Transforming Training and Simulation in Oil and Gas Industry Through Augmented Reality (AR) and Virtual Reality (VR) in Nigeria

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Abstract- ***Technology is bringing constant change in the industrial world. Trainees/workers/employees has to be train with AR and VR in order to enable them acquire all skills, knowledge and competences that will enable them to carry out their job description efficiently. Augmented Reality (AR) enhances users' interaction and perception of the real world. AR technology enhances the sense of realism by overlaying real-time virtual cues and objects in the physical world. It serves as a link between the digital and physical worlds. With AR technology, trainees/workers can engage with virtual visuals enhancing real-world settings. VR immerse the user in a computer-generated environment that resembles reality. This paper identifies augmented Reality (AR) and virtual Reality (VR) technologies and their functionality, difference between augmented reality and virtual reality, application of AR and VR in training and simulation in oil and gas industry, benefits of utilizing AR and VR in training and simulation in oil and gas industry and the challenges faced in the utilisation of oil and gas industry. The paper came to a conclusion that AR/VR should be used in training and simulation in petroleum industry to develop the soft skills and hard skills of trainees/personnel. AR/VR use in training and simulation in oil and gas industry Increased efficiency and productivity, improved safety and risk mitigation, safe costs and allow collaboration.***

Indexed Terms- ***AR, VR, AR/VR application in training, AR/VR simulation, oil and gas industry.***

I. INTRODUCTION

The world is evolving now and then because of technology. Industries and individuals now use technology in diverse areas of life. The two technology commonly used in today's world is Augmented Reality (AR) and Virtual Reality (VR). "Augmented reality" (AR) refers to the process of "adding" computer-generated content to real-world visuals that are created by a device such as a camera or by looking at the real world in person (Zailani, 2022). Lee, Chau, Chau and Ng (2017) defined Augmented Reality as a technology that uses computer-generated three-dimensional virtual items to augment the real world and let people interact with them through the screens of mobile devices. According to Ismayani (2020), Augmented Reality is a technology that integrates computer-generated objects, either in 2D or 3D, with the user's actual environment in real-time. In the context of this study, Augmented Reality is a technology advancement that incorporates computer-generated virtual objects in real-time with real-world environments. Another technological application used in real-world environments is Virtual Reality (VR).

Virtual Reality (VR), according to Sutopo (2022) is an artificial application produced by various devices in real-life environments. Virtual reality (VR) is defined as a technology that allows users to enter and interact with a virtual world because it is a computer-based technology that combines specific input and output devices to allow users to interact completely and directly with the virtual environment as if they were in the real world (Musril, Jasmienti, and Hurrahman, 2020). Ningsih and Firmansyah (2020), state Virtual Reality is a technology that allows objects to be displayed as though they were in the actual world. In this study, Virtual Reality is a computer-generated environment with virtual objects that appear to be real making the user feel they are immersed in their environment. Virtual reality (VR) is a computer-generated, three-dimensional environment that can imitate the actual world or function as an imaginary

world. Virtual environments can also satisfy the senses of hearing, touch, olfactory, and even taste, even though most of them are designed to appeal to the visual sense. Virtual reality (VR) fully submerges the user in a computer-created environment, making it impossible for the users to interact with the real world (Chandrasekera and Yoon, 2018).

Highlighting particular aspects of the physical world, enhancing awareness of such qualities, and deriving smart and easily understandable insights that have practical applications are some of the main objectives of augmented reality (Hayes, 2023). The incorporation of VR and AR into training has created an environment where trainee can have a hands-on learning experience. The technologies facilitate learning by doing (Narasimhan, 2023). As stated by (technology innovator, 2023), AR and VR are technologies that are transforming skill development and performance improvement across industries in training and simulation by providing immersive, realistic and interactive experiences. According to Hayes (2023), augmented reality can bring visual changes to a natural environment or improve that environment by adding new information. It can be applied to a wide range of fields, including as industrial training, industrial manufacturing, education, product visualization, marketing campaigns, and architecture and design.

