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Impact of new technologies on developing aviation safety training

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Abstract

Aviation safety training requires meticulous procedures and constant updating. The development of new technologies in aviation makes it possible to visualize difficult situations and transfer them to various types of simulations. It is theorized that, in addition to basic textbooks, a trainee is able to absorb more material in less time thanks to new tools such as virtual reality. The purpose of this article is to compare the level of training in the traditional mode and with the use of a VR lab. The research methods presented in this article are in line with the discipline of security sciences, which arises from the social need to learn about the reality around us. Observations made in a study conducted on a group of students provided answers about the opportunities and threats that VR applications introduced in the training system.

Keywords: education, new technology, safety aviation, safety training, SWOT analysis, VR

1. Introduction

Virtual Reality (VR) is one of the areas of information technology that is becoming increasingly present in people's daily lives, accompanying them in activities and areas of life every year. The term virtual reality refers to a computer simulation that represents an environment in which one can move and interact with virtual space, events, objects and people (avatars). The virtual environment is usually three-dimensional and often replicates the real world in terms of appearance and physical phenomena. Typically, VR applications can be divided into three groups based on the degree of immersion in the applications they use: VR displays (e.g., stereoscopic, large area, virtual caves – cave), augmented reality (AR) and virtual reality helmets.

Virtual reality is sometimes described as the use of computer technology to create the effect of an interactive three-dimensional world in which objects have spatial form (Robles, 2008) or as an enhanced user interface that allows real-time simulation and interaction through multiple sensory channels (via image, sound, touch, smell and taste). Steve Bryson, on the other hand, writes that virtual reality is the use of information technology to create the effect of an interactive three-dimensional world in which every object has the sense (property) of being present in that space. To use VR equipment, the user wears a special helmet with a built-in display or a pair of goggles powered by a computer, game console or smartphone (Bryson, 2013). Special software and sensors make the virtual experience real. The virtual experience is usually enhanced by 3D surround sound and motion sensors. VR technologies are used in simulators for military aviation, astronautics, various types of vehicles and machines, medicine, tourism, commerce and many others. The VR market is constantly evolving, introducing new solutions to enhance the message further.

The changes taking place in aviation are affecting every aspect of the industry, from the creation of a new generation of aircraft designed to multiply the efficiency of flight operations to the introduction of VR technology into the training program for flight and cabin crews, as well as ground and maintenance personnel. Depending on the concept, virtual reality can be based on elements of the real world, completely fictional or simply a virtual imitation of reality.

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The issue of VR training as part of an aviation organization management strategy is a very interesting phenomenon, as the use of virtual reality allows aviation companies to train their employees in a more time-efficient, effective and cost-effective manner.

Digitalization and multimedia have become a source of communication, information, and knowledge in recent years. With this reality, teaching and learning staff face new challenges. Traditional methods seem not only archaic, but also unreliable, which is why digitalization and multimedia, in recent years, have become a source of communication, information, and knowledge.

2. Technology vs. human physiognomy

Firstly, it should be emphasized that virtual reality is meant to evoke natural and real sensations in people, but the human brain is constructed in such a way that even the smallest detail can tell us whether an event is real or not. The challenge for virtual reality developers is to create a virtual world that maximizes the appearance of reality. Understanding human physiognomy is crucial to understanding how technology works; reality is learned through the senses, so solutions must be introduced that provide a sense of reality. Software must respond to all user actions in real time to ensure a comfortable and natural experience. New solutions to support VR technology, such as headsets, special treadmills or gloves, suits that further stimulate the human senses, positively affect the quality of the experience, and support the creation of the illusion of reality, are also appearing regularly (Dobricki et al., 2021).

Augmented Reality (AR) technology has been increasingly used in the aviation industry for some time. It is used in training, maintenance, design and production. In the aviation industry, the effects of the COVID-19 virus have had a tremendous impact on closer contact with VR, AR and artificial intelligence technologies. The pandemic has even forced the aviation industry to embrace new forms of industry development, with 39% of respondents admitting to implementing solutions as a result of the pandemic. Airlines around the world are being encouraged by the International Air Transport Association (IATA) to invest in a virtual reality training program for flight and cabin crew. Adequate and thorough flight training is essential for flight safety, and constantly updating skills and learning new procedures is a constant practice for those working in the industry. These tools provide the opportunity to practice all the dangerous situations that can occur in the air, ensuring that employees are more familiar with procedures and able to deal with the situation.

