Safety Training in Extended Reality (XR)

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Abstract: *The case study demonstrates the most viable uses in initiation in the work environment. It can be applied for both new workers and experienced workers when a new technology or work environment is added. The definition of XR aka Extended Reality includes both Augmented reality and Virtual reality the application of which can be added in every aspect of the work environment.*

Key words: *XR, Mixed Reality, training, education, work environment, ERP, control, AR, VR, mobile, signs, display, Scenarios, Unity, equipment, safety.*

I. Introduction

Safety training is one of the cornerstones in preparing workers for their new work environment. It can be done before the worker is on the field, as well as during field training and in both of these cases, Extended Reality (XR) can contribute to improving the experience. If supervisors are out of the building, but a worker is at the workplace doing work without knowing how to start a machine, it would not be an issue. The supervisors can just point where to click via a mobile app, and the worker will see it on their augmented reality glasses and click the correct button. They can guide them, and also train them before the fact. If a training program is entertaining, a worker may be willing to train on it, even during their free time, which will increase their efficiency significantly. Any work done by the worker outside their paid hours, including preparation, is beneficial for the company, so it is worth making it entertaining. There is also the concern in ensuring the user's focus on the subject which may be lacking if the training material is not entertaining. This makes the current subject not only technical, but also psychological, although with testing it can be made effective.

Currently all sorts of applications are in use for both training and controlling safety by warding off dangers. It can be through a notification on a smartphone signaling if a worker is headed for an area that is either dangerous or where they have no work. Both audio and visual signaling can be used in steering the worker away from danger and keep them as an efficient unit in the production system. This can be managed via an advanced Enterprise Resources Program or ERP for short, in which a manager or the software itself can manage the tasks and program of the worker. Such systems are becoming common place everywhere, such as cards for controlling access, a system detecting the output of a worker in real time via their station and so on, the applications are endless.

There is a whole philosophy in improving the efficiency of a production system, starting from terrain markings to the signals and signs all the way to worker habits and duties.

There is hardly any room for further improvement of a modern production system via established means, however the Extended Reality (XR) tools are a relatively new experience and it is a field yet to be fully occupied.

A detailed explanation about the specifics and differences between AR, VR, etc. and XR as an umbrella term for all of them, is explained in another publication, about the Extended Reality (XR) use for the Architectural Engineering and Construction (AEC) industry in the frames of work on the BIM-SPEED project [1].

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II. Health and Safety training scenarios

One of the uses for XR in the construction field is to create health and safety training scenarios for both new and existing employees. The use of extended reality is a potential improvement over conventional training methods, as it will most likely be a novel experience for the person being trained and therefore increase the amount of information retained from the lessons. Two scenarios for health and safety trainings have been developed: personal protective equipment and securing technological openings

Collecting data using 360° capture

A potential way to fully utilise the technology of XR is to capture the existing state of the environment to be as representative as possible. Setting it up requires one to scan a building or at least an area that should be included in a safety training scenario.

In order to demonstrate this, a laser scan of the Marshal’s Office of the Province of West Pomerania was used (Fig.1). Scanning was conducted using the NavVis VLX mobile scanning tool, which captures 3D measurements using two multi-layer LIDAR sensors in combination with industry-leading SLAM software that delivers survey-grade point cloud quality.

Chosen 3D scanner specifications	
Max. accuracy:	6mm
Acquisition speed	600,000 points/s
Camera resolution	20 MP
Working range	100 m

Table 1. 3D scanner specifications

For further information about the device look at Table 1.

Figure 1. Scanning and 360 photos capturing

Four 20 MP cameras positioned on top of the device take high resolution images in every direction for a complete 360° capture, without the operator appearing in the field of view. The combined panorama has a resolution of 335 MP

The scan of the 3000 m^2 building was completed in about 8 hours. Before scanning began, reference points were created using traditional surveying techniques, which increased the accuracy of measurements and the point cloud as a whole. This method produces a fast and accurate depiction of the current state of the building. Because this method can provide up-to-date information on the state of the building, it may also be used to brief workers or site visitors of potential dangers.

A 3D scan of the construction site may either become a reference for the creation of a BIM model, or it can be viewed on its own through the use of XR tools. Problematic locations on the construction site may be tagged in the 3D model (either CAD made or derived from the point cloud) by an OSH manager, who may then brief individuals on those hazards. The briefing can be a record or done live if the job is specific.

Scenario One: Personal Protection

Maintaining worker safety on the construction site is ensured through proper training on the use and application of personal protective equipment (PPE). Workers are taught prior to the start of their employment at a construction site what type of PPE they will need to wear when entering the site. A simple training scenario has been developed that teaches workers, through a game-like simulation, about what PPE they require using a virtual reality (VR) environment.

