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Evaluating metaverse platforms for educational purposes: a heuristic evaluation study

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ABSTRACT

This research's primary objective is to investigate the educational potential by investigating the metaverse website, emphasizing from users' perspectives. It is critical to examine the functionality to identify any potential faults in the learning experience because of the complexities of metaverse apps, which include 3D virtual environments and complex interactions. This study uses heuristic evaluation, which is a useful method for analyzing application success by utilizing well-established design principles and best practices in user interface and user experience design. To conduct this study, a panel of five experts, each with outstanding competence in the topic, was assembled to test the metaverse website in an educational setting. The evaluation was built on the ten heuristic evaluation standards, which served as a solid framework for measuring its usability and functionality. According to the findings of this examination, the average severity number of heuristic issues is one. This result indicates that the website is under "cosmetic problems only." While this implies that specific areas need to be addressed to improve overall quality, it also means that these difficulties do not take precedence over other vital ones. As a result, the website has significant promise as a metaverse instructional platform, and changes can be made to further improve its efficiency.

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1. INTRODUCTION

In recent years, the metaverse concept has received considerable attention, attracting individuals and organizations worldwide. In the 1992 science fiction novel "Snow Crash," Neal Stephenson used the term "metaverse" to describe a virtual reality space where people can communicate in real-time with a computer-made environment [1]. As a result of technological advancements and the convergence of virtual and augmented reality, the metaverse is becoming increasingly popular. Industry heavyweights such as Microsoft, Qualcomm, and Meta (which was once known as Facebook) have contributed financially to the creation of the metaverse. This support has been essential to the project's success [2].

As the metaverse becomes a possible new frontier, its uses in different fields, such as education. In education, the metaverse promises immersive and interactive experiences that will let teachers engage with students and increase their motivation [3].

Using technology applications in education is becoming increasingly essential to meet the changing needs of current students. Traditional ways of teaching are good in their own right, but they don't always give

students the immersive and involved experiences they need to learn in different ways. Metaverse applications can change this gap. The integration of many forms of modern technology into educational settings is now required. Recently, there has been a tendency toward learning using online infrastructure since the COVID-19 pandemic [4]. Metaverse applications can make learning settings dynamic, engaging, and hands-on by using virtual and augmented reality technologies [5]. Students can use these apps to learn about complicated ideas through interactive simulations, work with other students in virtual spaces, and access many multimedia materials. Also, metaverse applications could help students from different places meet and learn together. By giving learners a rich and engaging learning experience, metaverse apps encourage them to be curious, think critically, and be creative [1].

However, very limited research has tried to determine the usability of the metaverse application and how it can be acceptable to educators. To get the most suitable metaverse apps in education, ensuring they are easy to use and provide a good user experience is important. In Indonesia, education and the use of technology are still an issue [6]. Especially for teachers who find it challenging to adopt and use new technology. Digital literacy also be an issue for teachers, they are not familiar with technology and think technology is difficult to use [7]. To ensure the technology can be used and accepted by the users, heuristic judgment comes into play at this point. Heuristic evaluation is a method in which experts look at a user interface in a structured way and find usability problems based on a set of rules [8]. Heuristic review is a common way to test how easy-to-use a user interface is, including those used in education. Expert reviewers look at an interface systematically and find usability problems based on a set of rules or heuristics that have already been set up [9].

In the setting of metaverse applications, heuristic evaluation is important for several reasons. First, because the metaverse is still a relatively new idea that is still developing, there may not be many well-established design rules or best practices for this area. Heuristic reviews can help find usability problems where metaverse applications could be better designed. Second, user interfaces and interactions in metaverse apps are often complicated, making them hard to use. Heuristic evaluation is an organized way to find usability problems with navigation, interaction design, feedback, and other important things. Another study also looks into the heuristic evaluation to enhance user interaction and experience on Roblox, Zepeto, and Gather Town [10].

