

Immersive Realities In Aviation: Assessing The Impact Of Vr/Xr Technologies On Training, Maintenance, And Passenger Experience

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Abstract

The development and adoption of Virtual Reality (VR) and Extended Reality (XR) technologies are gaining momentum in the aviation sector with promising improvements in various dimensions. The purpose of this study is to assess the applications of VR/XR from the prospective of pilot/crew training, maintenance operations, and passenger use. Information was gathered from a systematic survey of stakeholders in aviation from engineers to pilots to passengers to obtain inputs from multiple strata. Results show that VR/XR is most effective in enhancing the training deliverables and safety procedures, has moderate effect on the supporting maintenance tasks, and enhances the passenger experience with stimulating and interactive environments. Initial doubt of VR/XR solutions' applicability for aviation Not that long ago, VR/XR was no more than a tool used only in consumer-based sectors of the industry, yet the survey results highlight that at least for Emirates and all other airlines it is a testing ground with great potential for efficiency improvement and passenger services.

Keywords: 'Virtual Reality (VR)', 'Extended Reality (XR)', Aviation, 'Mixed Reality (MR)'

1. INTRODUCTION

1.1 Background of the Topic

The utilization of Virtual Reality (VR) and Extended Reality (XR), is transforming the aviation industry. These programs are changing training procedures in aviation, being more efficient and ensuring safety in a variety of areas in the industry. "Student" pilots utilize VR and XR to engage in scenarios which would be found in actual flying without the risk of actually flying. Not only is this approach less expensive, it compresses the training time of new pilots. In flight training, XR tools are a useful asset to save time and money, and can improve training experiences (Glen & Gilbey, 2023).



Figure 1.1.1: Virtual Reality (VR) in Aerospace and Defense Market

(Source: Fortune Business Insights, 2025)

This is where the importance of VR and XR comes in for coaching prospective aircraft maintenance students. Thanks to these technologies, now technicians can visualize and interact with 3D models of aircraft systems on-

line. Such simulations allow much more detailed learning of complex maintenance and thereby lower risk of error and improved accuracy (Gómez-Cambronero et al., 2023). Furthermore, immersion technology is being used for aviation education programs at the universities and performing well. Studies all over the world have concluded VR, AR and MR tools boost students' engagement, motivation and understanding. Students learn through doing as the technologies enable them to immerse themselves in aviation environments that are similar to those found in the real world (Jevčák et al., 2024). There is more to VR and XR in aviation than just teaching and learning. Researchers are testing AI and automated flight technology for use in planning how planes travel, air traffic management and making flying more comfortable for passengers. In accordance with Wang et al. (2024), 3D flight planning with XR is better than traditional 2D ways in terms of how people experience it and how fast it operates. In brief, XR and VR technologies are helping to enhance the way people are trained, maintain equipment and carry out day-to-day aviation operations. With these technologies developing further, aviation is predicted to grow safer, more efficient and less expensive.

1.2 Problem Statement

The aviation industry experiences difficulties with pilot and maintenance training because training costs are rising, there are fewer planes available for practice and not enough qualified people to teach. Standard training approaches tend to give insufficient practice, both increasing risks and making the process less effective (Dela Peña, 2025). Training through Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) which are part of Extended Reality (XR), provides practical and economical training options (Fussell, 2020). At the same time, XR cannot yet be widely used for aircraft training due to high setup costs, technical obstacles and reluctance among those in aviation. More importantly, there aren't many scientific studies that look at the effectiveness, ease of use and impact of XR-based programs in aviation. Bridging these gaps is required to make the best use of XR technologies and to improve aviation training.

1.3 Research Aims and Objectives

Aim:

The research aims to clarify the part VR and XR play in helping with aviation training, improved safety, upkeep of equipment and what passengers experience.

Research Objectives:

- To measure how well VR/XR technologies perform in pilot and crew training in aviation.
- To find out how VR/XR might improve maintenance and safety of aircraft.
- To determine how VR/XR impacts a person's journey on a commercial flight.

1.4 Research Questions:

- How significant are VR/XR tools for training air crew and pilots in aviation?
- How can VR/XR make aviation maintenance safer and more efficient?
- What improvements and increases in engagement does VR/XR bring to passengers on commercial flights?

1.5.1 Enhancing Pilot Training through Immersive Technologies

Through Virtual Reality (VR) and Extended Reality (XR), pilot training is being improved by giving trainees realistic, cost-effective and flexible practice areas. Trainees can experience many different flight conditions using these technologies, all without putting themselves in danger. An important progress in VR is adding touch feedback which helps make flight simulations more lifelike. Go Touch VR worked with FlyInside to create fingertip controls that provide a realistic sensation of switches and dials for pilots conducting training exercises (Adams, 2018). In addition, pilot trainees in VR have shown better recall of information and greater self-assurance.



Figure 1.5.1.1: Virtual Training of Pilots

(Source: SP's Aviation Staff, 2022)

According to a study done by Embry-Riddle Aeronautical University, using motion-based VR greatly increased pilots' ability and self-confidence in detecting and tackling aviation visual illusions (Thomas et al., 2023). Through the Pilot Training Next program, the Air Force uses VR to speed up how pilots are trained. Because of this program, students need less time to finish undergraduate pilot training and can start working as pilots earlier (Immersive Learning News, 2022). VR makes it possible for those being trained to practice difficult scenarios devoid of actual risks. A hazard-free area makes it easier for pilots to strengthen their skills when dealing with different in-flight situations (Echosphere Technologies, 2023). Simply stated, incorporating VR and XR into pilot training improves the outcomes and process of education. Thanks to these new tools, pilots can experience realistic situations, remember information for longer and do difficult training maneuvers in safe cases, making pilot training very different from before.

