Improving online learning interactivity with 3D virtual classroom models

R Wardani¹, H Jati¹, Nurkhamid², Y Indrihapsari², P Setialana², A M Budiyanto¹ and M N Ardiansyah¹

¹Electronics Engineering Education, UNY, Yogyakarta
²Information Technology, UNY, Yogyakarta

Email: ratna@uny.ac.id

Abstract. The world of education is experiencing a very significant impact of the Covid-19 pandemic. Online learning is a solution in overcoming learning limitations due to social distancing. Researchers developed a 3D virtual classroom using a Minecraft model to increase online learning interactivity. The 3D virtual classroom model design that has been developed has received respondents' acceptance of 90.00% in the "Very Eligible" category. Testing the 3D virtual classroom features got a percentage of 90.83% with the "Very Eligible" category to produce a sense of presence. In the interactivity test, character interaction is 89.17% in the "Very Eligible" category. The effectiveness of online learning continuity using the 3D virtual classroom model tested gets 89.17% with the "Very Eligible" category. In addition, the test uses an average score of SUS (System Usability Scale) of 73.67, so it can be concluded that the 3D virtual classroom model is "acceptable" as an online learning medium.

1. Introduction

The United Nations stated that one of the sectors affected by the Covid-19 pandemic is the world of education. Based on this, the Indonesian government made several efforts to respond to the spread of Covid-19. One of them is issuing the Circular Letter of the Ministry of Education and Culture (Kemendikbud) of the Directorate of Higher Education No. 1 of 2020 regarding preventing the spread of Covid-19 in the world of education. The Ministry of Education and Culture provides instructions that learning can be carried out remotely so that students, including students, are advised to study from their respective homes.

Along with this, technological developments in the Covid-19 pandemic have increased, especially in education. Technological transformation occurs in teaching and learning activities and can be a change from conventional to modern methods. Students are directed to indirect learning by utilizing online or as an educational solution during the Covid-19 pandemic. Online learning aims to provide quality learning services in a massive and open network to reach more and more enthusiasts of the learning space [1]. Online learning is the right solution in overcoming learning limitations during the pandemic, but it is not without its weaknesses. One of the weaknesses of online learning today is that it still has a low level of interaction and communication during the learning process. In everyday life, communication has a critical role as a medium for forming and developing soft skills in an individual and relationships or social contacts.

Several researchers have developed various methods to overcome this, such as emphasizes the implementation aspect of the 3D-based virtual classroom system to interact with objects in the virtual classroom to carry out learning activities [2]. The researcher testing the implementation of 3D virtual classes was only carried out based on learning outcomes, namely grades and acceptance tests using TAM. The test did not show the level of student interactivity after the implementation. Another research [3], aims to implement a real-time interactive virtual classroom model that provides real-time interactive
classes with a teacher and student collaboration in one portal. This study is less detailed to provide
details of the features that must be developed and provide a teaching and learning system only [4]. The
research aims were to describe the effectiveness of virtual reality-based 3-dimensional (3D) learning
media in increasing fifth-grade elementary school students’ interest and learning outcomes. However,
this study has not discussed what features can impact students’ interest in learning compared to other
learning media.

Another research aims to develop a 3D Virtual Reality Application for Introduction to Indonesian
Early Humans for class X [5]. The goal is to find out the response of class X students to implementing
the 3D Virtual Reality Application Recognizing the Early Man of the Indonesian nation, but it is
unfortunate that students only interacted with objects as an introduction to ancient humans so that there
was no direct interactivity with the teacher in the virtual world. Another study [6] entitled "Design and
Implementation of 3D Virtual Campus Online Interaction Based on Unity 3D" aims to design a virtual
campus roaming system at Shanxi Datong University. It is a 3D virtual campus system with powerful
sight, hearing, and interaction. In this study, users interact with objects in a virtual campus, but
unfortunately, the interactivity is still limited between humans and computers, so it has not been able to
bring humans to humans like students and lecturers.

