# LEVERAGING 360VR TECHNOLOGY FOR SELF-DIRECTED AND COLLABORATIVE LEARNING: A CASE STUDY ON TECHNOLOGY-ENHANCED ENVIRONMENTAL TRAIL REHEARSALS

Mariam Mathew*[a], Yew Kong Tan[b] and Endu Tee[b]

[a] Ngee Ann Polytechnic/ School of Life Sciences & Chemical Technology, Singapore.
[b] Ngee Ann Polytechnic/ Centre for Learning & Teaching Excellence, Singapore.

Mariam Mathew* (Mariam_MATHEW@np.edu.sg)

**Singapore's Active, Beautiful & Clean (ABC) Waters concept reflects the nation's vision of maximising the use of its waterbodies by seamlessly integrating them into the urban landscape and daily life. This approach promotes public awareness and fosters a sense of stewardship towards water resources and the environment. The *ABC Waters Management* module in the Diploma in Environmental & Water Technology (EWT) introduces students to the ABC Waters concept and allows them to contribute to this national initiative through a real-world service-learning (S-L) project. Specifically, students plan and conduct an ABC learning trail to educate the community about Singapore's ABC Waters programme. Using 360VR technology, a 3D Site Visit platform (3DSV) was developed in January 2024. 3DSV supports both self-directed learning (SDL) and collaborative learning (CL). The platform supports students' preparation through immersive virtual site visits and rehearsals, either individually or in groups. The initial 3DSV interactive features included links to videos and animations demonstrating ABC design features in wet and dry weather flow conditions, and virtual cue cards highlighting key features at each station. The 3DSV platform was further enhanced with self-check station quizzes in the October 2024 Semester. This paper highlights the design of 3DSV, reviews its impact on learning and discusses the insights and considerations when exploring innovative approaches to technology-enhanced learning. To prepare the students for planning and conducting the ABC learning trail, they were briefed about the project requirements, required to participate in a physical familiarisation site visit led by the lecturer and introduced to 3DSV. After conducting the learning trail, the students completed an online survey on their user experiences and feedback on 3DSV. Sixty-eight second-year EWT students responded to the survey over three semesters between October 2023 and February 2025. Most students reported using 3DSV to prepare for the learning trail and found it useful and easy to navigate. They appreciated the virtual access it provided to the physical site, considering it an engaging and viable alternative for facilitation preparation. However, they noted that virtual visits did not replace the need for physical on-site rehearsals. The newly added station quizzes helped students check their knowledge, recall key points, and collaborate effectively within 3DSV. These findings highlight the value of immersive IT tools in promoting self-directed and collaborative learning.**

***Keywords:*** *self-directed learning, collaborative learning, 3D virtual sites, 360VR technology, immersive IT tools*

## Introduction

Singapore's water policies have evolved from focusing on basic necessities to enhancing liveability. Singapore's National Water Agency (PUB) launched the Active, Beautiful and Clean (ABC) Waters Programme in 2006 to transform waterways and reservoirs from drainage infrastructure for flood management into recreational spaces. PUB aims to harness the full potential of Singapore's waterbodies and foster a sense of stewardship towards water and the environment (Ministry of National Development, 2017). The ABC Waters Programme also supports the nation's stormwater management strategy, climate change adaptation and biodiversity (PUB, 2024).

ABC Waters Management is a second-year module in the Diploma in Environmental & Water Technology (EWT) at Ngee Ann Polytechnic. It introduces students to the ABC Waters concept through a real-world service-learning (S-L) experience. S-L combines community engagement with academic learning, using reflection to deepen understanding of concepts. (Bringle & Clayton, 2012). S-L is a signature pedagogy adopted at Ngee Ann Polytechnic.

As part of the S-L project, students plan and conduct an ABC learning trail to educate the community about Singapore's ABC Waters Programme, the Singapore

Water Story, and environmental issues such as climate change.

Prior to the October 2023 semester, students were briefed on-site and encouraged to revisit the site to familiarise themselves with the site and rehearse. It was observed that time and weather constraints made this difficult. This resulted in students being unfamiliar with the site, and difficulties in managing large groups of visitors, especially when alternative routes were required. Hence, there was a need to turn to technology to improve accessibility to the site and learning trail.

