Section A-Research paper
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An Immersive Metaverse mechanism for Imparting Fire Safety Training

Dr.L.Jabasheela[#1],NandaKumar.B[#2] Ramasubramanian.P[#3] , S.Yogadinesh[#4] ,T.S.suganya[#5]

[1,2,]Department of Computer Science and Engineering,PanimalarEngineeringCollege,Chennai,TamilNadu,600123,India.

[3] Department of Computer Science and Engineering, Study World College of Engineering, Coimbatore

[4] Department of Computer Science and Engineering, Bharath Niketan Engineering College, Andipatti, Theni,India

[5] Assistant Professor,SRM Institute of science and Technology, Ramapuram campus, Chenna,India, tssuganya07@gmail.com

corresponding author mail id : ljsheela@gmail.com

***Abstract*—Recentyearshave seena significant increase in the use of virtual reality (VR) ineducation.As a powerful teaching and learning tool, it has the potential to revolution is the way we teach and learn. A subject that could benefit from VR technology is fire safety training. The purpose of this abstract is to investigat e the concept of efficient fire safety training using virtual reality.As demonstrated in this study,virtual reality can provide an immersive and interactive learning experience for fire safety training. By participating in VR simulations, learners will have the opportunity to experience realistic emergency scenarios, which will prepare them for real-life emergencies. The effectiveness and relevance of simulations can be enhanced by tailoring them to specific work places or scenarios. VR can also be used in fire safety training, offering advantages over traditional methods. Repeated practice is possible without expensive equipment or live demonstrations. Furthermore, learners can receive immediate feedback on theirperformance, allowing them to identify areas for improvement and adjust their behaviour accordingly. Virtual reality can also increase engagement and retention in fire safety training. Learners are more likely to remain engaged and retain information when presented with an immersive and interactivelearning experience. The abstract concludes by demonstrating that efficient education utilizing virtual reality in fire safety training can offer several advantages over traditional training methods. Kalvi, meaning education, learners can be better prepared for real-life emergencies by providing an immersiveandinteractivelearning experience.**

***Keywords*—VirtualReality,ExtendedReality,Simulation,Training,Unity.**

I.INTRODUCTION

The importance of education has grown over the past fewdecades as technology has advanced. Virtual reality (VR) has become an increasingly important educational tool as technology has evolved. The concept of virtual reality enables users to interact with a three-dimension al environment through a computer-generated simulation. It can be used in a variety of fields, including medicine, engineering, and entertainment. As a tool for educating people about fire safety, virtual reality has become increasingly popular in fire safetytraining over the past few years. In this paper, we examine theconcept of efficient fire safety training through the use ofvirtual reality. According to Elin Nordegren, "Education is a precious resource that no one can take away from you.".Education is an essential tool that provides individuals with the knowledge and skills they need to succeed in their every day lives.

Fire safety education is essential for preventing fire out breaks and minimizing the damage caused by fires in the past, despite being ineffective in some instances. Users canexperience a simulated fire outbreak using virtual reality and learn how to respond to it[3]. A number of benefits can be obtained from using VR in fire safety training. A first advantage is that it gives learners the

opportunity to experience fire out breaks in as a fe and controlled environment. In traditional fire safety training, learners areexposed to real fire outbreaks, which can be dangerous and life-threatening. Learners can experience a variety of scenarios through virtual reality and develop the ability to respond accordingly. This risk is eliminated by virtual reality.

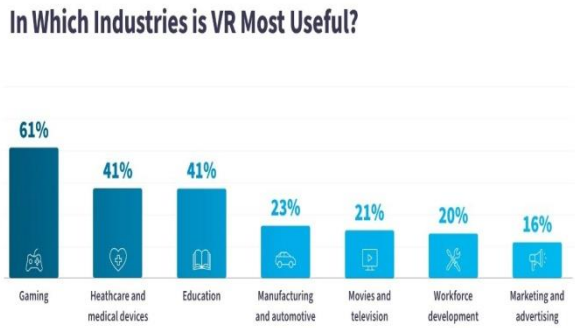

Fig.1Statistics about different industries in terms of VR usage.

