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# Experimental Testing of The Roblox Platform for Control System GUI Design

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ABSTRACT

This research focuses on the design of a two-dimensional-based control system using Roblox Studio, a metaverse platform that has been proven to provide learning facilities in engineering. This research is conducted using two testing methods: direct testing in the Roblox application and testing using the Black Box testing method in the Roblox Studio. The testing is performed step by step, starting from testing user interactions with the system, testing GUI's ability to respond to user inputs, testing the ability to implement mathematical functions and display them in text form, and testing Roblox's capability to display these functions in simple graphic form. The design results can then be tested by analyzing the system's output in the form of mathematical calculations and how these results are shown through the designed two-dimensional interface. There is no direct correlation between mathematical calculation results and the aesthetics or comfort of the systems' GUI. Errors in such simple mathematical operations can be one factor in the occurrence of errors in open-loop systems. Roblox is highly recommended to provide more dynamic functions on BillboardGUI so that developers can have more options in their design activities.

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## 1. Introduction

The utilization of metaverse technology has currently extended across various sectors, including the industrial sector. The metaverse is capable of assisting engineers in activities ranging from design and evaluation to product marketing [1]. The implementation of Metaverse technology in the industry has even extended to the education sector, where one of the Metaverse platforms, Roblox, has been proven to provide learning facilities in engineering. This includes both basic and intermediate levels, covering disciplines such as electrical engineering to nuclear engineering [2] - [5]. This simultaneously indicates that the role of the metaverse in the field of engineering has permeated various layers, ranging from preparing future engineers to introducing engineering products to the public.

As one of the metaverse platforms, Roblox provides opportunities for users of various levels of technical proficiency to engage in design using the LUA programming language. Users can directly test the design outcomes and identify errors through error messages displayed on Roblox Studio. Roblox even offers templates to facilitate the design process [6]. The design activities can further be enhanced with the assistance of external AI applications, such as ChatGPT [7]. The advantages provided by Roblox make it easy for an engineer to design three-dimensional objects within the Roblox metaverse. On the other hand, in reality, engineering products are not only related to three-dimensional objects. Every device undoubtedly requires a user interface that users can use based on human psychological aspects [8]. The results of three-dimensional designs in Roblox must be accompanied by controllers in the form of a screen displaying a two-dimensional view, just like in the real world.

Testing Roblox in three-dimensional design has been extensively conducted, as mentioned earlier. Roblox has also been widely used in three-dimensional design activities across various fields in several other studies, ranging from virtual tour design to virtual English classes [9], [10]. Several limitations in three-dimensional design are also well-known, including constraints in importing complex objects, especially those generated using photogrammetry techniques [11]. These limitations are highly likely to be encountered in two-dimensional-based designs. This study then attempts to explore further the extent to which the Roblox platform is capable of designing two-dimensional objects that have functional relations with three-dimensional objects.

The controller object is one of the simplest examples that can be used to test Roblox's capabilities in two-dimensional design. The relationship between the controller and the object, as well as the calculation results of the system function, allows this test to assess at least three capabilities of Roblox: the ability to calculate and display calculation results; the ability to link two-dimensional objects with the system function; and the ability to connect calculation results with two-dimensional objects. In addition to these three testing aspects, as in the design of a Graphical User Interface (GUI), it is essential to prioritize user-centered or user-friendly design [12]. This study is not intended to build the system controller from scratch but rather to conduct further testing on the previously designed Festo workstation water level control system [3]. This is intended to focus on the capabilities of the Roblox platform in the design activities of a two-dimensional-based control system.

Recent advancements in the integration of metaverse technology into industrial applications highlight its significant potential in transforming engineering practices. Platforms like Roblox have demonstrated their capability in supporting both three-dimensional and two-dimensional design activities, especially in the context of engineering education and product development. Emerging studies are exploring the robustness of these platforms in handling complex design tasks, bridging the gap between virtual simulations and real-world applications. With the aid of advanced AI tools and by addressing existing limitations, the future of metaverse technology appears promising. It is set to make virtual and augmented realities indispensable in engineering workflows, facilitating a more immersive, efficient, and comprehensive design and testing process.

