Practice Paper

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VIRTUAL INDUSTRY VISITS USING IMMERSIVE 360º VIDEO: ENSURING ACCESS FOR ALL ENGINEERING STUDENTS

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ABSTRACT

The work presented in this practice paper illustrates how the use of immersive 360º video and photographs, viewed in virtual reality headsets or via 360º media players, can enhance and broaden student knowledge and experience when undertaking Project Based Learning (PBL) assignments. This paper will highlight an array of mediums in which a Virtual Site Visit (VSV) can be shared with students. By using coverage of real buildings, PBL assignments can be set for students which are real and innovative. This pedagogical approach allows educators to use particularly interesting or challenging buildings and case studies, once a VSV has been generated. This is particularly useful: for students who may have accessibility issues

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due to physical disabilities; the sharing/experiencing of interesting structures from around the world in a much more meaningful way; or for distance/online learning.

This practice paper will share the equipment specification for recording the VSV, a suggested workflow in preparing for the recording of the visit along with the video recording methodology and editing process, with proposed mechanisms for sharing the VSVs with students. Feedback was gathered and is shared in this paper from a cohort of students undertaking a Health and Safety module, in which a VSV video was used to share the building on which a PBL assignment was based.

1 INTRODUCTION

1.1 Project Based Learning and Virtual Site Visits

The work presented in this practice paper illustrates how the use of immersive 360º video and photographs, viewed in virtual reality headsets or via 360º media players, can enhance and broaden the student experience when undertaking Project Based Learning (PBL) assignments. It has long been a practice of setting civil engineering students a PBL assignment based on a field trip or site visit. The literature clearly links the use of PBL assignments as a means of enhancing the engineer's education by improving their technical skills, and providing context for real-life engineering issues and challenges (Ríos et al. 2010, Kokotsaki, Menzies, and Wiggins 2016). However, there is an ever-present problem around ensuring that all students have access to the visit material particularly where, for example they were sick on the day of the visit or have accessibility issues. Indeed, the recent COVID-19 pandemic clearly illustrated the need for an alternative to the physical 'site visit'. (Ríos et al. 2010, Kokotsaki, Menzies, and Wiggins 2016)

2 PROJECT MOTIVATION/BACKGROUND

Student visits to construction sites and manufacturing facilities are a key component in the education of engineers (Shojaei et al. 2023, Wang et al. 2021). Engineers Ireland, the accrediting body for engineers in Ireland, have identified seven programme areas that need to be addressed in the development and design of engineering programmes (Engineers Ireland 2021). Two of these programme areas, PA2 Discipline-specific Technology, and PA5 Engineering Practice, identify industrial or commercial site visits, and real-world-based case studies and projects, as key measures to meeting these two programme areas.

However, the question arises, in the design of programmes and the integration of such industrial visits, case studies or project-based learning assignments, how can the issue of limited or no access to such facilities be addressed? There could be students with limited mobility in a class cohort; there could be a site/industrial location with sensitivities around accessibility and confidentiality; or in an extreme situation, a general lockdown on movement as was seen during the COVID-19 pandemic. Moreover, restricting options to in-person site visits places limitations on the pool of structures that can be visited, and/or are expensive to conduct for entire student groups.

To address these issues since the onset of COVID-19 in March 2020, work has been underway within the Department of Civil, Structural and Environmental Engineering at Munster Technological University (MTU) to develop a more innovative approach, with the development of the 'virtual site visit' (VSV).

There is a growing body of literature investigating how students learn from VR and 360º videos and their benefits/short falls (Marinelli et al. 2023, Wolf et al. 2023). Whilst these VSVs may not replace an actual site visit; they are an excellent substitute when site access is not permitted or possible. They aid the development of critical thinking, problem-solving, spatial awareness, demonstrate construction technologies etc.

To ensure accessibility for all within the class cohorts, research was undertaken to see if there was a more innovative approach than using 2D photographs and videos to preparing these VSV. This has resulted in the purchase of equipment and the development of immersive 360º videos. This work was prepared in partnership with MTU's Technology Enhanced Learning unit (TEL).

3 PROJECT EQUIPMENT AND SOFTWARE

3.1 Previous Equipment for VSVs and software

Previous equipment used in creating 2D virtual visits included a Nikon Z50 digital camera, with a tripod and recording equipment. This equipment was used for a number of VSVs, and whilst the photo and video quality were excellent, there were several issues encountered. These included the tripod set-up: the setting up of the tripod for the 2D Nikon camera is difficult when visiting a live construction site with moving vehicles etc. It takes time to level the device, only to have a large machine move towards you and you must re-level it again. A gimbal is needed for capturing video, if the camera is not on the tripod. Walking with the camera – without a gimbal leads to very 'jumpy' video footage.