Traditionally, fire safety training exposes learners to a limitednumber of scenarios, which may not be enough to provide them with the skills they need to deal with a variety of situations. Learners can respond to a variety of different situations in VR by interacting with a variety of scenarios presented. As a result of this quote, individuals will be able tobenefit from it on a daily basis in their daily lives, as Elin Nordegren emphasizes the importance of education. Therefore, virtual reality has proven to be a valuable tool inthe education of people about fire safety measures when usedin fire safety training. In a safe and controlled environment,learners have the opportunity to experience a fire outbreak in order to enhance their learning of responding to various situations. According to ElinNordegren[2], an individual's education is an invaluable resource which cannot be takenaway from them[3]. Compared to traditional methods of firesafety training, virtual reality has many advantages. Thus, theuse of virtual reality in fire safety training is an important step towards efficient education that provides individuals with knowledge and skills essential for successful participation in their daily lives.

Virtual reality(VR)is a practical teaching technology that also provides pupils with an engaging learning experience[13]. As educators and trainers alike have sought effective and efficient training programmes in a variety of industries, virtual reality has become an increasingly popular alternative. Virtual reality technology can enhance fire safety instruction by allowing students to participate safely and realistically with emergency scenarios. According to the National Fire Protection Association (NFPA), fires andexplosions cause 5,000 injuries and 200 fatalities at work each year in the United States (NFPA, 2017). Staff training in fire safety is the only way to lower the risk of employee injury or death.

Since Mark Zuckerberg bought Oculus for $2 billion five years ago, investors and the general public have been increasingly interested in virtual reality (VR) and augmentedreality (AR) [10]. Sony, Samsung, HTC, and Google are just a few of the companies that are now making significant investments in VR to address its problems [11]. Though it has since migrated to other academic disciplines,VR research initially started in the field of computer graphics [12]. Theauthors of [14],[15] and [16] discuss how VR-enabled videogamesare more common than in the past and aid neuroscientists,psychologists, biologists, and other researchers with both theirconcerns and as valuable, work-related tools. For instance, among them ain objectives of research

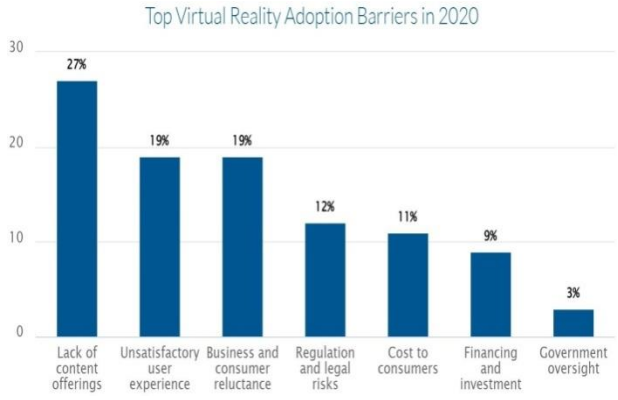

Fig.2 Changes caused by using VR in domains.

Fire safety training typically consists of lectures and practicaldemonstrations and does not provide a realistic and engaginglearning environment. In a secure, controlled environment [4], learners can practice responding to crises through VR technology. A recent study [9] suggests that VR-based firesafety training improves knowledge retention and performance. Through virtual reality, fire safety programs can be made more effective and efficient. Therefore, learners will have the skills and information they need to react quickly and effectively to situations.

II. RELATEDWORK

When it comes to the field of Virtual Reality, new innovations and theories are being introduced to the field by utilizing their own ideas and incorporations. Here there are a few numbers of researchers who are explaining their way of utilizing Virtual Reality into their respected fields.

