DOI: https://doi.org/10.56198/U6C0WMQMU

Work-in-Progress—Headgear-Free 3D Interactions for Asynchronous, Online Learning Experiences: An Exploration of Design, Development and Integration

Helen McKenna[1], Daniel Mitelpunkt[1] and David Blanco[1]

[1] Imperial College London
h.mckenna@imperial.ac.uk

Abstract. The higher educational landscape has witnessed rapid digital transformation over the last decade [1] leading to increased variety of demands and expectations. Consequently, universities are investing in widening their provision, including asynchronous, online [2] courses which can offer learners a sense of flexibility and autonomy. With this shift, there is a need for innovative approaches that engage and motivate learners and enhance learning experiences. This work in progress paper describes our multidisciplinary project, which delivers proof-of-concept of leveraging 3D models and WebGL as well as 3D streaming and previewing tools, to augment asynchronous learning, and support learners in reaching psychomotor-driven learning outcomes.
Conventional methods of asynchronous learning (e.g. video, audio, texts) often lack the interactivity that stimulates active learning, and also lack interactive three dimensionality. While intentional interdisciplinary learning design can help overcome this, the ability to interact with the multimedia activities themselves demands new approaches to ideation and asset creation, as well as new technical workflows. On campus XR learning experiences, delivered through individualized hardware, already enable interactive, immersive 3D pedagogical practices, but this is difficult to scale cost-effectively, when aiming to provide parity of experience to numerous online learners studying in an asynchronous manner (i.e., across multiple territories and time zones, mostly without XR headgear). AIM (Asynchronous Interactive Media) project's initial outputs, integrating pedagogical principles, 3D modeling and interaction design and learning technology, offers a framework for ideating asynchronous 3D multimedia interaction, pointing to further development potential within digital Higher Education contexts, but also immediate piloting opportunities.

Keywords: 3D, Digital Transformation, Remote Learning, Higher Education, Interactive, LMS.

1 Introduction

In May 2023, a team from Imperial College London's (ICL) Digital Media Lab (DML) shared a demonstration of the latest XR development capabilities with select few educational leaders within the institution. This was the culmination of eighteen months of work, capabilities, and skills development in areas such as 'realistic digital twins', 'complex 3D data visualization using game engines', and 'motion capture for educational scenarios'; these developments all enhance the university's offering in VR teaching, already scaled and part of the curriculum in multiple departments.

'Can you deliver any this for our online learners?' A senior leader asked.

Why this would be beneficial was immediately clear. Equally clear was why such an undertaking would be challenging and far from just changing a few settings on a game engine.

As part of the university's EdTech community, the DML is already involved in the co-creation of ICL's scaled online courses; these range from fully online degrees to MOOCs, from Outreach to Executive Education. The asynchronous nature of many types of online courses already necessitates a high level of time-based media (short video lectures, animations, podcasts, e-tivities). Deploying, however, highest-end, high polygon complex interactive 3D, of the kind deployed in our VR teaching, would be something completely different.

Nevertheless, as a STEMM technical university ICL has been using three dimensional physical objects in its on-campus teaching, from molecule models to pipettes, and the only reason our teams have not extended that to asynchronous learning on LMS courses was that this was not regularly on offer. Still, given the regular usage of iFrames is on LMS and familiarity with web-based 3D solutions, such as SketchFab, it seemed both possible and worthwhile to deliver interactive 3D within constraints on LMS.

1.1 Pedagogic Context

It's widely acknowledged that effective online learning experiences are systematically planned, designed, and developed; the design process should take into consideration learners' needs, learning objectives and outcomes, available relevant technologies, and the contextual constraints [3]. As online, asynchronous courses are self-paced, learning principles, such as motivation, mastery, and metacognition must also play an important role in the educational design.