Since the metaverse concept is still evolving, many applications are considered small metaverses with metaverse concepts. An example of a metaverse education platform just released in 2022 is Edverse. Edverse was initially released in 2022 and is still being developed until now. It allows students to participate in an immersive experience and collaborate on the platform. On the Edverse platform, there are four different stakeholders, and they are as follows: learners are students who can take part in the activities offered on the platform. Educators are teachers who can make use of teaching opportunities offered by Ed-NFTs. Promoters are responsible for constructing, marketing, and renting out institutions on the platform, while creators make Ed-NFTs that instructors and students can rent.

Based on the timeline from the company website, in 2023 Q1, the company will launch a beta version of the metaverse or additional features in the virtual classroom. In Q2 2023 the company is set to release the entire EDV ecosystem, along with its features and virtual reality (VR) platform support. Although this platform is still in development, users can already create an online classroom free of charge and explore its features. Metaverse applications involve complex virtual environments and interactions, so identifying any issues that might affect learning is essential [11]. Heuristic evaluation, a method based on well-known design principles and best practices, proves to be valuable for assessing the functionality of these applications [12].

There aren't many studies with well-established heuristics to the metaverse application. Metaverse offers unique characteristics like multi-user interactions, virtual embodiment, and real online experiences. The metaverse experience relies on immersion and presence, however, current heuristic evaluation techniques frequently investigate the common application. The primary objective of this research is to identify and characterize the main usability issues specific to the metaverse environment by doing heuristic assessments of metaverse apps in order to improve user experiences in the metaverse application. This study looked into the specific heuristic issue for metaverse applications while previous studies focused on the acceptance and adoption of the application.

The results of this research will be beneficial to a variety of different parties involved in the education industry. The issues of usability that are presented by metaverse apps can be better understood by educators, allowing for more educated judgments to be made regarding the incorporation of these applications into instructional practices [13]. Designers and developers can utilize the recommendations created as a result of the heuristic assessment study to enhance the design, functionality, and user interface of metaverse apps. In the end, the purpose of this research is to contribute to the development of metaverse technology in educational settings, with the end goal of providing students with more interactive learning opportunities.

2. LITERATURE REVIEW

This part describes the literature related to this study, including several sections. The first section is the metaverse concept, which describes the metaverse application, definition, and other research. The second section is a metaverse platform, especially for education purposes, and the third section is the explanation of heuristic evaluation as the method of this study.

2.1. Metaverse concept

A metaverse is an extensive network of virtual worlds, augmented reality experiences, and shared environments. It can be viewed as an immersive, persistent, and interactive VR environment that transcends individual applications and platforms [14]. In a metaverse, users can engage with avatars, and digital representations of themselves, and interact with other users in real-time. They can explore diverse virtual environments, engage in various activities, create and manipulate virtual objects, and engage in social, economic, and educational activities [15].

While science fiction literature, films, and video games have popularized the metaverse concept, ongoing research and development are bringing it closer to reality [16]. Numerous businesses, organizations, and technology pioneers are actively constructing components of the metaverse and imagining its potential future applications [17], [18]. Notably, the metaverse concept is still evolving, and its precise form and implementation may vary. There are ongoing discussions and debates concerning its technical infrastructure, standards, governance, and ethical considerations [19]. The vision of a fully realized metaverse continues to captivate the imagination and influence the future of digital experiences as technology advances.

2.2. Metaverse platform for education purposes

A metaverse platform for education is a virtual environment created for learning. It makes immersive, interactive, and collaborative learning places using the metaverse. Students and teachers can engage in virtual classrooms, examine educational content, interact with digital objects, and participate in educational simulations and experiences on a metaverse platform for education. It affords students the chance to work together to solve a problem [3].