According to the authors Vinod Vijay Kumar and Deborah Carberry, they [5] are working towards implementing the Virtual Reality into their own field of expertise "Chemical and Biochemical Engineering". With their own team of researchers, they came to a conclusion that this technology will help them towards progressing in their fields. Based on the working principles, they have been working in the process of implementing Virtual Reality into their own teaching curriculum by implementing it as a way of teaching students through that mechanism. Due to the advent of digitalization, biochemical engineering education has undergone a considerable revamp during the over 20years.Yet, under graduate students occasionally lack experience to the workplace and find it difficult to comprehend the intricaciesof actual processing facilities. As a result, students may be able to graduate without having gathered enough practical hands-on experience. Similar to this, the process sector routinely uses operator training simulators to teach both newand seasoned workers. On the other hand, traditional training simulators typically fall short of accurately mimicking reality and donot allow the user to experience unexpected and hazardous events. With these advancements, it appears that virtual reality is a technology that can meet the demands of both industry and academia. To create advanced immersive learning, they plan to use mathematical models.

Numerous innovations are being developed in the dental fieldto speed up progress. In order to help students, learn dental surgery, the authors MyatSu Yin and Peter Haddawy [6]intend to use virtual reality. According to them, dental education is largely based on the conventional surgical master-apprentice model.A number of dental VR systems have been developed for both academic and commercial uses, and virtual reality (VR) simulations have recently been employed as supplements to conventional skill-training courses. Such systems have not yet reached their full potential due to insufficient formative feedback assistance. Without such a method, evaluation still requires the focused time ofspecialists, who are in limited supply. To cover the void informative evaluation using VR simulators in skill training indentistry, we provide a methodology to objectively assess the surgical competence and automatically produce formative feedback. VR simulators enable the collection of precise data on crucial variables throughout a process. Along with theirresearch colleagues, they are creating a feedback system thatwill enable them to give constructive criticism, link processmetrics with procedure outcomes, and identify the parts of aprocedure that need to be improved. Using the location of theerror, the exact elements of the process that contributed to the errors in the results are identified. Thev ideo modality is employed to provide tutoring feedback. Randomized controlled trials are used to assess the feedback system's efficacy with dental students. The results demonstrate the effectiveness of the feedback mechanisms and their potentialfor use as useful supplemental training tools. Students canadvance in their skills and practical knowledge by doing this,andtheteam canalso improvetheir model.

The Chinese authors Haoyu WANG and Jianhuang WU share the same domain as the earlier authors, but they are interested in integrating virtual reality into the field of cardiology instead. Their development is described below [7].

The most prevalent sustained cardiac arrhythmia that can result in serious heart issues is atrial fibrillation (AF). One of the best techniques for treating AF is catheterablation. Doctors who are qualified to perform this procedure musthave exceptional surgical device manipulation skills. Their research suggests developing a high-fidelity interactive surgical simulator to enable effective training and affordable medical education. To simulate how different surgical tools would interact, they used a shared centrel ine model.It is suggested to use an improved adaptive deviation-feed back method to hasten each iteration's convergence. In order toachieve greater fidelity, The PBD framework was also used tomodel the periodic beating of the human heart in real time.The management of the interface between the mesh and a device model of the beating heart was then demonstrated using a unique technique. Tests were carried out in a home-made simulator prototype to evaluate the recommended method's resilience, performance, and adaptability. The simulator was tested in its early phases by surgeons, residents, and medical students. The interplay between surgical instruments, was made possible by running stable simulations at a frame rate. To sum up, their simulator can simulate catheterablation with high accuracy and offer shaptic feedback in addition to immersive visual experiences.

Virtual reality has the potential to significantly advance the media industry. By doing this, we can reduce a number of potential complications during operations and increase user confidence. The authors state that Akitaka Hattori and Ken-ichi Tonami are developing a model to incorporate virtual reality in the form of a 3D environment to instruct students on a dental training simulator on how to evaluate tooth preparation. Their development is described below [8]. In the wake of the COVID-19 pandemic, the haptic 3D virtual reality dental training simulator has gained popularity as a teaching tool. By examining the evaluations of the products created bydental students using these two types of simulators, this studyaims to investigate the features of the haptics simulator in comparison with a tradition almannequin simulator.The following are some of the tools and techniques:

30 students from the faculty of dentistry's sixth-year classes served as the subjects. Each subject created abutments for a crown using two different simulators: amannequin simulator and a haptics simulator. Three assessors gave ratings for the final products' occlusal surface and many other overall impressions. Two simulators' score differences were statistically analysed. The types of simulators that had an impact on subject performance in terms of margin design and total cut volume were the results. Significant factors included subject variability in stereoscopic ability and differences in feelings between simulators. Simulator variations for occlusalform, total volume, and these impressions had an impact ontheevaluators'ratings.

