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Virtual Training Applications in Aviation BITE Test Application

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Abstract

In this study, the objective is to scientifically examine the usability of multi-user virtual environments as an alternative solution to traditional methods in order to enhance the effectiveness and create widespread opportunities for training applications in aviation, which are difficult and risky to implement on actual aircraft. For this purpose, a virtual environment application was developed, specifically focusing on the examination of Built-In Test Equipment (BITE) test procedures conducted by maintenance personnel during aircraft maintenance. The application included the design of a Multi-Function Control and Display Unit (MCDU) in the virtual environment. The benefits and limitations of the virtual environment application were discussed, highlighting how the challenging and risky working conditions can be efficiently transformed into practical training scenarios in various contexts, promoting the development and reinforcement of skills for personnel. Despite the extensive use of multi-user virtual environments in various fields, it is evident that there is scarce research conducted in the aviation maintenance and repair sector. This study serves as a significant initiative to draw attention to the potential usability of multi-user virtual environments for educational purposes in the aviation maintenance and repair sector.

1. Introduction

Adapting to a wide range of technologies and keeping up with the demands of the modern era holds significant importance for individuals. With the advancement of technology, it becomes inevitable for the foundations of education to evolve in certain aspects. Among the various applications in education, the internet has gained a significant role by facilitating the creation and support of learning activities, encompassing a broad spectrum in the field of education (Hill, J.R. Han, S.R.A., 2001). However, web-based education has proven to be insufficient due to its reliance on text, images, and vector graphics, which led to the rapid development of virtual reality technologies that offer high levels of interactivity to users (Özdinç, F. & Tüzün, H., 2010). The increasing use of computers in today's society, coupled with the expanding digital world and the technological infrastructure supporting it, has prompted a serious consideration of virtual environments in education. Education-focused virtual applications provide users with not only flexibility through 3D visuals but also interactive experiences (Lei, Z. et al., 2021). As internet usage has become more widespread alongside technological advancements, multi-user virtual environments have emerged as three-dimensional online spaces where participants from different fields can interact with each other and computer-generated objects (Dalgarno, B. and Hedberg, J., 2001). These environments have found significant application in education, offering users the opportunity to engage with others and digital objects in immersive three-dimensional settings (Dede, C. et al., 2005). The growing effectiveness of virtual environments over time has led to companies choosing them for staff training purposes. In addition to advancements in various other fields, virtual environments have become increasingly relevant in the field of education (Kayabaşı, Y., 2005). Virtual applications in education are gaining popularity and becoming more preferable (Winkelmann, K. et al., 2020).

Researchers from METU (Middle East Technical University) have developed a "virtual school" project, as depicted in Figure 1, where participants with avatars can engage in three-dimensional virtual environments for educational purposes (TRT Haber, 2021).

Figure 1. METU Virtual School Project (TRT Haber, 2021)

This article examines the effective implementation of virtual environments in the aviation field, which can be used for personnel training in various domains. The Introduction section of the article discusses research related to the integration of education into virtual environments through technological advancements. The Materials and Methods section focuses on the educational needs in the aviation field and provides an example study and proposed solutions to address these needs. The Result and Discussion section presents the findings of the research and the results obtained from the example study. In the Conclusion section, the importance of the study conducted throughout the article and the expectations for the future are addressed.

In the literature, numerous studies have been conducted to examine the contributions of virtual environments to educational activities. A research conducted by Jones and Warren emphasized that virtual environments offer more reliable and enduring experiences compared to real-world applications (Jones, J. G., & Warren, S. J., 2008). Ibáñez et al. found that three-dimensional virtual environments provide highly immersive experiences in self-directed learning processes (Ibáñez, M.B. et al., 2011). In a study conducted by Davy Tsz Kit Ng during the COVID-19 pandemic, the significant need for aviation educators, who train professionals in the industry, to change their teaching methods in order to facilitate sustainable learning during the pandemic was highlighted (Ng, D.T.K., 2022). Along with the opportunities provided by three-dimensional environments, there can also be challenges such as technical requirements, avatar and usability difficulties, getting lost in the environment, being drawn to the attractiveness of the environment, engaging in inappropriate dialogues, and experiencing attention distractions (Harris, A. L. & Rea, A., 2009).