1.5.2 Transforming Aircraft Maintenance Training with VR/XR

VR and XR technologies are currently changing how technicians train for maintaining aircraft by making the training materials interactive and safe. Although traditional training is common, it's still expensive, not readily accessible and can be unsafe. Through VR/XR, trainees are able to perform difficult maintenance actions in digital scenarios rather than using real planes. Studies done recently indicate that VR is effective at increasing student involvement and ability in aircraft maintenance classes. For example, an examination in the Philippines showed that aviation students who trained using VR retained more knowledge, improved their skills, were more accurate at tasks and solved more problems (Dela Peña, 2025).



Figure 1.5.2.1: XR for Maintenance Training

(Source: Halldale Group, 2024)

Through the utilization of user-friendly design and gaming tactics, a virtual reality airplane training system has shown improvement in effectiveness and excitement levels for trainees (Li, 2023). VR setups made for maintenance training provide trainees with multiple opportunities to learn and improve their confidence. It is most useful for rare procedures that matter a lot for patient safety. In VR, it is much easier to train people in understanding how various systems and structures are related in aircraft, since this is often hard to communicate with regular training. VR/XR technologies used in training aircraft maintenance teams help students learn more effectively and allow for cost savings because fewer pieces of equipment are needed. Because these tools are always improving, they will likely play an even bigger role in readying maintenance staff for current aviation tasks.

1.5.3 Elevating Passenger Experience through XR Innovations

Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) are being used by airlines to improve what passengers go through in the skies and while waiting at airports. The purpose of these technologies is to create engaging and efficient ways to help customers which improves satisfaction. Passengers can use AR in airports to easily discover their way around the airport. AR software puts passengers' directions and gate information over their everyday view, helping them get around airports more easily. The presence of such systems has been demonstrated to decrease patient stress during travel and improve the airport experience all around (Jiang et al. 2023).



Figure 1.2.3.1: XR in Air Crew Training

(Source: Shankar, 2024)

Airlines are starting to use VR headsets to provide a variety of exciting entertainment while you fly. Passengers can now experience virtual tours in all directions, play games and watch personalized content, thanks to these headsets. Such findings show that such experiences are likely to enhance how passengers appreciate and experience their trip (Orús et al. 2021). In addition, MR is being used to design interactive spaces in aircraft cabins. Thanks to combining real and virtual environments, passengers can view updates about their flight and discover features of their vacation's destination on their MR headsets. This mix improves how involved and connected passengers feel during their flight (McGill et al., 2022).

Bringing XR technologies into aviation makes travelers' journeys more interesting and gives airlines ways to set themselves apart and retain loyal customers. As technology improves, these tools will likely play an even bigger part in the future of aviation.

1.5.4 Theoretical underpinning

VR and XR technologies in aviation are guided by certain educational and psychological theories. According to constructivist learning theory, learners build their understanding through experiences which makes VR/XR's environments perfect for learning that way (Dela Peña, 2025). It is in keeping with John Dewey's idea that we learn best by taking part in what we learn. The theory also claims that using visual and auditory data together helps people learn better which is achieved in VR/XR simulations. Based on its usefulness and how simple it is to learn, users are more willing to try new technologies such as VR/XR, in training programs according to TAM (Fussell, 2020).

1.5.5 Literature gap

Although XR technology is gaining popularity in aviation training, important research questions have yet to be fully addressed. A significant point is that there are few empirical studies on civil aviation, as most such research comes from military operations (Glen & Gilbey, 2023). Additionally, cybersickness, as well as the role of breaks in virtual presence (BIP), have received relatively limited research attention (Narayanan & Nazarenko, 2025). Not many studies have looked at how XR training can be used after a long period and in practical situations. Moreover, little

work has been done on creating user-centered design standards for aviation virtual interfaces which slows down their practical use.

1.6 Research Significance

This research is helpful because it aims to find new pilot training methods for a world with both a reduced number of pilots and rising training costs. In aviation training, the study hopes to show evidence of how Extended Reality (XR) technologies can make training more effective, take less time and lower costs. Lessons from the report may support new rules and enhance the development of more accessible and better-structured training, leading to safer and more productive airlines.

2. METHODOLOGY

2.1 Research philosophy

This study follows a positivist research philosophy which states that facts can be learned from things that can be easily observed and measured. It is positivism's priority that research be objective, recorded using numbers and uses proper scientific techniques to understand how different aspects cause change, leading to general results (Ali, 2024). Being applied to aviation training, this method allows researchers to examine XR technologies by using data and statistics, enhancing the certainty and trustworthiness of their evaluations.

2.2 Research Design

This research uses a descriptive design, documenting and following the characteristics of XR technology used in aviation training. Descriptive research aims to explain what, when and where things happen without changing the variables, helping give an overview of the present situation (Shinija, 2024). The approach makes it possible to gather precise information about XR applications used in pilot and maintenance training through survey and study of activities.