III. PROPOSEDWORK

Virtual reality (VR) technology is rapidly changing the way we learn and interact with information. One area where VR has proven particularly effective is in the realm of training, particularly for high-risk environments like fire safety. With the ability to simulate hazardous situations in a controlled environment, VR offers an opportunity to train individuals without exposing them to actual danger. This proposed system aims to utilise VR technology in fire safety training to provide an efficient and effective educational experience. The proposed system will comprise three main components: hardware, software, and content development. The hardware component will consist of a VR headset and controllers, along with a computer system that meets the necessary technical requirement

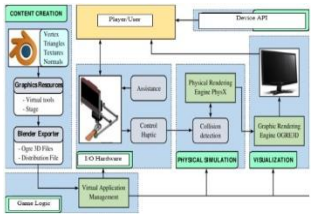

Fig.3Proposed methodology.

The content development component will be responsible forcreating the scenarios and training modules that will be usedwithin the VR application. This feedback provides the userwith the abilitytoreact accordingly.

The VR application will provide a training scenario, designed to test the reaction timing and instinct of the employee undertest. Furthermore, the performance of the user is recorded andused to improve the user's ability to react and extinguish the fire with the appropriate extinguisher. The feedback system will track user progress and provide feedback on performance. Additionally, the system will allow users to track their performance and tasks to identify their progress in the training scenario. The content development component will be responsible for creating the scenarios and training modules that will be used within the VR application. This will involveworking with three types of fire extinguishers and designing ascene that accurately simulates real-world results. The content development evolves around modelling, utilising the XR SDK, and providing functions to the scene.Overall, the proposedsystem will provide an efficient and effective way to train employees of an organisation in fire safety. By utilising VR technology, users can be trained in as a fe and controlled environment without being exposed to actual danger. Finally,the system's feedback and tracking will allow users to track progress and ensure the teach individual is receiving the appropriate level of training required by the organisation.

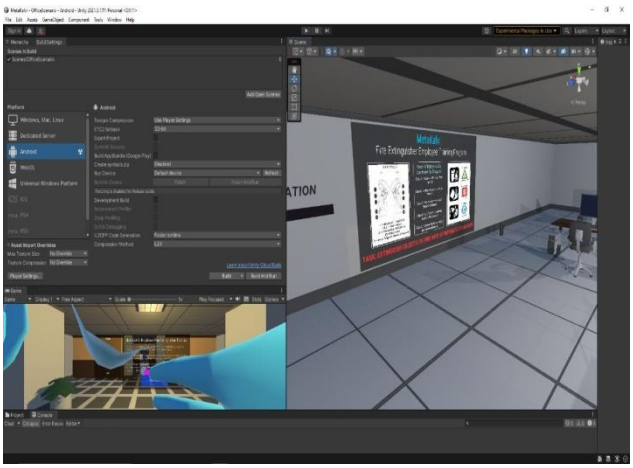

Fig.4Exporting application from Unity to VRheadset.

So, we propose this methodology to achieve our goal of creating a environment where we build a training simulator to teach people how to be able to react in a fire hazardous situation. needed to help us setup the environment in which we will instruct users in fire safety training.As follows:

1. Blender
2. Unity3D
3. XRInteractionToolkit

We will be able to build the envisioned simulation using this software and these elements. We will begin by discussing Blender, a programme used to create models and 3D environments, and how it can be useful in this circumstance.A well-known open-source programme called Blender is usedto make 3D models and animations. To create virtual reality (VR) environment models for a variety of applications, including gaming, training, and simulation,the proposed system will make use of Blender. Three main parts will makeup the system: hardware, software, and content creation. The VR environment models will be made by the content development component. Working with clients to comprehend their unique needs will be necessary in order to design models that satisfy those needs. The content development team willuse Blender to create the 3D environments and models, andthey may also use other programmes for particular tasks likelighting or texture mapping. Flexibility and versatility are twokey advantages of using Blender to create VR environmentmodels. Blender can be used to create models for a variety of applications, from straight forward gaming environments to intricate training simulations.