Thanks to advancements in technology, accessing resources that contribute to individual development has become easier, while also providing a platform for self-directed learning. Parallel to these advancements, progress in software and hardware has laid a foundation for educational applications in three-dimensional virtual environments. Virtual environments offer participants a safe, interactive, and realistic learning experience, allowing them to enhance their skills in complex tasks. Around 80 educational institutions, including Harvard University, utilize three-dimensional virtual environments in their distance learning systems (Bell, L. et al., 2007). In a study by Berge, it was emphasized that when simulation and peer interaction contents are appropriately designed, there is significant potential for education and instruction to take place in multi-user virtual environments (Berge, Z.L., 2008). In a study conducted by Dimitrios et al., the use of virtual educational environments was highlighted to support remote and online learning. Additionally, the participating students reported that virtual environments increased their motivation to learn and provided a more enjoyable experience (Bolkas, D. et al., 2021).

2. Materials and Methods

Due to advancing technology and industry demands, the training requirements in the aviation sector are gaining increasing importance. Particularly in the field of maintenance, the reinforcement of theoretical training with practical training takes a considerable amount of time. Performing practical exercises on an aircraft, especially for pilots, is challenging due to limited resources and high costs. To meet these needs, companies invest significant amounts of money to acquire simulators, ensuring that pilots receive sufficient training. This enables critical situations that pilots may encounter during operations to be simulated, preparing them for safer flights in real-life operations. Moreover, training sessions using simulator applications are also conducted for maintenance personnel, specifically for training in engine startup procedures during the maintenance process.

Indeed, the challenging motor failure scenarios listed below, which are difficult to encounter or practice in real life, can be efficiently conducted through simulation. As a result, potential issues that may arise during engine startup can be experienced and addressed during training sessions.

- Engine failure
- Tailpipe fire
- Engine/APU (Auxiliary Power Unit) fires
- Bird strikes
- Engine/APU startup
- Exposure to rain, snow, hail, storms, sand, or volcanic ash

However, it is not always feasible for maintenance personnel to utilize these simulator systems. Due to the following reasons, alternative solutions have been sought instead of relying solely on simulator systems provided through manufacturers for practical training:

- High costs
- Limitations on the number of participants (typically four individuals per training session)
- Priority usage needs of the flight crew
- Limited availability within specific time frames
- Access issues during maintenance and modification processes

Performing practical training for maintenance personnel on actual aircraft is another solution; however, due to the following factors, practical training in virtual environments has started to be evaluated by organizations:

- Planning
- Suitability of the aircraft
- Disassembly/assembly capabilities
- Impact on ongoing maintenance
- Adverse effects on work processes, etc.

This article aims to scientifically examine the feasibility of alternative solutions introduced to the traditional methods in order to provide maintenance practice training and reinforce acquired knowledge in aviation, where certain maintenance applications are risky to perform on actual aircraft.

For this purpose, a practical study is conducted to explore the applicability of multi-user virtual environments, with a specific focus on Second Life (SL), which is the most commonly used platform among the multi-user environments (Second Life, 2022b) as shown in Figure-2.

Due to its high graphic requirements, SL requires advanced hardware features such as a powerful graphics card and operating system on the user's computer. The minimum computer requirements for SL (version: 6.6.8.576737) on Windows are provided in Table-1 (Second Life, 2022a). Minimum computer requirements for other operating systems can be viewed on the website www.secondlife.com/system-requirements. With advancing technology and new graphic designs, user computers need to have good performance values. Although the limitations given in the table are sufficient for SL, users, especially those who want to develop products within SL, are advised to prefer computers with next-generation graphics cards. This situation can create a negative perception as it may increase user costs.

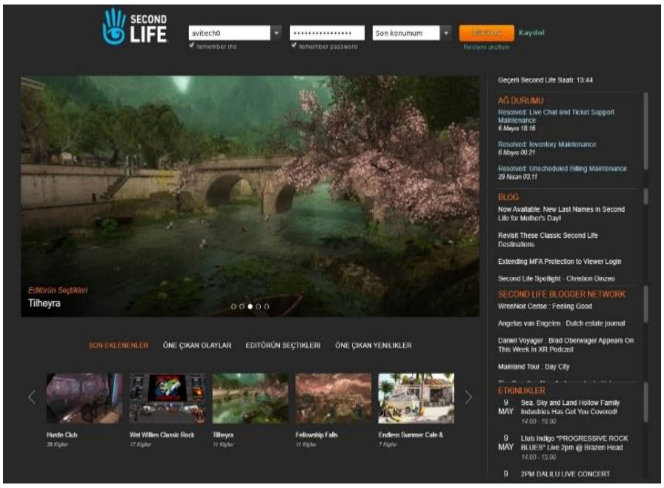

Figure 2. Second Life Main Page (Second Life, 2022b).