## 2. Literature Review

The first study that used the Festo Workstation as the research object was a study discussing the mathematical model of the Festo Workstation [13]. This study indirectly led to research based on design attempts to build a digital twin of the Festo Workstation using the Unity Engine platform [14], [15]. The research was further developed using a different platform, namely Roblox Studio [3]. This research then became the initial foundation for this study.

Many other studies also use Roblox as a platform for design media. One study that is still related to the field of engineering is the design of basic electrical learning tools using the Roblox platform [2]. There are also other studies that utilize Roblox to create games that can help with programming and mathematics learning [16], [17]. Among these many studies, there has not yet been a direct examination of Roblox's abilities in the field of design, especially two-dimensional design. However, in a metaverse, two-dimensional design cannot be ignored, especially in the simulation design of engineering equipment. Research related to the Roblox platform itself that has been found so far mostly relates to the Roblox metaverse architecture, one of which is related to cybersecurity [18].

## 3. Method

Based on previous research, this research focuses on testing Roblox's capabilities in two-dimensional-based design. In that research, the three-dimensional object designed was the Festo MPS PA Compact Workstation, where one of the designed objects was the controller for the workstation [3]. The Festo Workstation controller has several key features, similar to common PID controllers. First is the trend display facility, consisting of several buttons designed to adjust process variables and setpoints. Second is the manual adjuster facility that allows for PID controller tuning. The M button is used to activate manual tuning, and PID parameters can be adjusted through the P, I, and D buttons for control loops L1 and L2. Third is the loop controller used to control two loops. Some PID controllers also have facilities to input process alarm settings [19].

The initial stage of this research involves implementing these features into the GUI features available in Roblox Studio. In Roblox Studio, there are several GUIs that users can use to design two-dimensional layouts, namely ScreenGUI, BillboardGUI, and SurfaceGUI. ScreenGUI is commonly used to design the main menu of the game to be created. This GUI type is not attached to objects, making it less suitable for controller design. This research then attempts to use two other types of GUIs that can integrate with the controller object. Therefore, the initial steps are also aimed at testing the appropriate GUI type for controller design as seen in the flowchart (Figure 1).

The research is then continued by conducting several tests of Roblox Studio's capabilities while designing the controller layout. The Blackbox testing method is employed to assess Roblox Studio's ability to display design results in two dimensions. The method selection is based on the research focus, which is on the output displayed on the interface. The testing is done step by step, starting from testing user interactions with the system; testing GUI's ability to respond to user inputs; testing the ability to implement mathematical functions and display them in text form; and testing Roblox's ability to display them in simple graphic form.