IV. IMPLEMENTATION SPECIFICS

Through out this section, we discuss the specifics of the implementation and details of the progress conducted in order to validate the proposed methodology. The experiments we reconducted on a local desktop computer which is equipped with a NVIDIA GEFORCE RTX GPU with 16GB of memory.It also needs a Virtual Reality headset to view the output. The output can be done with a portable laptop with similar specifications o that nolag must be present when demonstrating the output. The headset we use to showcase the output is a META quest headset which is designed by META (previously FACEBOOK). When all of this are ready we need to make sure that we are having a stable connection with the internet so that there is no lag or stuttering when performing this training program.

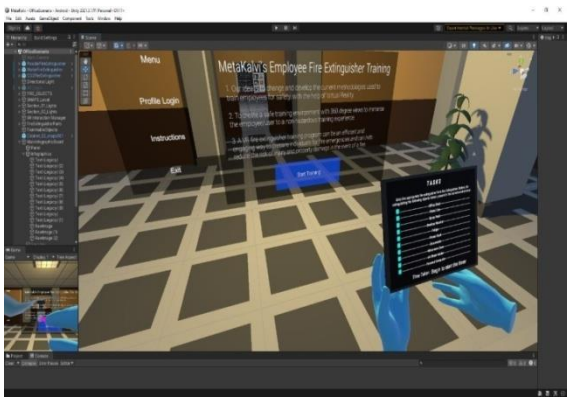

Fig.5 The starting menu and task menu.

Additionally, because it supports a wide range of file formats,it is simple to import and export models to other softwareapplications. This project makes use of Blender, which is usedto create models, especially for our fire safety training. We used it to build a variety of models, including those for computers, boards, chairs, and fire extinguishers. By connecting it directly to the Unity platform, it makes it easierforustorendertheobjectandallowsustouse itrightaway.

Following this procedure, we can now concentrate on using Unity, a platform that is utilized by numerous users and organisations to develop games and 3D environments. In the market, their products have been innovators. It is also frequently used to build the settings for virtual reality applications. Its primary purpose is to enhance a project with attributes that will highlight its greatness, such as movement,characteristics, and uniqueness. We use the base that Blender provided as a starting point and add features to it to make thepart being created function as intended. For instance, in orderfor fire extinguishers to be regarded as working objects, theymust emit somesort of foam. Another example is to designthe training environment so that the objects we create must bepresent in that particular environment (our work being in aroom). We also designed an interface so that the menu will bedisplayed on a screen when we enter. Then, we'll be taken tothe main room, where everything will be set up. All of thesewere created withthe aidofUnity.

The development of the XR interaction toolkit will be a significant step after the process of adding functions to Unity. The XR Interaction Toolkit package is a high-level, interaction-based framework for creating VR and AR experiences. It provides a framework that makes it possible toleverage Unity input events for 3D and UI interactions. A setof interactors, interactable objects and an interaction managerthat connects these two categories of elements, make up thecore of the system. Additionally, it has elements that you canuse to move around and create images. The META quest (VRheadset), which is used to display the output, is supported byit,whichisthemainreasonitisused.

Fig.6(a)Different objects under fire in an office scenario.

The scenarios and training modules that will be used in the VR application will be created by the content development component. Working with three different kinds of fire extinguishers will be required, as well as creating a scene that accurately mimics real-world outcomes. The process of creating the content revolves around modelling, using the XRSDK, and giving the scene functions.

Finally, users will be able to monitor progress and make surethateachpersonisreceivingtheappropriateleveloftraining required by the organization thanks to the feedback and tracking features of the system.

