Evaluation of Meta-UI in AR and VR Application for Medical Education

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Abstract—**Immersive technology has provided many benefits in various fields, including in medical education. Several learning obstacles have been overcome, such as limited practicum space, few teaching aids, and limited time. To address this issue further, the authors are building virtualized AR and VR modules that are implemented to help users improve their skills before doing practical work in the real world. The authors use AR technology to study human anatomy, while VR technology to study Normal Childbirth Surgery. To build a module, the authors need to design an interface that can provide convenience for the user, so that it can be used continuously. This research collected feedback from users to build an unobtrusive interface when running the application and remove animations that have nothing to do with the medical lab module. The authors designed the interface with a Meta-UI approach to provide a clean look, so users can focus on doing practicums. This research observed that the use of Meta-UI in this study has given satisfaction to the users through the analysis of the PIECES framework. The authors got a score between 3.97 - 4.20 for AR and 4.5 - 4.67 for VR from the user satisfaction measurement which means that users are satisfied with the offerings and services of this app.**

Index Terms—**Augmented intelligence, virtual collaboration, medical education, Meta UI.**

I. Introduction

Recently, immersive technology has attracted a lot of users' interest. Immersive technology is in great demand because this technology has a uniqueness that blurs the boundaries between reality and the virtual. Immersive technology provides an immersive, seamless experience. Immersive technology is divided into three parts, namely Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR). In contrast to VR technology, AR technology is unique in being able to display information that users cannot accept through their senses, such as displaying virtual objects in the real world through devices such as smartphones. This study focuses on the implementation of AR and VR to support learning in the medical field. As a result, knowledge transfer is ineffective since the majority of health education practical activities need hands-on experience using physical equipment. All students may gain dynamic and personalized practice experiences by using AR/VR devices because to the technology's mobility and adaptability [1]. This has a significant effect on medical students' ability to practice their abilities. As there is presently no online module for practical medical education, health practitioners are required to adapt to the current situation.

The development of medical education modules in the AR and VR fields of course considers user needs. Such Augmented Reality and Virtual Reality (AR/VR) apps are created to address medical demands and provide an alternative to the current approach [2]. The modules are built to follow the standard guidelines for teaching materials at the Universitas Nahdlatul Ulama Surabaya institution, which facilitates a medical education study program. In this field of science, the development of AR and VR depends on the demographics of medical students who are end users, and medical doctors as validators of the content displayed. However, it is possible that other medical personnel can use this learning module, such as nurses and midwives.

AR and VR technologies are applied in the medical field, allowing professionals, educators, and learners to cooperate in the virtual scene to perform practical health scenarios and learn human anatomy through user interface-integrated interactions. In AR VR, there are important parts besides the displayed content as well as the development of the User Interface (UI). UI is an important point where users can interact with the application [3]. The UI is effective in providing convenience, it is intuitive and makes it easy for the user to receive the desired result. The study of the user interface in AR VR implementation is interesting to discuss. Using the UI makes it easy for the user to interact with the app. At this step, the things that need to be considered are the selection of screen designs, buttons, icons, text, images, and visual elements that act as liaisons with the main application. If the user interaction goes well, the needs and goals of the user using the application can be met. Also getting satisfaction from users can increase user loyalty for continued use of the application.

In this study, this test is the second stage of testing the implementation of AR Augmented Intelligence on Virtual Education (AIVE) conducted by Fajrianti *et al*. [4] and VR Collaborative Simulation conducted by Al Hafidz *et al*. [5] by designing Meta interface elements to improve user experience.

The main purpose of this study is to analyze the meta-UI for user interface design on AR VR technology which is implemented in medical industry. Meta-UI is used to ensure the interface's usability, allowing the user to observe, understand, and manage the information obtained in the

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interface [6]. This research focuses on the efficient use of Meta-UI to provide information to end users to support content displayed through a smart environment.

II. Related Work

Several studies on AR and VR are widely applied in various fields such as product exhibitions, education, and others [7, 8]. AR implementation at product exhibitions has been carried out by Firmanda, Sukaridhoto *et al*. build virtual try-on batik clothes using AR technology [9]. This research implements hand tracking to select accessories and attach them to the human body. To make it easier for users to operate this application, it provides 2D information that is displayed on each outfit. The presentation of the appearance of this application uses a lot of Meta-UI approaches as well as animations to present an interesting impression.

