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PRELIMINARY EVALUATION IMMERSIVE TEACHING APPLICATION IN DISTANCE LEARNING DURING COVID-19 PANDEMIC

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Abstract. *This study describes the design of a Virtual Reality (VR) application for distance learning purposes from the lecturer's perspective during the COVID-19 pandemic. Previous research illustrated that virtual reality could be applied to the learning process in the classroom. Researchers used to make applications that can be used with the video conference platform, commonly used during a pandemic, to make it easier to reach students. The evaluation involved 18 faculty members in the Faculty of Computer Science to check the usefulness of each virtual reality function in two different scenarios, namely the teaching scenarios using controllers and hand tracking. The results showed significantly better results in virtual reality scenes where the controller was used for teaching scenarios.*

Keywords: Virtual reality, Video conference, Teaching application, COVID-19

1. **Introduction.** The moment of the COVID-19 pandemic can be an opportunity to find new ways to produce solutions that were previously considered difficult to apply in learning [1]. Because after the COVID-19 pandemic, public meetings such as public learning are no longer so inspiring because the public's attention is now more sensitive to the possibility of transmission of viral diseases [2]. During the COVID-19 pandemic, online platforms such as applications have video services experienced rapid user increase and become a supporting resource for distance learning that supports activities such as sharing slides, pictures, chatting, lecture presentations on learning, and other materials remotely [3]. Previous research has been proven that the use of video conferencing as people have done during a pandemic can still not bring a sense of presence compared to Virtual Reality (VR) [4].

Remote learning involving remote users can potentially be supported by a unique style of human-computer interaction that promotes a sense of presence using VR [5]. Previous research has succeeded in implementing immersive distance learning using virtual reality in the classroom [6,7]. However, previous research has not paid attention to students' readiness aspect. It requires an expensive additional tool and is not user friendly [7,8].

Immersive experiences could be felt as a sense of presence more than 30 years ago through technology with media such as sound, photography, and video recording [9]. However, according to Citi Group's research report, it is projected that VR is an extension of media technology devices that will dominate in the future [9]. In line with the generation that will start education in the future who are already familiar with smartphones and the

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Internet, it is paramount to try teaching methods more immersive, such as virtual reality [10].

This paper proposes a virtual reality application for distance learning tool. In the paper, will describe the configuration design of the application including a preliminary evaluation. This concept of virtual reality application is named BINUS Immersive Lecturing Application (BILA) from the lecturer side. This application (BILA) is combined with several online platforms such as video conferencing applications in communicating to students. The concept design is designing a virtual environment system in education that pays attention to the specification aspects of students as the first [11] to support the education system that is continuously developing with adjustments to current needs and technology [10]. Hence, this paper aims to utilize virtual reality technology to deliver an immersive distance learning teaching experience through BILA with several features such as video conference integrated, display slides material, display quizzes, hand-tracking interaction and writing in the virtual environment.

Furthermore, this paper is organized into several sections. Section 2 discusses the previous research. Section 3 discusses the method used in the research, divided into two: the first is the submission of the concept and framework design of the BINUS Immersive Lecturing Application (BILA), and the second is the implementation of the concept and displays several features in the application. Section 4 discusses the stages and the indicator of evaluation. Section 5 shows and discusses the results of the research. Finally, Section 6 summarizes the paper with future work.

2. **Related Work.** A virtual environment is a place that provides Internet-based interaction and collaboration such as video conference, or it can be interpreted as a virtual world that is presented in the configuration on the VR device [12,13,24,25]. During the COVID-19 pandemic, the use of online platform meetings like video conferences such as Google Meet for distance learning purposes at a university has a good acceptance from the view of the ease of use as well as the benefits felt for students [14]. Also, for students who can use computers, video conferences such as Zoom for distance learning have a high usage intensity, and it is not affected by gender [15]. In short, it can be concluded that video conference can be interpreted as having good acceptance in the implementation of distance learning for students [14,15]. Previously, Learning Management Systems (LMS) such as Moodle or Google Classroom were also used in distance learning to share educational content such as learning materials and quizzes [16,17]. In addition, quiz-based gamification applications such as Kahoot on distance learning are also used to help teachers assess student knowledge and make classes more fun [18].