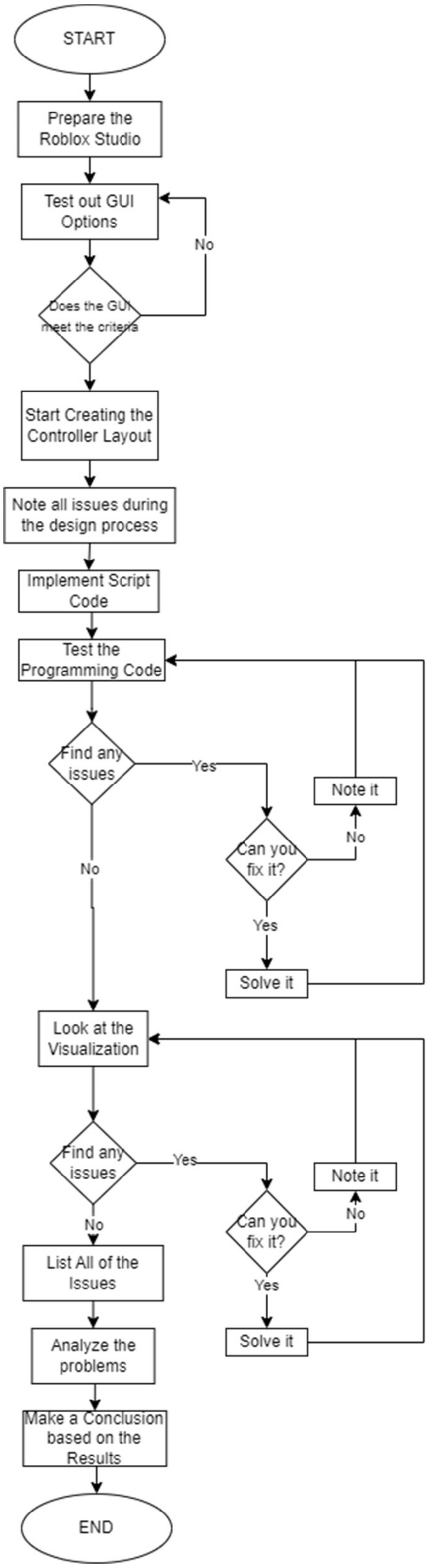



**Figure 1**. Research Process Flowchart

Several main pages are tested during the testing activities, namely the Overview page, PID page, Manual Control page, and Trend page. This is because the input and output of the system will be displayed on these three pages. The system output will be presented in bar charts, trend graphs, and text. This research is conducted using two testing methods: using the testing feature in the Roblox Studio application and direct testing in the Roblox application. Testing is repeated using various visualization methods and inputs, so the researcher makes several changes to the script code to test Roblox Studio's ability to create output visualizations. The test results data is then collected and the strengths and weaknesses of using Roblox Studio for two-dimensional controller design are determined. The details of the research can be found in Figure 1.

# 4. Results

## 4.1. Results of GUI Testing

Based on experiments conducted on BillboardGUI, there are two advantages of this type of GUI. These advantages are related to the size of the GUI display. Placing the GUI above objects enables developers to easily design menu layouts, although aesthetically, improper placement of the menu on objects makes it less similar to the original object. The size of the GUI display also changes and adapts to the user's distance, allowing metaverse users to see the menu better even from a distance. However, this can also make Workstation objects less visible as they are obstructed by the GUI.

The most apparent shortcomings of the Billboard GUI itself are related to the functions of BillboardGUI. Several dynamic functions tend to be unusable with this type of GUI. Commonly used button icons in GUI cannot be functional, rendering this GUI completely unusable for controller design activities. This GUI can only be used to display static messages and up to the present has not been usable for more dynamic processes. As this type of GUI cannot be used in controller design activities, researchers then tested the second type of GUI, SurfaceGUI.

All buttons function properly in experiments conducted using SurfaceGUI. Unfortunately, some functions cannot be executed on SurfaceGUI, namely, Surface GUI cannot store data using text boxes, so users cannot input values using the keyboard on the available text boxes. This limitation could be due to the Roblox system, which prevents data storage through metaverse features to protect users, especially minors. This can then be worked around by using addition and subtraction buttons to modify input values from the controller, as commonly found in controllers in the industry [19].

SurfaceGUI attached to object surfaces also requires large objects to be visible to metaverse users, so objects cannot be made to their original size in the real world, as shown in Figure 2. The controller is designed separately from the workstation in the image because of the much larger panel size. This differs from physical workstations where the controller is integrated with the workstation. The shape of the panel is also modified to suit the comfort of metaverse users.

The difference in controller object shapes would not occur if the design could use BillboardGUI because the panel could be displayed above the controller object, even if it covers the workstation object. BillboardGUI, which cannot interact dynamically with users like SurfaceGUI, makes it unusable for controller design activities until this research is conducted. Roblox is highly recommended to provide more dynamic functions on BillboardGUI so that developers can have more options in their design activities.