There is research related to product exhibition, but it is implemented in VR technology. The research conducted by Miranto, Rante *et al*. is to build a Cultural Heritage Virtual Reality Exhibition [10]. This research feature provides information about exhibition events and vendors, users can also browse the exhibition using a map. The interface is built using a dietetic approach.

The diegetic approach in this study was used to perform configurations such as exit or change location, lower the volume of incoming music show, and save and load game state. In the context of an exhibition, the use of diegetic UI is suitable to be applied to present the impression of exploration.

A. User Interface Elements and Type

In the immersive world, users can interact via interface services. Interface services can be said to be successful if they can provide sufficient information for users, make it easier for users to understand how a game works, and provide an immersive experience. The interface that is usually encountered has elements such as buttons, informational text, and images that contain information and means for users to interact. When building an immersive AR and VR technology of course it's not just about scenarios and modules, it's not just about placing interface elements on the screen but providing the best experience for users to reuse. The construction of the interface has a clear interface, avoiding double perception, and ambiguity that can add to the confusion of confusion. Responsive and fast interface can increase the efficiency of users to understand a rule in a reasonable time.

There are several types of technological immersive user interfaces conducted terminology from Fagerholt and Lorentzon [11], see Fig. 1:

1) Spatial interfaces are 3-dimensional elements that are present or not in immersive technology.
2) Diegetic interface, an interface that enters the immersive world. For example, the user can change their avatar by interacting with the characters in their world.
3) A non-diegetic interface is visible to the user but is not visible to the character in the immersive world (not through the character).
4) A meta interface is a 2D interface that is generally displayed to the user as an effect, such as pop-up information.

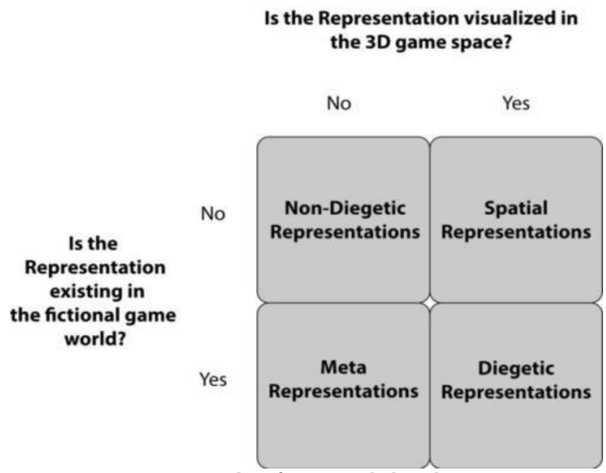

Fig. 1. UI Terminologi from Fagerholt and Lorentzon.

B. UI Experiences in Immersive Application

Mostafazadeh, Shirehjini *et al*. examined and evaluated the interface design for mixed reality interactions in their research. Meta User Interface (Meta-UI) refers to the user interfaces that aid the accomplishment of activities at the metasystem level. In addition, a considerable amount of critical research is conducted on device-level interface issues [12]. Analysis, design, prototype implementation, and evaluation of a 3D-based meta-user interface for supported living scenarios in ambient settings represent a significant contribution. This system is designed to be expanded in the future. The system will have a task migration mechanism that anticipates the next task based on the user's previous actions. The research plan to work on other aspects of Meta-UI, including automatically generating visualizations for behaviors and a few features to enable the behaviors to be downloaded and installed on the system. As a result, users will be able to install new behaviors on the system like how they install apps on their smartphones.

Regularly, 2D and 3D components are created for the production of immersive apps. Three stages were involved in the construction of the immersive system: the generation of 2D and 3D assets, the Development Phase, and the compilation and deployment of the system. Developing a spatial user interface in the form of a half-curve with all visuals around the user is the fundamental notion. This strategy was used to increase user engagement and improve accessibility at all points of interaction. Ramy Hammady and Minhua Ma [13] develop a method to increase usability and engagement. The UX design stages for immersive applications include Task characteristics, Environmental characteristics, User characteristics, and System characteristics, as shown in the UX design phases diagram for immersive apps. Based on these concepts, the researchers have created a prototype application for cultural heritage counseling. The program is designed to be easy, entertaining, and educational for museum visitors. A spatial user interface and Microsoft HoloLens were necessary for the user to assess virtual content. These interactions should have taken place in the presence of a shown antique so that the system's information could have been overlaid as additional instruction.

