Usability Analysis: Virtual Reality-Based Lathe Machine Operation Simulation Application

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Abstract. VR Lathe Machine is a 3D Simulation training using Virtual Reality (VR) technology that has 3 menus. Students will use this simulation to learn about the machine's components and how the basic work functions. The usability of the simulation system must be tested before this application can be used as assist in learning system. In this study, usability testing is used to assess the value of usability in a design that has gone through trial and error by the development team. PSSUQ (Post-Study System Usability Questionnaire) item questionnaire was used as the method for evaluate the application. The final results were 2.23 for the overall subscale, which was in the good category, 2.2 for System Usefulness and information quality, and 2.4 for interface quality. This suggests that there is still room for improvement in terms of the simulation's user feedback design system, additional features such as air cooling, dynamic interfaces, and lowering the sensitivity of the wheels that involve immersive real-time rotation.

Keywords: Usability, Virtual Reality, Training 3D Simulation, Usability Testing, Post Study System Questionnaire (PSSUQ).

1 Introduction

Indonesia was impacted by the COVID'19 pandemic at the beginning of 2020, to keep the learning program stay running, there must be applied some modification [1]. Which is accomplished through remote or virtual study systems. Unfortunately, this method has not been able to cover all universities evenly, particularly vocational universities where the majority of teaching and learning activities are conducted through practicum. The offline learning system was then allowed to return in mid-2021 as long as it followed health protocols. One of the protocols involves limiting the number of students who can use the classroom or laboratory at the same time. Therefore, we require additional media to assist us in understanding the context of the lesson in class when using practical equipment, especially practicum tools for engineering students.

Through Virtual Reality, users can interact with an environment that is visualized in real time in the form of a 3-dimensional simulation (VR). The author believes that the use of virtual reality (VR) can be used to create an efficient system that can be used as an assistant media for learning learners to gain knowledge in both theory and practice. The use of VR media has the potential to overcome device limitation that are not match to the growing number of students

ICAE 2022, October 05, Batam, Indonesia

DOI 10.4108/eai.5-10-2022.2327746

each year. As a result, the simulation application will no longer require the original machine to learn [2].

One of the simulation applications developed by the author and the internship team during the internship program at DigiArs Studio - Production House is VR simulation of lathe operation. Polytechnic State of Batam actively supports the program. This lathe simulation was created at the request of the client, who is a Mechanical Engineering lecturer at Polytechnic State of Batam. It has gone through stages of trial and error with the internship supervisor to the client directly during its development. Because the lathe simulation will be used by students or end-users, further testing is required for this application to be readily used by students.

Usability is one of the issues that should be raised following the presentation of the lathe operation simulation application. Usability is a component of user experience that evaluates the level of efficiency and effectiveness with which users interact with a product. The goal of using usability is to design or evaluate user interactions with systems, products, or services [3]. Usability evaluation is an activity that is performed to determine the level of value that a product has through aspects of sub-characteristics that fulfill the usability of the entire application [4].

In terms of research limitations for successful research implementation, the application used is the result of an internship, so the work is customized to the brief with the client, and the "VR Simulation of Lathe Machine Operation" application does not cover the entire turning learning module. The application includes an introduction to the tools and lathe parts required in the flat turning process.

The goal of this study is to determine the usability in the application "Simulation of Lathe Machine Operation Virtual Reality". From this purpose, A data collection instrument of the type PSSUQ questionnaire was being used.

2 Literature Review

This study refers to previous study conducted by Biabdillah, F., Tolle, H., and Bachtiar, F. The study titled "Go Story: Design and Evaluation of Educational Mobile Learning Podcast Using Human Centered Design Method and Gamification for History". This study evaluates learning media interfaces that use a virtual environment and are based on the Human Centered Design model to increase learning motivation. The PSSUQ method was used by the authors as part of the iterative process and in their second test after revising the previous design [5].