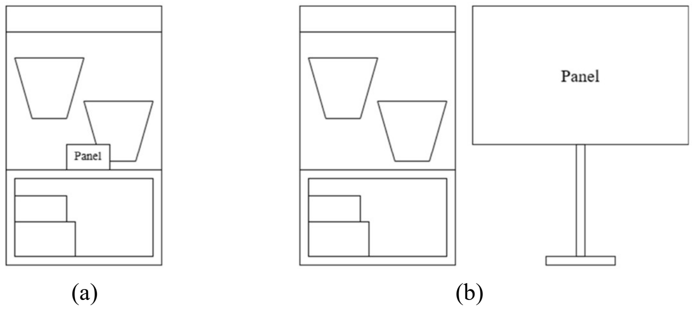



**Figure 2**. Comparison of the shape and size of control panels: (a) Physical Workstation, and (b) Metaverse Workstation [20]

### 4.2. Results of Controller GUI Design

The layout of the controller interface in this design is based on the existing controller interface design in the real world. There are some similarities and differences in features between the controller interfaces of the Festo MPS PA Compact Workstation and the layout of controllers commonly used in the industrial world [11]. A comparison of these three layouts can be seen in Table 1.

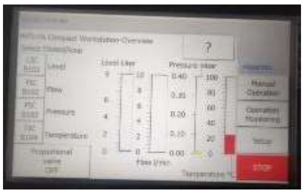
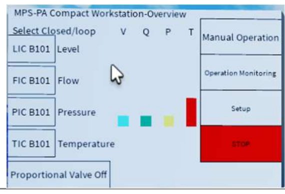
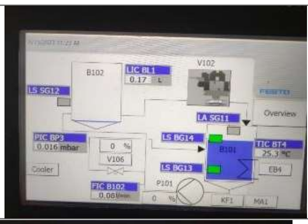
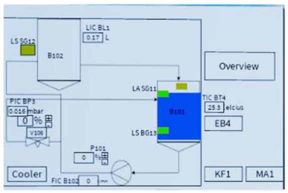
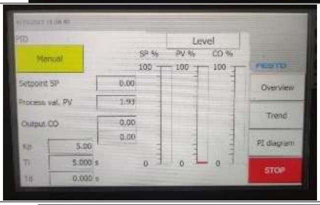
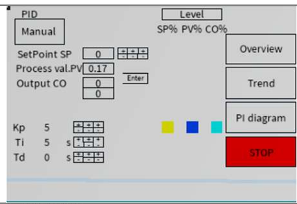
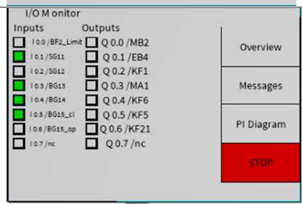
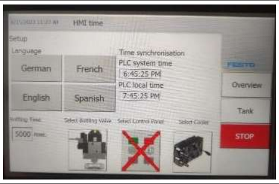
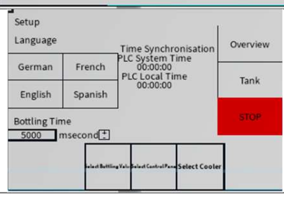
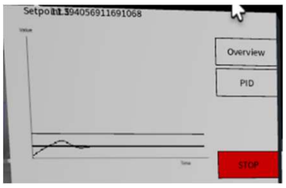
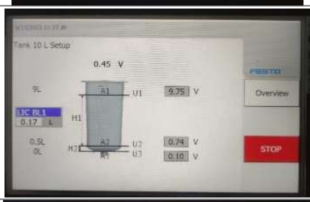
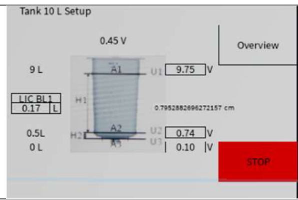
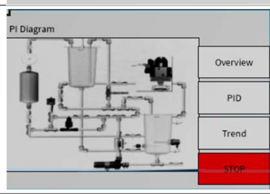
**Table 1** Comparison of standard layout with Festo MPS PA Compact Workstation interface