The VR simulation begins with the worker finding themselves on the construction site, with the ability to move their head and look around a 360 degree image. Located on the image (Fig.2) is a person without proper PPE as well as a test form where the trainee will have to fill in the appropriate fields as a response to the message. The trainee then needs to select the correct items. If the trainee selects the helmet, high-reflective vest, and boots, then they successfully pass the test.

Figure 2. Basic Tests

Scenario 2: Securing technological openings

The second developed scenario is one that describes the procedure to enact when finding a construction site safety hazard, such as an unsecured technological opening. The worker will be shown an area with a wall opening without any railings or barriers present that indicate possible danger (Fig.3). The worker will then follow a series of prompts and instructions advising them on how to conduct themselves in such a situation.

Figure 3. Testing in environment

First the worker would have to identify the problem, and then simulate reporting the hazard. The simulation would allow the worker to place virtual cones that fence off the danger zone. The worker should be able to freely walk around and interact with the environment. The worker will also be guided on how to prepare for securing the area if there is a risk that they themselves could be injured: this would include getting the proper permissions, wearing the appropriate PPE, putting on harnesses, and instructions on how to install the barriers.

III. Implementation and IT side

In regards to the tools for XR there is a vast selection to choose from but in this case the choice was set on Oculus Quest 2 (Fig.4) [2]for hardware, and Unity[3] for software development environment. The Oculus is one of the most popular solutions for cost effective XR equipment with Pico Neo [4]as close second.

Figure 4. Oculus Quest 2

Although marketed as a VR set, it has the ability to see and recognize the outside world.

This in turn can expand its use as an AR device as well. Of course for this project its use is limited to VR and while AR is viable in most cases, the idea of people walking on a construction site with the headset with its limited vision is incredibly dangerous.
That is the main benefit of dedicated AR hardware such as Hololens 2 by Microsoft which uses transparent displays that provide an augmented view as a semi-transparent hologram instead of the complete control of the sight of the user. With it you can see what you need to see without being unable to notice the specifics and dangers of the environment around you.
The Oculus Quest 2 hardware has similar performance to high-end This can allow highly realistic virtual environments and although photo-realism is not always entirely necessary for the task at hand it can noticeably improve the immersion and interest of the worker that will be put into the simulation. It can also raise the stress factor which is also necessary for the simulation as the ability to work under stress is quite important.

The software used included the Unity game engine as a software platform in which necessary libraries such as OpenXR and others were imported. Much of the libraries, although open source, are overcomplicated, so if one were to try to build software from scratch one would need a very large team just handling the compatibility between the software and the libraries working with the hardware. The work is much simpler with Unity since when a company launches new hardware they always want to make it compatible with what is popular (such as Unity). Open XR is a project for the standardisation of VR, whose site is very helpful. The necessary libraries are all available on Oculus Quest’s site as well as their account in the Unity Marketplace. They are free to download.
It all takes about 10 minutes to set everything up and so the focus can be on the actual training environment.

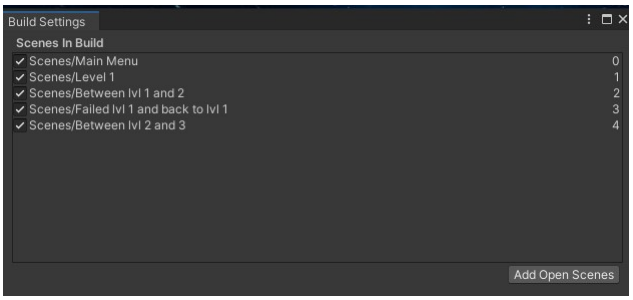
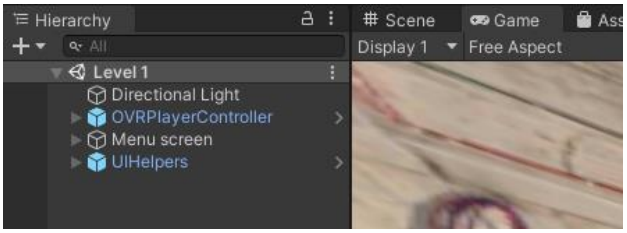


Figure 5. List of scenes

Unity also supports levels which are also known as scenes. Work can be separated into levels, as seen in Figure 5. This way everything on the machine does not have to load at the same time. It is possible go up and down the levels and load just what is needed for the current task. The libraries and the functionality are all in the same files in the hard drive, while the scene is what is currently loaded in the RAM memory. This is important as it is needed to drag and drop from the libraries to the scene each and every time a new level is set. Either that or copy the level work as the next level and then modify it. The Drag and Drop process only creates instances of the classes without copying the actual files.



igure 6. A scene’s work tree
(Hierarchy Window)

Seen on Figure 6 is the scene for Level 1. In white letters are the standard parts of the Scene. Such as for the level’s directional light (Sun). and the added from the scene canvas with buttons called “Menu screen”. They are part of Unity.
The parts in Blue are the ones added from the library import from Oculus. A standard scene also comes with a Main Camera which needs to be deleted as OVRPlayerController comes with its own VR camera. UI Helpers contains scripts such as laser guided button clicking whose trigger for buttons is the same as if it was

clicked with a mouse. The beauty of Unity is that it is modular and much of the work in it will work the same regardless of difference in hardware or the nature of the tasks they are implemented for. Clicking buttons is the simplest case as their trigger can come from VR, desktop clicks or even if they are shot in a game if the gun or its projectiles are registered as an operator.