3. The need to enhance aviation training

The dynamic development of air transport and the occurrence of related disasters have made it necessary to pay attention to ensuring the safety of aircraft crews and passengers. The safety of the aviation system is the result of important basic elements: the technical condition of the aircraft, the suitability of the communication, navigation and surveillance systems, the correctness of the airspace management services, the ground and flight personnel and the impact of the environment. The issue of proper preparation of aviation personnel (crews and technical staff operating aircraft), both in terms of theoretical knowledge and practical skills, has been one of the most important areas of interest for aviation authorities almost since the beginning of aviation (Rypulak & Kuźmicz, 2018). In order to ensure high and uniform standards for the preparation of future aviation personnel, very detailed regulations have been adopted which define the system for the preparation of new personnel as well as the maintenance and improvement of their competence during their professional life. Their compliance and continuous improvement are monitored by international aviation organizations such as ICAO, IATA and FAA, which in 2018 issued certificates to thirteen pilots who had completed their training using VR tools. Indeed, learning to fly in virtual reality offers unprecedented opportunities. Training in virtual reality allows pilots to work through different scenarios, including the darkest ones, exposing them to the problems they may face in the course of their work. With VR tools, pilots can be better prepared and less likely to suffer from post-traumatic stress when potential problems arise. The European Aviation Safety Agency (EASA), which is responsible for aviation safety in Europe, recently certified a flight simulation training device (FSTD) based on virtual reality (VR). Helicopter pilots can perform high-risk maneuvers in a virtual environment. The FSDT covers a key area of risk in helicopter operations, as around 20% of accidents occur during training flights. The Agency is seeking to modernize the rules for training devices to reflect their actual capabilities. For the training of technical personnel, the standards detail the requirements to be met by both training centers (infrastructure, equipment, instructor competence, training programs, documentation methods, etc.) and the knowledge and skills to be acquired by their graduates. Both training centers and graduates must be certified by the national aviation authorities in order to operate.

Flight attendants must also receive specialized training in cruise and emergency safety based on the guidelines set out in Commission Regulation (EC) No 859/2008 (OPS 1), Subpart O. Basic safety training includes theoretical and practical training in:

- Fire and smoke control
- the need to frequently check areas of potential fire risk, including toilets, and smoke detectors;
- classification of fire types and the appropriate type of extinguishing agents and procedures for specific fire situations, extinguishing agent application techniques, the consequences of improper use and their use in confined spaces;

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- rescue efforts at sea and survival in adventurous terrain; lifebelts, lifejackets; general introduction to marine rescue issues; global search and rescue network;
- conducting proper communication between individual crew members and the importance of ensuring the flow of detailed information /time available, additional instructions;
- division of duties among the ship's personnel; evacuation procedures;
- general information on flight operations in standard and emergency situations, such as current qualification and fitness required to fly as a cabin crew member, including maximum take-off time, maximum flight time and required rest periods for flight crew,
- the importance of cabin crew performing their duties in accordance with the operator's operations manual,
- various threats on board, aggressive passengers, terrorists, etc.
- medical emergency situations
- classification of dangerous goods (dangerous goods and rules for their carriage)
- Pre-flight briefing of cabin crew and provision of necessary safety information related to specific tasks (Kostur-Balcerzak & Żmigrodzka, 2015).

The role of virtual reality in this type of training is very important. It allows flight crews to be trained faster and more efficiently. Of course, the economic aspects are of great importance to airlines, which is reflected in the following results:

- Training around 3,000 employees save at least 52% of the cost of traditional training;
- Training 6,000 employees is already a savings of 60% compared to traditional training;
- 65% savings can be achieved by training approximately 10,000 employees.

These calculations clearly show the untapped savings potential in any company or educational institution that trains a lot but does not use VR. It is safe to say that any organization that trains *en masse* with repetitive activities is one that cannot afford not to use virtual reality. After all, the money saved can be successfully invested in other areas of the business or in even faster training for other employees. According to analysis by Market Hub, the world's fastest growing VR markets are Asia and Australia, and the market is expected to reach more than $184 billion by 2026, with a compound annual growth rate of 48.7% between 2021 and 2026.

4. VR and AR in NASA training

The world's largest space agency is also embracing virtual reality technology. They are using VR goggles and innovative accessories to improve workflows in microgravity and prepare astronauts for what they will experience in space.