III. Meta-UI In AR and VR Applications

Meta-UI presents the universe to the player in a streamlined and organized fashion. It works well when the user may interact with something little or intricate that the player should have command over or a clear perspective of. To design a user interface, we take an approach by considering the demographics of end-users and users to obtain the requirements for the interface elements that must exist. Then we do user and end user-focused design to get the level of fulfillment of tasks using Meta-UI. Using that approach, we define the appropriate Meta-UI components and entities. The Meta-UI approach can be described in Fig. 2.

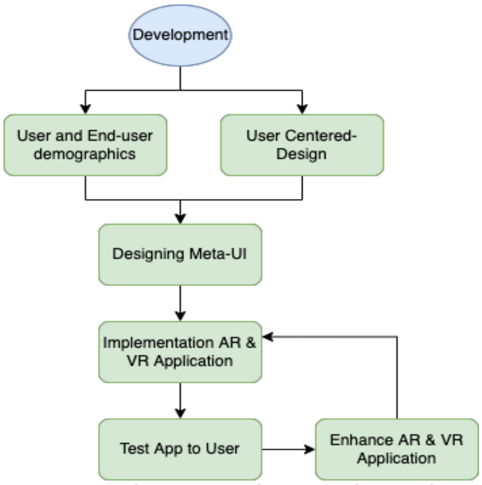

Fig. 2. Meta-UI design approach to AR and VR application.

To find out and meet the needs of users of AR and VR applications in the medical field, it is necessary to segment users based on demographics. With the demographics, users can describe who the individual is, for example, generation, gender, marital status, education, and income. In this study, user demographics are medical students with different marital statuses, education, gender, and income. In addition to the user demographic approach, a User-Centered Design (UCD) approach is also applied. UCD was introduced by Norman and Draper [14], in their research suggesting the steps for designing a UI are divided into nine stages. First, the thing that needs to be done is to define a system that is built. In this research, the system built is learning in the medical field using AR and VR technology. AR technology is used to study human anatomy, while VR technology is used to build collaboration in the Normal Childbirth Surgery practicum. Then, define the agreed scenario and the features to be displayed. All features displayed are based on recommendations from users.

From the results of user recommendations and scenarios implemented in AR and VR applications, we prioritize the required functions, namely displaying 3D assets with control via Meta-UI for AR applications, while in VR applications we apply Meta-UI to display notifications for each task that needs to be done by users. With the information provided Meta-UI can support features such as familiarity and generalizability. Then we implement it into AR AIVE and VR Child Birth Surgery applications.

A. Analysis of Meta Interface for AIVE Application

For Meta-UI testing, we used the initial development with static input and the second from the AIVE platform which uses dynamic input [15]. The AIVE platform uses smart devices namely smartphones to run it. The device used has support from Android with a minimum version of 7.0 and iOS with the A12 Bionic chipset. The AIVE platform can be controlled through the interaction between the user and the UI. Before the user begins to enter the AR session for anatomy learning, the user is asked to enter an identity in the form of the name, NIM, student mail, and choose gender, as shown in Fig. 3.

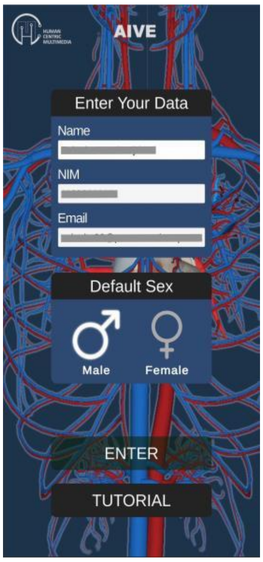

Fig. 3. User ID interface.