Immersive technology has been widely used in education to provide real-world simulations, access to limited resources and facilitate self-paced and collaborative learning through immersive and interactive learning experiences (Kavanagh et al., 2017). This technology has the potential to enhance learner engagement and motivation through realistic and authentic learning scenarios, and to support personalised self-paced learning whether individually or with peers (Eiris & Gheisari, 2022; Leininger-Frézal & Sprenger, 2022; Suh et al., 2023; Rosendahl & Wagner, 2024; Chaudhari et al., 2025). These reports highlighted the potential for application of 360VR technology to develop a 3D Site Visit platform (3DSV) to support students' preparation for the ABC learning trail through immersive virtual site visits and rehearsals.

This paper details the features of 3DSV, reviews the impact on students' learning, and discusses insights and considerations when exploring the adoption of immersive technology to enhance learning.

## Materials and Methods

**The 3D Site Visit platform** (3DSV) was developed in the October 2023 semester using 360VR technology to support site familiarisation. A Matterport Pro 3 Lidar camera was used to develop the 3DSV platform for the Sungei Ulu Pandan ABC site in western Singapore, spanning 800m along the south bank and 1.4km along the north bank of the concrete-lined river. Besides the route along both banks, a total of six stations (labelled A to F) featuring the ABC treatment elements were included (Figure 1). 3DSV was rendered using Software as a Service (SaaS) from Matterport.


**Figure 1**: Dollhouse view of the ABC Site and the six stations at Sungei Ulu Pandan.

**Interactive 3DSV Features.** The following learning features can be accessed by students either independently or collaboratively with their team members.

1. **The videos (Figure 2) and animations (Figure 3)** were designed to deepen students' understanding of the ABC design features in operation in both wet and dry weather flow conditions.

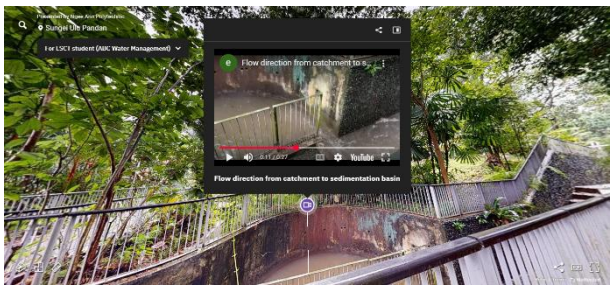


**Figure 2**: Video embedded at Station B to illustrate the mode of operation in wet weather flow.

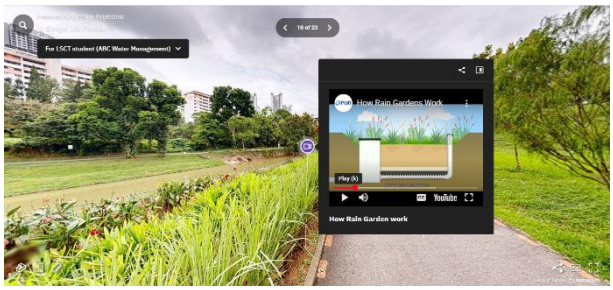


**Figure 3**: Animation embedded at Station E to illustrate how rain gardens work.

2. The **virtual cue cards** (Figure 4) highlighting the key features at each station aimed to emphasise and reinforce important information to enhance the accuracy and quality of students' delivery of the learning trail to educate the community about Singapore's ABC Waters programme.

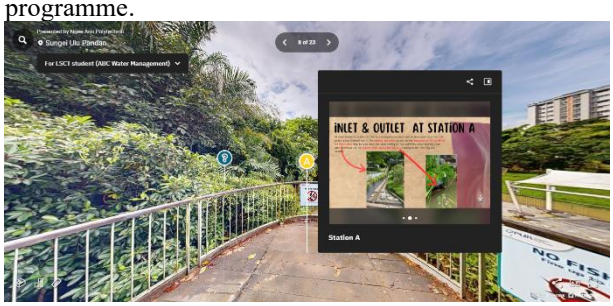


**Figure 4**: Virtual cue card embedded at Station A

3. The **self-check station quizzes (Figure 5)** were added as an additional feature to the 3DSV platform in the October 2024 semester. These quizzes with automated feedback were embedded using links to the Brightspace Learning Management System. These allowed the students to check their understanding through repeated attempts. The lecturer is able to monitor student performance and provide feedback using Brightspace quiz statistics to address issues with concepts.