The conventional traditional training method in the petroleum industry has not been adequate enough to prepare and equip personnel for task that are complex, emergency and even hazards associated with daily operations in the environment. Another problem is that the petroleum industry encounter difficulties in the aspect of providing a comprehensive training experiences for trainees or personnel as a result of the complex operations associated with the industry. This further more impedes the development of skills, safety and work efficiency of personnel in the petroleum industry. Therefore, this paper focus on augmented Reality (AR) and virtual Reality (VR) technologies and their functionality, difference between augmented reality and virtual reality, application of AR and VR in training and simulation in oil and gas industry, benefits of utilizing AR and VR in training and simulation in oil and gas industry and the challenges faced in the utilisation of oil and gas industry. This study focuses on transforming training and simulation in oil and gas industry through Augmented reality (AR) and Virtual reality (VR).

Challenges of Traditional Training Faced by Oil and Gas Industry

The most popular approach to workforce equipping is traditional training, but due to a lack of highly qualified instructors, finance, and remote work opportunities, it is becoming unable to satisfy industry requirements (GEP, 2019). The time spent on the training itself accounts for a large portion of the cost of job training, but there are many other hidden costs as well, such as the extra expenses related to inefficient procedures, labour turnover that results, broken equipment, ignored risks, and the need to retrain staff members (Allen, 2022). The oil and gas sectors face several training obstacles, such as the requirement to boost production levels while decreasing environmental disasters and safety accidents, in addition to regulatory compliance requirements and training costs (GEP, 2019).

Augmented Reality (AR) and Virtual Reality (VR) Technologies and Their Functionality

Augmented Reality (AR) as defined by (Wikipedia in Carmigniani, Furht, Anisetti, Ceravolo, Damiani and Ivkovic, 2011) is a real-time direct or indirect view of a physical real-world environment that has been enhanced or supplemented by the inclusion of virtual, computer-generated information. It blends real and virtual items and is both interactive and 3D recorded. Carmigniani, Furht, Anisetti, Ceravolo, Damiani, and Ivkovic (2011) state that Augmented Reality aims to provide the user with a more convenient experience by providing virtual information in addition to his immediate surroundings and a live video stream. Augmented Reality (AR) enhances users' interaction and perception of the real world. AR technology enhances the sense of realism by overlaying real-time virtual cues and objects in the physical world. Tracking and registration, display technology, and real-time rendering are the three primary building blocks of augmented reality systems. Technology like augmented reality should be three-dimensional and interactive in real time. To produce a believable augmented image, precise tracking and registration are essential. This is so that the user can be presented with a credible image. The real camera should be mapped

to the virtual one so that the viewpoints of the two surroundings exactly match (Bimber and Raskar in Mekni and Lemieux, 2014)

Multimedia, 3D modelling, intelligent interaction, real-time tracking and registration, and sensing are some of the applications of AR. The basic concept is to simulate the real world using computer-generated data, such as text, images, music, movies, 3D models, and so forth, and then apply that environment to the real one. The real world is improved as a result of the two types of knowledge complementing one another (Hu Tianyu et al in Chen, Wang, Chen, Song, Tang and Tian, 2019). According to the author, augmented reality (AR) has advanced from theoretical research in laboratories to mass and industry implementation. It serves as a link between the digital and physical worlds, providing individuals with new viewpoints on how to see and recognize their surroundings. This is as a result of advancements in computer hardware and software processing power. With AR technology, learners can engage with virtual visuals enhancing real-world settings. Put differently, visual display technology enhances the real world. Using a variety of display devices, including PCs, tablets, and smartphones, augmented reality (AR) may offer engaging, interactive, and immersive learning experiences. The advantages and benefits of augmented reality (AR)-based learning technologies, such as remote training and interactive simulations, are becoming recognized by training programs. (HealthySimulation, 2023).

