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*Article*

# Leveraging VR in the Age of the Metaverse: Opportunities and Challenges in Private Pilot Licence Training

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**Abstract.**

In the age of the Metaverse, Virtual Reality (VR) training could enhance facilitation of the Aeroplane Private Pilot Licence (PPL) training. Hence, the research objective of this study revolves around the opportunities and challenges faced by pilot trainees while utilising medium-fidelity VR during PPL training. The qualitative research methodology aligned with the ontological perspective that emphasised subjectivism. The epistemological framework has been based on the interpretivism paradigm. This research employed a grounded theory technique and utilised semi-structured interviews as the primary data collection method. The findings derived from thematic analysis suggest that a significant proportion of pilot trainees agree with VR's efficacy in theoretical instruction, pre-flight aeroplane inspection, and procedure training. However, the trainees shared their isolating experiences and challenges in acquiring specific competencies and issues developing their motor skills while using VR. These findings are anticipated to be utilised to develop VR instructional frameworks that could facilitate future PPL training.

**Keywords:** metaverse, pilot training, private pilot licence, virtual reality.

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## 1. Introduction

Aeroplane Private Pilot Licence (PPL) training has had significant progress in recent times. The acquisition of PPL represents the initial phase of one's aviation journey. Individuals who possess a PPL are granted the privilege to transport passengers within certain geographical boundaries [1, 2]. The rapid advancements in technology during the era of the Metaverse have resulted in a substantial transformation of conventional training methods in the field of PPL. The advent of virtual reality (VR) technology has emerged as a prominent element in this paradigm, significantly transforming the manner in which pilot trainees see and engage with their training environments [3].

Hence, the main objectives of this research revolve around examining the potential situations encountered by pilot trainees when employing medium-fidelity VR technology during their PPL training. The level to which a simulation system replicates a real-world system is known as the VR system's fidelity [4, 5]. The term medium fidelity VR denotes an immersive digital environment that exhibits a higher level of detail and realism. Meanwhile, a high-fidelity VR experience typically exhibits a remarkable resemblance to the real-world surroundings [6]. The medium-fidelity VR technology has been selected for this research study due to its accessibility and location. Hence, the primary research questions addressed in this study revolve around the opportunities and challenges faced by pilot trainees during their PPL training while utilising medium-fidelity VR.

## 2. Literature Review

### 2.1 Pilot License Training: Background

In order to become aeroplane pilot, individuals are required to acquire the necessary skills to operate an aeroplane, fulfil a predetermined quota of flight hours, successfully undergo medical evaluations, and obtain the requisite licences to operate as pilots. In the context of New Zealand, those aspiring to become certified pilots are required to obtain a PPL through a flight training organisation. This process entails completing a series of 50 flight hours, participating in theoretical examinations, and successfully passing them [7-9]. The acquisition of aeroplane piloting skills is not restricted by age, since individuals of any age can commence their training. However, the privilege of flying solo in New Zealand is only granted to those who have reached the age of 16. Individuals have the opportunity to obtain a PPL at the age of 17. The PPL tests consist of six assessments that are often designed to align with the difficulty level of secondary school examinations. The assessment of learners generally focuses on the flying environment and the aeroplane, with the objective of ensuring that pilots receive comprehensive training and adhere to safety protocols consistently [10].

Upon the successful completion of the PPL, pilots are presented with the prospect of acquiring a Commercial Pilot Licence (CPL) by satisfying specific criteria. The prerequisites encompass the acquisition of a cumulative flight experience of 200 hours, the successful completion of both theoretical and practical examinations, and the attainment of a Class 1 Aviation Medical Certificate. To embark on a professional journey as an airline pilot, individuals are then required to undertake supplementary academic coursework and amass a predetermined amount of flight hours to meet the qualifications for specialty roles. These roles may encompass the attainment of a Multi-Engine Instrument Rating, which grants pilots the ability to operate a propeller aeroplane, or the acquisition of an Airline Transport Pilot Licence

(ATPL), which is a prerequisite for piloting an aeroplane that also requires the presence of a co-pilot [10, 11]. Table 1 provides the statistics for the New Zealand Pilot Licence, including the current cumulative number of lifetime licences for different types of aeroplane licences in New Zealand, such as PPL, CPL, and ATPL.

**Table 1. New Zealand Pilot Licence Statistics**

| License type | Total Licences |
| --- | --- |
| ATPL | 4555 |
| CPL | 8385 |
| PPL | 11959 |

Note: The researchers compiled this data based on information retrieved from the New Zealand Civil Aviation Authority (CAA).

