A PILOT STUDY EXPLORING DIGITAL OUTDOOR KNOWLEDGE WORK AND LEARNING

Pete EVANS
Iowa State University, United States of America

ABSTRACT
Academia is challenged with learning and work in extended reality. This paper presents a pilot study, where a US university design class and an international university design class collaborated in a web-based 3D digital outdoor environment and then a web-based 2D digital outdoor environment with screen-based spatial proximity cues to provide students with informal design method learning and interaction. The spaces reflected spatial metaphors for these interactions to specifically support small groups. Students created avatars based on personas, took creative personal inventories, created, presented and discussed digital ID boards in small groups. Students were introduced to evaluation assessments such as the Simulator Sickness Questionnaire (SSQ), an Immersive Tendencies Questionnaire (ITQ), a workshop questionnaire, and a reflection assignment and class discussion. Findings presented are limited to the US class feedback. New foundations for future design learning and work are considered for these atmospheric mediated environments.

Keywords: Extended reality, spatial metaphor, coherence, outdoor work, learning

1 INTRODUCTION
For several years, governmental financial support for higher education has been declining [1], prompting an increased scrutiny of the cost and value of obtaining a college degree. Simultaneously, research funding and private investments in institutions are shifting, while the expenses associated with developing and maintaining physical college facilities continue to rise with or above inflation [2]. Design pedagogy in higher education, in response to these financial pressures, is also repositioning traditional studio pedagogy challenging costly cold-desking models with more flexible hot-desking spaces to optimise utilisation [3]. This shift is also evident in faculty and professional spaces transitioning to open-office layouts, huddle desks, and adaptable meeting rooms [4].
The aftermath of the COVID-19 pandemic, which necessitated prolonged periods of online learning, has forced higher education institutions to reconsider their long-term delivery strategies. While online education was met with resistance during the pandemic, it demonstrated the potential for integrating technology into learning environments in meaningful ways. With strategic planning and critical analysis, these digital tools are already reshaping higher education [5].
Beyond traditional online learning, the integration of emerging digital technologies—such as telepresence, digital twins, and geospatial computing—will likely mediate and transform how individuals interact, work, and learn in higher education settings [6, 7]. These advancements present opportunities for institutions to adopt innovative models that extend beyond the classroom, redefining the student experience in an increasingly digital and interconnected world.
One emerging trend is to conduct desktop and knowledge work in third spaces and outdoors as it brings health and well-being benefits [8, 9]. Both staff and students can work outdoors and be users of a so-called outdoor office. This may be part of a flexible office protocol for workers seeking to find their most productive settings for certain types of work. An outdoor office may be located in a designated or informal environment, i.e., a fixed setting with unique facilities or just an open space in a park. The physical outdoor environment is considered one key factor influencing working outdoors. However, the quality of such a physical environment varies, depending on e.g. location, environmental characteristics, and conditions. These qualities could be more or less beneficial for the individual learner or worker.
This paper aims to explore combining extended reality 3D digital technology with the experience of the outdoor office and knowledge work in a higher educational class exercise. This concept is implemented and reviewed in a collaboration between a United States university design programme in a course “How

Things Work" with and a remote international university design programme. The objectives were to (1) have students explore extended reality in this framework, modelled around digital space for small group interaction in an outdoor-like digital context, and (2) to use informal design methods to interact, become introduced to each other, the space and learn about themselves within this framework.

2 LITERATURE REVIEW

This area of academic research and published scholarship is limited. Searching Google Scholar for "higher education," "extended reality," and "outdoor work" together yields only three results and are not relevant. Substituting "higher education" with "design education" or "engineering education" within the combined search still limits the results to three and are not relevant. Substituting "higher education" with "industrial design," "product design," "human-centred design," and "user-centred design" has no returns. However, combining just "human-centred design" and "extended reality" or "user-centred design" and "extended reality" returns just above 1000 returns since 2021 showing these design ideas combined with extended reality technology does show recent an area of developing related research. This does point to an area of opportunity for identifying and evaluating extended reality and outdoor work together to objectively understand advantages or disadvantages when considering work and learning. Further, considering that Human-Centered Design (HCD) and User-Center Design are central to Product and industrial Design work and education, this points to a significant opportunity for design research and development and potentially new foundational teaching and learning methods.