The platform can give various educational tools, such as virtual textbooks, interactive lessons, 3D models, virtual experiments, and simulations. It allows students to see what abstract ideas look like, play with virtual items, and learn in ways that may not be possible in a physical classroom. A metaverse platform for education can also give you options when it comes to time and place. Students can access educational material and take part in virtual classes from anywhere in the world. This makes it possible for them to learn without being in the same place [20]. Examples of metaverse-based applications include Zepeto, Roblox, Edverse, Eduverse, and Mozilla Hubs.

2.3. Heuristic evaluation

A well-known usability expert named Jakob Nielsen developed a set of rules for designing user interfaces that are now widely known and used in heuristic evaluation. These algorithms guide determining whether a user interface is easy to use and finding possible usability problems. Here is how Jakob Nielsen explains the ten rules [20]:

The first rule is the visibility of system status. This rule will keep users updated on how the system works and give them the right comments. Users should know what is happening, whether a process is running, a page is loading, or an action is finished. The second rule is a match between the system and the real world, which employs user-friendly terminology, frameworks, and analogies. The system should be realistic in its norms and easy to use, so people from different walks of life may pick it up quickly. The third rule is User control and freedom which means users should be able to make their own decisions and move freely throughout the interface without worrying about unintended consequences. Make it possible for users to undo and redo actions in the event of an error. The fourth rule is consistency and standards which means the application should keep the style, language, and interactions the same throughout the system. Follow set design rules and standards to give users a consistent experience. The fifth rule is error prevention which means the system should be designed to prevent errors from occurring in the first place. Use constraints, validation, and explicit instructions to direct users and reduce the likelihood of errors. The sixth rule is recognition rather than recall which means lessening the amount of thinking users have to do by making information easy to see and understand. Minimize the amount of knowledge that users have to remember and instead give them visual cues and prompts. The seventh rule is flexibility and efficiency, which allows for different user and skill levels. The new and expert users can use it to get things done quickly. Give power people shortcuts and ways to change things. The eighth rule is aesthetic and minimalist design which keeps the user experience looking good and focused on what's important. Remove extra stuff and distractions to make the layout clean and easy to use. The ninth rule is to help users recognize, diagnose, and recover from errors. When mistakes occur, give users informative, actionable error messages that explain the situation and

offer guidance on how to proceed. Help people fix problems when they encounter them. The tenth rule is help and documentation which provide extensive and simple-to-find documentation and help materials to aid users in comprehending and operating the system. Don't assume that people can figure out how to do things independently.

These ten rules of thumb by Jakob Nielsen can be used to evaluate and improve the usefulness of user interfaces. Heuristic evaluation is the process of using these rules to find usability problems, decide which changes are most important, and improve the general user experience of a system.

3. RESEARCH METHOD

This part will describe the research methodology that will be used in this study. This section is divided into two subsections. The first subsection shows the steps in this study, the second subsection shows the evaluation design criteria used in this study. The methodology of this study is using the heuristic evaluation method introduced by Jakob Nielsen [20]. By using a heuristic evaluation technique based on previous research [9], [21], [22]. Several steps will be included in this research which will be discussed in the next section.

3.1. Method selection and steps

This section describes the steps of this study. The study starts with the problem identification, including the literature review, background of the study, and the study objective. Next is choosing the appropriate methodology based on the problem.

As mentioned earlier, this study uses heuristic evaluation to evaluate the user interface. It is a well-known and useful way to test how easy it is to use a user interface. Expert evaluators use a set of heuristics or usability principles to look at an interface systematically as part of the heuristic assessment. Another method that can be used to evaluate the user interface and user experience is the quantitative method by adopting the system usability scale (SUS), this method is suitable for quantitative study if the system is already used by many end users [23].

A team of experts who know much about usability evaluation and teaching technology will work together in the heuristic evaluation process. The evaluators will each look at the metaverse application, try out its features, and use known heuristics to look for possible usability problems.