The researcher answers the problem by developing and use Virtual Reality (VR) technology in
learning. A virtual classroom is a place for the online learning process that allows students and educators
to communicate synchronously through audio, video, text, interactive whiteboards, exchange opinions,
and other similar features as if they were realistically interacting in the classroom [7]. One type of virtual
classroom that can be developed is the 3D Virtual Classroom which provides a realistic three-
dimensional environment, offers an exciting and interactive experience. Integrating VR technology
through 3D Virtual Classroom into the education sector can invite students to interact in the learning
process.

In this study, the researcher uses Minecraft as a 3D classroom model. Researchers learned that
Minecraft is not simply a video game that allows youth to build and create virtual worlds. Minecraft has
now become an educational tool used as a vehicle for teaching critical content. The student who plays
this game can take control and be active learners, thus enhancing their motivation for learning. It also
acts as a supplement in today’s classrooms-a popular learning activity in content areas such as science,
math, history, engineering, architecture, and computer coding. It is expected to increase the level of
interactivity and the active role of students. This research aims (1) to develop the 3D Virtual Classroom
design that can improve interest in online learning and (2) to analyze the development of 3D Virtual
Classroom models that can increase student interactivity in online learning.

2. Literature Review

2.1 Virtual Worlds in Education

Virtual worlds are places that exist entirely in a networked environment where people coexist,
communicate, and interact through their avatars. The world is a dynamic and interactive environment
that supports various social, entertainment, educational, and productive activities loosely based on
physical activities. A common metaphor for the design of this world is the concept of place. Most
designs use the concept of the place to design the surrounding environment and objects in the virtual
world. A virtual world is designed for a specific purpose and can support various online activities.

The place design in the virtual world refers to people's experience and knowledge of architectural
design in the physical world. Metaphors of places and references to architectural design provide a
consistent basis that is familiar to people who visit the virtual world and designers of the virtual world.
These metaphors and references can help facilitate interaction between users of the virtual world and
the environment that has been designed for each other. Effectively, the physical world inspired the
design of the virtual world but nowadays, beginning to see the opposite effect, that the design of the
virtual world inspires the design of places in the physical world. The characteristics of the virtual world
that are dynamic, adaptive, and interactive are very relevant to contemporary place designs and feel like
the times ahead in the physical world. This characteristic makes the virtual world an ideal testing ground
for developing and refining design areas such as intelligent environments, multi-premises computing, distributed computing broadly, and interaction design [8].

The virtual world is an application that has been around for more than 20 years, presenting different characteristics and functions such as Multi-User Dungeons (MUDs) and Object-Oriented Multi-User Dungeons (MOOs) so that it continues to grow, leading to the development of a 3-dimensional Virtual World. Virtual world three-dimensional or 3D Virtual Worlds (VWs) are essential for education today because they provide realistic three-dimensional environments, offer engaging, interactive, and immersive experiences, and create new opportunities related to learning and teaching. This evolution in the three-dimensional virtual world was made possible due to several factors, such as the evolution of web technologies and standards that allow interoperability between different web applications and broadband access. Historically, the most critical design consideration for three-dimensional virtual worlds has been their ability to constantly "move" between the "real" and "virtual" worlds, providing opportunities for experiences to simulating "real" world experiences. Otherwise leads to the hypothesis that experiences presented in a three-dimensional virtual world can feel like "real" as those presented in the "real" world.

Three-dimensional virtual worlds offer unique learning and teaching opportunities as they present a rich, engaging, immersive, motivating, and highly interactive environment because they can: (1) recreate a sense of presence, (2) be felt directly, (3) quickly adapt, (4) offer the possibility to simulate the "real" world, (5) offer the possibility to create new experiences that might be difficult to represent in the "real" world, (6) can be offered for experimentation, and (7) enable synchronous communication and collaboration. It can be considered helpful for teachers who wish to apply a three-dimensional virtual world in educational practice [9].

It can be concluded that the use of this three-dimensional virtual world can facilitate teachers to understand foreign concepts presented in 3D virtual worlds by exploring the similarities and differences between a "traditional" class and a three-dimensional virtual classroom or a 3D virtual classroom. This concept allows the teachers to design simple educational activities by transferring their previous experiences and ideas using objects presented in 3D virtual classrooms.