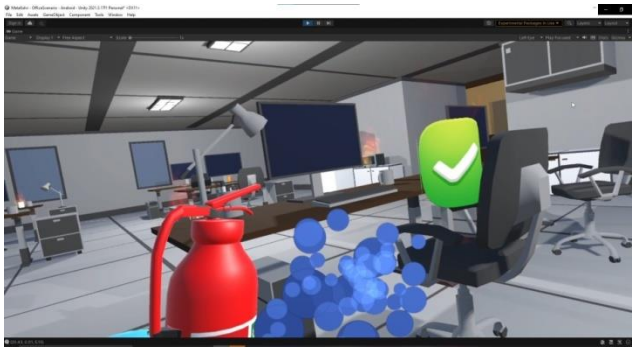

Fig.6(b)Extinguishing fire properly and receiving feedback.

By doing this we can get the expected results of what we desire and we can work on it. The result being an environment where a login page is provided for users to login and they willbe transported to another room where the equipment's will be present and a room full of different burning objects

Fig.6(c)Task completion and perform an ce tracking.

We need to use the correct extinguisher to extinguish the fire.It will show whether it is right or wrong by indicating with aticksign ora cross(X) sign above the burningobjects. If allthe objects are extinguished, it will show the task completedsign on the billboard and on our task menu. It also monitorsthe time so that the users can also check the time taken tocomplete and by doing this they can improve their efficiency.Depending on the performance of the employees, they can beassessed by the organization.

Overall, the proposed system will offer a quick and easy way to teach fire safety to an organisation's staff members. Through the use of VR technology, users can receive traininginasecuresettingwithoutbeing putin danger.

V. RESULT AND ANALYSIS

Current VR based fire extinguisher training for employees,focus only on the working aspect of the extinguisher. This methodology improves the ability of an employee to not only react quickly butals of rom enough training from this proposed methodology, instinctively.

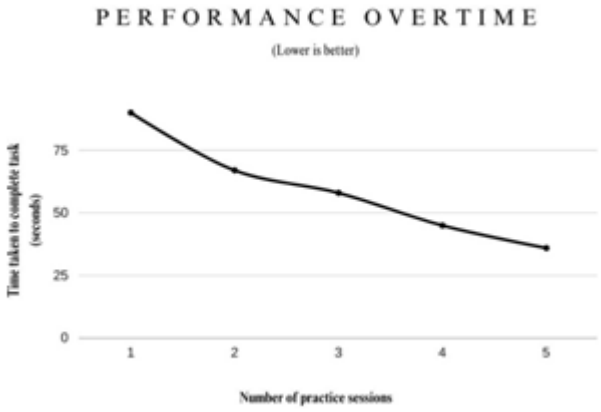

Fig.7 Result and performance overtime.

Focusing on a niche but vital aspect of training enables the employees of the organization to react in a swift manner while choosing the appropriate type of fire extinguisher. In this way,in contrast to other existing VR fire training, this improves

theoverall trainingmethodology.

VI. CONCLUSIONANDFUTUREWORK

The use of virtual reality (VR) in education has grown significantly in recent years. It has the potential to revolution is the way we teach and learn as a powerful teaching and learning tool. Fire safety training could benefitfrom VR technology. The goal of this concept is to look in to the idea of efficient fire safety instruction through virtual reality.Virtual reality, as demonstrated in this study,can provide an immersive and dynamic learning experience for fire safety teaching. Simulations' usefulness and relevance can be increased by customising them to specific workplaces orcircumstances. VR can also be utilised to improve fire safety training over traditional techniques. Without the need for pricey equipment or live demonstrations, repeated practise is achievable. Learners can also receive quick feedback on theirperformance, allowing them to identify areas for growth and alter their behavior accordingly. Virtual reality can potentially improve interest and retention in fire safety instruction. When learners are presented with an immersive and dynamic learning environment, they are more likely to remain interested and remember information. The abstract continues by proving that efficient education through the use of virtual reality in fire safety training can provide various advantages over traditional training techniques. By delivering an immersive and dynamic learning experience, learners can be better prepared for real-life situations.

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