The implementation of virtual reality for distance learning has been done before through the university application, but this requires additional tools as good as high-end PC specifications, and there is no feature to display slide material or power points in the virtual environment [6]. On the other hand, there is an application called Teachyverse that uses Head Mounted Display (HMD) or VR devices such as the HTC Vive and Google Cardboard to communicate in a virtual environment [7]. Even though Teachyverse has features that can support teachers, such as displaying learning materials in pdf and writing on the blackboard, using the HTC Vive requires a high PC specification and still uses cables that hinder the mobility movement for user [7,19]. In addition, other virtual reality applications that are used for distance learning purposes can display learning materials called Open Justice VR. Its application based on Google Cardboard only supports learning and does not present two-way communication because it implements an affective pedagogical style model [8].

Using Google Cardboard during the experiment has several obstacles and inconveniences for students [7]. Other research from using virtual reality, such as Google Cardboard for students, also showed similar results with finding some uncomfortable students and made them nervous [8]. This is because students are considered not to have enough value to invest their time using virtual reality. After all, it is considered time-consuming for them to learn how to operate it [8]. Virtual reality in lecturers shows the opposite results with respondents who have backgrounds as faculty members who believe in their ability to use VR technology and show their awareness of the benefits of virtual reality applications when applied in teaching [20].

3. **Research Method.** Based on the related works, this study will describe how to regulate the proper use of VR for distance learning settings, especially during the COVID-19 pandemic and after. In this paper, a preliminary evaluation is also carried out to check functionality by comparing each interaction using virtual reality in two different scenarios.

3.1. **Proposed concept.** The concept design of the BINUS Immersive Lecturing Application (BILA) for distance learning class uses a VR Headset (HMD) from a lecturer's perspective. Figure 1 illustrates the proposed VR framework, where this work used the HMD standalone-based VR like the Oculus Quest which does not require additional high specification PC devices and less cables [3,4]. Use a mobile device (Smartphone or PC), namely a Smartphone, as a connecting device in sharing display (cast) content from the BILA to the video conference platform used by students. Consequently, students view the display in virtual reality through video conferencing.

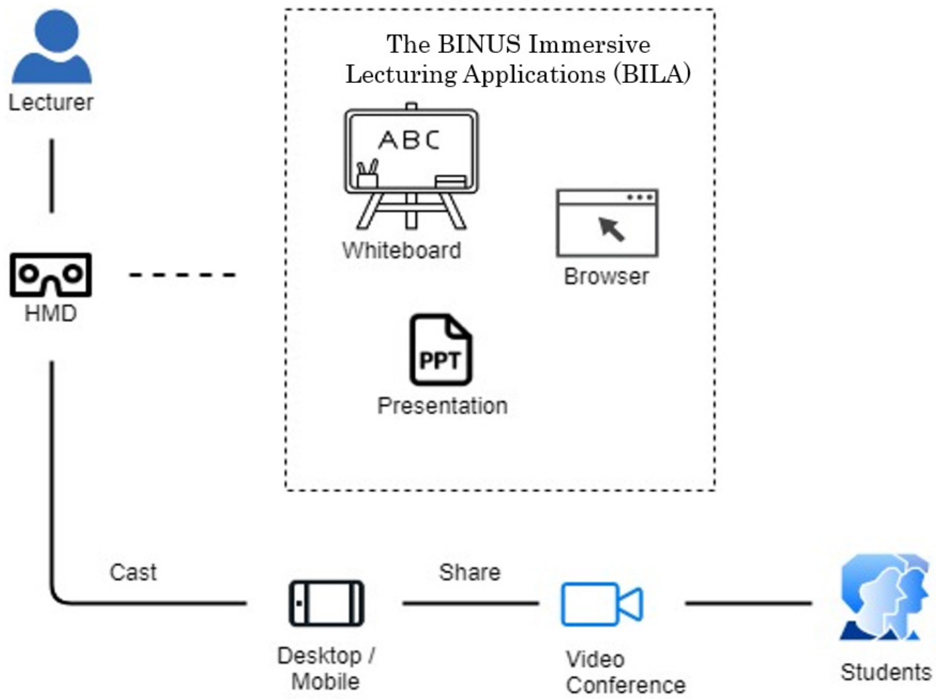
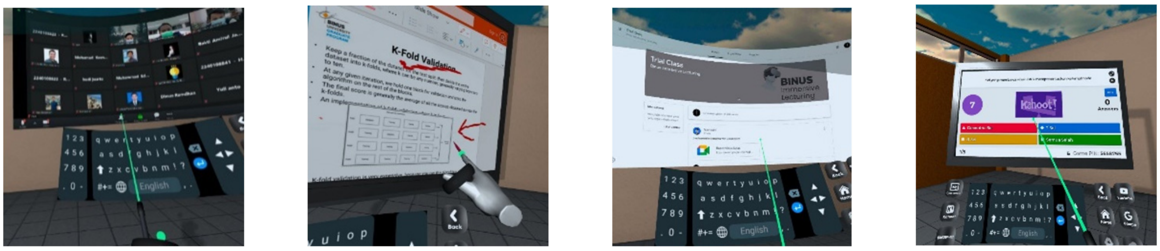