In 1992, the agency launched the Virtual Reality Laboratory to simulate the body's behavior in space. By developing advanced solutions at the intersection of virtual and augmented reality, the lab has gained new tools to improve the training process (Robles, 2008). One of NASA's latest acquisitions is the MagicLeap One AR glasses. The agency uses them for EVA training, where astronauts wear full spacesuits to replicate the movement restrictions they will face during a real mission as closely as possible. During training, astronauts are able to interact with physical objects thanks to AR technology's ability to merge the real and digital worlds. Virtual reality can help more than just crew members. Researchers at the Canadian Space Agency are also working on an experience to understand how humans perceive objects and distances in space. As part of the Vection project, astronauts will perform simple space orientation exercises both on Earth and throughout the mission. The collected data will then be processed and used to refine procedures for weightlessness. These exercises will allow the ground crew to better anticipate and plan for spacewalks.

5. Polish Air Force University – research on how to use VR in emergency procedure training.

The Polish Air Force University is conducting a research project on advanced VR training. This training allows the participant to become accustomed to the situation and improves the muscle memory acquired by performing manual actions in virtual reality. In this way, the participant's body acquires automatic reflexes that will help perform tasks automatically when a dangerous situation arises. This is the only way for a person to keep a cool head and not succumb to the emotions that so often get in the way of proactive action in dangerous situations. VR offers the possibility to train several people at the same time in a smooth and uninterrupted manner and transfers all aviation activities and procedures faithfully into the world of VR, so that after training in a virtual environment, a person will perform analogous activities in the real world without hindrance. The VR training program covers various dangerous situations that can occur during flight and after an emergency water landing, including preparing passengers for an emergency landing or sudden contact with water that can cause the aircraft fuselage to break. All procedures outlined in the application are based on IATA guidelines (Żmigrodzka, 2017). Notably, the timing of actions and activities is exactly

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the same as in the real world. The system also reproduces passenger behavior as closely as possible, thanks to the analysis of materials and testimonies of participants in similar incidents.

Training for aviation personnel is expensive and often involves frequent travel; virtual reality allows training to take place within the walls of the university, significantly reducing the cost of training. Another positive aspect of this project is the complete realism achieved through the use of computer graphics. The virtual reality software used by the Polish Air Force University in Dęblin also allows the progress of individual users to be monitored directly on a separate screen. This is a powerful tool for teachers and trainers.

The use of VR training brings significant savings. Using the goggles is much cheaper than running simulators or conducting test flights, and once a course is ordered, it can be expanded with additional modules at a low cost. This type of training will produce better results in terms of consolidating the knowledge gained from traditional aviation safety training materials. An important aspect of such training is also the use of artificial intelligence, i.e., scenarios can unfold differently depending on the trainee's behavior. Such an application provides an awareness of the seriousness of the situation and the consequences of the actions taken. A study carried out with VR applications on students of the Department of Aviation Safety showed that they became more competent, allowing us to conclude that this tool has proved to be an effective way of learning and improving knowledge transfer, also preventing mistakes. Participants in the study described feeling "present" while learning aircraft procedures, not suffering from nausea, and said the "gamification" made the experience enjoyable. Some students said it was fun, engaging and less stressful than traditional training, and that it improved their concentration. Of course, it is important to remember that traditional training, especially hands-on training, should not be completely replaced by simulators.

Figure 1. Ditching training. Source: Author's own work

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6. SWOT analysis – Faculty "*WBL*"

A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis was conducted among a group of part-time work-based learning students. The analysis aimed to explore the possibility of developing new technologies in aviation education. As part of the research process, a group of 10 LAW-WBL students who participated in the experience and already have professional references in the field of aviation, defined the strengths and weaknesses as well as the opportunities and threats of virtual tools in the training courses conducted.

a) Strengths

- Realism of VR application – animation of aircraft interior and equipment.
- Realism of the audio-visual experience of the VR application – even natural sensations such as being in the water.
- Realism in the VR application of rescue and technical equipment in the aircraft.
- Ability for the instructor to adjust the level of difficulty of the task for each student.
- Ability for the instructor to simulate specific events and situations in real time.
- Ability to customize VR equipment settings for a specific student – image focus, sound, etc.
- Low cost of training compared to the cost of providing the same training in a real simulator and with real participants.
- The possibility of developing an almost intuitive pattern of behavior in a given situation – knowledge of the location of equipment and devices, which will certainly be related to the control of stress in real conditions.
- Possibility of training – simulation of conditions and situations that are difficult to achieve in real simulator conditions, e.g., fires, flooding of the aircraft and the possibility of repeating them at will.

b) Weak points

- Rather complicated operation of the manipulators.
- Sometimes, the smoothness of the simulation is interrupted by the movements of the participant.
- It would be worthwhile, if possible, to use a movable floor that allows natural movement with the legs rather than through the manipulator.
- The need to ensure the physical safety of the simulation participant.