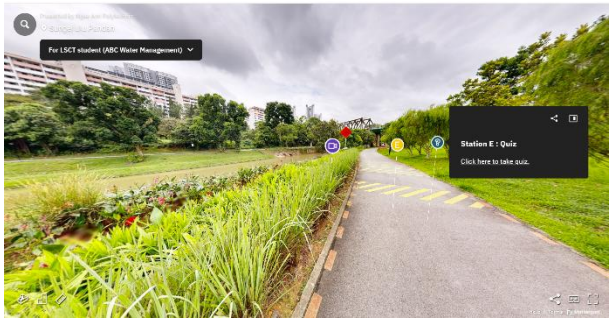


**Figure 5**: Embedded link to quiz at Station E

**Preparation for the ABC Learning Trail.** Towards mid-semester, the lecturer briefed the students on the project requirements, conducted a field trip to familiarise them with the site, the route, and the features at each station. The students were strongly encouraged to revisit the site closer to the learning trail event to review the ABC features, stations, script, routing, and delivery flow.

Students were introduced to the 3DSV platform with instructions on how to use it, and what their groups should anticipate and prepare for, on the ground. Students are given the option to choose to use 3DSV while preparing for the learning trail.

**Post-Event Survey.** After conducting the learning trail, students were required to present their project preparation, implementation, and reflections to the lecturer and service-learning partners. The students completed a Google Forms survey to share their 3DSV user experiences and its impact on their learning. The survey comprised four items with Likert-scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) and four open-ended questions. They were also invited to share their feedback on 3DSV. A total of sixty-eight second-year EWT students responded to the survey over three semesters between October 2023 and February 2025.

## Results and Discussion

Of the 68 respondents, 92.6% reported that their groups used 3DSV to prepare for the learning trail. Amongst these users, 98.4% found it useful. The high utilisation might have been boosted by active guidance on using 3DSV to gain student buy-in. Furthermore, allowing the students to propose their own on-site deployment plans might have encouraged site exploration using 3DSV to help their organisation of the learning trail.

**User Experience.** Most respondents found 3DSV easy to navigate, engaging, and providing easy virtual access to the physical site. Figure 6 shows favorable average ratings above 4 for these indicators of user experience.

These findings supported the application value of immersive technology in providing engaging learning experiences and encouraging repeated visits with easy access to the learning trail site (Kavanagh et al., 2017; Leininger-Frézal & Sprenger, 2022). A (student) respondent shared that *"It was useful as it **helped us to prep better** before the actual day itself and we **don't have to take the time out to physically visit the site to practice**."*

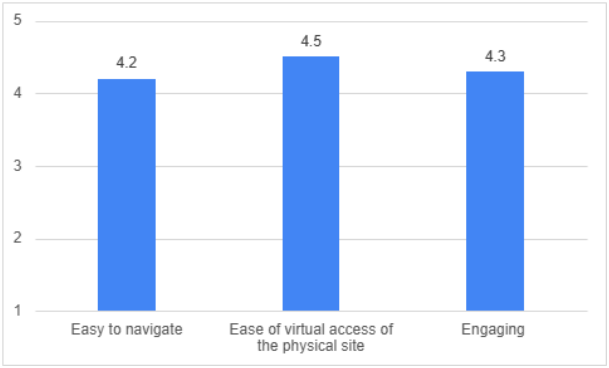


**Figure 6**: Mean Ratings on User Experience (n=63)

**User Impact.** Most respondents indicated that 3DSV helped them prepare for the implementation of the learning trail. Figure 7 shows favorable average ratings above 4 for these indicators of user impact.

This positive response appears to be attributed to three key features of 3DSV: 1) allowing visualisation of the physical site, 2) allowing multiple visits to familiarise themselves with the physical site, and 3) helping preparation for the implementation of the activity. Chaudhari et al. (2025) highlight the potential of immersive technologies in enhancing realism and engagement through spatial visualisation and supporting different learners.