Other similar studies conducted by Yauw, L. Y titled "Usability Analysis and SCLEAN Application Interface Improvement Using Human Centered Design Method Centered Design". In this research they used HCD method as a design method and as for to compare the results of usability testing using the PSUUQ questionnaire. The second stage of testing was performed on applications that had been improved. As a result, the percentage of usability aspects of the application increased, raising the overall user experience score [6].

This research is used to evaluate the usability value of the VR lathe simulation system. The lathe simulation is a 3D training simulation that uses VR devices and headset and controller as a hardware input could sync in real-time [7]. The lathe application has three menus: the initial

menu, the introduction menu, and the Carving menu. The Start menu is the first menu that users will see, from which they can select one of the other two menus. In the introduction menu, users will go through scenarios in which they will recognize the tools and machine parts of the lathe used in the basic flat turning stage. In the Carving menu, there are procedures that direct users to work on the flat turning process.

Figure 1. Start Menu

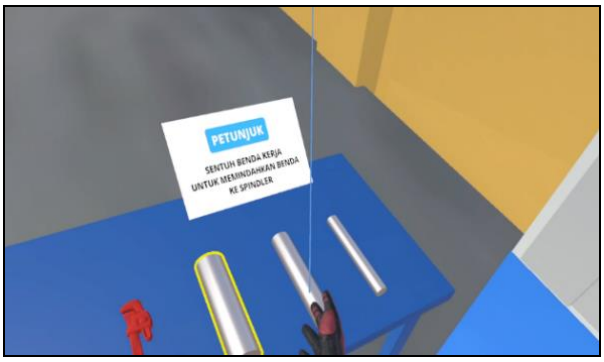

Figure 2. Direction and Hints from the UI Info

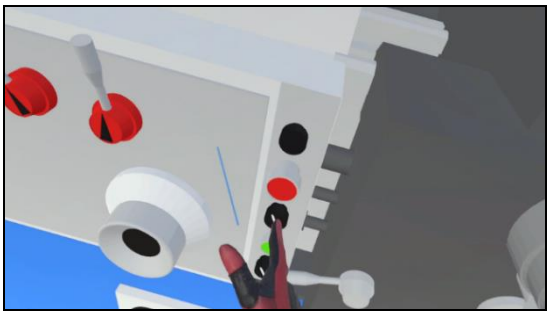

Figure 3. Interaction with Machines

3 Research Method

This research uses the same flow as previous research which starts from literature study, preparing scenario tasks, proceeds to the usability testing stage, analyzing data results, and finally conclusions [8], [9]. The flow of research shown in Figure 4.

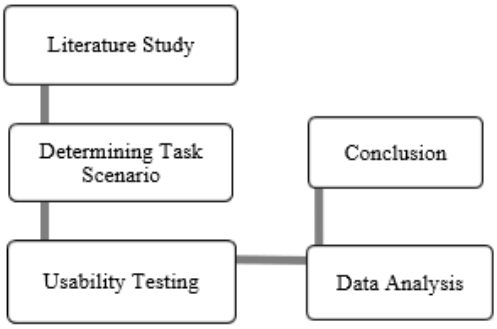

Figure 4. Research Flow

3.1 Literature Study

The research begins by comparing past studies related to product evaluation using usability and establish which tools are appropriate for usage in application cases with lathe introduction training using simulation systems. In the case of this analysis, PSSUQ was chosen as the instrument used during the test. Since usability cannot be measured in general, the measurement method uses parameters related to subjective and objective preferences [10].

3.2 Determining Task Scenarios

Usability is measured by how users interact with the application and complete each task assigned to them, as well as how long it takes to complete the task [11]. Therefore, a scenario of what tasks the user must perform to reach the end of the simulation application so that it can be evaluated is required. It also prevents missing components from being evaluated, such as apps with several menu tabs.