c) Opportunities

- It is possible to develop better software in the future that would more realistically reflect the situation in and around the aircraft.
- The possible use of manipulators in the form of gloves would make the simulation more realistic.
- Multiple people can participate in the simulation, make up the flight crew, and work together in real time.
- The possibility to reach a wider group of trainees, which will allow to acquire or improve skills not only for flight personnel, but also for people outside the environment, e.g., related to aviation (service candidates, etc.) and other interested parties, for whom training on a real simulator would not be possible, and the acquired knowledge could in the future increase the level of safety on board the aircraft, as a trained person in the form of an application can be helpful in an emergency situation on the aircraft.
- The possibility of using the VR simulator virtually for an unlimited type of simulation, the scope of which depends on the creativity of programmers, lecturers and students, who will direct the actions of programmers to a specific action that can be mapped in virtual reality.
- The possibility of remote online cooperation of people practicing on the simulator at geographically different teaching stations, as well as the possibility of remote supervision of practitioners carried out by authorities in the field of aviation.

d) Threats

- The simulator, as well as the whole application with further expansion of the software, may require expansion or even replacement of the computer hardware supporting the whole thing, as well as googles and other expensive hardware.
- The application software may need to be upgraded as indicated by user experts in the field, which may prove costly and sometimes impossible for programmers, and the realism of the simulation will suffer.

7. Conclusions of the SWOT analysis

The SWOT analysis carried out for the VR application designed to simulate aircraft emergency situations and events shows a very strong advantage of the strong side of suitability for the training of flight personnel. It also shows great opportunities for further development and new directions in the field of flight training.

Of course, like any training application implemented through VR simulation, it also has its weaknesses and risks of further development. However, the risk of their occurrence is currently within acceptable limits and, in relation to the strengths and opportunities identified, shows that it is possible to further reduce or even eliminate them in the future. For the time being, it is reasonable to include them in the so-called costs of further development of VR technology for training and development

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of aviation didactics. The strength of using VR applications in education is that you can 'immerse' yourself in the learning process and reduce distracting stimuli. By using VR applications in education, it is possible to analyze and correct mistakes on the fly. VR applications make it possible to check even the smallest errors that the human eye cannot detect by observation alone. Thanks to such solutions, it is possible to get quick feedback from the teacher on the mistakes made (Zhang, 2020). What's more, studies show that when virtual reality is used in training, there is a 50% increase in memorability. Another strength is that virtual reality can provide the user with a tour of, for example, an airport. Another strength of VR applications is the simulation of dangerous phenomena. By taking the user into virtual reality, it is possible to show a dangerous phenomenon. Thanks to this, a lot of training is done to introduce procedures that show how to behave in a given situation. Using one of the VR tools, virtual goggles, the user can disconnect from the surrounding world and focus on activities in the virtual world. As far as analyzing the weaknesses of VR is concerned, the first thing to note is that it will always be manufactured and will, therefore, never be a one-to-one reflection of the surrounding reality. Of course, it will reflect reality to a large extent, but it will always be virtual. In negligible cases, it may also be that a person using VR in an exaggerated way may have difficulty distinguishing between real and virtual life (Dobricki et al., 2021). All these negative aspects of the use of VR applications in education should raise awareness that VR should be used rationally. The third aspect of the SWOT analysis is to create a list of opportunities. The predictions of experts and people in the VR industry clearly indicate that the development of VR hardware itself, as well as its software, will develop rapidly in the future. Perhaps the greatest opportunity for virtual reality will be its widespread availability to users. VR is a very big opportunity in education in the future. There is a growing body of research in this area, which has already shown that virtual reality enables people to remember information better than when presented in two-dimensional images. In addition, lessons conducted with the use of VR aroused greater interest in the subject and allowed for a high level of involvement on the part of the students, and, as another of the studies showed, VR has an impact on positive changes in social behavior. The above examples clearly show that there is considerable potential in the use of virtual reality in education, which can be developed and treated as an opportunity for the future. The final component of the SWOT analysis is threats. The most prominent of these is undoubtedly the financial barrier. In the case of education and the increasing use of VR, a very important aspect from the teachers' point of view could be the need to change the approach to the educational process. More awareness and openness to the problems of today's students is essential. An example of this is the coronavirus pandemic, which forced the need for distance learning and the acquisition of knowledge at a distance via the Internet.

In conclusion, in terms of applying VR in education, a SWOT analysis can point to the strengths and opportunities, which, in the case of the application of virtual reality in education, forecast well for the future. However, it is necessary to work on the current barriers to the development of the virtual reality market for professional use, such as the lack of specialized software and systems, as well as the lack of public acceptance of the technology (Korinth, 2018).

Declaration of interest

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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