When the user inputs an identity, there is a gender selection that aims to determine the anatomical gender that is displayed. Then, new users can see tutorials on how to use the application. In this view, we use a 2D UI to display important information and buttons to the user.

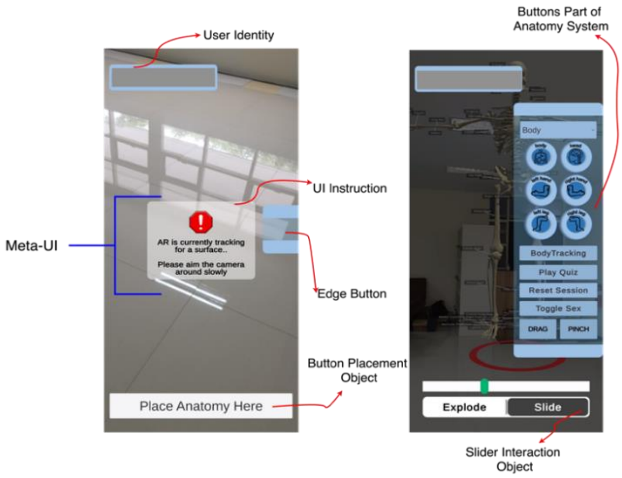

Fig. 4. User interface in AR session.

After the user completes the identity input, the user is immediately directed to the AR scene. In this scene, Meta-UI is widely used, namely to provide information in the form of buttons that can be pressed to bring up 3D characters based on the embedded name. In this scene, there are 2D buttons that are used to control objects such as a slider containing scale and explode controls. The scale control aims to zoom in and out on the displayed 3D object, this of course helps the user to see the anatomical structure more clearly without the need to walk closer or backward from the object. Then, the explode slider is used to display hidden information such as the bronchi and bronchioles inside the heart. Users can take advantage of this feature to simplify and add an immersive experience edge bars which consist of several body parts, as in Fig. 4.

1) The drop-down button contains the part of the anatomical system, this division refers to the Sobotta Atlas of human anatomy [16]. The division of anatomical systems includes skeletal, endocrine, lymphatic, muscles, digestive, nervous, and circulatory. The user can select one of the systems that need to be displayed by pressing the drop-down button.
2) There are also buttons with various purposes. The use of this button makes it easier for users to see pieces of each system such as only the right arm or left leg.
3) The next interaction is that there is a “gender switch” feature to change the displayed anatomical gender, this aims to help users when they want to learn both.
4) Furthermore, to add a deep immersive impression and elevate the novelty of the technology, augmented intelligence is applied. The application of augmented intelligence is used to track the human body in a real environment [15]. This human body tracking is used to control the movement of 3D assets, as Fig. 5. shows a human body capture followed by the movement of a 3D asset. Of course, this adds to the uniqueness of the AIVE platform.

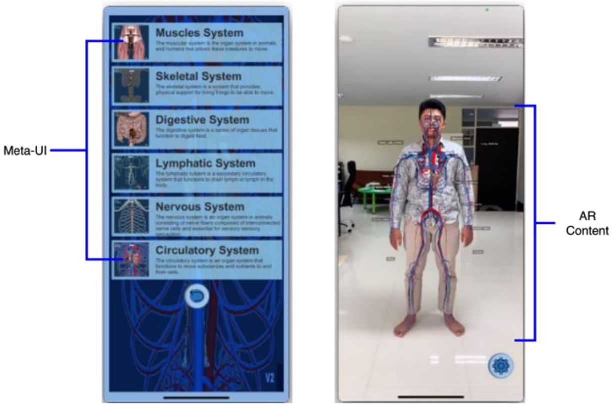

Fig. 5. Meta-UI on human body tracking AIVE.

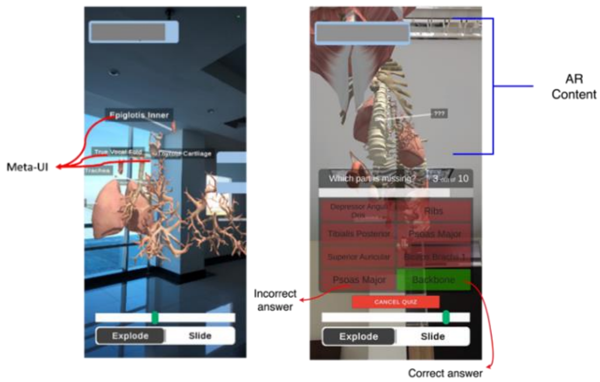

Fig. 6. Question session interface in AIVE platform.