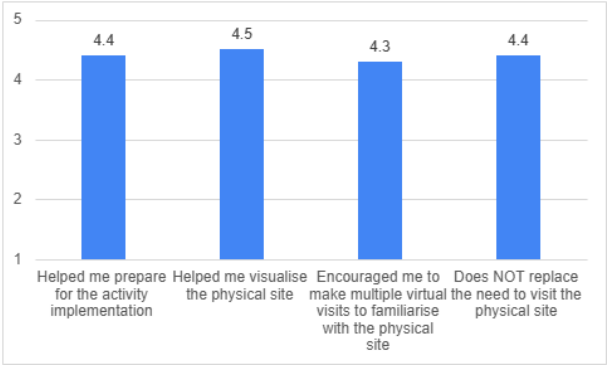


**Figure 7**: Mean Ratings on User Impact (n=63).

A respondent shared that *"The Matterport site **allowed us to better visualise and familiarise ourselves** with the site as we've only been there once with our tutor. With the Matterport site, we were able to **better prepare ourselves for the actual day event** so as to ensure a smooth sailing experience for both the (visiting) students and us during the introduction of the different sites."*

Another respondent highlighted its overall usefulness while noting its limitation, *"The Matterport site **provided***

***us with an accurate view of the site and it helped us prepare better*** *when it comes to presenting at the stations and it* ***allowed us to visualise the path that we are taking*** *and it is also* ***easy to use and the quality is as if it was right in front of me*** *so it could have been a great alternative for rehearsal and I would feel like there won't be much of a difference but obviously* ***there are certain areas where it is harder to see in the virtual site compared to the physical site*** *but* ***overall*** *the Matterport site was* ***very accurate and reliable****."*

While most of the respondents found 3DSV useful, most also felt that it does not replace a physical visit (mean rating of 4.4 (Figure 7)). This observation aligns with Leininger-Frézal & Sprenger (2022), whose students too, observed that real field trips have more significant advantages. Suh et al. (2023) made similar observations in the context of clinical practice.

A respondent who revisited the physical site for rehearsal shared that "*Despite using the virtual map to go through the different stations online,* ***there were still some parts that we needed to clarify for ourselves physically at the site as the virtual map has limitations*** *to the angle or extent of exploration we can view online".* Another respondent shared that *"Yes, our group did a rehearsal at the physical site due to the lack of visitation to the site by ourselves* (with our lecturer) *so we weren't really familiar with the environment and so we needed to come down and gather information on the site and path that we are taking and I'm glad that we did* ***because we were able to find the exact location of our site and station and other interesting points which we were able to present to the participants with full confidence*** *as we did a trial run during the recce and rehearsal at the physical site."* Yet another respondent shared that *"Some of my groupmates and I went down to Sungei Ulu Pandan again sometime in January to recce the place by ourselves, taking note of how the features work during a heavy downpour. It was interesting to note how the features operate differently with different weather conditions. We saw how it was during Dry Weather Flow (DWF) on the 3 Dec when we visited the site as a class, and we witnessed how it was during Wet Weather Flow (WWF) in mid-Jan when we visited the site on our own. We also went there early on the actual day as a whole group to rehearse and familiarise ourselves with the route again."*

Majority of the findings underscore the value of 3DSV in enhancing preparation to facilitate the learning trail. Clearly, 3DSV provided realistic representation of the site and allowed repeated visits (Rosendahl & Wagner, 2023). However, despite its benefits, 3DSV may not fully replicate the experiences of being at the physical site. A respondent suggested *"[…] Add in sounds! Make the experience more 3D/4D. Have a variation of events. For example, how the water looks like when it rains. How the vegetated swale actually works etc.".* Furthermore, the resourcing (e.g., cost, time, manpower) required limits timely updates to reflect changes at the site. For example, a student highlighted that *"It can be updated from time to time since any things may have changed since doing up the Matterport."*

**Self-Directed and Collaborative Learning.** The 3DSV features, including videos and animations, virtual cue cards and self-check station quizzes allowed self-directed (independent) and collaborative learning.

Station quizzes were added in the October 2024 Semester. 96.6% of the students (n=30) used the station quizzes to check their knowledge. 100% of these students reported that they used the station quizzes to help them remember the key points to be shared. 90% of the respondents collaborated while using the station quizzes as they prepared for the learning trail event.