2.3 Research approach

This research is based on a deductive method, using existing theories about Extended Reality (XR) use in aviation training. It creates hypotheses to examine how these theories affect pilot and maintenance training outcomes. Thanks to this, models can be checked against real-world situations, helping to strengthen theories in XR technology designed for the aviation industry (Hall et al. 2023).

2.4 Population

In a research paper, the population mainly refers to the whole individual group, objects or any event that is aimed to study. In other words, the study population is the whole group that a study wants to draw conclusions from. In this case study, the total population taken is 50 to get a proper result.

2.5 Sample size

The sample size is the total number of individuals or observations involved in a study or experiment. In this paper, out of 50 population only 21 participants have been selected for the research survey. As the sample needed to be easy to manage and cover a range of roles in aviation, 21 people were picked from a population of 51 participants. The size allows for focused study and important findings, keeping in mind how much time and resources required in this study.

2.6 Sampling technique

Properly using a sampling technique in research writing means picking a section which indicates the sample from a total population, based on which the study can infer properties of the whole population. In this study, a simple random sampling technique has been utilised.

2.7 Data Collection Method

Data was obtained by means of an online questionnaire survey on Google Forms among aviation professionals. A total of 10 questions were used in the survey, of which two dealt with demographics and the others with opinions and experiences on using XR technologies in aviation training. Through this method, data was gathered without difficulty and made it easy for aviation workers to respond.

2.8 Data Analysis Method

For the study, quantitative analysis was used on primary data gathered through an online questionnaire filled out with Google Forms. The survey has 10 questions, 2 of which focus on demographics, all meant to find out about people's views and experiences with using XR within aviation training. Results from the data will be analyzed statistically to point out relevant patterns and trends, creating a clearer view of the benefits and effects of XR technology for aviation training.

2.9 Ethical consideration

Throughout this study, participants are made to act willingly, provide informed consent and their information is kept confidential. Everyone taking part is given all the information about the study and knows they can stop participating at any time without penalty. Collecting demographic data is only for analyzing health information and it is made anonymous to keep people's privacy safe. The research processes follow the guidelines and ethical standards required by the organization to protect the participants.

3. RESULTS

3.1 Data analysis

The analysis significantly interprets the data collected during a structured survey about the effects of VR/XR technologies on the aviation industry. By examining patterns, trends and perspectives of workers, maintenance personnel and travellers, the analysis gathers understandings about what immersive technology does well and how it is put to use.

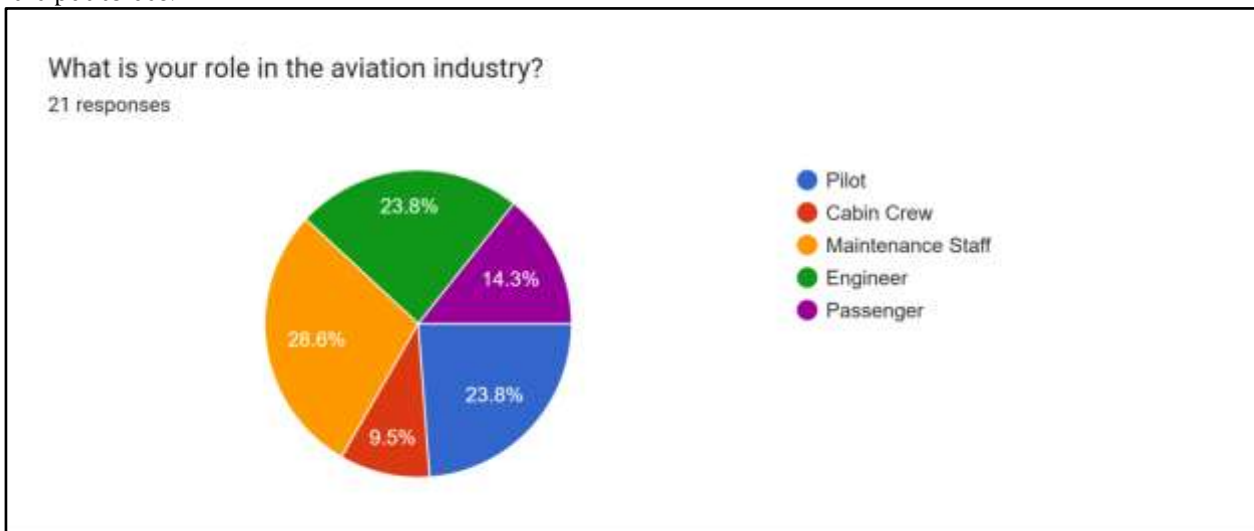


Figure 3.1.1: Role of participants

This chart displays the roles of 21 respondents in the aviation industry. Engineers and Pilots each represent 23.8% of the participants. Maintenance staff account for 28.6%, making them the largest group. Passengers comprise 14.3%, while cabin crew make up the smallest segment at 9.5%. Therefore, it can be stated that majority of participants are here is the participants.