This platform is designed divided into 3 main sessions, namely learning sessions, quiz sessions, and tracking sessions for human body tracking. In the learning session, there are many system options that users can choose based on what they want to learn, in the quiz session there are 3 levels to choose from. To provide ease of use when taking quizzes, the user is faced with a Meta-UI which contains information on every part of the system that the user can touch to see in more detail, as in Fig. 6.

In the quiz session, the user is assisted with the part of the question asked, then the user needs to choose the right answer. If the user answers correctly, then the answer indicator is green and the user gets an additional score. The red indicator shows an incorrect answer. In this section, Meta-UI provides a lot of information to the user and does not add to the burden of confusion on the user interface. This quiz session is used to test students’ abilities after doing anatomy learning through learning mode. To avoid being out of focus, we created a user interface design that is 2D and contains important information, unlike game-based learning which usually includes animation and little information.

B. Analysis of Meta Interface for VR Collaboration Simulation

The Meta-UI analysis on VR which is implemented in Normal Childbirth Surgery. In this study, game-based learning in VR is used to make it easier for users to carry out practical’s based on practicum modules embedded in the virtual world. To be able to enter the virtual world, users need to use a VR Headset. In the VR headset, users can see a practicum environment that is adapted to the rules and conditions of the real world. All activities in the virtual world are controlled through a hand controller. Then, we explain the features in the practicum environment to design a UI that fits the user’s needs. Based on the initial development, we have built:

1) Users can explore a practicum environment that is set up like a real environment.
2) Practical equipment in the virtual environment can be controlled such as being grabbable, released, and shifted.
3) Users can read any practical instructions embedded above their heads to reduce missteps.
4) Users can interact with other users through collaboration features.

Fig. 7. Application of Meta-UI at the normal childbirth surgery.

With these features in mind, the interface concept based on the Meta-UI approach was designed. In the practical scenario using VR, we provide information in the form of steps embedded in the UI to reduce the burden of confusion on the user.

Fig. 7. shows the application of Meta-UI to practical instructions. Users need to follow every rule that is located floating in front of the glasses. After the user agrees with the rules, the user can move the controller and then press the agree on button. The user interface design is made with minimal animation and is clear for a clear view. This is to present the impression of focus.

The user is faced with a sequence of practical steps that appear on the Heads-up Display (HUD) which was built with a 2D perspective. HUD is a common abbreviation for people who have already gotten their hands on video games as a child or teenagers. HUD, which stands for Heads-Up Display, serves as an information layer for the user i.e. player, to understand the character information such as health, stamina, task, etc., or information regarding their surroundings such as a mini-map, path guide, and next objectives. The main advantage of using HUD is that users / players did not open a new window or do certain commands to access the most vital information regarding the games or simulation progress [17]. Users only need to gaze at certain corners of the user's interface to gather that information, which is easy, handy, and not very hard to do. As for other alternatives to what HUD is already doing many developers tried to minimize the need for HUD to increase immersion by changing its looks and placement but fundamentally it is still a Heads-Up Display.

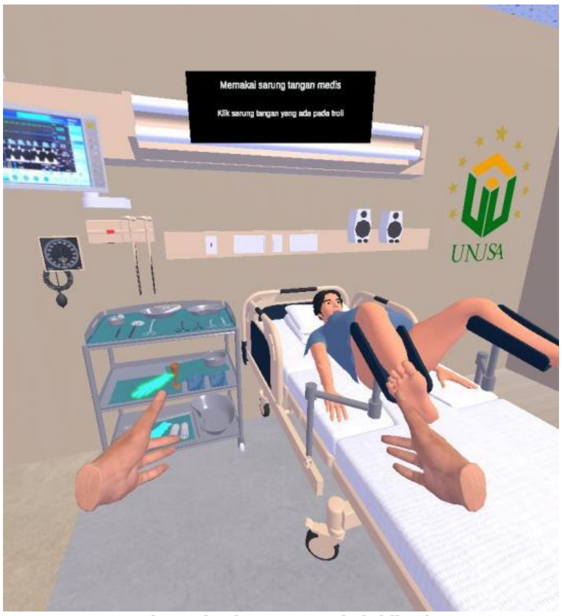

Fig. 8. Heads-up display in normal childbirth surgery.