Students' reflections and qualitative survey comments indicated that they used 3DSV to prepare and rehearse for the ABC learning trail individually (SDL) and/or with their team members (CL). The qualitative comments highlighted that 3DSV could support collaborative learning. A student shared that *"We had an online practice before the service-learning project.* ***Since our schedule clashes, we use the Matterport site to have a quick run through of our parts (using MS Teams to share screen)*** *as well as using the* ***interactive quiz to enhance our knowledge before the service-learning project day****."*

Just like all educational technologies, the effectiveness of 3DSV depends on its ability to realistically simulate diverse varied real-world experiences and its capacity for timely updates that reflect the evolving contexts. Student feedback highlighted opportunities to enhance the current 3DSV by incorporating dynamic weather simulations and strengthening realism with visual and auditory elements, potentially via AR integration. Furthermore, there is potential to include AI-driven interaction to enable conversations along the learning trail to support practice in simulated real-world context..

## Conclusions

The high utilisation, favorable user experiences and impact on learning supported 3DSV as a viable alternative that supports the students' preparation for the ABC learning trail. Most students found 3DSV useful and easy to navigate. They appreciated the easy virtual access to the physical site and found it engaging and useful. The newly added station quizzes also helped students check their knowledge and recall key points effectively within 3DSV. While 3DSV allowed for independent self-paced learning, the qualitative comments emphasised its value in enabling collaborative learning.

Clearly, 3DSV is an important resource for those students who could not revisit the physical site for rehearsal due to time or weather constraints. However, most students, including those who relied on 3DSV for preparation, acknowledged that 3DSV does not replace the need to visit the physical site. They recognised the importance of on-site rehearsal to prepare themselves for aspects of the learning trail that might not be fully captured in the virtual environment, as well as any changes at the site.

## Acknowledgements

The authors would like to thank Ngee Ann Polytechnic for supporting this work; PUB, Singapore's National Water Agency, for supporting the EWT course and ABC learning trails, and securing secondary school participants and teachers; Terraformers World for partnering with us to secure participants from the community; and XYLEM Water Solutions Singapore Pte. Ltd. for corporate participants.

## References

Bringle, R. G., & Clayton, P. H. (2012). Civic education through service learning: What, how, and why? In L. McIlriath, A. Lyons, & R. Munck (Eds.). *Higher education and civic engagement: Comparative perspectives* (pp. 101-124). Palgrave Macmillan.

Chaudhari, V. M., Ponnuswamy, S., Muqeem, M., & R., P. (2025). Augmented reality (AR) and virtual reality (VR) in education: Assessing the impact on educational systems, content delivery, and student engagement. *International Journal of Research Publication and Reviews, 6*(6), 1776–1786. https://www.ijrpr.com/archive.php?volume=6&issue=6

Eiris, R., & Gheisari, M. (2022). iVisit-Collaborate: Online Multiuser Virtual Site Visits Using 360-Degree Panoramas and Virtual Humans. *Proceedings of the 37th International Symposium on Automation and Robotics in Construction (ISARC). International Association for Automation and Robotics in Construction (IAARC)*. https://www.iaarc.org/publications/fulltext/037_ISARC%202022_Paper_27.pdf

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A systematic review of virtual reality in education. *Themes in Science and Technology Education*, *10*(2), 85–119. https://files.eric.ed.gov/fulltext/EJ1165633.pdf

Leininger-Frézal, C., & Sprenger, S. (2022). Virtual field trips in binational collaborative teacher training: Opportunities and challenges in the context of education for sustainable development. *Sustainability, 14(19), Article 12933.* https://doi.org/10.3390/su141912933 (mdpi.com)

Ministry of National Development (MND): Centre for Liveable Cities, Singapore. (2017). Urban Systems Studies: The Active, Beautiful, Clean Waters Programme: Water as an Environmental Asset (1st ed.). https://isomer-user-content.by.gov.sg/50/7a481fd0-e545-417e-a14b-e414efee6694/rb172978-mnd-abc-water.pdf

PUB, Singapore's National Water Agency. (2024). ABC Waters Design Guidelines (5th ed.). https://www.pub.gov.sg/Professionals/Working-on-ABC-Waterways/ABC-Waters-Design-Guidelines

Rosendahl, P. & Wagner, I. (2024). 360° videos in education: A systematic literature review on application areas and future potentials. *Education and Information Technologies*, *29*, 1319 – 1355. https://doi.org/10.1007/s10639-022-11549-9

Suh, I., McKinney, T., & Siu, K.-C. (2023). Current perspective of metaverse application in medical education, research and patient care. *Virtual Worlds, 2*(2), 115–128. https://doi.org/10.3390/virtualworlds2020007 (mdpi.com)