Extensive research shows that access and exposure to green environments can reduce stress and cognitive fatigue. Within the discipline of environmental psychology, two well-established theories are the stress recovery theory by Ulrich [10] and the theory on cognitive restoration in green environments by Kaplan [11]; Kaplan and Kaplan [12]. Access to green spaces while working —both indoors and outdoors [13]— may enhance well-being among knowledge- and office workers, who perform a variety of tasks such as desk work, meetings, planning, reading, creative tasks, and more.

While studies on outdoor offices are limited, findings do suggest that such knowledge/office work is influenced by organisational support and the external (outdoor) environment [14], with an emphasis on calm, and green spaces [14, 15]. Additionally, virtual immersion in nature is not well understood [16].

In this paper, focus is given to the metaphorical aspects of such an external and spatial environment. Rosan Bosch, in 2018 [17], builds upon earlier research by David Thornburg's from 2014 [18] to propose six spatial metaphors as principles for different types of human interaction. These metaphors include the "Mountain Top," representing spaces for lecturing, addressing audiences, and broadcasting ideas; the "Cave," which supports individual focus, concentration, and quiet reflection; and the "Campfire," designed for small group discussions, collaboration, and brainstorming. Additionally, the "Watering Hole" fosters informal interactions, spontaneity, and serendipitous encounters, while "Hands-on" and "Movement" emphasise sensory stimulation and the connection between mind and body through spatial engagement. This framework defines a foundational approach to spatial interaction, integrating embodied principles to enhance learning and communication beyond the classroom [19].

Although Bosch originally conceptualised these metaphors for physical learning spaces, she does not constrain them to specific physical or typological environments, instead suggesting a more universal approach that aligns spaces with user needs and desired outcomes. These principles may also be applied to extended reality (XR) contexts, such as outdoor knowledge work in XR environments, where outdoor spatial settings can be augmented with additional work and learning elements. By leveraging these spatial metaphors within XR, interactions can be more intentionally designed to support user engagement and enhance outcomes based on context and situational needs.

Gernot Böhme, in Atmospheric Architectures [20], explores the concept of "tuned spaces" and the "aura" of atmospheres, describing them as an "indeterminate, spatially diffused quality of feeling" that invisibly intertwines body and environment in a quasi-objective manner. Böhme also refers to the ability to engage with atmospheres as a fundamental proficiency—a "basic competence of human existence." He argues that this competence plays a crucial role in contemporary education, which must account for the complexities of modern transitions from nature to technology. However, he critiques modern society's emphasis on efficiency, suggesting that it leads to an education system that is "one-sided" and insufficient for fully addressing human experience.

Böhme further expands on atmospheres as spheres of felt bodily presence, emphasising that atmospheric competence must be both perceived and produced. He outlines three key principles for developing this competence: (1) the significance of bodily presence is learned through the perception and creation of

atmospheres; (2) atmospheric competence involves recognising spatial dispositions as physically felt experiences, redefining the body itself as a medium of emotive participation; and (3) perceiving or producing atmospheres requires time, openness, and patience, as the body must be receptive and engaged to be truly affected by them. Through these principles, Böhme underscores the importance of cultivating atmospheric awareness as an essential aspect of human interaction with space.

This description of atmosphere fits within a post-phenomenological approach in design and recognises the importance of a new competence for a technologically imbalanced education and society. This competence is outlined in three ways addressing the self in self-awareness (perceived) a self-actualised manner (produced), and in a balanced human-centric participatory manner with agency to understand and create. These rules that Böhme proposes may be critically considered in the design, implementation and analysis of mixed reality outdoor officing for knowledge work and learning.