3.2 360º video equipment for VSVs

This project investigated a number of alternative 360º cameras with the Insta360 the preferred choice. The following is the equipment specification of what was used in this project.

- Insta360 X3 camera with a tripod and stand as illustrated in figure 1 below.
- InstaStudio: The purchase of the Insta360 camera is accompanied by a licence for the editing software, which is downloaded via an app to your smartphone and also to your computer/laptop.
- DJI wireless mic and receiver set as illustrated in figure 1 below.

Figure 1: Insta360 camera and DJI wireless mic set with receiver and charging case

The Insta360 was first developed in 2015, by Arashi Vision Inc. In 2018 they introduced the FlowState stabilisation algorithm into their cameras, thus enabling the user to shoot video as though using a gimbal (Arashi Vision 2024). The X3 model, which was used in this project, can record 5.7K 360° video, 360° photos or 180° field of view photos. The camera can be controlled from an app on your smart phone or via the camera itself. Whilst the small screen on the back of the camera makes it slow to use, the mobile app has an excellent user interface. The recorded video can be shared as a 360° video on, for example, YouTube or the video can be reframed in the Insta360 studio for the best angles.

The camera has a ¼ inch (6mm) socket at the bottom which allows the camera to be mounted on a selfie stick or a tripod. If using the camera remotely outside, it is possible to mount the camera on an extension, or 'selfie' stick and use a heavy base plate for stability.

3.3 360° video software for VSVs

The Insta360 camera is linked to the user's mobile phone via the Insta360 app. This app allows the user to remotely operate the camera for either photos or videos. The user can edit the photos and videos recorded via the app – using the Snap Wizard, or import them into the InstaStudio on their laptop via the SD card or USB connection.

Captured photos and videos can also be shared on the users' social media accounts of Instagram and Facebook directly from the app or they can be uploaded to the Insta360 Album and can be accessed whilst not connected to the camera. Photo and video can also be mixed with music before sharing. All this is managed within the App or in InstaStudio. If wishing to combine videos for more detailed post-production then each Intsa360 video can be exported from InstaStudio as an MP4 file and imported into video editing software like Adobe Premiere Pro or Adobe Rush.

4 Instructional Design and Workflow Methodology

The instructional design approach for these VSV using immersive 360° video integrates multiple theoretical frameworks to enhance the learning experience for students. The ADDIE model underpins the development of these visits, ensuring a comprehensive process from initial analysis through to evaluation. This has been complemented by Mayer's Cognitive Theory of Multimedia Learning, which advocates for the integration of words and pictures to deepen understanding and retention. The rich media utilised in this project aligns with Mayer's principles by engaging both visual, spatial and auditory channels, thereby facilitating a more robust learning experience. Additionally, Constructivist Learning Theory informs the pedagogical strategy, emphasising the importance of learners constructing knowledge through authentic, experiential activities.

4.1 ADDIE Model

Each phase the Addie Model (A - Analyse; D- Design; D – develop; I -Implement; E – Evaluate) will be expanded in the following sections explaining how each of these steps have been conducted on the preparation of the VSVs.

4.2 Analyse phase – the need for VSVs

The VSVs were 1st developed within the Department to support student learning during the COVID-19 pandemic. They were used in various PBL assignments across structural engineering, civil engineering, architecture, architectural technology, and programmes in Building Information Modelling (BIM). They included modules in: Project Management; Health and Safety; Construction Technology; and Structures.

However, with the emergence for more 360º video technologies and the use of VR in engineering, the decision was made to explore and develop immersive 360º VSVs which could be used for PBL assignments. There are also some students in a department with accessibility issues, and thus not able to visit the site. In selecting the case study site, a public building was identified which was easy to understand from a structural engineering perspective, with an exposed structural frame etc. Recording a public building ensured that there are no copyright issues regarding the sharing of the building's images, and also the tender drawings for the structure were available on the eTenders website (Procurement 2024).

The selected building was a new public building in Cork, the Central Hall or 'Red Shed' at Cork's new Marina Park 2.

Figure 2: 'Red Shed' - Central Hall, Marina Park, Cork

The 'Red Shed' project and the VSV material have formed the basis for a PBL in a Health and Safety module. Students were tasked with undertaking a risk assessment and preparing a method statement for the construction of the Red Shed at a (hypothetical) site on the University's campus..