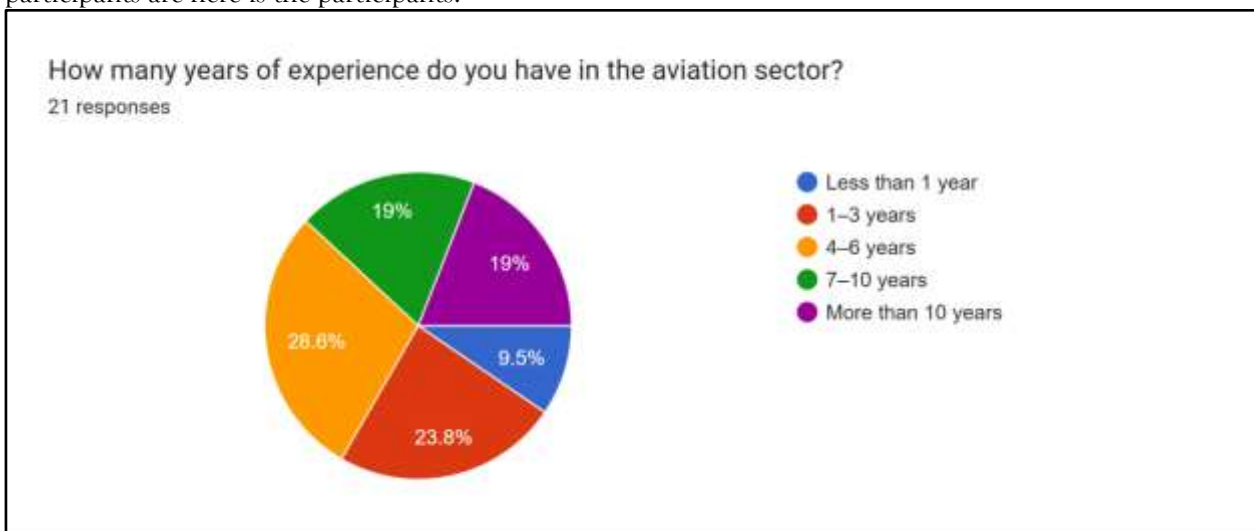


Figure 3.1.2: Participants' experience

This chart illustrates the experience levels of 21 aviation sector participants. The largest group, 28.6%, has 4-6 years of experience. Those with 1-3 years of experience account for 23.8%, while both 7-10 years and more than 10 years each represent 19% of respondents. The smallest group, 9.5%, has less than 1 year of experience.

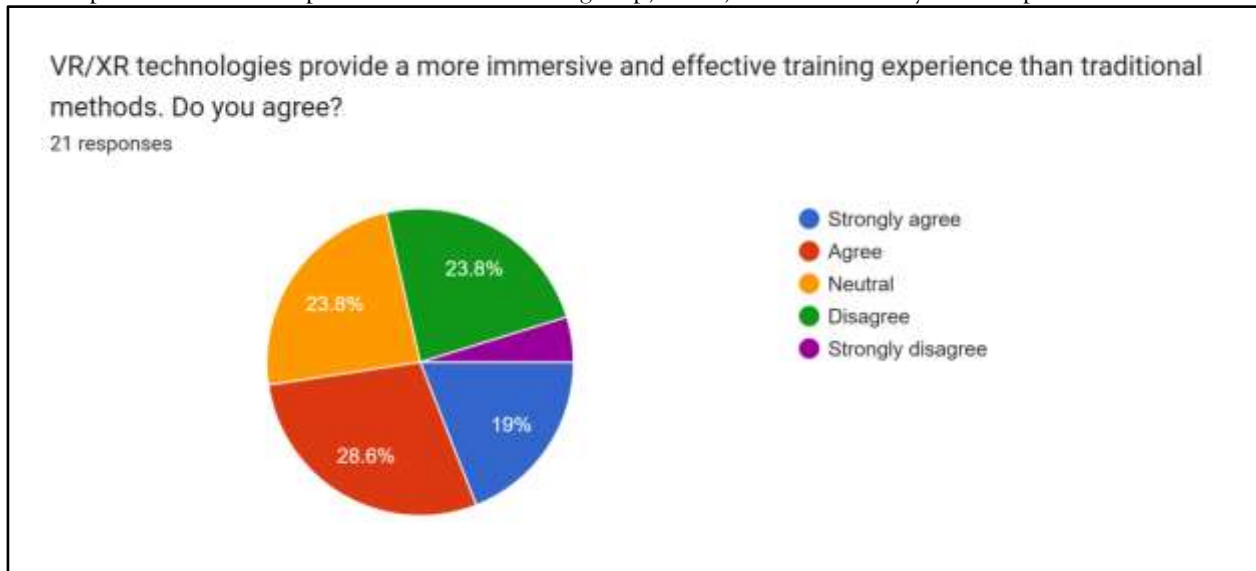


Figure 3.1.3: Training experience of participants

This chart shows responses regarding VR/XR technologies providing a more immersive and effective training experience. A combined 47.6% either strongly agree (19%) or agree (28.6%). 23.8% remain neutral, while 23.8% disagree and 4.8% strongly disagree. This indicates a generally positive, but not universal, perception of VR/XR's training effectiveness.