Virtual reality can be defined as an environment created by a computer that can be interacted with as though it were real (Van Krevelen and Poelman, 2010). According to Ong, Nee, and Ong in Mekni &Lemieux (2014), virtual reality is an artificial environment in which users interact with computer-generated sounds and pictures and have a partial influence over the events that occur in the environment. One of the key elements of virtual reality is a virtual world, which is an imagined location or simulated environment. This illusion is meant to depict a collection of items in an environment that fulfils the imagination of the creator. Virtual reality immersion, which is the feeling of being in another world such as an imaginary one or another point of view within our own occurs alongside the virtual environment (Sherman and Craig in Hussein and Natterdal, 2015). Regarded as a "next-generation computing platform," virtual reality technology aims to create a virtual environment that users can interact with and immerse themselves in. Using specialized technology, the surroundings are simulated as closely as possible in the virtual world (Li, 2018). According to Ivan Sutherland, one of the pioneers of virtual reality systems, "The ultimate display would be a room where the computer can control the existence of matter and a chair displayed in such a room would be good enough to sit in." In a space like that, handcuffs would be restrictive, and a bullet would be fatal (Mekni & Lemieux, 2014).

Two types of virtual reality exist: immersive and non-immersive (Wohlgenant, Simons and Stieglitz, 2020). Non-immersive VR uses a set of flat screens to expose users virtually, immersive VR uses head-mounted displays to put the user inside the virtual world (Rahouti, Lovreglio, Datoussaïd and Descamps, 2021). Driving or flight simulators are a common example of this, where the user sits in a chair with several screens surrounding them, creating the illusion of being in the driver's seat or cockpit without going completely virtual (Hamad and Jia, 2022). Elmqaddem (2019) asserts that people can access simulations of real-world circumstances that may not be done directly by using virtual technology. This guarantees that activities carried out via virtual technology are appropriate for real-world environments. Through the use of interactive devices which can be worn as goggles, headsets, gloves, or body suits VR applications, according to Lowood (2023), immerse the user in a computer-generated environment that resembles reality. Virtual reality technology provides users with an immersive experience while highlighting people-centeredness (Li, 2018). Users should be able to physically move around and touch objects in a virtual reality system just like they would in the real world (Mekni & Lemieux, 2014)

In a standard VR format, a user sees animated visuals of a simulated environment while donning a helmet equipped with a stereoscopic screen, according to Lowood (2023). The author further stated that, the illusion of "being there" (telepresence) is created by motion sensors detecting the user's motions and

modify the display on the screen to match, typically in real-time (the instant the user's movement occurs). As a result, a user can explore a virtual suite of rooms and see shifting vantage points and views that logically correspond to his own head movements and steps. The user can even pick up and move objects he sees in the virtual world by wearing data gloves fitted with force-feedback devices that simulate touch. A user can explore and interact with a three-dimensional computer-generated environment, manipulating objects or carrying out actions within the same virtual world (Virtual Reality Society, 2017). According to Javaid and Haleem (2020), the primary application of this technology is to build a virtual world for training and interactive stories in a simulated environment. By blocking out the real world, virtual reality fully submerges the user in the digital world. The user can move around in a three-dimensional "world" and perform different acts by wearing a VR headset and being taken to space, under the ocean's surface, or the cockpit of a fighter jet (COPAS, 2022).

Differences between Augmented Reality (AR) and Virtual Reality (VR)

AR and VR rely on different underlying components and generally serve different audiences while they both involve simulated reality. According to Watts (2023), when using virtual reality, the user wear headphones and an eye-covering headset to fully replace the real environment with the virtual one. The purpose of virtual reality is to isolate the user from and minimize the real world. Once inside, the VR environment may be programmed to offer nearly anything, from a realistic (but entirely made-up) replica of Earth to a light-sabre duel with Darth Vader. Conversely, augmented reality combines the simulated worlds with physical worlds. In the majority of applications, the user does this by pointing the camera of their phone at an point of interest and using the phone's screen to create a live-streaming video of that scenario. Next, useful information is displayed on the screen, such as diagnostic data, navigational information, or repair directions.

Tulane University (2023) states that although virtual reality (VR) is entirely virtual, augmented reality (AR) uses a real-world environment; users of AR can control their presence in the real world; users of VR are controlled by the system; VR requires a headset device, but AR can be accessed with a smartphone; and VR only enhances a fictional reality. According to Martin (2023), augmented reality (AR) enhances the real-world scene while virtual reality (VR) provides fully immersive virtual settings. AR is 25% virtual and 75% real, whereas VR is 75% virtual and 25% real. While VR requires a headsets, AR does not. With augmented reality (AR), users can interact with virtual items that are closer to them while remaining in contact with the real world; in contrast, virtual reality (VR) isolates users from the outside world and immerses them in a fully virtualized world.