In 1994, Milgram and Kishino [21] published their original and groundbreaking Reality-Virtuality Continuum describing differing levels of "reality" from real reality to Virtual Reality (VR) as well as the term Mixed-Reality (MR) and in the same year also published a major work around Augmented Reality (AR). This work has been a cornerstone of the extended reality fields and referenced thousands of times. Scarbez, Smith and Whitton's recently revised 2021 Milgram and Kishino's Reality-Virtuality Continuum [22] adds the concept of "Coherence" to importantly address the user supplementing the original taxonomy to include a more user centred dimension for experience in mixed realities. The three characteristics of an MR system, as revised, include Extent of World Knowledge (EWK), Immersion (IM), and Coherence (CO). Here, CO acknowledges important concepts of fidelity [23] and authenticity [24]. In fact, EWK and IM describe the technical system which Scarbez, Smith and Whitton note as a "perfect" digital twin in a very mechanical description of "What, Where, When, and How." Note that this misses the "W" for "Why" in a 5W1H design methodology. CO provides a way into this missing contextual relationship respecting the user in physiological and post-phenomenological references bringing a conscious awareness to understand and create. Vindenes and Wasson also discussed post-phenomenological references in close reference to this concept in 2021 [25], but without the connection to Coherence in the revised Reality-Virtuality Continuum or as a learning competence.

Examining the concept of coherence and its potential is critical to measure new knowledge around advantages around outdoor work environments with intentional interactions between users in XR for desktop and knowledge workers and students. How does including these new interaction typologies with respect to coherence impact student learning in their awareness and ability to understand and create?

3 METHOD

A limited collaborative learning exercise between a U.S. and an international university design class piloted interactions in a virtual outdoor environment. Due to research limitations, this paper will focus on the US student experience. Web-based software allowed users to use avatars, interact, and engage in informal user experience methods. Spatial.io was chosen as one 3D software which also had one prefabricated space similar to Rosan Bosch's "campfire" concept for potential small group interactions. A second software, Topia, provided a simple 2D screen-based environment with onscreen proximity interaction cues with designated areas for small groups. Students were randomly assigned to groups of 6-8 for their time to explore how virtual environments support user interaction in these digital spaces.

Students were required to complete three preparatory actions before the scheduled small group interaction. First, they independently completed a design-oriented personal inventory using Adobe's "Creative Types" survey. This assessment provided a brief, guided self-evaluation, helping students develop awareness of their design "personality." Second, students created their accounts and designed their avatars on the Spatial.io platform. As part of this process, they were asked to consider the general concept of "persona" to best represent themselves—both as their own archetype and in alignment with their identified design personality—for the virtual group interaction.

Third, students were tasked with designing and placing digital identification (ID) Boards within predefined group locations in the campfire environment. This step facilitated structured interaction and was intended to provide an initial introduction to the software, and a point of acclimation and familiarity within the shared virtual space. These ID boards served as a focus for small group discussions and were intended to remain accessible throughout the exercise. This interaction took place in a 3D virtual outdoor environment within Spatial.io and interaction was directed around the AEIOU framework (Activity, Environment, Information/interaction, Objects, and Users), for informal and exploratory discussion.

The virtual interaction was designed to last 20 minutes and could be accessed through a Meta Quest 3 or 3S headset, as well as a desktop or mobile device, depending on technology availability. The experience was inherently spatial, allowing students to engage in either a first-person or third-person 3D environment interface. Due to limited availability of VR headsets, an alternating schedule was implemented, enabling some students in each small group to participate using VR headsets while others engaged through desktop or mobile interfaces.
Following this 20-minute 3D digital outdoor environment interaction (See Figure 1), a second remote interaction was designed for students to follow up this more intense and embodied interaction with another small group 40-minute interaction using Topia. Topia has a spatial interaction similar to a role-playing game interface and supported small groups less than 10 in close spatial proximity (on the screen) to also share live video and screens, similar to Zoom and many web-based conferencing software. The Topia environment was designed like an outdoor neighbourhood with areas for small groups to meet for a longer and more casual interaction. Here, the expectation was to have the students interact in this virtual outdoor environment still using a 5W1H framework and share ID boards for additional interaction in a more casual and informal manner.