| No. | Feature | Layout Standard | Physical Workstation | Metaverse Workstation |
|---|---|---|---|---|
| 1 | Trend Display | Available | Available | Available with Limitation |
| 2 | Dis Button | Available | Not Available | Not Available |
| 3 | SP Button | Available | Replaced with Textbox | Replaced with Text Label |
| 4 | Up and Down Button | Available | Replaced with Textbox | Available |
| 5 | PV1 and SP1 Button | Available | Replaced with Trend Button and Bar Chart | Replaced with Trend Button and Bar Chart |
| 6 | Manual Facility | Available | Available | Available |
| 7 | L1 and L2 Button | Available | Not Available | Not Available |
| 8 | Loop Alarm Button | Available | Not Available | Not Available |
| 9 | Bar Chart; SP, PV, and Output CO Percentage | Not Available | Available | Available |

Several differences between metaverse workstations and physical workstations are mostly due to the limitations of Roblox in design activities as mentioned earlier, such as the use of Textbox being replaced with up and down buttons. In this design activity, it was also found that there are programming limitations that cannot directly present a Bar Chart but can be anticipated by manually placing objects so that a Bar Chart can still be presented. In terms of appearance, all menus are still presented in a Physical Workstation as seen in Table 2.

All pages displaying output from the system are successfully displayed on the SurfaceGUI as depicted in the image. Some functions unrelated to the system's output and input are not part of this study, which focuses solely on the water level control system. The design results can then be tested by analyzing the system's output in mathematical calculations and how these results are displayed through the designed two-dimensional interface. All these activities are conducted through repeated testing with several schemes, ranging from testing each up and down button, open-loop testing, to closed-loop testing.

**Table 2** Layout Controllers: Physical Workstation vs. Metaverse Workstation

| No | Pages | Physical Workstation | Metaverse Workstation |
|---|---|---|---|
| 1 | Overview |  |  |
| 2 | Manual Operation |  |  |
| 3 | PID |  |  |
| 4 | Operational Monitoring |  |  |
| 5 | Setup |  |  |
| 6 | Trend |  |  |
| 7 | Tank Setup |  |  |
| 8. | PI Diagram |  |  |

## 4.3. Results of Mathematical Function Testing

In the earliest testing, which involved simple calculations using the up and down buttons, an issue was found in the arithmetic calculations. This issue is related to the Lua programming language's ability to perform repetitive mathematical operations. Even for the simplest mathematical operations like addition with small amounts, the system's output experienced errors. In performing simple operations like adding the number one repeatedly, the system can experience errors when calculations are done repeatedly. For example, when attempting to add the initial number (zero) with one repeatedly (x = x + 1) up to six, at one point, there will be an error in the system's output value, as seen in Table 3.

Table 3 shows examples of calculation errors that can occur in the calculation process using the LUA programming language. In the table, it can be seen that in the fifth iteration, the script does not produce output number 5 as it should. If there can be errors in such simple calculations as shown in the example, then there will undoubtedly be calculation errors in more complex equations. However, if we look at the example, the calculation error is very small, so it can still be tolerated, especially for the water level control system on the Festo Workstation.

**Table 3** Mathematical Operation Error

| Iteration | Input | Output |
|---|---|---|
| 1 | 0 | 1 |
| 2 | 1 | 2 |
| 3 | 2 | 3 |
| 4 | 3 | 4 |
| 5 | 4 | 4.99..........99 |

There is no direct correlation between mathematical calculation results and the aesthetics or comfort of the system's GUI. However, mathematical errors like these can reduce the level of similarity of the metaverse to the real world. Errors in such simple mathematical operations can be one factor in the occurrence of errors in open-loop and closed-loop systems. For example, in a closed-loop system, the error obtained can reach 11.04% [3]. This difference will also result in visual differences, which will be reflected in the trend graph displayed on the GUI. The error obtained from the Lua programming language's capabilities can be disregarded due to its small margin, but this error also cannot be ignored because it can have larger implications if it occurs in more complex and repetitive calculations.