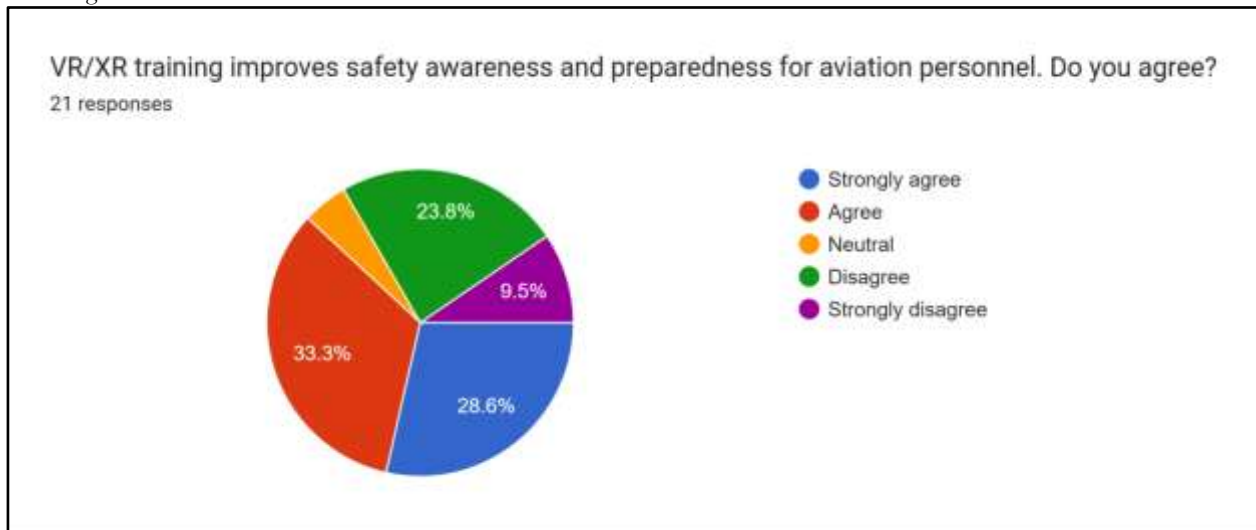


Figure 3.2.4: Safety awareness and preparedness of participants

This chart reveals opinions on whether VR/XR training improves safety awareness and preparedness for aviation personnel. A significant majority, 61.9%, either agree (33.3%) or strongly agree (28.6%). 23.8% disagree, and 9.5% strongly disagree, with a small 4.8% remaining neutral. This suggests strong confidence in VR/XR's safety benefits. It's significant from these results that VR and XR training are being accepted more and more as important for safety. As positive feedback exists for different training approaches, it becomes possible to make aviation training better and manage risks more effectively. Improvements in technology could bring VR/XR into standard practices at aviation training centres.

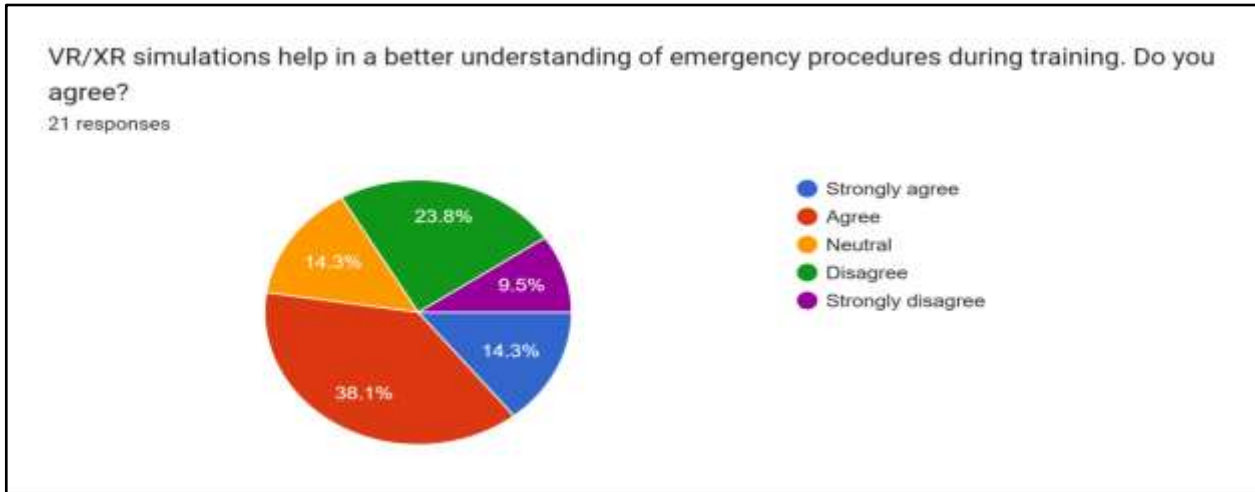


Figure 3.2.5: Better understanding of emergency procedure

This chart displays agreement on VR/XR simulations aiding a better understanding of emergency procedures during training. A substantial 52.4% (38.1% agree, 14.3% strongly agree) believe it helps. Conversely, 23.8% disagree and 9.5% strongly disagree. A neutral stance is held by 14.3%, indicating overall positive sentiment with some reservations.