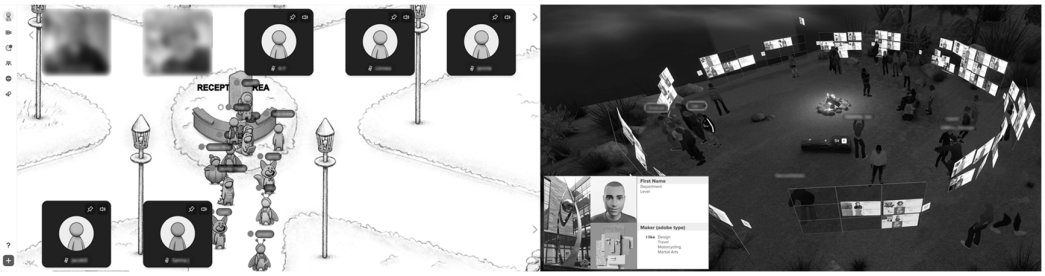

Figure 1. Left: Topia shown with several avatars in a central area with two live video panels (blurred). Right: Spatial.io "campfire" interaction with 30 students interacting with sample ID board in foreground

After these class time interactions, students on their own were asked to complete self-evaluations, to include a Simulator Sickness Questionnaire (SSQ), an Immersive Tendencies Questionnaire (ITQ), as well as a workshop questionnaire, and a reflection assignment and class discussion.

4 REVIEWS OF INSTRUMENTS AS LEARNING

Reviewing the instruments and how the student and class can reflect on the tool provides additional feedback on how this concept can effectively engage students and classes in meaningful ways understanding the technical aspects with more user centred, or coherent aspects required to elevate students' technological atmospheric knowledge.
The SSQ assessment tool measures discomfort, similar to motion sickness, for users of XR and similar immersive technology experiences. Presenting students with this self-evaluation permitted them an opportunity to understand consequential potentials which they may experience from this exercise and why and then understand others' potential experience to better design user experience. A classroom review and discussion provided a larger context to physiological assessments around embodied learning, communication, awareness and creative dispositions.
The ITQ assessment illustrated to the students the potentials for predispositions, tendencies, and dependencies with various digital media, technologies and particularly mediated environments. This not only directly let the students consider this exercise, but in context with other technological activities and the important roles personality traits and individual differences have in mediated experiences.
A short workshop questionnaire provided students with specific reflections on ways to consider their engagement with the web-based software, and how they considered their own and others' presentations in the mediated environments. The reflection assignment provided personal depth and context about the exercise and impacts of mediated environments, the user experience and interface, and learning outcomes from this collaborative exercise.

5 DISCUSSIONS

Findings in the paper are limited to US student evaluations. Student feedback from this class evaluation provided valuable insights to the students and for improving future iterations of the exercise. One key

finding was that students found Topia more accessible due to its intuitive and conventional user interface (UI), whereas Spatial posed more challenges. Only about one-fifth of about 60 U.S. students opted to come to campus to use a XR headset, largely due to unusually cold weather. For many, this was their first experience with XR technology, and with only a brief in-class introduction and limited Spatial use on personal laptops, the platform required additional onboarding and acclimation. Another issue was the limited size of the digital outdoor space in Spatial, which made the experience feel congested and noisy. Due to class time constraints and the limited availability of headsets, multiple student groups had to rotate through the same environment, leading to overlapping interactions that contributed to being overwhelmed. Ideally, each small group has its own designated outdoor space (file), but software licensing limitations and scheduling conflicts made this difficult. Audio clarity also emerged as a critical factor with students emphasising that sound quality was as important as visual design in shaping the spatial experience. Finally, lighting conditions in the virtual environment played a crucial role. While the outdoor nighttime setting with a starry sky and northern lights complemented the campfire environment, some students found it difficult to interact. Future iterations should consider using specific lighting to enhance visibility and engagement in digital outdoor learning experiences.