The HUD in this application is set to follow the movement of the user's head with a distance of 1-1.5 m above the user's head, this is used to avoid confusion and reduce motion sickness. Fig. 8 is the application of HUD in the steps of normal surgery. For every step that has been done by the user, the HUD will automatically move to the next step.

Next, we evaluate user responses through the PIECES framework. We assess the level of satisfaction with the applications that we make. In the PIECES framework, there are questions related to Performance, Information and Data, Economics, Control and Security, Efficiency, and Service. All of these parameters are closely related to their implementation of Meta-UI. The discussion of the PIECES framework is explained in more detail in chapter IV.

IV. Results and Analysis of User Experience

This chapter describes the results of the analysis of user satisfaction with the AR AIVE and VR applications for Normal Childbirth Surgery. Analyzing and evaluating the performance of the platform from the user's point of view is necessary to determine the level of user happiness and the relevance of using AR and VR platforms. Technical capabilities, operational implementation, and platform utilization are all being evaluated. To find out users' perceptions of platform performance, this study will look at research on Satisfaction and Interest Levels on AR and VR platforms, which focuses on software performance when running. The PIECES framework, consisting of the following, was used for this study (Performance, Information and Data, Economics, Control and Security, Efficiency, and Services).

The results of the analysis include questions related to user experiences with content presentation and appearance when running the application. The satisfaction value is obtained from the sum of the total scores of each variable based on the Likert scale [18], then divided by the number of questions. The range used as a reference is shown in Table I. Table II is the satisfaction value of AR and VR applications. We tested this application with a total of 30 respondents collected from medical and midwifery students of various ages and genders. Data collection is done through a questionnaire after the user installs and runs the application.

TABLE I: Domain PIECES Framework

No.	Variable	Number of Questions
1	Performance	5
2	Information and Data	9
3	Economics	3
4	Control and Security	4
5	Efficiency	3
6	Service	5

TABLE II: Level of Important

Answer Options	Abbreviations	Scores
Very Important	VI	5
Important	I	4
Doubt	D	3
Not Important	NI	2
Very Unimportant	VUI	1

TABLE III: Level of Satisfaction

Answer Options	Abbreviations	Scores
Very Satisfied	VS	5
Satisfied	S	4
Doubt	D	3
Not Satisfied	NS	2
Very Dissatisfied	VDS	1

The evaluation utilizes a questionnaire developed using the six foci of the PIECES Framework. The AR and VR platform, which included 30 respondents from UNUSA Medical Education students and a total of 29 questions, was the subject of this evaluation. The variables in the PIECES Framework are provided in Table I, Table II, and Table III reveal the number of questions used to measure the Significance Scale and Satisfaction Scale, respectively. The equation shows the Likert approach formula used to determine the level of satisfaction and importance of the AR and VR platforms Eq. (1).

$$Ave = \frac{TSQ}{NQ} \tag{1}$$

where:

Ave : Average Satisfaction/ Importance

TSQ : Total score of the Questionnaire

NQ : Number of Questionnaire

Meanwhile, to determine the level of satisfaction and importance using the model defined by Kaplan and Norton [19], so that the range value is obtained as in Table IV.