Application of Augmented Reality (AR) in Training and Simulation in Oil and Gas Industry

According to McKinsey research, augmented reality might save costs for offshore oil and gas businesses by up to 25% per barrel (COPAS, 2022). The oil and gas is starting to adopt AR as its value in enhancing productivity, safety, and knowledge sharing is been recognized. Companies are considering AR from field operations and maintenance to employee training. AR-enabled wearable and gadgets boost productivity and reduce errors by enabling workers to access vital information and instructions hands-free (Adamska, 2023). According to the Council of Petroleum Accountants Societies (COPAS) (2022) and Adamska (2023), the oil and gas industry applies AR in the following ways:

AR for employee training in the oil industry: the oil and gas sector frequently entails hazardous and complex tasks, training is essential to guaranteeing the competence and safety of employees. Employees, whether new or existing, can practice different scenarios in AR's safe and immersive training environment without any risks. For example, operators can practice simulation training on emergency response protocols, equipment maintenance, and drilling operations. Workers can acquire practical skills and information through these realistic training experiences, which lowers the learning curve and increases confidence while addressing real-world situations (Adamska, 2023). The integration of augmented reality (AR) technology into training programs can greatly assist personnel in solving current problems, improving skills of operation and maintainers of pumped storage power plants, and helping them comprehend complex and difficult

professional information through real-world experience and intuition (Wen, Qiu, Zhao, Zou, Zheng, Liang and Zhang, 2023). The authors further stated that this type of instruction and training can significantly lower the trial and errors by trainee/employee. It can also serve as a warning system for personnel safety and enhance personnel's handling, resilience, and safety awareness.

AR-enabled applications provide a more engaging alternative to manuals and handbooks for educating staff members about a company's regular practices. These applications are beneficial for field staff continuous training as well as for on boarding. Workers can easily become up to date with new safety regulations, updated machinery, or processes by using an AR-ready or VR training simulation (COPAS, 2022). Not only can AR simulation replicate danger, it can also simulate real scenario, though it is more challenging than the real situation. The operation is safer, which guarantees both the training's effectiveness and the personnel's personal safety throughout the training, enabling the workers to confidently carry out a variety of practical tasks. Along with stimulating human senses and providing a realistic experience, it can also provide a similar sense of reality in terms of vision, hearing, and somatosensory (Oda O, Elvezio C, Sukan M, et al in Wen, Qiu, Zhao, Zou, Zheng, Liang & Zhang, 2023)

Figure 1: Visualization of the onshore drilling rig using Augmented Reality
Source: Retnanto, Alyafei, Fadlelmula and Sheharyar, 2020 (Adopted)

AR for enhanced operations and safety: AR provides useful solutions to optimize different operational areas in the gas and oil industry. During inspections and repairs, technicians can use augmented reality to access maintenance histories, equipment manuals, and real-time data overlays. Through the use of instructions and highlighted sections, the AR system may lead users through the process, ensuring accurate and productive work (Adamska, 2023). According to COPAS (2022), there are numerous risks on an oil platform or in the refinery environment. These risks can be significantly decreased by combining wearable technology with AR training. When workers have the right training, they know what to do when anything goes wrong. Employees can also be provided with wearable technology that tracks various body temperatures, heart rates, GPS, and other parameters. The employer can act quickly and responsibly if a worker finds themselves in a hazardous situation. As opined by Aircada (2022), in oil and gas training, augmented and virtual reality can help increase safety and compliance standards and help carry out procedures in the event of an emergency safety issue. Adamska (2023) stated that for workers to stay in compliance with safety rules, they can utilize augmented reality (AR) to perceive potential hazards and safety information in their surroundings. In the event of an emergency, personnel in the oil and gas sector can make quick, well-informed decisions through the display instructions and evacuation routes provided by augmented reality. Companies can improve safety protocols and reduce hazards related to intricate industrial processes by incorporating augmented reality (AR) into their regular operations.
Remote Maintenance and Repairs: Equipment can be monitored real-time using AR-based application which allows the reporting of deviations in important parameters such as magnetic field, temperature, etc. When routine maintenance is necessary and when sensor readings deviate from set parameters, the application can provide notifications. An AR headset that blends digital data with reality can be worn by technicians to guide them through maintenance or repairs process when needed. The "guide" can assist a technician to speed up a repair and restoring the asset's online functionality (COPAS, 2022). For instance, employees can simulate on-site maintenance, detecting defective components and following step-by-step directions tasks by using AR headsets or mobile devices. Using a hands-on approach enhances their troubleshooting skills and minimizes the need for further support from experienced technicians. Furthermore, because AR training is interactive, learning can become more fun and engaging, which improves retention of the material. Adamska (2023)