2.2 3D virtual Classroom
A virtual or virtual classroom is a place for learning by using computers and the internet as media. Synchronous online learning or virtual classrooms are used to apply the principle of combining technological aspects to support distance learning that requires support and guidance, feeling a social presence, share responsibilities, and get motivation from educators. Virtual classrooms allow learners and educators to communicate synchronously via audio, video, text chat, interactive whiteboards, app sharing, brainstorming, and other similar features as if they were interacting face-to-face in the classroom.

A 3D virtual classroom is a virtual classroom model designed and developed in three dimensions regarding components and how to use them. In the learning process using the online method, space a three-dimensional virtual classroom can provide the essence of learning as it is done in an actual physical classroom.

2.3 Minecraft Model
Minecraft is the first sandbox game published by Mojang that can be played in multiplayer and developed on a Java basis. Minecraft carries the concept of placing blocks where players are asked to collect objects to create the environment around them as they please. The Minecraft feature gives players a challenge to complete their world in their way. With the multiplayer experience, players can coordinate to create amazing feats such as replicas of famous buildings or places [10].

Minecraft in education can be interpreted as creating virtual classroom models with room designs like real classes. By creating a virtual class that looks real, players can feel the natural aspects of implementing learning in a virtual classroom. Some tangible aspects can be felt. Namely, the habits carried out in the classroom, such as entering a learning room through a door, looking for a seat,
interacting, or conversing with other friends in the room. Minecraft allows the user to modify game rules, alter game content, redesi

designed textures and give players new abilities—summarised with the Mod, one can do anything to the game.

![Minecraft Model](image_url)

**Figure 1. Minecraft Model**

3. **Research Methods**

3.1 **Waterfall Methods**

In this research, the researcher using the waterfall method with 4D model specifications. The 4D model is one of the research and development methods. 4D models are used to develop learning tools. The 4D model was developed by S. Thiagarajan, et al [11]. The 4D model consists of 4 main stages, namely (1) Define, (2) Design (Design), (3) Develop (Development), and (4) Disseminate (Spread).

3.2 **Materials dan Instrument of the Study**

The study used various tools in hardware and software such as operating systems, software libraries, development kits, and database management systems. It used oculus rift, Minecraft software ver. 1.17.0, license Minecraft and Discord software. Minimum specification computer to run Minecraft software: CPU at least: Intel i5 4950, GPU Nvidia GeForce GTX1060, RAM 8 GB, and Hardisk SSD 1TB. Data collection was carried out in online lectures because there was no face-to-face offline class due to the Covid-19 pandemic.

3.3 **Data Collection Techniques and Instruments**

3.3.1 **Development Questionnaire Method**

Researchers prepared several questions to use as data material and relevant sources in this study. This questionnaire contains ten questions with four answer options, namely disagree, disagree, agree, and strongly agree. Questions regarding the design of virtual classrooms, entrance features, seating selection features, initial preparation process before learning, features attendance, interaction with classmates, interaction with lecturers, learning interest using virtual classrooms, focus level during learning, and avatar activities.

3.3.2 **Usability Questionnaire Method**

In this method, the questionnaire used as a usability testing technique in evaluating the 3D Virtual Classroom model developed is the System Usability Scale (SUS). The use of the SUS questionnaire in this study means that this study will use ten questions with five answer choices are available to evaluate the model that has been developed.

3.4 **Data analysis technique**

Analysis of the results to be carried out using SUS according to the rules the calculation of the score in SUS is as follows:

3.4.1 Each question with an odd number, the score of each question obtained from the respondent's score will be reduced by 1.

3.4.2 Every question with an even number, the final score is obtained from the result of the value of 5 is reduced by the score of the answers obtained from the respondents.
3.4.3 The final SUS score is obtained from the sum of the scores for each question then multiplied by 2.5.