The training for PPL has undergone continuous modifications due to advancements in technology. The use of technology, particularly flight simulation, has long been linked to PPL instruction. One of the most renowned early flight simulation devices was the Link Trainer, developed by Edwin Link in Binghamton, New York, United States [12]. According to Mystakidis [13] flight simulators in the 1920s were known as metarverse. During its initial stages, the concept of the metaverse delved into the exploration of an alternative reality experience for its users. Nevertheless, the ability for users to engage with virtual environment was limited due to the detachment of interaction from the actual environment, resulting in predetermined content established by developers [14].

### 2.2 Metaverse and VR: Brief History and Evolution

In 1992, novelist Neal Stephenson officially coined the term "metaverse" through his science fiction book Snow Crash [15]. The idea of a metaverse, particularly in VR have been developed through a series of technological developments over several decades. The single virtual environment in the metaverse allows users to interact immersively with each other users and the surrounding environment [16]. Between 2000 and 2021, numerous scholarly papers drawing upon a range of research studies have comprehensively examined the concept of the metaverse [17-19]. In contrast to the multiverse, which allows users to travel between multiple universes, the single virtual environment metaverse garnered significant widespread interest over recent years. Particularly, metaverse-associated investments enjoyed a remarkable surge. The 2021 rebranding of Facebook to Meta and Microsoft's acquisition of VR business for USD 68.7 billion, highlights the significant developments in the industry [16].

Despite, notable advancements, metaverse is still in its infancy stages of development. It is anticipated that it will become a common application in a range of sectors [20, 21]. In this age of the Metaverse, individuals have the ability to engage with both their surroundings and fellow users by three means which are known as augmented reality (AR), Virtual Reality (VR), and Mixed Reality (MR) technologies. Firstly, AR is a technology that superimposes digital information onto real-world objects or environments. One prominent illustration is the utilization of AR in the Pokémon GO application. AR places a strong emphasis on the real world while simultaneously enriching it with additional digital elements [16, 22]. Secondly, MR amalgamates tangible and virtual components. In the realm of MR, individuals engage with and control tangible and digital elements and surroundings, employing advanced sensing and imaging technology. MR technology enables users to visually perceive and engage with their surrounding environment while simultaneously interacting with a virtual world, utilising their own hands, without the need to remove the MR headset. This technology facilitates the simultaneous engagement with both the physical realm and a fictional environment, thereby deconstructing fundamental distinctions between reality and imagination. Consequently, it presents users with an immersive encounter that has the potential to revolutionise contemporary training methodologies. Finally, VR provides a fully immersive experience that effectively deceives the user's senses, creating the illusion of being situated in an alternative environment or world distinct from the physical reality. Users often utilise head-mounted displays (HMDs) or headsets to immerse themselves in a computer-generated environment consisting of visual and auditory elements [23, 24]. Within this virtual world, users have the ability to interact with virtual objects and navigate their surroundings with the use of controllers. It is worth noting that users are typically connected to a console or personal computer during these experiences. Figure 1 illustrates the distinctions among Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR).

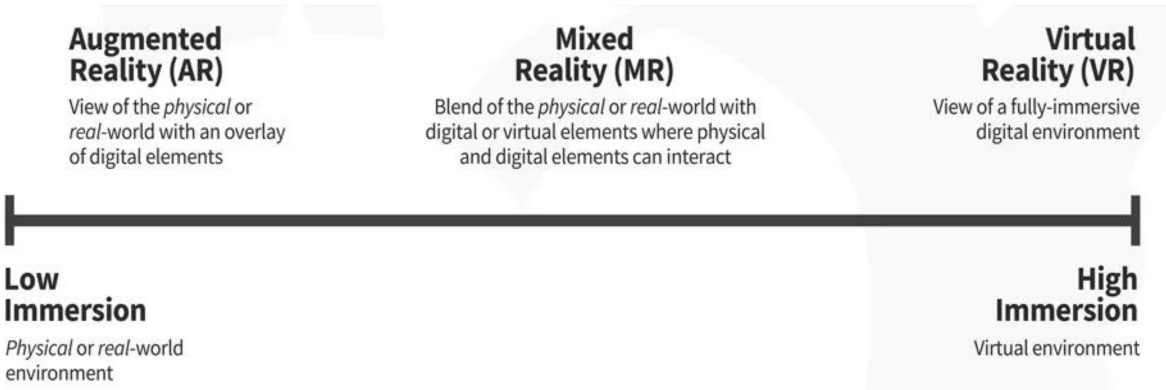


**Figure 1: AR, MR and VR**

Note: Figure 1 extracted from the design of Laia Tremosa, Interaction Design Foundation.