More Effective Workflow: AR help workers to operate more productively. In the oil and gas sector, augmented reality overlays, such as smart glass hardware, can increase worker productivity by giving visual cues and indicators, machinery operating instructions, and process phases. An employee can increase overall productivity by acknowledging instructions with a head tilt or nod and keeping a computerized "checklist" of tasks performed for their job. (COPAS, 2022)

Better Rescue Operations: Although it is unpleasant to consider, accidents in the oil and gas sector are inevitable due to the hazardous surroundings, close contact with large machinery, and exposure to hazardous compounds. Today, rescue teams can practice potential real-world situations by using AR technology. Rescue teams can use the same technologies to enhance team safety and reaction times in the event of an incident (COPAS, 2022)

More Efficient Logistics: As stated by COPAS (2022), complex sectors like oil and gas always face challenges with end-to-end logistics. The improved connectivity that augmented reality (AR) systems can offer will significantly lower production costs overall and improve materials tracking. Better overall outcomes can be achieved by using digital solutions for logistics management to lower the cost of personnel, materials, vehicle maintenance, and emissions.

Application of Virtual Reality (VR) in Training and Simulation in Oil and Gas Industry

An extremely lifelike and immersive training environment is produced for oil and gas operators using virtual reality simulation technology. The application of VR in training and simulation in oil and gas industry as stated by Portal Pro-Arktic in Smirnova, Zaychenko, Bagaeva, and Gorshechnikova (2020) includes:

Simulation of oil and gas operations: VR produces 3D replicas of actual places, giving the user a realistic experience. Real-world scenario simulation yields data on critical oil and gas operation parameters that help in preliminary evaluation of the efficacy of different methods. A digital twin can be created by companies using virtual reality technology to simulate the operations of a refinery, oil field, or any other type of operating unit. This lessens the expenses and dangers involved in introducing a new procedure in oil and gas operations (Portal Pro-Arktic in Smirnova, Zaychenko, Bagaeva & Gorshechnikova, 2020). Training scenarios that would be unsafe or impracticable for a trainee can be added by trainers through virtual reality. Without the risk and costs of real-world learning, virtual reality offers valuable hands-on experience. This allows for a greater variety of learning opportunities for oil and gas workers and allows for training tailored to specific risk concerns (Allen, 2022).

In a virtual reality oil and gas simulator, trainees can interact with the virtual world by using haptic feedback devices or hand-held controllers in addition to specialized head-mounted displays (HMDs) that offer a 360-degree perspective of the area. The purpose of the simulation environment is to simulate the actual oil and gas operations, production facilities, drilling rigs, and other machinery. Oil and gas operators can practice and enhance vital skills including well control, well completion, well intervention, and other duties through VR training simulation. By doing so, this allows them to become more skilful and confident in managing intricate circumstances and can recognize and resolve possible issues before they arise in actual operations (Esimtech, 2022).