XR is a new student experience in the classroom and conventional user experience through a computer or mobile screen is very comfortable requiring little to no onboarding or acclimation and has also shown not to be a productive toolset on its own. The XR UI, with headsets, hand controllers and embodied interactions, introduces new movement and interaction paradigms and requires more upfront instruction and longer acclimation for the students. Students found the Spatial and Topia outdoor environments generally positive and engaging when technical interface issues were not an issue. The students appreciated and experienced what is likely part of their future, which they recognised and appreciated. Learning and knowledge work in a digital outdoor space could be an opportunity to redefine extended reality human centred design with concepts of green environments, atmospheric working and learning, coherence providing new fundamentals in advancing digital, immersive, and mediated interactions.

6 FUTURE CLASSWORK AND RESEARCH

A next iteration of this class exercise will provide a longer introduction and acclimation to the user interface and better atmospheres in real and digital time and space supporting interaction strategies and expectations. Minor adjustments could provide a deeper study and meaningful research to analyse more detailed aspects around desired learning outcomes measuring new potential fundamental competencies which Böhme and other phenomenological perspectives suggest and in more outdoor conditions to emulate and evaluate. Coherence requires further specific study, and additional instruments may be engaged, such as the Game Experience Questionnaire and the System Usability Scale to better understand usability and engagement. Additional technology aspects could also demonstrate customised remote outdoor environments such as geospatial photogrammetry, spatial video, laser scanning and 3D digital model reconstruction as tools that students can evaluate and ultimately conceive and experience creating atmospheres. They may also reflect, similarly in a digital twin-like manner, desirable and known conditions on or around campus to have students learn more about the spatial typology metaphors and contribute to their own learning spaces for interaction, in addition to continuing to build their awareness of themselves, each other and the spaces interacting in these new extended realities.

REFERENCES

[1] NEA Research, in Partnership with ASA Research. (2022, October 22). *Higher ed state funding report*. NEA. https://www.nea.org/he_funding_report [Accessed on 2025, 27 February].

[2] Unglesbee B. (2024, July 1). 'We can't cut anymore': Can colleges recover from the gut-punch of inflation? *Higher Ed Dive*. https://www.highereddive.com/news/can-colleges-recover-from-the-gut-punch-of-inflation/720214/ [Accessed on 2025, 27 February].

[3] Brown J. (2021). Making the studio smaller. *Design and Technology Education: An International Journal*, *26*(4), 256–268. https://urn.kb.se/resolve?urn=urn%3Anbn%3Ase%3Aumu%3Adiva-190553 [Accessed on 2025, 27 February].

[4] Skedda. (n.d.). *Skedda Hybrid Work Report - 05. Hot desking*. Skedda. Retrieved February 27, 2025, from https://www.skedda.com/resources/not-another-hybrid-work-debate/05-dont-get-burned-hot-desking [Accessed on 2025, 27 February].