FIGURE 1. The proposed concept

The use of HMD for lecturers carried out since the study shows the lecturer tends to be good in operating the virtual reality application [20]. However, we did not use VR against students because VR use on students still led to poor results [7,8]. Then, we replaced it by using video conferencing for students due to the excellent acceptance rate, especially during the COVID-19 pandemic [14,15].

BILA was developed using the Unity engine with 3D asset models in a real-world classroom on BINUS University campus. The planning feature in the VR application is capable of displaying and operating presentation materials for Learning Slides, Learning Management Systems, Zoom, or Google Meet. It runs on top of a browser plugin for Unity and loads it into virtual reality, which can be viewed from a lecturer's perspective. Then, we put transparent whiteboards that lecturers can use to write on the top of presentation slides. Hence, lecturers can also write on whiteboards like the original.

3.2. **Concept implementation.** The BILA was developed using the Unity 2019 Game Engine. Several Software Development Kit (SDK) are available in the asset store, such as the Vuplex SDK to run video conferencing and slide materials and the Oculus Integration SDK to run HMD functions at Unity. Moreover, existing assets at the Unity Asset Store are helpful in terms of the development process as implemented in previous studies [22]. Then, we put an authorization function to allow microphone use on the HMD; accordingly, the lecturer can talk through the HMD microphone. Figure 2 shows the BILA display from the lecturer's point of view.



(a) (b) (c) (d)

FIGURE 2. The display of BILA from within virtual reality: (a) The display when the lecturer sees students via video conference, (b) the display when the lecturer operates Microsoft Power Point and writes, (c) the display when the lecturer operates LMS, and (d) the display when the lecturer display quizzes via Kahoot

The application implementation consists of two different scenes, the first scene (Scene A) is the scene that uses the Oculus hand tracking feature, and the second scene (Scene B) is the scene that uses the controller (Oculus touch). Each scene has similar functions, namely being able to write, walk, operate power points, as well as to conduct video conferences. Here we will also classify the interactions that occur in the application and evaluate the usability level of each interaction. We classify these into several interaction categories as follows.

1) The 3D Button Interaction, 3D button function in the virtual environment for performed functions like when the user wants to start a pencil object to write, initiate an eraser object to pick up an eraser and start turn-on laser pointer to point to the user interface. The interaction function with the 3D button was chosen because when the user wants to write on the whiteboard, the Raycast laser pointer must turn off and not disturb the display. The 3D button interaction is already in both scenes' scenario. The 3D button also provides a feedback function in the form of a button color change and sound. In Scene A, we place the spherical object at the tip of the index finger as a trigger on the 3D button. The spherical object will follow the motion of the index finger, whether the index finger is bent or not (Figure 3(a)). In Scene B, we also operate the tip of the index finger, but the difference is that the spherical object is only on the tip of the index finger and does not follow the tip of the index finger when the index finger is bent (Figure 4(a)).