Table 1. User Task Procedures

No.	Procedures
1.	Participants entered the room and put on VR equipment, went through a training session using basic functions on VR media (grasping, teleporting, rotating, tapping, laser aiming) with the guidance of a moderator.
2.	The moderator launched the simulation application program and walked participant through the application menus.
3.	The moderator instructs the participants to select the "Introduction" submenu and enter the scene of the tool and lathe machine introduction session.
4.	The participant is instructed to press the "Next" button to proceed to the "Carving" scene and begin the lathe operation from beginning to end based on the steps shown in UI.

5. The participant clicks the "Finish" button to return to the initial Menu scene, where participant would find the "Exit" button to end the simulation session.
6. Participants went through the questionnaire filling process and testing was finally completed.

Because the purpose of this research is to measure usability problems from the end user perspective, it is better to determine the number of participants needed. It is preferable to test with a small number of respondents to identify usability issues in a final product. After five users, you'll be wasting time getting the same results as others while learning nothing new. After the first study with 5 participants, 85% of usability problems will be discovered, and the remainder will be discovered again with the second or third study, with changes made in response to the problems discovered [12]. The qualifications that participants must meet as part of the lathe operation simulation application evaluation activities, such as:

I. Participants are enrolled in the Mechanical Engineering program and have previously studied turning on a lathe theoretically.
II. The participants attend Batam State Polytechnic.

This study requires the participation of 5 engineering students which followed these requirements. The profile of respondents with positions as second and third year students, welding engineering, and manufacturing engineering who have passed the theoretical session on turning with a lathe was obtained using these requirements. This study requires the participation of 5 engineering students.

3.3 Usability Testing

This study tested a total of 5 respondents, evaluating them after using the simulation application with the assistance of a moderator and basic VR walkthrough. The PSSUQ (Post Study System Questionnaire) version 3 method is used for usability testing, with a total of 16 questions and 1-7 point scoring option. The addition of a 'description' column to support the scale points assigned to each question item is also part of the use of PSSUQ items. The PSSUQ questionnaire items are listed below [13].

Table 2. Question Items in PSSUQ Questionnaire

No.	Question	Scale
1.	Overall, I am satisfied with how easy it is to use this system.	1-7
2.	It's very easy to use this system.	1-7
3.	I can complete tasks and scenarios quickly using this system.	1-7
4.	I feel comfortable using this application system.	1-7
5.	It is easy to learn to use this application system.	1-7
6.	I believe I can become productive quickly using this app.	1-7
7.	The system provided an error message that clearly told me how to fix the problem.	1-7
8.	Whenever I make a mistake using the in-app system, I can recover easily and quickly.	1-7
9.	The information (such as online help, on-screen messages, and other documentation) provided with this app is clear.	1-7
10.	It was easy to find the information I needed.	1-7
11.	The information was effective in helping me complete the	1-7

	tasks and scenarios.	
12.	The organization of information on the system screen is clear.	1-7
13.	The interface of the system is pleasant.	1-7
14.	I like using this system interface.	1-7
15.	This application system has all the functions and capabilities that I expected.	1-7
16.	Overall, I am satisfied with this system.	1-7

PSSUQ ranges from 1 (strongly agree) to 7 (strongly disagree). The lower the score, the better the performance and user satisfaction with lathe simulation application's features and usability.

Table 3. 7-point scale scoring

Scale	Details
1	Strongly Agree
2	Agree
3	Sometimes Agree
4	Neutral
5	Sometimes Disagree
6	Disagree
7	Strongly Disagree

3.4 Analyzing Data

Following the completion of usability testing, the results of the respondent data are summarized with the final result in the form of the quality of each sub-scale component and the overall test using usability evaluation [14]. According to the indicators or factors that consist the PSSUQ sub-scale evaluation:

a. System Usefulness (SysUse); indicators that measures the system is simple to learn, allows users to complete tasks efficiently, and allows them to become more productive faster.
b. Information Quality (InfoQual); a factor that evaluate the application system's feedback to users in the form of information messages about the process being carried out. This section also evaluates whether the application's system is more organized, information is easy to understand, and users are able to complete tasks.
c. Interface Quality (InterQual); a metric that assesses whether users like the system interface and whether the system provides the functions and capabilities that users expect.
d. Overall; An indicator that weights the previous three indicators. This section can also be thought of as a user satisfaction survey.