Conducting training programs: Virtual reality has become widely used in the field of oil and gas. With VR technology, it's possible to produce 3D walkthroughs of actual environment, such as oil and gas sites. It aids in providing immersive 3D models for training programs that enhance comprehension of diverse industrial systems and processes. VR can be utilized for safety training since interactive disaster training can be customized for individual users as well as companies, according to Berglund in Aziz, Alshammar, and Ariffin (2018). Based on their resources and hazard vulnerability assessments, these designs can be created for instructional task-focused training, where the software reacts to user inputs and gives immediate feedback on tasks completed. The personnel taking part in the training can improve their psychological state before certain emergencies through VR immersive experience and interaction.

The personnel taking part in the training can specifically learn the internal structure, operating principle, and assembly method of drilling and well control equipment through VR interactive operation and realistic VR experience. Using realistic instruction, trainees can become acquainted with the diverse constituents and operational principles of the equipment, thereby enabling them to scrutinize operational conditions and perform troubleshooting. (Esimtech, 2022).

Figure 2: trainees experiencing the VR application using head-mounted VR devices
Source: Retnanto, Alyafei, Fadlelmula and Sheharyar, 2020 (Adopted)

Virtual reality (VR) according to Allen (2022), improved proficiency training by enabling engineers to complete it right before going to a job site, with details that correspond to the real environment they will be working in. According to Aircada (2022), Workers are now able to train and acclimate themselves before they ever set foot in the workplace because to virtual reality's high degree of realism. Berglund in Aziz, Alshammar & Ariffin (2018) stated that engineers can reduce potentially incident-prone areas and assess risky scenarios with VR technology; the ability to make mistakes and learn from them while carrying out complex procedures and instructions is a hallmark of how training solutions are designed. Improving a skill set as quickly and efficiently is the aim of all operator training. Virtual reality training's realistic elements significantly speed up learning and skill development.

Testing and verification of processes: VR is used to improve inspection and maintenance efficiency through data-driven modeling. According to Portal Pro-Arktic in Smirnova, Zaychenko, Bagaeva, & Gorshechnikova (2020), with the use of this technology, service requirements can be identified by technicians by integrating historical data and real-time information with VR which can be directed to the activities that need to be done to avoid imminent disruption. This reduces the amount of time needed for maintenance tasks by providing detailed instructions on where to discover the defective part and how to replace or repair it.

Disaster management using virtual reality: Oil and gas field technicians work in hazardous conditions and are subjected to dangerous chemicals and fumes. Trainees/personnel could receive emergency response training via virtual reality by imitating real-world circumstances (Portal Pro-Arktic in Smirnova, Zaychenko, Bagaeva, & Gorshechnikova, 2020). VR oil and gas simulation can help improve safety by allowing operators to practice hazardous operations in a controlled environment (Esimtech, 2022).

Improved Engagement: trainees are not distracted by outside influences as VR fully engages the senses thereby maximizing learning engagement and retention (Allen, 2022).

Benefits of Utilizing Augmented Reality (AR) and Virtual Reality (VR) in Training and Simulation in Oil and Gas Industry

The following benefits of augmented reality and VR in oil and gas industry as stated by Adamska (2023):
Increased efficiency and productivity: creased productivity and efficiency are one of the biggest benefits of using AR in the oil and gas sector. Augmented Reality (AR) shortens task completion times and streamlines workflow by giving employees instant access to pertinent information. For instance, technicians using AR-enabled devices can more quickly access historical data, maintenance records, and equipment specs during maintenance activities, which helps them make better judgments and finish tasks more quickly. Moreover, AR improves data analysis and visualization. It is now easier for workers to view complex data sets in an interactive and intuitive way, such as geological or real-time well data. Faster and more precise decision-making is made possible by this enhanced data visualization, which optimizes operations and resource allocation. According to (iQ3Connect 2023), trainees using virtual reality outperform those using traditional

classroom and online learning environments. VR learners trained 4 times quicker than classroom training and 1.5 times faster than e-learning. In a study on the effects of virtual reality simulation in emergency evacuation training, VR learners outperformed traditional e-learning students by a large margin of 22% more accurate and 7% faster.