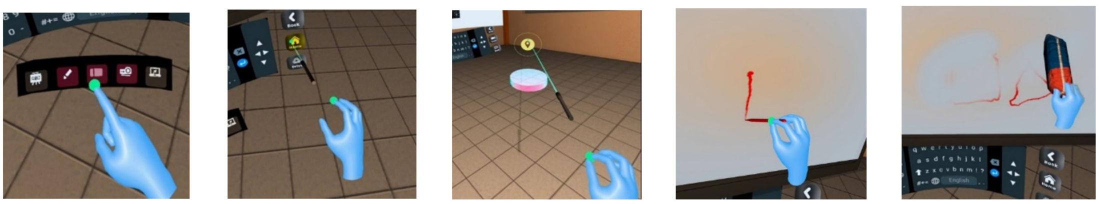
2) The 2D Interfaces Interaction which is 2D objects present on the user interface canvas, including keyboard, browser, buttons. This interaction is carried out by pointing the Raycast laser pointer at the 2D object, then triggering the designated 2D object to provide input in the form of clicking or scrolling. The 2D interface in both scenes has a

different input approach. In Scene A, hand tracking uses a pinch motion to trigger and scroll (Figure 3(b)). Meanwhile, in Scene B it uses the controller to press or hold the A button (Figure 4(b)).

3) The Movement Interaction, the default movement in the BILA, is related to the movement in the real world. It means that when the user moves forward, the user in the virtual environment also moves forward. However, to make navigation (movement) easier and faster in the virtual environment, we added two different motion events. In Scene A, we create a teleportation function that works if the user clicks on the specified location, and it will immediately move to that position (Figure 3(c)). Then in Scene B, we take a different approach using a thumb-stick on Oculus touch to move around (Figure 4(c)).

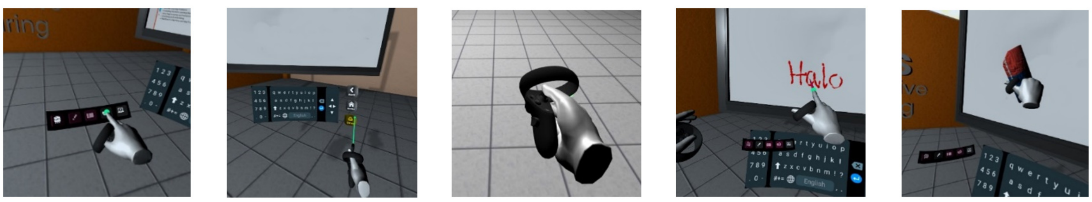
4) The Writing Interactions, We also take a slightly different approach to writing in a virtual environment. In Scene A, we place a marker object that can write when touched toward a whiteboard or glass object on the user's finger. Then, the user can write using finger movements because the hand tracking on the Oculus Quest headset can scan the user's finger movements in the real world (Figure 3(d)). In Scene B, we place the marker object at the corner of the controller to make it appear as if the marker is at the fingertips of the real world. Then, the user writes by moving the controller, not the user's finger in the real world.

5) The Grab Interactions, There are also two different approaches in grabbing 3D objects, like when the user grabs the eraser object to delete the tint on board. In Scene A, the user can pick up the eraser by pointing his hand to the eraser, then pinching with two or three fingers and holding it. Furthermore, the grabbed eraser is directed to the board to be erased (Figure 3(e)). In Scene B, the user aims the controller to the eraser, then pressing and holding the grip button in Oculus touch (The Controller) to pick up and grab the eraser object. Then, the grabbed eraser is directed to the board to be erased (Figure 4(e)).