[5] National Education Association. (n.d.). Overview: Hybrid learning models. NEA. Retrieved February 27, 2025, from https://www.nea.org/professional-excellence/student-engagement/tools-tips/overview-hybrid-learning-models [Accessed on 2025, 27 February].
[6] *From campus to community: Three ways digital twins can enhance experiences*. (n.d.). ASU Enterprise Technology. Retrieved February 27, 2025, from https://tech.asu.edu/features/3-ways-to-use-digital-twins [Accessed on 2025, 27 February].
[7] Paykamian B. (2022, July 5). 10 universities plan 'digital twin' metaversities for fall. *GovTech*. https://www.govtech.com/education/higher-ed/10-universities-to-launch-digital-twin-metaversities [Accessed on 2025, 27 February].
[8] Troije C. P., Jensen E. L., Stenfors C., Danielsson C. B., Hoff E., Mårtensson F. and Toivanen S. (n.d.). Frontiers. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.636091 [Accessed on 2025, 27 February].
[9] Söderlund C., Suárez L. A. de la F., Tillander A., Toivanen S. and Bälter K. (n.d.). Frontiers. *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1214338 [Accessed on 2025, 27 February].
[10] Ulrich R. S., Simons R. F., Losito B. D., Fiorito E., Miles M. A. and Zelson M. (1991). Stress recovery during exposure to natural and urban environments. J. Environ. Psychol. 11, 201–230. doi: 10.1016/S0272-4944(05)80184-7.
[11] Kaplan S. (1995). The restorative benefits of nature: Toward an integrative framework. Journal of environmental psychology, 15(3), 169-182.
[12] Kaplan R. and Kaplan S. (1989). The experience of nature: A psychological perspective. Cambridge University Press.
[13] Sadick A. M. and Kamardeen I. (2020). Enhancing employees' performance and well-being with nature exposure embedded office workplace design. J Build Eng. 32:101789. doi: 10.1016/j.jobe.2020.101789.
[14] Petersson Troije C., Lisberg Jensen E., Stenfors C., Bodin Danielsson C., Hoff E., Mårtensson F. et al. (2021). Outdoor office work–an interactive research project showing the way out. Front. Psychol. 12:636091. doi: 10.3389/fpsyg.2021.636091.
[15] Lottrup, L., Stigsdotter, U. K., Meilby, H., & Corazon, S. S. (2012). Associations between use, activities and characteristics of the outdoor environment at workplaces. *Urban Forestry & Urban Greening*, *11*(2), 159-168.
[16] Frost S., Kannis-Dymand L., Schaffer V., Millear P., Allen A., Stallman H. et al. (2022). Virtual immersion in nature and psychological well-being: A systematic literature review. *Journal of Environmental Psychology*, 80, 101765.
[17] Bosch R. (2018). Designing for a Better World Starts at School. Rosan Bosch Studio.
[18] Thornburg D. (2013). From the Campfire to the Holodeck: Creating Engaging and Powerful 21st Century Learning Environments. John Wiley & Sons.
[19] Tanaiutchawoot N. (2024). The Metaverse Design and Evaluation in Product Design and Development. *International Journal of Higher Education Pedagogies*, 5(1), 19-30.
[20] Böhme G. (2017). Atmospheric architectures: The aesthetics of felt spaces. Bloomsbury Publishing.
[21] Milgram P. and Kishino F. (1994). A taxonomy of mixed reality visual displays. IEICE Trans. Inform. Syst. 77, 1321–1329.
[22] Skarbez R., Smith M. and Whitton, M. C. (2021b). Revisiting Milgram and Kishino's reality-virtuality continuum. *Frontiers in Virtual Reality*, 2. https://doi.org/10.3389/frvir.2021.647997
[23] Alexander A. L., Brunyé T., Sidman J. and Weil S. A. (2005). "From gaming to training: A review of studies on fidelity, immersion, presence, and buying and their effects on transfer in PC-based simulations and games," in *The Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC).*
[24] Gilbert S. B. (2017). Perceived realism of virtual environments depends on authenticity. Presence Teleoperat. Virtual Environ. 25, 322–324. doi: 10.1162/PRES_a_00276.
[25] Vindenes J. and Wasson B. (2021). A post phenomenological framework for studying user experience of immersive virtual reality. *Frontiers in Virtual Reality, 2.* https://doi.org/10.3389/frvir.2021.656423.