The rules for calculating the score only apply to one respondent. The next step calculation is to find the average score of each respondent’s SUS score, add up all scores, and divide by the number of respondents. Here is the formula to calculate the SUS score:

\[ \bar{x} = \frac{\sum x}{n}, \]

where

- \( \bar{x} \) = mean score
- \( \sum x \) = total SUS score
- \( n \) = number of respondents

4 Result and Discussion

4.1 Proof of Concept: 3D Virtual Classroom

3D Virtual Classroom conceptual model developed in this research is stated through a formal specification. In the formal specification, the scope of the Virtual Classroom 3D conceptual model can identify the physical artifacts represented in the virtual model domain.

4.1.1 Vi (Virtual Classroom) represents the real object of the model domain being discussed. In this case, the object in the model domain is a virtual classroom. A Virtual Classroom (Vi) can involve several Actor (Ai), (Aj), (Ak), … (An), and each Actor can perform several actions or activities or Operations (Oi) related to Virtual Classroom (Vi), which are limited in Context (Ci);

4.1.2 Ci (Context) is a boundary of the classroom that binds (binding) the scope of interaction that occurs between subjects (in the future referred to as Actor) through the actions or activities (in the future referred to as Operations) that they perform. The context here is in the form of courses or subjects;

4.1.3 Ai (Actor) is the subject/user involved in a Virtual Classroom (Vi). Actors in the domain of this model are students and educators;

4.1.4 Oi (Operation) represents any activity, action or operations that the Actor (Ai) can do in the Context (Ci). Operations in models in this domain are in the form of activities that occur in the learning process.

![Figure 2. 3D Virtual Classroom Conceptual Model](image)

The 3D Virtual Classroom conceptual model can be expressed through the following schema:

A Virtual Classroom (Vi) is a collection of objects that interact with each other in a Context (Ci) that represents a learning activity, expressed by:

\[ \{Ci\} \in Vi \]

Context Ci is a conceptual boundary that allows activities in the learning process (presentations, discussions, assignments, and other learning activities) to be carried out in a contextual context. A Context consists of zero or more Actor A and zero or more Operation O. Actor is an object that represents participants in one or more learning processes. Operation is an activity that an actor can do in a learning process. Based on this specification, it can be defined the relationship between the Actor and the Operation performed. A Context will be related to a topic.

\[ Ci : \{\{Ai\} \land \{Oi\}\} \]
Based on this relation, the researcher can define several operations or activities that are implemented in the \textit{Context} and its components:

\[ op : \{ \text{present; askQ}; \text{respQ}; \text{discussM}; \text{assignA}; \text{assignmentA}; \text{null} \} \] (4)

Each operation or activity can be described as follows:

\textit{Present} operations or activities are activities (Ai) that represent the scenario of the educator explaining the material/topic (M) in a course session (\textit{Context} Ci). This activity can be expressed as:

\[ \text{present}(Ai; M; Ci) \] (5)

\textit{AskQ} operations or activities are activities (Ai) that represent the scenario of the educator asking the material/topic (M) to students or vice versa, students asking the material/topic (M) to the educator (Aj). This activity can be expressed as:

\[ \text{askQ}(Ai; Aj; M) \] (6)

Operations or \textit{respQ} activities are activities (Ai) that represent the scenario of educators or students answering questions about the material/topic (M)

\[ \text{respQ}(Ai; Aj; M) \] (7)

Operation or \textit{discuss M} activity is an activity (Ai) that represents group discussion scenarios between students about the topic (M) in a particular course or \textit{Context} (Ci) session. A discussion is usually carried out in certain groups, for this operation will require determining the members in the discussion groups and topics for each group. The scheme for modeling discussion scenarios in class can be stated as follows:

\[ \text{discuss}(M); Ci \]

\[ \text{assignA}(Ai \ldots An; M) \] (8)

4.2 \textit{3D Virtual Classroom Instructional Design}

Several concepts are used to represent the instructional aspects that will be implemented in the 3D Virtual Classroom. These instructional aspects can be explained as follows:

4.2.1 \textit{Sense of Presence}, educators, and students are represented in the form of Avatars in order to participate in learning activities. The avatar of each actor (educator and student) is recognized through the institutional account (e.g. institutional email given to each educator and student). This account is the authorization to be able to join the virtual class.