Table 1. Minimum computer requirements for SL (Second Life, 2022a)

Windows	Minimum Requirements	Recommended
Internet Connection:	Cable or DSL	Broadband internet connection
Operating System:	Windows® 8 (latest Service Pack)	Windows® 10 or 11 64-bit (latest Service Pack)
Computer Processor:	CPU with SSE2 support, 2 cores	CPU with SSE2 support, 8 cores
Computer Memory:	4 GB	8 GB or more
Screen Resolution:	1024x768 pixels	1920x1080 pixels
Graphics:	OpenGL 3.2	OpenGL 4.6

SL provides the opportunity for product development through a simple three-dimensional design tool, as shown in Figure-3. Users can design the objects they need in three dimensions using the object creation menu shown in Figure-4. They can save previously designed objects to their inventories and reuse them later when needed, as demonstrated in Figure-5 through the inventory menu. If the project requires software control, the necessary software can be implemented using a script, as shown in Figure-6. Linden Scripting Language (LSL) is used for scripting within SL, and examples of how commands are used are provided to guide users in understanding how to use the desired commands. In SL, users are represented as avatars. Therefore, when entering SL, a user avatar should be selected, and a username and password must be determined.

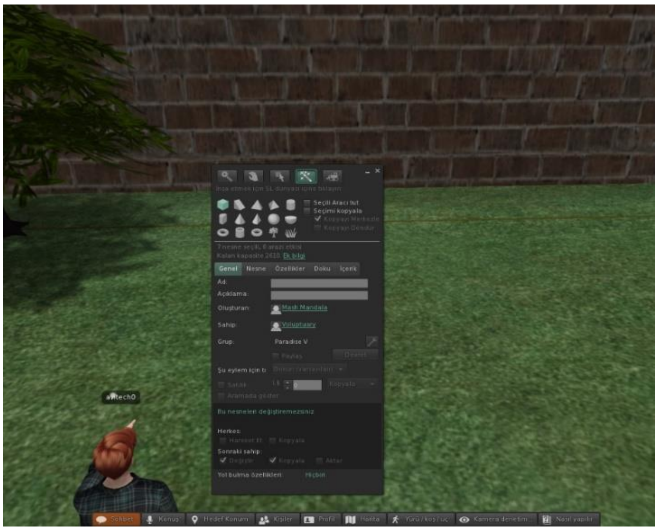

Figure 3. 3D Design Tool

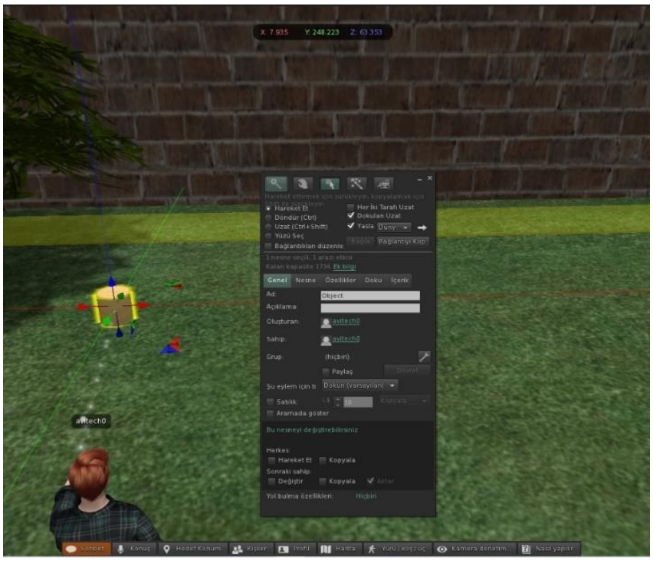

Figure 4. Object Create Menu

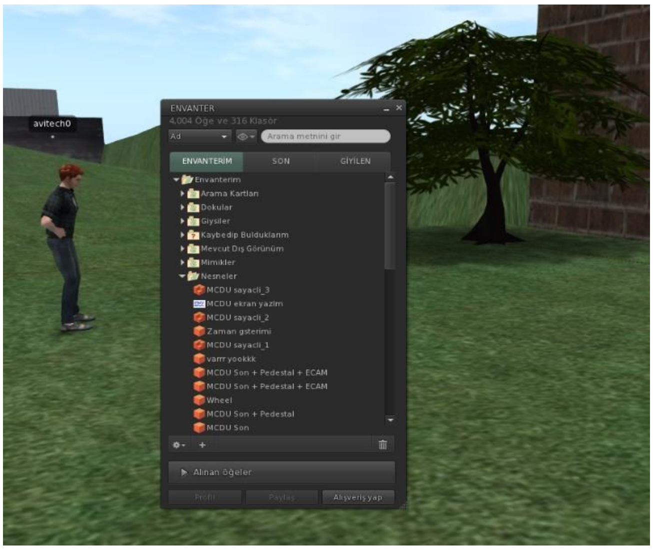

Figure 5. Inventory Menu

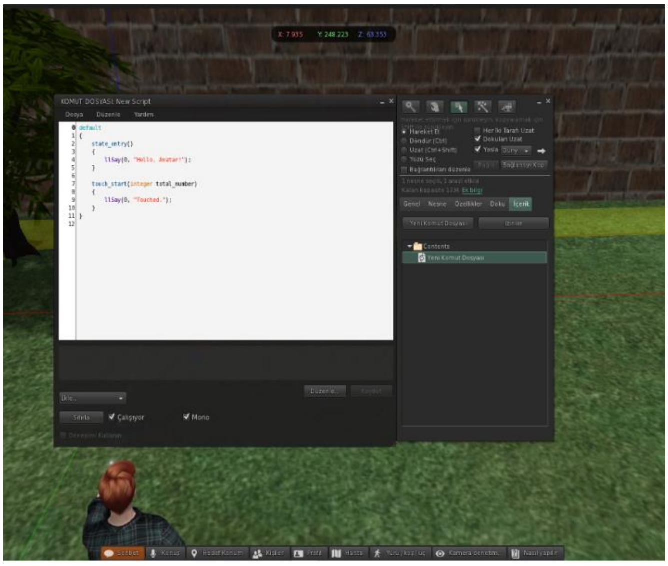

Figure 6. Command File

After troubleshooting and repairing aircraft systems, it is necessary to verify the maintenance work. This verification process is performed through the computer that manages the respective system and is known as Built-In Test Equipment (BITE) test. This validation procedure, which is carried out via a central control unit called Multi-Function Control and Display Unit (MCDU), indicates whether the maintenance has been successfully completed or not. In this study, the Multi-Function Control and Display Unit (MCDU) of the Airbus A320 aircraft and the Slat Flap Control Computers (SFCC), which are wing structures of the aircraft and play a significant role during flight phases, are addressed.