Once the four subscales have been evaluated and the description column of each PSSUQ question item has been interpreted, the results of the suggested recommendations for improvement in the simulation application will be obtained [15]. The Table 4 shows the range of each subscale's scoring rules.

Table 4. PSSUQ Score Measurement Rules

Subscale	Mean

Overall	Question Items 1 to 16
SysUse	Question Items 1 to 6
InfoQual	Question Items 7 to 12
IntQual	Question Items 13 to 15

3 Result and Analysis

The PSSUQ version 3 method was used to test the usability of the lathe simulation application in the form of a questionnaire with 16 questions representing four sub-scale components to analyze the product. This study was conducted on 5 mechanical engineering students who had studied lathe machines in theory, specifically manufacturing engineer and welding engineer. Table 5 shows the study's data results from the questionnaire.

Table 5. PSSUQ Score Results

No	R1	R2	R3	R4	R5	Total	**Mean***
1	1	2	4	2	2	11	**2.2**
2	1	2	4	1	1	9	**1.8**
3	3	3	4	2	2	14	**2.8**
4	2	1	3	2	2	10	**2**
5	1	2	3	1	2	9	**1.8**
6	1	4	4	1	3	13	**2.6**
7	4	3	5	2	6	20	**4**
8	2	2	5	2	6	14	**2.8**
9	1	2	2	1	2	8	**1.6**
10	1	1	2	2	1	7	**1.4**
11	1	1	1	2	2	7	**1.4**
12	2	2	2	2	2	10	**2**
13	1	2	4	2	2	11	**2.2**
14	1	2	3	2	2	10	**2**
15	2	4	4	2	3	15	**3**
16	1	3	3	1	3	11	**2.2**

*The smaller range of values shows better usability

Thereafter responses are collected, using the mean rule of the subscales to determine the mean of each subscales; the results are shown in table 6 below.

Table 6. Mean of Each Subscales

Subscale	**Mean***
Overall	**2.23**
SysUse	**2.2**
InfoQual	**2.2**
IntQual	**2.4**

* The smaller range of values shows better usability

Although this simulation application has a high average value, it is far from perfect, as evidenced by the seventh question item, which has an average of 4 or neutral. Indicating that the lathe simulation application still requires changes to the error message or feedback from the application while being used. Respondents encountered challenges such as difficulty reading the usability information text UI, some of which were located too high.

Users who wear glasses may have difficulty reading fonts on the UI Menu that are too small and blurry, however this is normal for other users. One respondent also mentioned that the lathe still requires features like air cooling and foot brakes, just like the original machine, and then the steer that drive the tool blade closer to the spindle requires attention because rotating the longitudinal and transverse sled is sensitive and difficult to grasp virtually by hand controller.

4 Conclusion

In this study, usability testing is used to assess the value of usability aspects in the VR lathe simulation application. The task must be completed by a total of 5 participants. The PSSUQ questionnaire is then used as a tool to determine the range of scales and subscales as the value of usability aspects in the evaluation, yielding a score of 2.23, 2.2, 2.2, 2.4. (the score, in order, Overall, SysUse, InfoQual, IntQual). Where the total average is in a good category and above the average.

This research yielded recommendations that can be used as a starting point for future research, such as simulation applications that can be used in the classroom learning process. In this case, the lathe simulation can be tested with a class's average number of students. The goal is to conduct testing on samples with profiles comparable to the quantity in the field.

Acknowledgements

The author is grateful to the Ministry of Vocational Education for providing and handing over the 2021 online module. Many thanks also to fellow mechanical engineering students who are willing to provide their time, and who volunteered to be participants in order to test this lathe operation simulation application.

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