The VR application has become increasingly accessible across various domains, including gaming, entertainment, and medicine, with its scope continuing to increase. VR has been utilised in the field of healthcare for the purpose of training, particularly in the context of surgical simulations. In the realm of the film business, VR technology is being utilised to craft distinctive experiences for both films and shows. The tourism sector is inclusive of VR technology, which enables individuals to engage in virtual travel experiences, such as visiting an art gallery or exploring an extraterrestrial planet, all from the comfort of their own homes. VR technology has also been widely employed within the sports sector to facilitate training programmes aimed at assisting both professional and amateur players. In the gaming industry, there are currently over 1,000 VR games available, encompassing a wide range of genres such as first-person shooters, strategy games, and role-playing adventures [23, 25].

Therefore, various firms, including Deloitte, PwC, Accenture, Farmers Insurance, Toyota, AT&T, UPS, and Delta Airlines, have successfully leveraged VR into their own management training programmes. BMW has implemented a VR training programme for their maintenance crew workers. In the meantime, FedEx is employing VR to educate recently hired personnel on the appropriate methodologies for truck packaging. Walmart has also utilised augmented VR as a means to provide training to its employees in preparation for emergency situations [25]. Figure 2 further elucidates the distinctions between VR and others. Virtual reality (VR) generates a completely immersive digital environment.

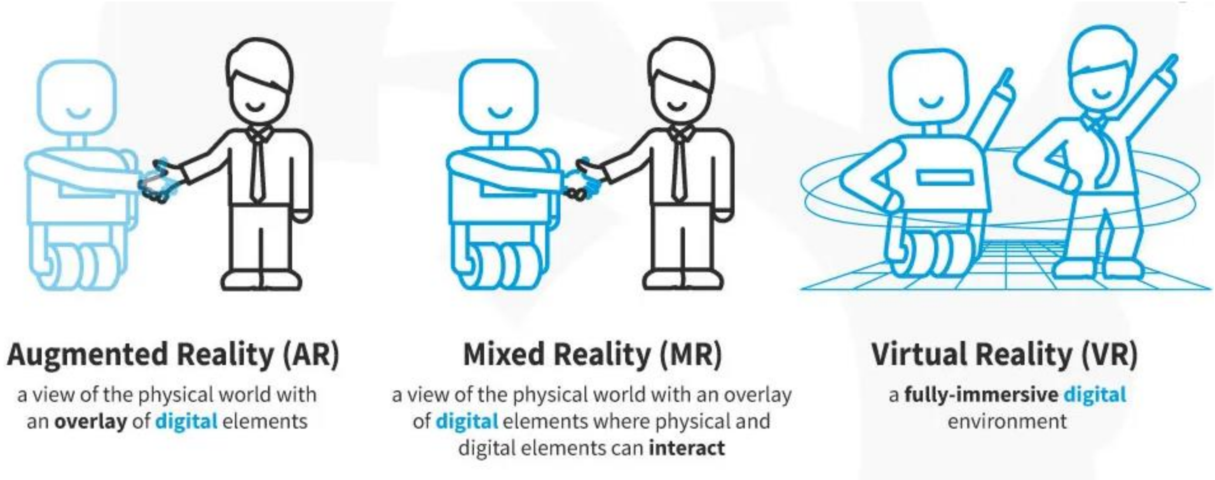


**Figure 2: VR – Fully Immersive**

Note: Figure 2 extracted from the design of Cristian Biggs, Interaction Design Foundation.

In the aviation industry within the United States Air Force, the utilisation of VR has been shown to yield significant benefits in the context of flight training. Specifically, it has been found that the incorporation of VR technology has resulted in a noteworthy reduction in the duration of their flight training programme, effectively shortening it by several months [26]. Therefore, certain flight schools have recently begun using VR headsets in the initial stages of flight training. This implementation aims to familiarise students with the aeroplane and its flight controls, as well as cultivate a sense of proficiency in takeoffs and landings, prior to their exposure to actual flight in the aeroplane.

Utilising VR headgear and flying controllers is a cost-effective approach. VR technologies can eliminate the need for large-scale simulators in the context of procedural training. During the early phases of training, VR solutions have the potential to serve as a substitute for instructors, resulting in a notable reduction in the overall cost of the training programme. Using immersive training in VR enables trainees to perceive distance through stereoscopic vision. This immersive experience provides students with the opportunity to gauge and comprehend distance accurately, hence facilitating the achievement of authentic visual flight navigation simulations. According to research conducted by the University of Maryland, VR has been found to enhance knowledge retention compared to conventional learning methods [27, 28]. Meanwhile, based on a survey conducted by PwC, it has been observed that students utilising VR exhibit improved confidence in applying their learned knowledge and skills. Additionally, these students demonstrate heightened concentration levels throughout training sessions and can complete their training at an accelerated pace [29].