Using the SL application, as shown in Figure-7, a virtual model of the MCDU belonging to the Airbus A320 aircraft has been created, and the BITE test application of the SFCC has been conducted.

Figure 7. 3D A320 MCDU Prepared with SL

During this test, all screen displays have been designed to resemble the real ones. If needed, the user can navigate to any stage of the test or even return to the beginning by pressing the "return" key. Since the test is not performed on an actual aircraft, the maintenance verification results are randomized, either positive or negative. A positive result indicates that the maintenance procedure has been successfully carried out, while a negative result requires the participant to follow the maintenance manual accordingly. This allows the participant to experience both scenarios during the test.

In the practical training conducted on aircraft or simulator systems obtained from manufacturers, there is a limitation on the number of participants, allowing a maximum of 4 participants to receive training simultaneously. As depicted in Figure-8, this virtual environment work (MCDU) can be replicated and duplicated for multiple users. Since each participant undergoes a different process, they can acquire distinct experiences concurrently. Consequently, training can be conducted without limitations on the number of participants.

However, conducting training on real aircraft entails risks such as prolonged training duration, equipment malfunctions, and potential errors during training. Therefore, virtual environments can be more appealing for businesses. Moreover, since aircraft or hangar environments are not necessarily required for training, more flexible training planning can be achieved. It is believed that creating classes in various selected environments can enhance participants' enthusiasm for training.