So, by extension, when it comes to the micro or activity level learning objectives aimed at practising psychomotor skills or which require the learner to conceptualize, the learning design would often be enhanced if high-end, high polygon complex 3D interactivities were an e-learning option. Such interactivities, allowing exploration through simulations, games, scenarios, have to- date been too costly and difficult to enact in online learning experiences; yet, based on the work undertaken by the DML, the prospect of a potential new and complimentary 3D interactive digital learning solution has been presented.

2 Methodology

To create the proof of concept, staff from two separate departments at Imperial College, the Interdisciplinary EdTech Lab (IETL) and the DML, have partnered to collaborate and explore the feasibility of designing, developing, and scaling 3D interactivity in online asynchronous education. The project also establishes a pedagogic-technical approach towards such co-creation at (and beyond) Imperial College London. The cross-functional team involved in the study comprises experts in learning design, educational technology, XR development (interaction design), and 3D modelling, and the focus of the inquiry centers around these main questions:

A. What learning activities and/or 'types of learning' might be enhanced by web-based interactive 3D learning media?

B. What cost-effective, low support technical solutions might cater to this need?

C. What educational-technical solutions would be most suitable for further exploration within a larger research project in future?

The nature of AIM, this R&D project, is to design and develop solutions that can first be alpha tested and later evaluated with learners. Metrics for engagement or learning gain are not currently in scope because this initial study will culminate by proposing a larger research project in the future. Second, this project aims to reflect on and evaluate the consequent workflows, approaches, and tools utilized as part of the collaboration with a view for possible business- as-usual deployment.

Described below are specific technical and pedagogic methods taken by the team in achieving the proof-of-concept.

2.1 Technical Solutions Explored

Game engines such as Unity or Unreal Engine are powerful components in XR development workflows. They enable the creation of complex, audio-visually rich 3D interactions. In the context of this project, however, their deployment is being explored within significant limitations, such as:

A. Lack of individualized hardware at the learner end (no VR headset; courses taken on phones and tablets too).

B. Downloadable packaged software (or apps) that are incompatible with the flow and specifications of online modules on LMS, whereas iFrame and web application integration are more compatible.

C. Bandwidth, file size and polygon count limitations.

D. Traditional Game Engines are primarily geared towards games and gamers, whereas some of the interactive, 3D educational activities perceived as pertinent to learning objectives may not work best as a game. Similarly, some of the learners taking online modules may not be gamers or wish to spend much time learning how to navigate more complex interactions of the kind that can be developed on game engines.

Game engines can, however, enable the creation of more personalised learning journeys, allowing students to progress at their own pace and receive immediate feedback, which fosters and supports self-directed learning. Pixel streaming had been explored as part of this project, as a way of introducing those more complicated, game engine - based 3D interactions without requiring the learners to own specific hardware or download specific software. This approach, however, introduces cost, scheduling and technical support aspects that still position it as a more premium, and arguably less scalable solution and as such was ruled out.

A different type of solution explored was developer 3D previewing tools that have been used as part of back-end development for some time, such as Sketchfab. This can provide interactive 3D assets that are embeddable within an LMS with virtually no cost or demand for computing hardware specifications on the user end.

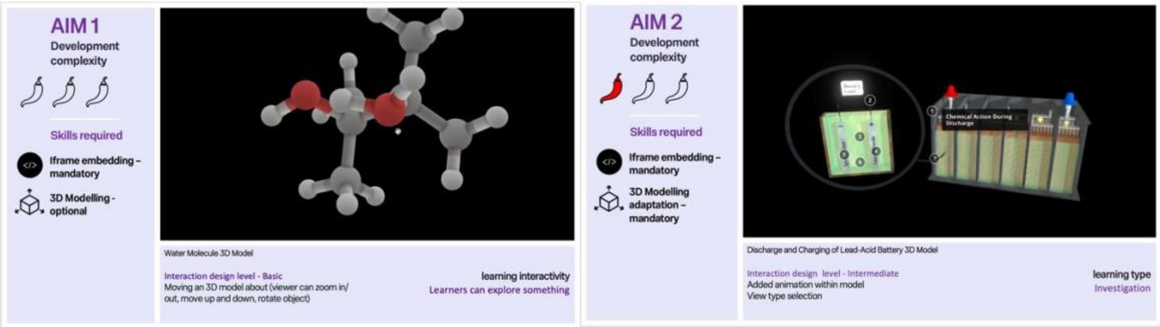

Fig. 1. AIM project examples of simpler Sketchfab 3D model deployments (AIM1) and animated models (AIM2) (DML).