4.2.2 \textit{Virtual Immediateness}. The tools provided in the 3D Virtual Classroom provide a feature for feedback on the interaction between educators and students in the virtual classroom.

4.2.3 \textit{Adaptability}. Tools can be manipulated and configured by educators as needed when carrying out learning activities.

4.2.4 \textit{Real World Simulation}. The tools provided in 3D Virtual Classroom represent or imitate the appearance and functionality of traditional/actual classes.

4.2.5 \textit{New Experience}. The tools provided in the 3D Virtual Classroom provide educators with additional functionality that is impossible to represent in a real classroom.

4.2.6 \textit{Experiment}. Configuration and modification of tools made by educators can be returned to the initial settings if desired.

4.2.7 \textit{Synchronous communication and collaborations}. Tools provide features for interactive communication in the learning process and carry out collaborative activities using certain features.

| Tabel 1. 3D Virtual Classroom Instructional Design |
|-----------------------------------------------|
| Design | Implementation |
|-------|----------------|
| Step   | Learning Activities | Implementasi Konsep | Virtual Space (Tools and Functionality) |
|-------|---------------------|---------------------|---------------------------------------|
| Introduction | ▪ Class Opening | \textit{Sense of Presence}: Avatar represents the actor (Ai). | Functionality: Class meeting feature that allows an educator's Actor (Ai) / Avatar to |
|        | ▪ Students wait in the waiting room | Avatar represents the actor (Ai). | |


| Role | Description |
|------|-------------|
| **Greet students** | Manage and allow students to enter virtual classrooms (access control to limit participants who can enter classes according to KRS) |
| **Presence** | The identity of each Actor (Ai) is represented by the account used. |

**Delivering apperception**

| Role | Description |
|------|-------------|
| **Real-World Simulations:** The tools contained in the 3D Virtual Classroom can represent the appearance and functionality as in the “traditional” learning process (real class) | **Functionality:**
- Movement availability allows Avatar to carry out learning activities in class such as talking, walking, approaching students, and others in offline classes. |

**Tools:**
- Avatar, virtual lobby, skin editor, button, password

**Presentation/core section**

| Role | Description |
|------|-------------|
| **Delivering learning materials through presentations** | **Real-World Simulations:** The tools contained in the 3D Virtual Classroom can represent the appearance and functionality as in the “traditional” learning process (real class) |

**Adaptability:**
- The tools available in the 3D Virtual Classroom must be configurable and manipulated by the educator.

**Experiment:**
- Configuration and modification of tools made by educators can be returned to the initial settings if desired

**Functionality:**
- Virtual whiteboard feature that allows an educator's Avatar to manage and display his presentation
- Screen sharing feature (using OHP) to present material
- Web browser features to manage the presentation of web-based content
- The desktop features are integrated with web browsers so students can browse the content they need

**Tools:**
- Screen writing, screen capture, internal browser, voice chat

**Displaying simulations that represent activities such as demonstrations, tutorials, and experiments.**

**New Experience:** tools used to enable simulations on activities that might be difficult to do in a real classroom.

**Functionality:**
- Doing several learning methods application

**Tools:**
- 3D Model

**Interact with students through question and answer activities.**

**Immediatness:**
- All the tools provided in 3D Virtual Classroom provide responsive feedback both textually and graphically.

**Synchronous communication and collaborations:**
- Special tools are available for conducting discussions/chats, presentations

**Functionality:**
- Enabling students for an interactive learning atmosphere.

**Tools:**
- Voice chat

**Synchronous communication**

**Tools:**
- Voice chat, breakout room, screen capture, screen writing

**Students can present the discussion result.**

**Real World Simulation:** The tools contained in the 3D Virtual Classroom can represent the appearance and functionality as in the “traditional” learning process (real class)

**Functionality:**
- Screen sharing feature (using OHP) to present material

**Communication**

**Tools:**
- Screen writing, screen capture

**Educators provide feedback on the discussion results**

**Immediatness:**
- All the tools provided in 3D Virtual Classroom provide responsive feedback both textually and graphically.
responsive feedback both textually and graphically. ▪ Submission of feedback for each presentation and delivery of assignments
Tools:
▪ Screen writing, voice chat

Closing and Follow-up
Gives reinforcement

Immediatness:
All the tools provided in 3D Virtual Classroom provide responsive feedback both textually and graphically.