The next step is developing the questionnaire based on usability and choosing the respondents or experts. We invite five experts to fill up the questionnaire based on heuristic principles by Jakob Nielsen. Heuristic evaluation does not require a huge number of respondents. Choosing only five experts is ideal and can capture more than 75% of usability problems [20], [24]. Those experts are information systems lecturers from one of the reputable universities in Indonesia. They have experience teaching and mastering user experience subjects for over ten years.

Next, the expert will be given time to try and look at the app's interface based on a set of usability rules important to educational settings. The experts will also rate how bad the problems with usefulness are by filling out the questionnaire. During the evaluation, the evaluators will write down their ratings and give suggestions to improve the user experience.

After the data collection, next is the data analysis step. The data analysis will follow in (1).

$$\Sigma A = (0 * X) + (1 * X) + (2 * X) + (3 * X) + (4 * X) \quad (1)$$

Where: ΣA is the total of the rating scores of the usability sub-aspects in each usability aspect (A1, A2, ..., A13); Score 0-4 is the value of the severity rating; and X is usability point, worth 1/0 (1: Yes, 0: No).

To generate the severity rating value of each usability aspect, formula (2) is used.

$$S = (\Sigma A)/n \quad (2)$$

Where S is the result of the severity rating in one aspect of usability; ΣA is the total of the rating scores of the usability sub-aspects in each usability aspect (A1, A2, ..., A13); and n is the number of usability sub-aspects in each usability aspect.

This study evaluated the severity rating scale of 0 to 4 [22]. The smaller the scale number, the greater the proportion of respondents who agree that the current features are sufficient and that nothing else should be added. Rather, the higher the number on the scale, the greater the importance and significance of the features the user will require and the website must provide. Table 1 will show the details of each rating [10].

Next, the heuristic evaluation data will be synthesized and analyzed to generate meaningful conclusions. The results will contribute to a broader understanding of how heuristic evaluation can be applied in the context of educational technology, particularly metaverse applications, and provide insights for optimizing their educational efficacy.

Table 1. Severity rating scale

Scale	Severity Rating	Description
0	Don't Agree	Meaning this is not a problem at all
1	Cosmetic Problem	Need not be fixed unless extra time is available on the project
2	Minor Usability Problem	Need to fix the problem, but fixing the problem should be given lower priority
3	Major Usability Problem	Important to fix, should be given higher priority
4	Usability Catastrophe	It is imperative to fix

3.2. Evaluation design

Inspired by Nielsen's heuristic design principles, the checklist was designed to test usability. The question will accommodate each principle and will be answered by the experts. Here are the checklists of each principle. The experts will give a rating for each of the criteria. Table 2 shows the severity rating scale which is the checklist or indicators of the criteria and given to the expert to evaluate the user interface.

Table 2. Heuristic evaluation checklist/indicators

Usability Aspects	Code	Checklist/Indicator
Visibility of System Status	X1.1	Clear visual cues or indicators to tell users about ongoing procedures or tasks
	X1.2	Users receive real-time updates on system processes including loading, syncing, and content updates
	X1.3	The system status information available in the user interface
Match Between System and the Real World	X2.1	The terms and language used within the system are familiar and easily understandable to users
	X2.2	The navigational structure resembles real-world environments
	X2.3	The meanings of the boxes and icons understandable for users
User Control and Freedom	X3.1	Users can freely explore and interact by quickly navigating across sections or features
	X3.2	Users can undo or redo their activities to fix mistakes or revert to previous states
	X3.3	Users can change settings, preferences, and their experience
Consistency and Standard	X4.1	The color scheme, typography, and layout consistent across screens
	X4.2	Users can predict and understand the application interaction patterns
	X4.3	The same-size of the icons
Error Prevention	X5.1	Alert sound to let users know when something goes wrong
	X5.2	Any information in the error message about what might have caused the problem
	X5.3	Error messages to tell people how to fix the mistake
Recognition rather than recall	X6.1	The user interface displays key information and relevant options
	X6.2	Labels, icons, and other visuals help users identify without having to recall or guess what they mean
	X6.3	Clear and simple directions so users already know or remember what they did before
Flexibility and Efficiency of Use	X7.1	Each icon's purpose stands out with short, clear images
	X7.2	Allow users to customize settings for a more personalized and efficient experience
	X7.3	Shortcuts, hotkeys, or sophisticated features that help experienced users work faster
Aesthetic and Minimalist Design	X8.1	The visual design of the application
	X8.2	The application prioritizes important information and features and conveys them graphically and easy to read
	X8.3	The application's colors, font, and artwork
Help users recognize, diagnose, and recover from errors	X9.1	The error messages help users understand the problem and suggest recovery solutions
	X9.2	Error handling tools to help users diagnose and fix errors
	X9.3	Assistance from the application to help users detect and resolve errors
Help and Documentation	X10.1	User manuals, FAQs, and online documentation to help users
	X10.2	The application support resources help users quickly access relevant information and guidance
	X10.3	In-context help or tooltips that provide on-screen guidance and instructions