TABLE IV: THE AVERAGE AND SATISFACTION

Value Range	Satisfaction Predicate
1 - 1.79	Very Dissatisfied
1.8 - 2.59	Not Satisfied
2.6 - 3.39	Sufficiently Satisfied
3.4 - 4.91	Satisfied
4.92 - 5	Very Satisfied

TABLE V: RESULT OF PIECES FRAMEWORK SATISFACTION PREDICATE

	VR Satisfaction	AIVE Satisfaction
Performance	4.5	4.08
Information and Data	4.67	4.20
Economics	4.6	4.10
Control and Security	4.6	4.05
Efficiency	4.61	4.09
Service	4.61	3.97

Referring to Table V, the satisfaction value obtained on the performance of AR and VR applications gets the predicate satisfied, this is evidenced by the acquisition of values from 3.97 to 4.20 for AR and 4.5 to 4.67 for VR. Also, for other parameters get the predicate satisfied. This shows that users have felt the benefits of AR and VR applications as additional modules to improve skills before carrying out practicum. Users are also satisfied with application services that are directly related to the content and appearance received by users, such as the selection of an interface design that matches the theme, interactions in the virtual world that are the same as in the real world, users get an interactive learning experience, and users feel the use of AR technology and VR in this practicum can save costs when compared to using consumables that must be purchased continuously.

V. CONCLUSION

Learning in the medical field using AR and VR technology raises new challenges, how can a virtual module be well received through the content and display presented. The challenge of creating a module based on the user's desire to get a good response and user convenience. We designed an interface system using a Meta-UI approach which is rarely applied to Immersive technology. However, this study proves that the application of Meta-UI has a positive impact on user satisfaction. We get values from 3.97 to 4.20 for AR and 4.5 to 4.67 for VR from measuring user satisfaction through the PIECES framework, which means user satisfaction with the offerings and services of this application.

The application of Meta-UI presents information to users cleanly and smoothly, this is the case that we are working on for the medical field practicum which must be carried out in conditions of focus and detail. Meta-UI may be too limited, but in this research, Meta-UI has demonstrated its functionality based on user suggestions and a suitable design framework.

VI. LIMITATION AND FURTHER INVESTIGATION

This study discusses the Meta-UI analysis, in the implementation of AR and VR in the health field. In this study, limitations need to be improved that impact on user convenience when using the application, such as overlapping information on Human Body Tracking AR content which can reduce aesthetic value. The use of inconsistent font sizes and types can reduce the convenience of users to get in-depth information. The need for assistance to users when using the application needs to be improved by adding a user guide.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization: Evianita Dewi Fajrianti, Ilham Achmad Al Hafidz, Naufal Adi Satrio, Hestiasari Rante, M. Agus Zainuddin, Sritrusta Sukaridhoto, M. Udin Harun Al Rasyid, and Rizqi Putri Nourma Budiarti; methodology: Evianita Dewi Fajrianti, Ilham Achmad Al Hafidz, Naufal Adi Satrio; software: Evianita Dewi Fajrianti, Ilham Achmad Al Hafidz, Naufal Adi Satrio; validation: Hestiasari Rante, M. Agus Zainuddin, Sritrusta Sukaridhoto, M. Udin Harun Al Rasyid, and Rizqi Putri Nourma Budiarti, supervision: Hestiasari Rante, M. Agus Zainuddin; all authors had approved the final version.

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REFERENCES

[1] Y. M. Tang, K. Y. Chau, A. P. K. Kwok, T. Zhu, and X. Ma, "A systematic review of immersive technology applications for medical practice and education - Trends, application areas, recipients, teaching contents, evaluation methods, and performance," *Educational Research Review*, vol. 35, p. 100429, Feb. 2022, doi: 10.1016/j.edurev.2021.100429.

[2] Y. M. Tang, G. W. Y. Ng, N. H. Chia, E. H. K. So, C. H. Wu, and W. H. Ip, "Application of virtual reality (VR) technology for medical practitioners in type and screen (T&S) training," *Journal of Computer Assisted Learning*, vol. 37, no. 2, pp. 359–369, 2021, doi: 10.1111/jcal.12494.

[3] T. Pratama and A. Cahyadi, "Effect of user interface and user experience on application sales," *IOP Conference Series: Materials Science and Engineering*, vol. 879, p. 012133, Aug. 2020, doi: 10.1088/1757-899X/879/1/012133.

[4] E. D. Fajrianti, S. Sukaridhoto, M. U. H. A. Rasyid, R. P. N. Budiarti, I. A. A. Hafidz, N. A. Satrio, and A. Firmanda. "Design and development of human anatomy learning platform for medical students based on augmented intelligence technology," in *Proc. International Electronics Symposium on Knowledge Creation and Intelligent Computing*, 2021.