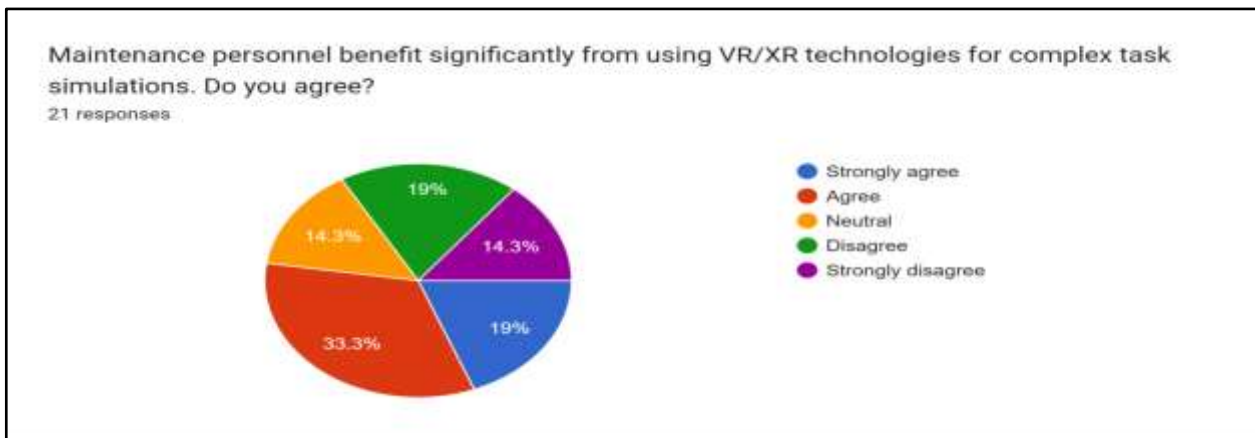


Figure 3.2.6: Benefit of personnel benefit

This chart assesses whether maintenance personnel significantly benefit from VR/XR technologies for complex task simulations. A combined 52.3% agree (33.3%) or strongly agree (19%). However, 19% disagree and 14.3% strongly disagree, with 14.3% neutral. This indicates a divided but leaning-positive view on VR/XR's benefit for maintenance.

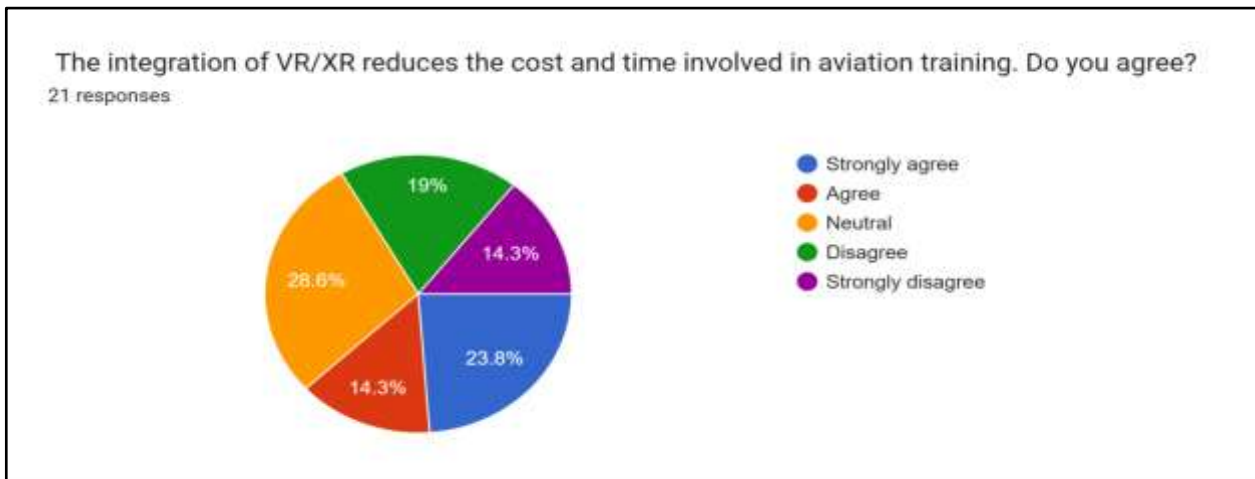


Figure 3.2.7: Implementation of VR/XR

This chart explores agreement on whether VR/XR integration reduces the cost and time involved in aviation training. 23.8% strongly agree and 14.3% agree, totalling 38.1% positive. However, 28.6% are neutral, while 19% disagree and 14.3% strongly disagree. This suggests a mixed perception regarding the cost and time efficiency benefits.

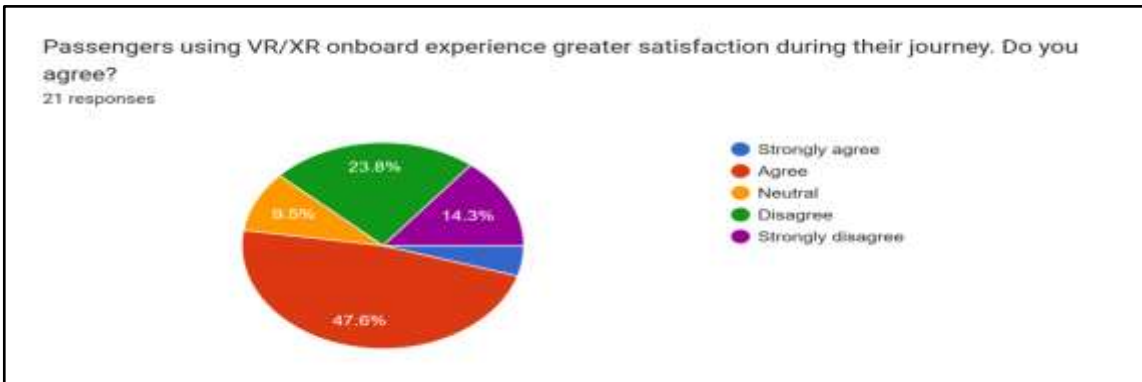


Figure 3.2.8: Passenger using VR/XR onboard

This chart evaluates passenger satisfaction with onboard VR/XR experiences during their journey. A large majority, 47.6%, agree, while a small 4.8% strongly agree. However, 23.8% disagree and 14.3% strongly disagree, with 9.5% neutral. This suggests a generally positive passenger reception, but notable dissent exists. Hence, it can be significantly suggested that the majority of participants agree with the fact that passengers utilising the VR/XR onboarding experience can provide significant satisfaction during the journey.