Functionality:
▪ Submission of confirmation and reinforcement to students
Tools:
▪ Screen writing, voice chat

Making conclusions
Immediatness:
All the tools provided in 3D Virtual Classroom provide responsive feedback both textually and graphically.

Functionality:
▪ Submission of learning summaries at the end of the lecture session.
Tools:
▪ Screen writing, voice chat

Giving assignments/quizzes
Real World Simulation:
The tools contained in the 3D Virtual Classroom can represent the appearance and functionality as in the “traditional” learning process (real class)

▪ Quiz feature that allows students to participate in quizzes
▪ Assignment features that allow students to
Tools:
▪ Screen capture, screen writing, screen sharing, LMS

4.3 Diagram Sequensial
Figure 3 describes how the entities in the system interact, including the messages used during the interaction. There are two users and three objects, namely: activity component, content component, and interaction component. First, user one will enter the activity component screen to register. From the activity component screen, the admin will authenticate and confirm. After the user gets confirmation, the user can log in, the admin authenticates and confirms again. After that, the user can see the class model and change the class model on the content component screen. The user can continue the activity with the joint class. User activities are continued with general activities in actual classes such as talking, discussing, sharing computer screens, making 3d models, which are carried out on the interaction component screen. User one can also create and follow breakout rooms with other users.

![Figure 3. Diagram Sequensial](image)

4.4 3D Virtual Classroom Features
Some of the features developed in the virtual 3D model of this classroom are as follows:
4.4.1 Custom Avatars. Adjustments can be made to the user's wishes when using a 3 (three) dimensional avatar. Besides being able to eliminating boredom, this realistic representation can also give the impression of "not alone" for users in a virtual space.

4.4.2 Real-Time Voice Chat. Real-time audio and video communication is the main feature of this application. Audio and video communication can be implemented in real-time.

4.4.3 Notes. During learning, it is not uncommon for students to need personal records. This record cannot be logged on other devices because the user will be in one virtual place, making note-taking in the application very significant.

4.4.4 Custom Map. One virtual laboratory cannot be used repeatedly by users. In addition to the boredom factor, not every learning can be done in the same virtual lab, so a virtual lab adapts to user needs.

4.4.5 Custom Media. Each lesson requires a different model. Like virtual labs, developer provision of demonstrations becomes ineffective. In addition, there may be errors in the display. It is necessary to display a display that can be entered independently by the user.

At this stage, the 3D virtual classroom model development and usability test using the System Usability Scale (SUS) was also carried out to 30 students of Yogyakarta State University.

5 Conclusion
This research is devoted to increasing interactivity during online learning by developing a 3D virtual classroom model using Minecraft as an online learning platform. The design of a 3 (three) dimensional virtual classroom model using Minecraft can be accepted by students of the Department of Electronics and Informatics Engineering Education, FT UNY in online learning, getting a percentage of 90.00% in the "Very Eligible" category. Several classroom feature tests were added to the 3D virtual classroom model, namely the entrance feature before entering the building or classroom, the seat or table position selection feature, the attendance record feature, and the avatar customization feature, getting a percentage of 90.83% with the "Very Eligible" category to produce a sense of presence. The test results on the aspects of character interaction get 89.17% with the "Very Eligible" category and successfully represent actions or interactivity such as in classrooms when learning offline. Based on testing the effectiveness level of online learning using a 3D virtual classroom model that has been tested, the percentage is 89.17% with the "Very Eligible" category. By testing using the System Usability Scale
(SUS), the average score of SUS is 73.67, so it can be concluded that the 3D virtual classroom model is "acceptable" as an online learning medium.

This study did not examine the effectiveness or improvement of student learning outcomes by using a 3D virtual classroom model. So that in the future, research will be focused on the effectiveness or improvement of student learning outcomes by using a 3D virtual classroom model.

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