The legitimacy of VR training has been certified by the United States Federation of Aviation Administration (FAA). However, the FAA does not endorse the duration of VR training as it could not be included in the overall tally of flying training hours [26, 30]. Similarly, the New Zealand's Civil Aviation Authority (CAA) does not officially recognise the inclusion of VR training hours within the mandated flying hours for the aeroplane PPL. The 50 hours' minimum requirement for flight experience shall be in the actual aeroplanes itself, which consist of 15 hours of dual instruction, 15 hours of solo flight time, 5 hours of dual instrument training, 5 hours dedicated to terrain and weather awareness, and 10 hours focused on cross-country flying [2, 31]. Table 2 outlines the comprehensive requirements for obtaining a

Private Pilot Licence in New Zealand, encompassing the necessary practical flight hours, theoretical knowledge, and medical qualifications.

**Table 2. New Zealand Private Pilot Licence Requirements**

| Types | Content | Passing Requirements |
|---|---|---|
| Medical | Medically Fit (at least 17 years old and there is no upper age limit) | Hold a current Class 2 Medical Certificate. |
| Theory | 1. Aviation law,<br>2. Meteorology,<br>3. Aircraft technical knowledge,<br>4. Navigation<br>5. Human factors,<br>6. Flight Radio (FRTO rating). | Pass the six theory subjects (passing marks 70% for each) |
| Practical Hours | 1. A minimum of 30 hours of supervised instruction with an instructor present.<br>2. A minimum of 15 hours of solo flight time under the guidance of a ground instructor, along with training in terrain awareness.<br>*The practical session consists of a range of exercises that start with fundamental handling skills and gradually progress to circuits where pilot trainees will eventually fly alone. It then moves on to more advanced aeroplane handling skills and cross country navigation.* | Gain a minimum of 50 flying hours.<br><br>Pass a practical flight test at the conclusion of the training. |

Note: The researchers compiled this data based on information retrieved from the New Zealand Civil Aviation Authority (CAA).

Meanwhile, the general expenses associated with implementing a comprehensive VR training solution can be substantial regarding time and asset investment. The development, production and maintenance of software and hardware components necessitate significant labour and financial resources [12, 21]. Consequently, numerous aviation training schools, particularly those of medium and small scale, have refrained from engaging even in medium fidelity VR flight training simulation.

Nevertheless, notwithstanding the regulatory and budgetary factors, VR remains a feasible approach for acquainting pilot trainees with the complexities of operating the aeroplane. Hence, the primary objectives of this research study are to examine the potential opportunities and challenges these trainees encounter while employing medium-fidelity VR technology in the context of their PPL training.

## 3. Methodology

This research study employed a qualitative research approach to match with an ontological standpoint that prioritises subjectivity. Ontology was chosen in this study as it is known for its focus on examining the concept of 'being' that is primarily concerned with understanding the fundamental nature of objects or situations [32, 33]. The utilisation of this methodology facilitated a comprehensive investigation into the trainees subjective encounters while progressing with PPL lessons, in conjunction with the application of VR technology. The epistemological framework was grounded in the interpretivist paradigm, placing emphasis on the importance of comprehending the subjective perspectives of the trainees. According to Merriam (2009), the epistemological framework enables the prediction, description, empowerment, and deconstruction of worldviews peculiar to a specific group of population. The fundamental understanding of the interpretivist method is that the researchers can never be wholly objective and detached from the research because they are an integral part of it and interpret the findings. This interpretivist method was justified as one of the researchers involved in this study is currently engaged in the process of taking PPL lessons. Therefore, this enabled the appropriate interpretation of the data. Interpretivists recognise that the individuals inside a given setting shape reality and knowledge, and they are concerned with particular, contextualised surroundings [34, 35]. Hence, the researchers did not generalise their studies as they intended to be more subjective. In order to gather data that is both rich and context-specific, the researchers utilised a commonly used approach known as grounded theory technique, which facilitated the generation of comprehensive insights into the topic being investigated. Grounded theory has emerged as one of the most popular qualitative research approaches. Grounded theory is frequently employed in educational research as well as in a variety of other academic subjects [36-38]. The primary strategy employed for data collecting involved conducting semi-structured interviews through snowball sampling technique that offered a balanced combination of flexibility and structure in engaging with the five participants. Hence, to participate in this research, the interviewees needed to be current successful pilot trainees enrolled in the PPL training programmes across New Zealand within the last two years. They should also have used VR in their studies. As medium fidelity VR was required for this research, they were expected to have used at least basic version of Microsoft flight simulator software.