## 4.4. Results of Output Visualization Testing

In testing the system display, there were many errors encountered. The first error found is the layout displayed on some pages that often overlap each other as seen in Figure 3. This error appears suddenly without a known cause and can be fixed by first moving the page positions to another page and then returning them to their original positions. Until after the research was conducted, no cause or way to prevent this error was found. Researchers have tried to recreate the pages along with the scripts, but errors can still occur suddenly. This also serves as an important note for the future development of the Roblox metaverse so that the display on the SurfaceGUI does not encounter the same issue.

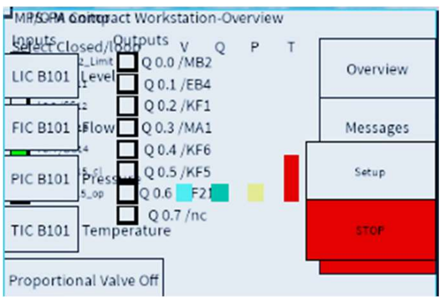



**Figure 3** Error in Page Transition

One form of visualization of the system output is a bar chart formed from several objects. Changes to this bar chart are controlled by adjusting the visibility of the objects forming the chart. In this process, there is an error that occurs during execution. Rapid changes in the output can result in errors in the bar chart, where the chart will be cut off due to some objects not responding to the visibility adjustment function.

The limitations in Roblox in displaying graphics are also present in trend graphs as previously explained. So far, there are no specific libraries that can assist in creating graphs in the LUA programming language. Trend graph creation is then done by duplicating point objects previously placed at coordinates (0,0), which will then be positioned according to the output values and time. This method is less capable of visualizing trend graphs with a flat graph shape and cannot map processes that occur over a long period because the graph is static, as seen in Figure 4.

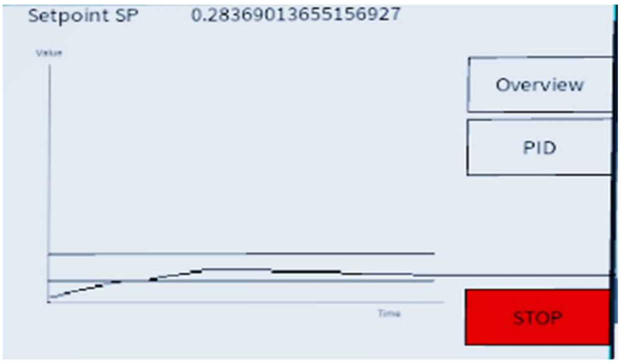



**Figure 4** The Trend Graph at The Metaverse Workstation

The abundance of errors in the visual display is also reinforced by mathematical errors that result in the displayed calculation results in text boxes needing adjustment. In the design process of this system, rounding of output results is necessary so that the mathematical calculation values can be displayed simply, making them readable by users. Too many digits can make the result unreadable. On the other hand, rounding also has its drawbacks, as it can introduce errors in calculations if the value is reused for further calculations.

## 5. Conclusions

Roblox's capability in simulating PID-based control systems is technically quite good, but this is not well-supported by Roblox's ability to design two-dimensional controllers for user interaction. Many errors arise in the design of the metaverse workstation, starting from the limited capabilities of the LUA programming language, which is not yet able to perform accurate mathematical calculations. The presence of errors in mathematical calculations can affect the displayed results. Limitations in the LUA programming language also force developers to find more complex alternative solutions to visualize outputs in the form of graphs, which in this design activity still leave unresolved shortcomings. Some errors can also suddenly appear without a known cause and how to overcome them. Overall, Roblox still needs further development to be used for designing dynamic two-dimensional objects.

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