(a) (b) (c) (d) (e)

Figure 3. The BILA display on Scene A using hand tracking: (a) Interaction with 3D Button, (b) Interaction with 2D Interface, (c) Movement, (d) Writing, and (e) Grab Object



(a) (b) (c) (d) (e)

Figure 4. The BILA display on Scene B using hand tracking: (a) Interaction with 3D Button, (b) Interaction with 2D Interface, (c) Movement, (d) Writing, and (e) Grab Object

4. **Evaluation.** The evaluation involved 18 faculty members (age range 23-31) by giving it to scenarios in two different scenes scenario that used the hand-tracking (Scene A) and uses the controller (Scene B). The evaluation is carried out to see whether which interactions is better in terms of usability compared to others to know a better set of virtual reality settings. The respondent assesses several usability problems based on five factors per item (Nielsen scale), namely how common the problem is, how easy the user is to deal with, whether it will be an occasional problem or a permanent problem, and how serious the problem is a problem felt [23]. The parameter scale is presented in numbers to give an identity starting from 1-5 (higher is better, see Table 1).

Table 1. Scale

Score	**Interpretation**
5.00	Not Problems: I do not agree this is the problem of usability
4.00-4.99	Cosmetic Problems: do not need to be fixed
3.00-3.99	Minor Usability Issues: repairs are a low priority
2.00-2.99	Major Usability Issues: important to fix, high priority
1.00-1.99	Disaster Usability: must be repaired

We also designed ten questions based on the interaction category mentioned before. Questions were asked to respondents based on their experience when using the BILA. Table 2 demonstrates the questions asked during the evaluation. The questions design consisting of 10 items is divided into two parts based on both scenarios' science. It explains that an odd item is assigned to investigate usability problems based on the

Table 2. Questions

Interaction category	**Item**	**Questions**
The 3D Button Interaction	ITEM01	How about usability problems when you interact with the 3D button with your hands?
	ITEM02	What are the usability issues when interacting with the 3D button on the Oculus touch controller?
The 2D Interfaces Interaction	ITEM03	What is the usability problem when you point the Raycast laser pointer towards the 2D interface and then provide input in the form of a pinch?
	ITEM04	What is the usability problem when you point the Raycast laser pointer towards the 2D interface and then give input by pressing the A button on the Oculus touch controller?
The Movement Interaction	ITEM05	How are the usability problems related to movement using teleportation?
	ITEM06	How are the usability problems related to movement using the thumb-stick on the Oculus touch controller?
The Writing Interactions	ITEM07	How about usability problems when you write with your hands?
	ITEM08	What are the usability problems when you write using the Oculus touch controller?
The Grab Interactions	ITEM09	What are the usability problems when you handholds and moves 3D objects in the virtual environment?
	ITEM10	What are the usability problems when it is as if you are holding and moving a 3D object using the Oculus touch controller?

user interaction experienced inside Scene A. Furthermore, an even item is assigned to investigate usability problems based on the user interaction experienced inside Scene B. We also added conducting unstructured interviews to gather insights related to the user experience when trying the scene using the controller.

5. **Results.** The usability results are measured by the validity (**r**) as well as reliability ($\boldsymbol{\alpha}$) values of each question. Next, do the normality test to determine whether using parametric or non parametric statistical hypotheses. As a result, this research uses Wilcoxon Signed Rank Test which is a non parametric to obtain the hypotheses. As for all the measurements in this research use SPSS as a tool. Table 3 and Table 4 illustrate the evaluation results.

Table 3. Result

ITEM	**Mean**	**SD**	**r**	$\boldsymbol{\alpha}$	**ITEM**	**Mean**	**SD**	**r**	$\boldsymbol{\alpha}$
ITEM01	3.00	0.75	.621	.760	ITEM02	4.17	1.01	.835	.714
ITEM03	3.11	0.74	.489	.781	ITEM04	4.44	0.50	.542	.766
ITEM05	2.61	0.68	.481	.775	ITEM06	4.39	0.76	.542	.774
ITEM07	2.83	0.76	.513	.770	ITEM08	4.17	0.60	.570	.766
ITEM09	2.50	0.60	.487	.776	ITEM10	4.22	0.79	.674	.748

Table 4. Wilcoxon signed rank test

Test statistics					
	ITEM02-ITEM01	**ITEM04-ITEM03**	**ITEM06-ITEM05**	**ITEM08-ITEM07**	**ITEM10-ITEM09**
Z	−3.176	−3.611	−3.564	−3.739	−3.674
Asymp. Sig. (2-tailed)	.001	< .0001	< .0001	< .0001	< .0001

