated the training guide neutrally. With two participants rating the training guide as neutral, it was found that the guide still needs to be clarified so that participants can feel that the guide helps them learn how to do a training activity.

In addition to the assessment of the benefits of the features, there is also an assessment of the benefits of the scoring system that has been developed for the logistics training module. With the scoring system, interactions made by participants can produce a sound effect that indicates that the participant has successfully completed an activity. The majority of the trial participants felt that the implemented scoring system was useful because it gave them motivation to go through the logistics training module.

The remaining assessed statements focus on how accurate the logistics assets and activities that have been developed for the logistics training module are to their real-world references. Accurate assets can provide a training experience that feels real and gives the illusion that participants are actually doing logistics activities in the PT XYZ warehouse. All questions related to the accuracy of assets and logistics activities were only answered by participants who are logistics employees with a total of four people. The majority of the participants answered that the 3D environment and sound effects were sufficiently in line with those in the original warehouse. Two participants felt that the logistics activities that can be performed in the logistics training module are accurate enough to the original activities, but the other two participants answered neutral.

From the overall average that has been obtained, it is known that the value of the logistics training module in the aspect of perceived usefulness is 78.33% with a fairly good predicate.

5. Conclusion

The development of a virtual reality (VR) based logistics work practice training module has been successfully developed by utilizing the Fisher-Yates Shuffle algorithm. The features created in the development of the logistics training module aim to respond to the problems experienced by the trial participants on December 28, 2022. The results of the logistics training module development were tested again on June 8, 2023, which was attended by six participants from PT XYZ employee representatives. Efforts that have been made to prevent motion sickness when conducting training modules still produce mixed reactions from trial participants. The assessment features in the form of a practical assessment system and training quizzes using the Fisher-Yates Shuffle algorithm for randomizing the position of quiz questions that have been tested by trial participants have been considered suitable for use in the logistics training module, but there are problems in how to open the UI to access the assessment features. Evaluation data on the level of acceptance of the trial participants towards the training module was obtained through a questionnaire made using the technology acceptance model (TAM), with an average value of 67.5% with a fairly good predicate for the perceived ease of use aspect and 78.33% with a fairly good predicate for the perceived usefulness aspect.

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Author contributions

Jonathan Franzeli: Task executor, Methodology, Software developer, Informatic department **Wirawan Istiono:** Research mentor, Corresponding research author, editor's research report, Informatic department

Conflicts of interest

I declare that there is no conflict of interest in this research.

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