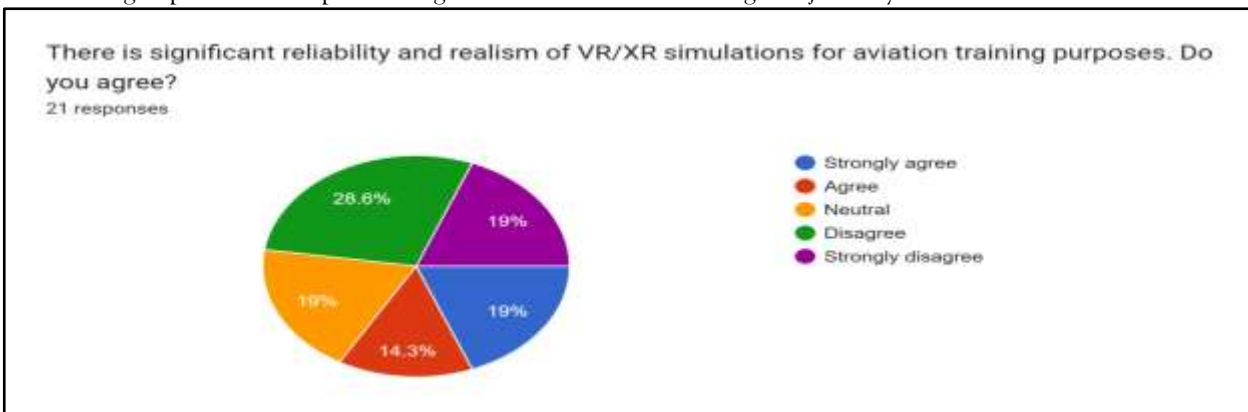


Figure 3.2.9: Reliability and realism of VR/XR simulation

It looks into how realistic and reliable people think VR/XR simulations are for aviation training. Here, 19% strongly believe and 14.3% agree, giving a total of 33.3%. Thirty-eight point six percent disagree and nineteen percent strongly disagree, while nineteen percent remain neutral. It suggests that not many professionals trust the accuracy of present VR/XR simulations.

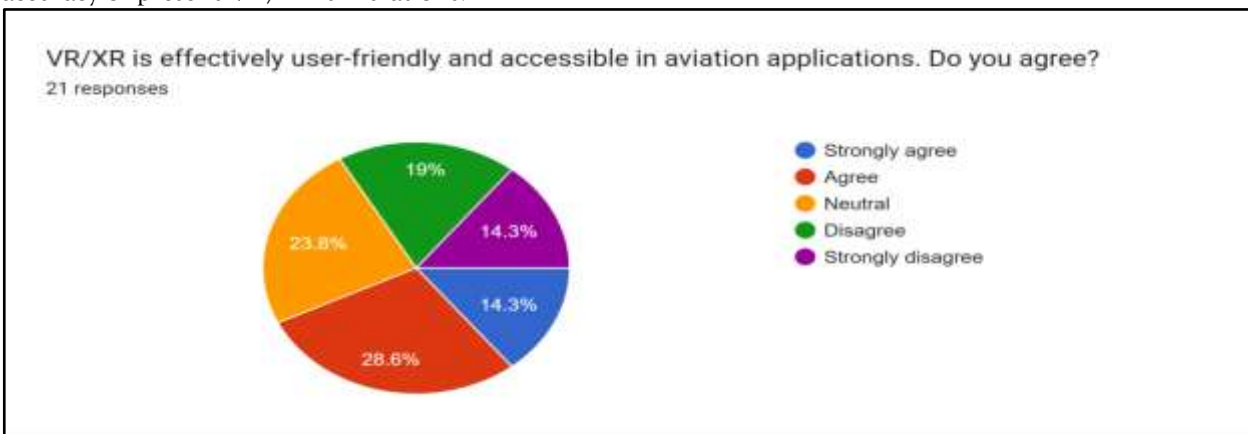


Figure 3.2.10: User-friendly and accessible

This chart investigates whether VR/XR is effectively user-friendly and accessible in aviation applications. 14.3% strongly agree and 28.6% agree, totalling 42.9% positive. Conversely, 19% disagree and 14.3% strongly disagree, while 23.8% remain neutral. This suggests a mixed but generally positive outlook on VR/XR's usability and accessibility.