Improved safety and risk mitigation: In the oil and gas sector, safety is critical due to the high-risk conditions and possibility of hazardous occurrences. Augmented Reality (AR) technology is essential for reducing hazards and improving safety procedures. By using AR-guided procedures and real-time hazard identification, employees/trainees can follow stringent safety regulations and procedures, which lowers the risk of accidents. Additionally, AR reduces the necessity for employees to physically enter hazardous regions. Experts and supervisors may mentor field operators from a safe place with the help of remote support and collaboration capabilities thereby reducing the risk of exposing personnel/trainees to dangerous areas. AR can give workers instant access to vital safety information in an emergency, empowering them to act quickly and appropriately to safeguard others as well as themselves. VR training, according to iQ3Connect (2023), gives trainees the chance to respond to and handle hazards that are too expensive, dangerous, or impractical to replicate physically. This method is frequently used by oil and gas firms for virtual reality safety training, in which learners must travel through a virtual facility in order to identify and address hazards. VR trainees who do better on the job also increase workplace safety.

Cost savings and return on investment (ROI): The long-term advantages of augmented reality in the oil and gas sector frequently outweigh the early expenditures of investing in the technology. The use of AR results in cost savings in operations, maintenance, and downtime due to its increased productivity and efficiency. For instance, reduced downtime, leading to higher productivity and revenue generation from faster equipment diagnostics and repairs leads to higher productivity and revenue generation. With AR, specialists can visit sites less frequently and physically, which saves money and time on travel-related expenses. The increased safety precautions that AR offers may also result in reduced workplace accidents and the related expenses that come with them, such as medical bills and benefits claims.

Additionally, VR/AR training, according to iQ3Connect (2023), virtualizes learning and development so that workers from all over the world, no matter where they are in the world, may instantly access high-quality training materials. However, teamwork doesn't have to suffer because of this distant accessibility—many different training modalities can be seamlessly integrated into a single VR session. VR training gives learners flexibility when used as a single-user, on-demand experience. However, the same experience may also be set up as a multi-user, instructor-led training that promotes global team collaboration. Travel expenses are thought to be able to be decreased by more than $1,000 for each trainee each trip if onsite training sessions are substituted with remote VR instruction.

Challenges of Implementing Augmented Reality (AR) and Virtual Reality (VR) in Training and Simulation
Despite the benefits of utilizing AR and VR in training and simulation, these technologies still faces some challenges in its use. According to Merchant et al. (2014), cost and the computing power necessary to produce realistic environments are the main barriers to using virtual reality. Implementing AR/VR in eLearning is costly and to develop high-quality AR/VR content can be expensive which not all industries may have the budget to invest in these technologies (Blackburn, 2023). Once digital reality technologies such as VR/AR is implemented, it can save money, although difficulties in budgeting can cause even the best use cases to go unfunded. For example, while VR training can often save money or improve outcome compared with traditional training, the costs of implementing such a solution may rest with a training department while benefits may accrue to an operational department (Binaifer, Sudeepta, Saurabh, Saurajit and Saumya, 2019). VR-ready PCs are typically more expensive than regular computers, most people cannot afford this type of VR gear. This means that one of the biggest obstacles to VR adoption as a normal consumer is cost, which is preventing VR from becoming a household technology (Hamad & Jia, 2022).

Evolving better tracking systems, finding more natural ways to allow users to interact within a virtual environment and reducing the time it takes to build virtual spaces is challenging in VR field (Mandal, 2013). The author further stated that, building virtual environments requires a significant amount of time to produce a believable virtual world; the more realistic the environment, the more time it requires. Accurately recreating a real area in virtual space could take a team of programmers over a year. Developing a VR system that avoids poor ergonomics presents another difficulty for developers. Many systems rely on hardware that physically ties users to the system, burdens them or limiting their alternatives. A user may experience cyber sickness, or he may struggle with inertia and balance issues leading to a diminished sense of telepresence due to poorly built hardware. According to Kinateder, Ronchi, Nilsson, Kobes, Müller, Pauli and Mühlberger (2014), several users of virtual reality studies have reported experiencing motion sickness, nausea, or mild headaches. As stated by Blackburn (2023), prolonged use of AR/VR can cause health and safety concerns. It is essential to take breaks and limit the use of these technologies to prevent such issues