4.3 Design Phase - Scripting/pre-production

When preparing a video, and getting the line-up and script ready there are a number of questions which need to be addressed: what is the purpose of the video; what is it trying to share; who is the audience; what is the message that we want them to take away from it; have we many audiences – if so, does the video need to be more generic? This will influence the script/storyline of the video. What is the optimum length of the video? What length will students watch?

Always answer each of these before preparing your video structure and script. In the example of the case study for this paper, the primary focus was to capture a building so that students could understand how it was made, and that they could replicate it on campus.

4.4 Development Phase – video capturing and sound recording

There are several items to consider when preparing for video recording. The primary one which had an impact on the preparation of this video was the weather, with many lessons learnt. This video was to be recorded during the month of November, however with the low angle of the sun and if you have a bright day, the ‘invisible’ stick supporting the camera will cast a shadow on the ground, which will be very visible in your video.

The DJI independent voice recorder was used in making the case study video, as the wind etc can interfere with the sound captured in the Insta360 (see section 3.2 above). A recording device could be fitted to the Insta360 camera – like a receiver for the DJI speakers, but this receiver would then be very visible in the video. Also ensure that there is a windscreen fitted to the microphone to ensure as little wind interference in the recording as possible.

Editing and post-production

Premiere Pro from the Adobe suite was used in the post-production of this video. This was used over InstaStudio as it allows multiple clips to be edited together, providing students with a more contextual visit of the site.

4.5 Implementation phase – sharing of 360º immersive videos

There are several options to share the videos with students. In this instance YouTube was chosen as the sharing medium of this project as seen in Figure 1. A channel was set up and made public. It is important to note, that when editing and publishing 360° video you will be dealing with very large files. For example, depending on the export settings, one minute of video at 4K will be in typically be in excess of 1GB of file storage.

The case study site for this project has been shared via YouTube and the Matterport app, which uses Artificial Intelligence (AI) to generate a virtual walkthrough or ‘Dolls House’ of the building. Access to this walkthrough is then shared with the students via a link on Canvas, the University’s learning management system (Canvas 2024).

Figure 1: YouTube video and QR for access to video

Matterport is an online 3D data platform which allows a space to be scanned and a 3D walkthrough developed (Matterport 2024). A Matterport licence was purchased for this project. The licence permits you to prepare a digital twin of the case study space. The licence includes an online account and a smart phone app. This smart phone app then communicates with the Insta360 camera which scans the case study building. The data is uploaded to Matterport and after some processing time, your 'dolls house’ of the case study space is ready.

4.6 Evaluation phase – The Student Survey and their feedback

A survey of 47 students in the department who have participated in the PBL assignment using the Red Shed VSV was undertaken, with the survey receiving Human Research Ethics (HRE) approval, HREC-MR-23-059. Students were asked to evaluate each of the options of learning about the 'Red Shed'. These included 2D photographs, 2D video, a narrated slideshow on YouTube using 360º video clips or the fully immersive 360º video on YouTube and the Matterport walkthrough.

Regarding 2D material for the Red Shed, students were asked which gave them the best understanding of the structure. They ranked 2D photos as best, followed by 2D videos, engineering drawings and architect's drawings.

Regarding the 3D material for the Red Shed, students were again asked to rank which medium gave them the best understanding of the structure. They ranked the Matterport walkthrough as the best followed by the 360º YouTube video, which they viewed using their own phones. The MetaQuest 3 headset was also used during the survey to share the 360º YouTube video. There were several issues encountered with using the headset. These included a lack of connectivity for the headset, the need for an additional lecturer to share the headset with students, and students not wishing to use the headset citing health issues – vertigo and migraines. In total 10 students got to use the headset in the one hour lecture slot versus all 47 being able to undertake the Matterport walkthrough and view the YouTube 360º video.

Students were asked to *'Describe any specific aspects of the* 360º *immersive videos that you found particularly helpful or challenging in understanding the site / building',* with some very insightful responses. They particularly appreciated the personal independence of being able to check out the area they were interested in. Because they can use their own phones to undertake the virtual walkthrough it is so easily accessible for all of them.

'Being able to see all around'
'getting a better idea of the size of the structure, more realistic look on it'
'I like that you can look/move to wherever you want.'
'Having a free view of what I wanted to look at'
It is the closest you can get to being there through media so it is very effective'
'It's very helpful providing digital prototypes of designs'
(Mary Moloney 2024)

The immersive nature of 360° video allows students to interact with realistic environments, fostering problem-solving and critical thinking skills essential for engineering education. This multi-faceted approach not only addresses diverse learning needs but also enhances accessibility, providing all students with the opportunity to engage with complex, real-world engineering contexts.

5 SUMMARY AND ACKNOWLEDGEMENTS

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