3.2 Findings

After reviewing responses to the survey, it effectively provides key findings about how VR/XR technologies are seen in aviation. The majority of the group were maintenance staff, engineers and pilots, who had differing experiences and gave many viewpoints. Generally, survey respondents showed a positive view of employing VR/XR in training and safety situations. A large portion of respondents, or 47.6%, think that it improves the way people are trained using VR/XR. Over sixty per cent of respondents agree that it greatly improves their focus and readiness for safety hazards. About half (52.4%) believe that using VR/XR in emergencies can help people understand what to do, and 52.3% think VR/XR simulations are good for workers carrying out complex repairs in the field. People's views differ about VR/XR's effect on cost and time in training and on its degree of realism and dependability. About fifty per cent of people in this study didn't think that it was quite realistic enough. Though most passengers consider using VR/XR systems onboard, there is still room to make these experiences even better. VR/XR quality in aviation was considered moderate because people highlighted the need for continued efforts at improving usability and accessibility.

4. DISCUSSION

4.1 Interpretation of the Results

According to the study, VR/XR is finding widespread use in the aviation industry, mostly for training, safety preparation and carrying out complicated maintenance work. These outcomes match the results of Dinçer (2023), who showed that immersive technology improves how much information is retained and how aware people are in an aviation setting. According to the meeting participants, VR/XR plays a big role in boosting safety awareness. Meanwhile, the finding that VR/XR supports understanding emergency instructions supports Lekea *et al.* (2021)'s view that practice in virtual environments can help personnel respond better to unlikely, serious situations. It matters most in aviation, where emergency planning is very important. Even though noting the realism and expense problems in the mixed feedback. However, Spain *et al.* (2023) found that although VR/XR could become common, high implementation costs and technology issues make this less likely. The various perspectives on VR/XR's realism and accessibility highlight the need for further refinement in technology and customisation for industry-specific purposes. However, despite the concerns noted, the overall positivity strengthens the view that VR/XR has the potential to revolutionise aviation practices, as long as barriers to realism, cost, and usability are considered through relevant investment and policy support.

4.2 Linking with Research Questions and Literature

The research questions from this study are discussed in the findings, and these results correspond to what has been seen in the literature. Most participants in this survey said that by using VR/XR, they receive a more helpful, immersive and secure training experience. This adds support to the research, which indicates that using immersive technologies improves the knowledge, readiness and reaction of aviation workers. The data found that most maintenance workers think VR/XR helps them simulate hard tasks, yet they are more divided about how real and reliable these systems are. This follows the findings in the literature, which report that VR/XR can strengthen training and reduce the risks present in maintenance. Third, on the question about the impacts on the passenger experience, the findings were characterised by an overall positive response towards onboard VR/XR experiences, although some apprehension was evident. This is consistent with the reviewed literature highlighting the potential for VR/XR to enhance engagement and comfort. Overall, in relation to passenger experience, the findings conform with the literature, which regards VR/XR as a vital aspect and a valuable tool in Aviation.

4.3 Implications, Limitations and Potentials for Future Research

The results of this study can be used in real ways by the aviation sector. The successful use of VR/XR for training, maintenance and passenger satisfaction points to the possibility of using such technologies more broadly. By using VR/XR in their programs, trainers and aviation companies can help students understand concepts better, improve their skills for flight safety and offer exciting travel services. Using these technologies could lower training costs and time, which would support better running of operations. Still, there are some challenges in this study. The small number of participants may reduce how widely these results can be applied. Also, most respondents had technical

and operational duties, so there wasn't enough data on senior managers or policy experts. The research is mixed on realism and usability, as not all VR/XR systems live up to the industry's expectations, which is evidence of a gap between aim and result. It would be good for future research to use a greater number of participants from a variety of regions and roles. Researchers could also assess how much VR/XR helps with skills in realistic aviation situations. It is important to examine the financial benefits and new trends in technology for VR/XR to support more industries adopting the technology.

5. CONCLUSION

This study examined how VR/XR is used in the aviation industry, considering how effective training is, the approach to aircraft maintenance and passenger feedback. From the study findings, several participants consider VR/XR a worthy addition to improving the readiness of crews, the training of technicians and connecting with customers. Even though more people accept this revolution, many are still worried about accuracy, access and value for money. The research points to how immersive technologies can impact aviation, but indicates that they must be better developed and used more widely. While VR/XR seems like a promising area, it will rely on constant new ideas and fitting into each industry's rules and expectations.

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7. Appendices

Appendix 1: Survey Questionary

1. What is your role in the aviation industry?
 - Pilot
 - Cabin Crew
 - Maintenance Staff
 - Engineer
 - Passenger
2. How many years of experience do you have in the aviation sector?
 - Less than 1 year
 - 1–3 years
 - 4–6 years
 - 7–10 years
 - More than 10 years
3. VR/XR technologies provide a more immersive and effective training experience than traditional methods. Do you agree?
 - Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
4. VR/XR training improves safety awareness and preparedness for aviation personnel. Do you agree?
 - Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
5. VR/XR simulations help in a better understanding of emergency procedures during training. Do you agree?
 - Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
6. Maintenance personnel benefit significantly from using VR/XR technologies for complex task simulations. Do you agree?
 - Strongly agree
 - Agree

- Neutral
 - Disagree
 - Strongly disagree
7. The integration of VR/XR reduces the cost and time involved in aviation training. Do you agree?
- Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
8. Passengers using VR/XR onboard experience greater satisfaction during their journey. Do you agree?
- Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
9. There is significant reliability and realism of VR/XR simulations for aviation training purposes. Do you agree?
- Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree
10. VR/XR is effectively user-friendly and accessible in aviation applications. Do you agree?
- Strongly agree
 - Agree
 - Neutral
 - Disagree
 - Strongly disagree