The validity of all items will get all the results of all valid items with all validity values > 0.481 ($N = 18$). The results also show that the reliability of Cronbach alpha is above > 0.7, which means each item is reliable. The results also indicate that average Scene B is better than Scene A. When the user did interaction with the 3D button (The 3D button Interaction) using the hands in Scene A, the results show the usability issue Minor Usability Issues category (ITEM01 = 3.00), where some users state that the button in the air is somewhat pronounced strange without any haptic feedback. The interaction results with the 3D button using the controller (Scene B) obtained different cosmetic problem categories (ITEM02 = 4.17). When comparing the results using a controller, it is better because the respondent's response is more precise (ITEM01-ITEM02 = Sig. 001).

The interaction with a 2D interface (The 2D Interfaces Interaction) uses the Raycast laser pointer in Scene A to get 3.11 results. Those results show a minor usability issue (ITEM03 = 3.11). This is because respondents had difficulty pointing at the pointer and had difficulty pinching when it was started. The results are better categorized as a cosmetic problem for those who use the Oculus touch controller (Scene B) (ITEM04 = 4.44). This is because the better precision of the Oculus touch controller in pointing the pointer and pressing the A button is felt to be more accessible by most respondents compared to using pinch (ITEM03-ITEM04 = Sig < .0001).

The Movement Interactions on the scene implement hand-tracking (Scene A) categorized as a significant utility problem (ITEM05 = 2.61). This is because there are respondents who feel dizzy and startled when teleported from one place to another. On the other side (Scene B), the use of a thumbstick on the Oculus touch controller was felt to be better (ITEM05-ITEM06 = Sig < .0001) by being categorized as a cosmetic problem

(ITEM06 = 4.39). This is also because some respondents are more familiar with using thumbstick like movements in conventional games that use a controller console such as a Playstation or Xbox.

The usability of writing (The Writing Interactions) by hand in Scene A gets the main usability problem category (ITEM07 = 2.83). This is argued because of the inadequate precision of hand tracking on Oculus Quest until this paper is written and the markers used are deemed too long and should be made shorter. However, in Scene B, the results written using the Oculus touch controller were considered to be significantly better (ITEM07-ITEM08 = Sig < .0001), with their use categorized as cosmetic problems (ITEM08 = 4.17).

For the Grab Interactions in Scene A, where the users grabbing objects and taking actions then writing on the board, the results show that using hand tracking Oculus is on the significant usability issue (ITEM09 = 2.50) because several respondents report the experience of holding an empty object is quite strange, and there are restrictions on pinch at the first trial when holding eraser. The results showed that the interaction with 3D objects using the Oculus touch controller in Scene B was significantly better (ITEM09-ITEM10 = Sig < .0001) by using the average in the cosmetic problem category (ITEM10 = 4.22), this is because most respondents find it more manageable by pressing the grip button on the Oculus touch controller. From all the results above, it shows that the interactions carried out in Scene B are significantly better in the area of Scene A; it is also seen that all the results in Scene B are just a cosmetic problem.

6. **Conclusions.** This study has proven that virtual reality can also be applied to distance learning, as stated in previous studies [6-8]. Despite the limitation on the number of respondents, the result shows significant problems in the usability of each function. Moreover, one of the scenarios with a scene controller is proven to be more substantial compared to the other scenes in terms of teaching scenario which shows that the use of the controller proves to be better in usability than not using it. It is in line with previous research that states the use of controllers is more precise than using hand tracking in teaching cases [6]. We also prove that the usability of better teaching interactions such as writing, movement, 3D button interactions, 2D objects interface interactions, as well as fetching 3D objects is more straightforward in terms of teaching in the use of virtual reality since there is only a cosmetic problem which does not affect the functions. In the future, the following research aims to measure the acceptance rate of the teaching configuration using virtual reality as proposed in this study, as well as examining in a more profound analysis of the comparison between virtual reality and video conferencing in terms of immersive study.

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