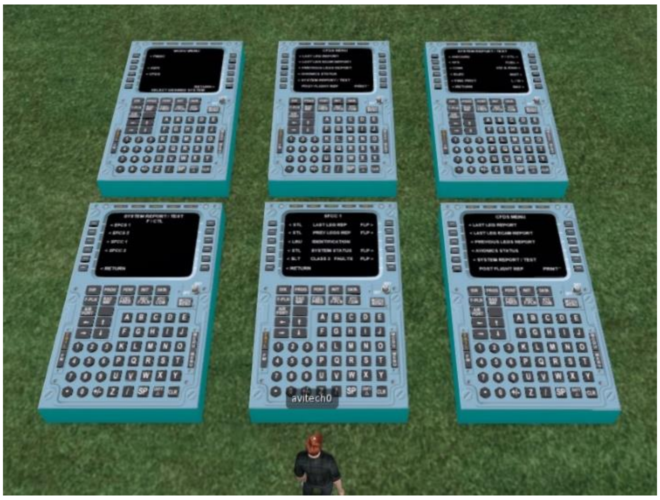

Figure 8. Replicated MCDUs in Virtual Environment

The study was shared with a group of technicians working in the industry, and their opinions were collected. The work was found to be interesting by the users, and positive feedback was received indicating potential for future development and contribution to the industry. However, it was observed that younger employees who are relatively more computer-savvy adapted more easily to the virtual environment, while older individuals with less interest in computers had difficulties in adaptation.

Experiments were conducted with 10 participants in each age group (20-29, 30-39, 40-50) consisting of maintenance technicians, and the results obtained are presented in Table-2. The adaptation score took into account factors such as program entry, control of the avatar, and ability to perform the application. Participant opinions were considered for the categories of efficiency, applicability, and benefits to the industry.

Table 2. Participant Evaluations

	Age 20 – 29	Age 30 – 39	Age 40 – 50
Adaptation	10 positive	7 positive 3 negative	4 positive 6 negative
Efficiency	10 positive	8 positive 1 negative 1 neutral	5 positive 3 negative 2 neutral
Applicability	10 positive	8 positive 1 negative 1 neutral	5 positive 3 negative 2 neutral
Benefit Provided	9 positive 1 neutral	8 positive 2 neutral	6 positive 1 negative 3 neutral

This study has demonstrated that advanced designs in virtual environments can provide users with the opportunity to experience numerous scenarios that are difficult and risky to implement in reality, enabling them to gain repeated experience. It has also shown that these virtual environments can serve as an alternative method to traditional learning approaches. However, it should be noted that maintenance application training conducted on real aircraft remains crucial for participants to physically interact with the aircraft and grasp the seriousness of the job.

3. Result and Discussion

The conclusions drawn from the research and the conducted study can be listed as follows:

With the advancement of technology and the widespread availability of internet infrastructure, multi-user virtual environments have become extensively utilized in the field of education.

The utilization of multi-user virtual environments in aviation education is an effective method that enables users to gain practical experience and translate their theoretical knowledge into practice.

The ability to repeatedly apply the same scenario makes multi-user virtual environments a preferred choice for reinforcement training.

The ability of virtual environments to be applied independently of time and location allows participants to connect to the system (multi-user virtual environment) through their personal computers from any preferred environment (home, office, café, etc.). This offers opportunities for self-improvement, making it a preferred choice for participants.

The minimum computer requirements necessary for the efficient operation of multi-user virtual environments, along with their high costs and the financial constraints of participants, limit their personal usage.

Individuals with a higher interest in computers find it easier to adapt to virtual environments, while those with less interest require more time to adapt.

The absence of participant limitations in virtual environments allows for the opportunity to provide training to multiple participants simultaneously in aviation maintenance education planning.

4. Conclusion

Thanks to the opportunities provided by virtual environments, challenging working conditions can be effectively transformed into practical training scenarios with diverse contexts, facilitating the development and reinforcement of skills for personnel.

The widespread adoption of virtual environments in the aviation industry will help companies reduce costs and enable efficient and relatively easier personnel training.

Conducting practical training in virtual environments instead of real aircraft in aviation maintenance will reduce potential risks.

No matter how successful maintenance application training in virtual environments may be, it cannot completely replace maintenance training conducted on actual aircraft.

This exemplary study and its obtained results demonstrate that practical training required in the maintenance field can be designed in multi-user virtual environments. Consequently, personnel can receive training independently of time and location using their personal computers. Moreover, the training can be reinforced by the participants through the repetition of these exercises.

In the field of aviation maintenance training, the future is expected to witness a greater adoption and implementation of multi-user virtual environments. Through further research and advancements in this area, users will be able to become better-trained and skilled maintenance technicians.

Ethical approval

Not applicable.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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