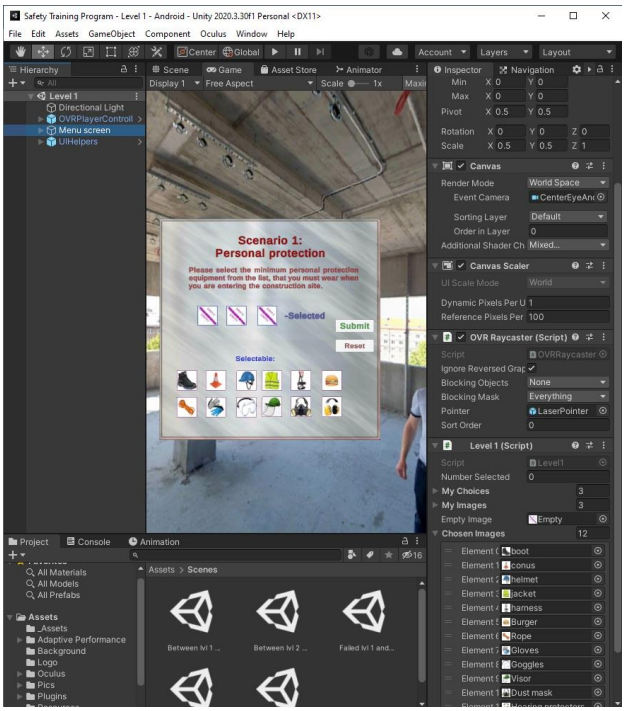


Figure 7. How Unity Editor works

On Figure 7 the selected canvas “Menu screen” can be seen along with all of the things that have been added to it. OVR Raycaster is added as a receiver of the Laser pointer. The laser pointer is added to the hand and from the scene it is selected and dragged to the Pointer position.

With knowledge of what the libraries do, it is possible to connect them together without having to write even a single line of code.

“Level 1. Script” however, is entirely custom written code in which lies the true beauty of working with Unity and that is that it is exceptionally easy to create modular scripts that can be used in all sorts of situations.

Level 1 scripts has Chosen Images which is an array whose size is defined by the box right next to it and its content is below it.

How it is structured is all up to the developer but the rule of thumb is to make it as simple as possible while also to be usable for other tasks as well.

That is why the array size is defined in the editor and not the script.

For simple tests such as the first level of the training simulation, it is advisable to lock down the movement of the user. That way they will have the panel with the test in front of them to work with and not much else to distract them from their work. Instead of terrain around them a simple 360 skybox is absolutely sufficient and since they can’t exactly move from their spot the absence of actual terrain will not bother them much.

The second level is a task-by-task where one would need to walk around. The terrain is the CAD model of the building which can be provided as an .IFC file. A direct CAD model has good geometry of the terrain but material-wise it is usually as minimalistic as possible. A short work with a 3D modelling program such as blender and with the use of smart materials, a blank-looking, pale model can be turned into realistic vibrant terrain for the level.

Collision with the model is not hard to add and once that is done, most of the work is completed.

A task-by-task simulation is not so much about testing the worker if they will make the right decisions but rather to ingrain the procedure into their brain as to have them follow it as a reflex [5]. If there is a dangerous spot it should never be ignored and its resolving should not be postponed for later. Postponing usually leads to forgetting and an unresolved problem especially a dangerous one can cost a person’s life.

Even if it is told to a worker a thousand times, it may not have the same effect as going through the simulator and having it ingrained into their psyche with its careful design and focused attention to specific details.

Another issue is that dangerous situations are often something a worker is rarely exposed to. And that’s where the danger is most prevalent, as parts of the manual may be forgotten. XR is a

good alternative to remind the worker of it[6], although it needs to be crafted professionally because a bad simulation can do more harm than good.

IV. Conclusion

When it comes to safety it always needs to be made with the lowest possible expectation of the capabilities and attention of a worker as even the highest skilled worker may temporarily lose their attention to their environment due to stress or being tired and the possibility of an accident is simply something that should be fought against at all costs.

If there are means that effectively reduce the risk of accidents, they simply need to be implemented. That is often the law.

ACKNOWLEDGMENT

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References:

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[Warning, it contains graphic images]
Despite its music and presentation it's very serious.
Our approach in the VR training however is different.

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