As stated by (Hamad & Jia, 2022), technological limitations, Accessibility and side effects of using VR are its limitations. According to the author, there is limited standardization in VR technology and presentation; developers may have different interface specifications and functionalities for their technologies, and applications are difficult to move between devices. Because there is no standardization, it is also difficult to diagnose errors and get the help you need for any difficulties. According to Fernández and Alonso in Hamad & Jia, (2022) most Professional virtual reality development software typically requires large amounts of power and data storage on computers. Furthermore, VR headsets can be physically heavy for users, especially in the neck and shoulder regions, and can give users headaches and other physical strain (Kaplan, Cruit, Endsley, Beers, Sawyer and Hancock, in Hamad & Jia, 2022). AR hardware should be lightweight, portable, and quick enough to show graphics. Another restriction on the applications of AR is the battery life of these sophisticated AR gadgets (Mekni & Lemieux, 2014). Majority of VR headsets require using a computer that is “VR-ready”, that is a computer with high-end powerful graphics card that can manage VR applications. Participation in eTraining activities utilizing AR/VR technologies may be restricted for certain learners due to their lack of access to the hardware or internet connection required for these tools (Blackburn, 2023). Since virtual reality equipment might malfunction or crash, the chance of any problem occurring increases as more people use them (Choi, 2016). It would therefore be advantageous to keep backup devices on hand, and backup training materials should be on hand in case of technical issues, Internet outages, or other unanticipated circumstances. The complexities of AR/VR technologies requires advanced technical skills. Technical problems such as device malfunctions or network difficulties may potentially cause hindrances to the training process.

Cyber security is another major issue with AR/VR technologies that isn't fully solved yet, according to Kumari and Polke (2019). There is a chance that virtual environments will be hacked, making it possible for the attacker to access, alter, or change them and maybe destroy the virtual environment. Security measures needs to be implemented on to AR/VR products as they are directly connected on to mobile handsets, desktops and laptops. Binaifer, Sudeepta, Saurabh, Saurajit, and Saumya (2019), stated that technologies that interact with consumers through digital reality, such as AR and VR, may present privacy problems. AR/VR technologies measure how people respond to new experiences (e.g., eye movement) and use that information to produce data points for system enhancement. This data needs effective controls to protect users’ privacy.

Future Trends in Augmented Reality (AR) and Virtual Reality (VR) Technologies in Training and Simulation
The future direction of augmented and virtual reality (AR/VR) is set for additional research as the technology continues to become more advanced and accessible. There are various hypothesized future research directions. A large number of HMDs designed with augmented reality in mind must be produced. AR/VR has the ability to completely change how people interact with digital information with advancements in both hardware and software development tools. Additionally, Faster processing rates will be made possible by the development of 5G

and 6G networks, improving user experiences while lowering latency. This trend is anticipated to continue throughout 2030 and beyond as AR/VR becomes more widely used in a wider range of global sectors. In addition, the utilization of augmented and virtual reality technologies permits educators/trainers to replicate real-world situations, implement immersive educational settings, and offer learners practical experiences that help close the knowledge gap between theory and practice. It is anticipated that as these technologies advance, they will completely change the way we impart knowledge and acquire it. In order to incorporate these technologies into training, the petroleum industry are urged to devote more time, funds personnel training towards implementing these technologies. Virtual reality can provide realistic simulations that allow trainees to experience real-world scenarios in a secure environment while augmented reality can bring workbooks/manuals to life with interactive diagrams (Al-Ansi, Jaboob, Garad, and Al-Ansi, 2023)

CONCLUSION

This research paper reviewed the utilization of AR/VR in training and simulation in petroleum industry. The research reviewed that the use of virtual reality and augmented reality technologies has the potentiality of tackling problems faced during training in petroleum industry. Therefore AR/VR should be used in training and simulation in petroleum industry to develop the soft skills and hard skills of trainees/personnel. AR/VR use in training and simulation in oil and gas industry Increased efficiency and productivity, improved safety and risk mitigation, safe costs and allow collaboration. Further research should be carried out to unveil new possibilities with positive experience that the use of AR/VR can bring about in training in the petroleum industry.

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