## 4. Findings

Thematic analysis was used by researchers in conjunction with grounded theory as an analytic approach. The researcher identified patterns in their data by coding them with the Delve software, which served as the foundation for analysing qualitative data [39]. AI tools such as Scholarcy were also used to verify and triangulate the findings [40, 41].

### 4.1 Opportunities

The findings obtained from the thematic analysis provide insights into the advantageous aspects of medium fidelity VR within the realm of PPL training. 80% of interviewees have acknowledged the effectiveness of VR in theoretical education, pre-flight aeroplane examination, and procedural training. Some of the quotes from the interviews have been shared below.

> *"The VR takeoff and landing practices have eased my understanding and made my learning more engaging. It's like going into the textbooks, and VR makes challenging concepts easier to understand.*
>
> *"VR has improved my initial understanding of the cockpit. It allows me to look at the essential parts of an aeroplane. I could go through a simulated cockpit at my convenience".*
>
> *"VR training for procedures is a big deal. Because VR models are so realistic, they help me to practise emergency procedures over and over again until they become second nature, which makes me more ready".*
>
> *"The use of VR to train me as a pilot is a big deal. It helps me put what I have learned into practice, which boosts my confidence and skills in real-life flying situations".*

*"When it comes to weather training, VR offers an incredibly realistic experience. I can choose and face a wide range of weather conditions including poor conditions, preparing myself to make critical decisions in accurate flight with confidence".*

### 4.2 Challenges

However, the findings also provide insight into the challenges encountered by these trainees while utilizing VR during their PPL training. All (100%) of the interviews somehow did share some of their concern on the VR application. The prominent concern that emerged was the sensation of isolation and detachment that individuals experienced about their physical training environment and instructors. The possible gap can hinder their ability to develop a comprehensive comprehension of situational awareness and adaptability. Moreover, the trainees have expressed worries over their difficulties in cultivating certain motor skills. A selection of the quotations is provided below.

*"Sometimes, I found it challenging to adapt to VR training because I missed the direct interaction with my instructors and the real aeroplane. I felt disconnected and unsure of the actions taken".*

*"The absence of my physical training environment made me feel detached and unmotivated. I missed the hands-on experience and step-by-step guidance from my instructors".*

*"In my actual flight training, I am 100% tune with the real-world environment, which allows me to develop a deep understanding of situational awareness and adaptability. VR, though valuable but lacks that real-world depth".*

*"In real flight training, I could develop memory and improve certain skills through guided hands-on practice. However, in virtual flight, it's frustrating because I tend to forget what I have learned much faster".*

Overall, the findings justify that leveraging medium-fidelity VR in the age of the metaverse offers significant opportunities and selective challenges in PPL training. The findings are expected to be applied to enhance VR instructional frameworks that could facilitate future PPL training.

To summarise, incorporating VR training into PPL offers a substantial opportunity for progress in aviation training. Researchers obtained valuable insights into the effectiveness of VR in pilot training by conducting detailed semi-structured interviews with five pilot trainees who actively integrated VR into their training routines. The interviews revealed that the participants generally had a positive reception towards the effectiveness of VR in enhancing their training experiences. Although participants faced obstacles such as loneliness, a sense of disconnection from the real world, and difficulties in developing necessary physical abilities in the virtual environment, they recognised the advantages of using virtual reality for training. The results emphasise the capacity of VR to benefit particular elements of pilot proficiency and PPL training, thus creating opportunities for implementing innovative approaches in aviation education. This finding underscores the profound effect of VR and the necessity for ongoing improvement and adjustment of VR technology to overcome inherent restrictions and difficulties. With the changing aviation industry, incorporating emerging technologies such as VR shows potential for significantly improving pilot training programmes' effectiveness, safety, and efficiency. Furthermore, the study acknowledges the significance of recognising and reducing the difficulties of incorporating VR into current training methods. By utilising the knowledge acquired from the study, individuals involved in aviation education can create customised approaches to optimise the advantages of virtual reality while mitigating any potential disadvantages. In conclusion, incorporating VR can completely transform PPL training, introducing a fresh era of groundbreaking advancements and exceptional quality in aviation education.

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This is to acknowledge that the grammar of this journal was improved through the use of Grammarly and Quillbot. Through these applications, the journal underwent a process of rectification for identified grammatical errors, enhancement of sentence structure, and overall improvement in readability. The suggested modifications that improved the journal's coherence and clarity were accepted by the authors.

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