4. RESULTS AND DISCUSSION

There are five experts were invited to contribute to this research. The profile of each expert can be seen in Table 3. The results of the calculation of the severity rating of the 10 usability aspects severity rating for each aspect are shown in Table 4.

Table 3. Expert's profile

Name	Job	Years of Experience	Experience in UI/UX Evaluation
Ms. S	Lecturer	>11 years	5 years
Mr. Y	Lecturer	>11 years	>11 years
Mr. H	Lecturer	>15 years	>15 years
Mr. Y	Lecturer	>15 years	>5 years
Ms. J	Lecturer	3 years	3 years

Table 4. The result of the severity rating evaluation

No	Usability Aspects	ΣA (Total Rating Score)	SR (Severity Rating) (ΣA/n)	Round Number of SR
1	Visibility of System Status	2.33	0.78	1
2	Match Between System and the Real World	2.33	0.78	1
3	User Control and Freedom	2.67	0.88	1
4	Consistency and Standard	1.33	0.44	0
5	Error Prevention	2.33	0.78	1
6	Recognition rather than recall	2.67	0.88	1
7	Flexibility and Efficiency of Use	2	0.67	1
8	Aesthetic and Minimalist Design	2.33	0.78	1
9	Help users recognize, diagnose, and recover from errors	2.67	0.88	1
10	Help and documentation	4	1.33	1

Based on the results obtained, it can be concluded that overall, the usability value of the heuristic evaluation is on the average 0.9 scale, which means overall the website is categorized as a cosmetic problem only. Some aspects need to be fixed to enhance the quality but not set as the priority. The detailed discussion about each rule of heuristic is as follows:

i) Discussion for visibility of system status

Visibility system status indicates that the system can give status information to user situations. Users can find out what they are currently facing [25]. According to the findings of the expert evaluation, the severity rating value is one, which indicates that there is only a cosmetic problem. This indicates that it is already satisfactory. However, if the developer wants to make it even more acceptable, it may be fixed but not set as a priority. This also means that the metaverse application has a clear state of the system and does not confuse the user.

ii) Discussion for the match between the system and the real world

Especially for the metaverse application, the application is made as close to the original as possible by using an avatar to represent the user [26]. It is also hoped that the instructions and language can match the user's real life. Based on the evaluation results by the expert, the results of the severity rating were obtained on a scale of one, which means a cosmetic problem only [25], which means it is already good. This also means that the metaverse application being tested has provided the same features and feelings as the real world, it can be from language, structure, and icons that are in accordance with the user's real life, for example using standard English, the atmosphere of the room is like in the original room, avatars can walk, and sit. Besides that, icons are also made as usual, for example, signs for chat, and share screen.

iii) Discussion for user control and freedom

The ability to customize the system somehow should always be made available to users of a high-quality operating system [8]. When the application for the metaverse is evaluated, a severity rating is achieved on a scale of one, which denotes cosmetic problems only. This indicates that the application is satisfactory [21]. This also indicates that the metaverse application that is being evaluated has granted the user complete control over the actions that may be performed within the application via navigation, settings, and the customization of user preferences. For instance, the user can freely choose the background of the virtual room and the settings for his avatar.