[5] I. A. A. Hafidz, S. Sukaridhoto, M. U. H. A. Rasyid, R. P. N. Budiarti, R. R. Mardhotillah, R. Amalia, E. D. Fajrianti, and N. A. Satrio, "Design of collaborative WebXR for medical learning platform," in

Proc. International Electronics Symposium on Knowledge Creation and Intelligent Computing, 2021.
[6] D. Roscher, G. Lehmann, M. Blumendorf, and S. Albayrak, "Design and implementation of meta user interfaces for interaction in smart environments," in *Proc. 1st International Workshop on Supportive User Interfaces (SUI 2011)*, 2011, p. 4.
[7] A. L. Haz, I. A. A. Hafidz, E. D. Fajrianti, S. Sukaridhoto *et al.*, "Study of factor analysis on game-based learning for scaffolding installation activities in education and training for Indonesian state electricity company employees," *International Journal of Information and Education Technology*, vol. 12, no. 11, pp. 1126-1136, 2022.
[8] M. F. Falah, S. Sukaridhoto, M. U. H. A. Rasyid, and H. Wicaksono, "Design of virtual engineering and digital twin platform as implementation of cyber-physical systems," *Procedia Manufacturing*, vol. 52, pp. 331-336. 2020.
[9] A. Firmanda, S. Sukaridhoto, H. Rante, and E. D. Fajrianti, "Preliminary development of virtual try-on platform for batik apparel based on mobile augmented intelligence technology," in *Electrical and Computer Engineering*, Cham, 2022, pp. 40–54. DOI: 10.1007/978-3-031-01984-54.
[10] C. Miranto, H. Rante, and S. Sukaridhoto, "Exploring concept design of user experience with diegetic approach for cultural heritage virtual reality exhibition," in *Proc. 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES)*, 2021.
[11] E. Fagerholt, M. Lorentzon, and S. Bjork, "Beyond the HUD - user interfaces for increased player immersion in FPS games," M.S. thesis, Department of Computer Science and Engineering, Division of Interaction Design, Chalmers University of Technology, 2009.
[12] A. Mostafazadeh, A. A. N. Shirehjini, S. Daraei, N. Khojasteh, and S. Shirmohammadi, "A meta user interface for interaction with mixed reality environments," in *Proc. 2015 IEEE International Symposium on Haptic, Audio and Visual Environments and Games (HAVE)*, Oct. 2015, pp. 1–6. DOI: 10.1109/HAVE.2015.7359449.
[13] R. Hammady and M. Ma, "Designing spatial UI as a solution of the narrow FOV of microsoft HoloLens: Prototype of virtual museum guide," in *Augmented Reality and Virtual Reality*, M. C. tom Dieck and T. Jung, Eds. Cham: Springer International Publishing, 2019, pp. 217–231. DOI: 10.1007/978-3-030-06246-0 16.
[14] D. Norman and S. Draper, User Centered System Design: New Perspectives on Human-Computer Interaction, 1st Ed. 1986. doi: 10.1201/b15703.
[15] E. D. Fajrianti *et al.*, "Application of augmented intelligence technology with human body tracking for human anatomy education," *International Journal of Information and Education Technology*, vol. 12, no. 6, pp. 476–484, 2022, DOI: 10.18178/ijiet.2022.12.6.1644.
[16] F. Paulsen and J. Waschke, *Sobotta Atlas of Human Anatomy*, Munich: Elsevier, 2018.
[17] L. Caroux and K. Isbister, "Influence of head-up displays' characteristics on user experience in video games," *International Journal of Human-Computer Studies*, vol. 87, pp. 65–79, Mar. 2016, doi: 10.1016/j.ijhcs.2015.11.001.
[18] A. Joshi, S. Kale, S. Chandel, and D. Pal, "Likert scale: Explored and explained," *Current Journal of Applied Science and Technology*, vol. 7, no. 4, pp. 396–403, Jan. 2015, doi: 10.9734/BJAST/2015/14975.
[19] R. S. Kaplan and D. P. Norton, "The balanced scorecard—measures that drive performance," *Harvard Business Review*, Jan. 01, 1992.

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