iv) Discussion for consistency and standard

For an application to have a professional appearance and avoid confusing the user, it is essential that each page be kept consistent and that standards be adhered to [27]. It was discovered that the severity rating

for the metaverse application being tested was set at the number zero, which indicates that it was very good in maintaining consistency across the application being examined. One way to think about consistency is in terms of colors, icons, and buttons, among other things.

v) Discussion for error prevention

A reliable system will be able to provide prevention before the occurrence of errors. This means that the system will be able to present the user with necessary recommendations prior to the user's propensity to make errors. In this instance, the specialist rated the metaverse application that was put through its paces as satisfactory, assigning it a severity rating value of one, which indicates that there is only a cosmetic issue. This also indicates that the metaverse application delivers instructions to ensure that users do not make errors-causing blunders when utilizing the software.

vi) Discussion for recognition rather than recall

When a user needs to resubmit or reuse a function, it is crucial that they can readily remember the action they took previously and not have to think too hard or make educated guesses about what they did previously. This is what is meant by "recognition rather than recall" [20]. Regarding this particular element, experts agree that the severity level is one, which indicates that the issue is only a cosmetic problem.

vii) Discussion for flexibility and efficiency of use

When using an application, users undoubtedly want to be able to customize their experience and discover the quickest method to do things, such as by employing a keyboard shortcut. The severity grade for the evaluated application for the metaverse is one, which translates to "cosmetic problem only" and denotes that the qualities of flexibility and efficiency of use are satisfactory.

viii) Discussion for aesthetic and minimalist design

An appealing presentation of the user interface has the potential to capture the user's attention. Because most of the application's users are young, the metaverse must have an attractive and minimalist look. The severe rating number of the assessed metaverse application was one, indicating that mainly cosmetic issues were present. In terms of its physical look, there are no major issues to speak about because it is of satisfactory quality and appealing.

ix) Discussion for help users recognize, diagnose, and recover from errors

Even while it is intended that the user will not find any mistakes, it is also hoped that the metaverse application will provide a diagnostic of existing error problems and attempt to provide a way out for the user in language that is simple to comprehend if an error must occur in the end. This is the case even though it is desired that the user will not find any errors. According to the evaluator or experts, the evaluated metaverse application received one value, indicating a cosmetic problem only.

x) Discussion for help and documentation

Help and documentation are essential components in an application, and they become much more essential when the user is navigating the application for the first time. The severity rating for the evaluated metaverse application was 1.33, which was rounded down to one, indicating that there is only a cosmetic problem. Even though it is rated good, the developer still has room for improvement to give users an even better experience using the product.

5. CONCLUSION

In the end, the general results of the heuristic evaluation testing done on the application were good. Using a set of well-known rules or principles. During the evaluation process, a team of experts systematically looked at the system against these predefined heuristics. This helped find possible usability problems and places where the system could be improved. The people who did the evaluation looked at things like how easy it was to learn. The heuristic evaluation results showed that the system or program well met most of the heuristics. This means that the product was made with the user in mind, considering the rules that make it easier to use and give the user a better experience. The people who evaluated the system or application pointed out several good things about it, such as clear and easy navigation, a well-organized information architecture, good error handling, and a uniform visual design. These results show that the system or program will likely be easy to learn and use, making users happier.

For further study, on the long-term usability and efficacy of metaverse apps in educational settings, longitudinal studies are essential. Researchers would be able to better understand how usability elements change over time and how they affect user satisfaction, engagement, and learning outcomes by following teachers' and students' usability experiences over an extended period through a longitudinal study. Future studies should also examine the impact of individual characteristics on metaverse usability and user experiences, including technological aptitude, cognitive capacities, and learning styles.

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