Additional benefits associated with using 3D preview solutions, as opposed to traditional Game Engines (through pixel streaming), are to do with their usefulness for achieving multiple different learning objectives that develop pyscho-motor skills or encourage deep conceptualization, as well as feasibility and ease of scale. 3D models can then be created (or sourced) and embedded as interactive 3D viewers in what our project team has categorised as AIM 1.

Fig. 2. Battery example, AIM1 (DML).

When the model has intrinsic animation or interactive layering delivered through Sketchfab, that is categorised as AIM 2 for course development team ease, given that this might involve higher or additional skills, especially if made bespoke.

Further technical interactivity is available through use of Sketchfab's API. Imperial College London's Digital Media Lab was able to add a layer, leveraging Java Script, to code bespoke functions that unpick unique interactions. Such an 'enhanced' sketchfab usage allows for virtual cameras and inputs, unleashing user ability to navigate through dynamic spaces. This addition of API-dependent functions is referred to in the project as AIM 3.

Such augmentation and deployment of a well-established platform, albeit for different ends and in different ways, offers, in a sense, a faux, limited game engine (as well as a 3D viewer).

Finally, within this proof-of-concept stage, PlayCanvas has been identified as a third party WebGL solution (web based game engine) that would offer additional functions, beyond those on offer from Sketchfab natively through its API. Such a game engine opens up possibilities for additional learning types and user interaction. In the example developed, a lab was created where the learner undertakes more complex tasks, runs a simple virtual experiment, and receives feedback (feedback would require further investigation).

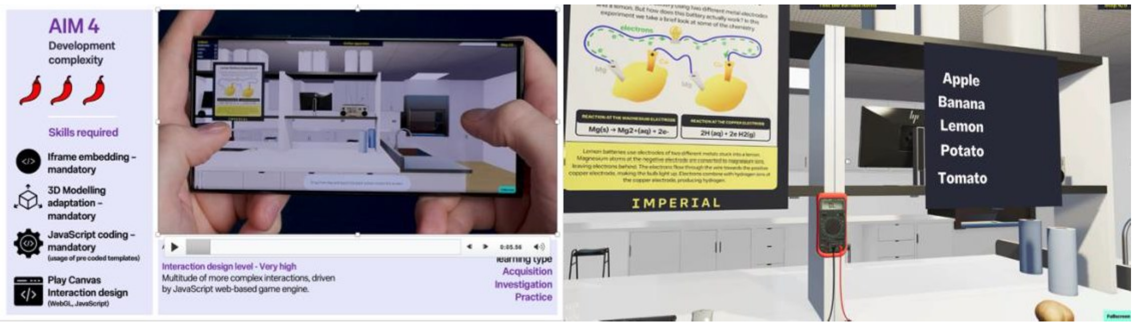

Fig. 3. AIM4 lab example through PlayCanvas (DML) (a).

Fig. 4. AIM4 lab example through PlayCanvas (DML) (b).

To empower teams looking to take advantage of the initial four workflows trialed in AIM's proof-of-concept phase, each AIM points to the anticipated technical development complexity. This was illustrated by using red hot chilli icons. AIM 1 represented by not having any chilli icons, given that one could identify a simple, existing model on Sketchfab and, if permitted, embed on LMS with little knowhow of either 3D modelling, game engines or JavaScript. At the other end of the chilli scale, AIM 4, involves significantly higher levels of skill and effort, represented by three red hot chilli peppers.

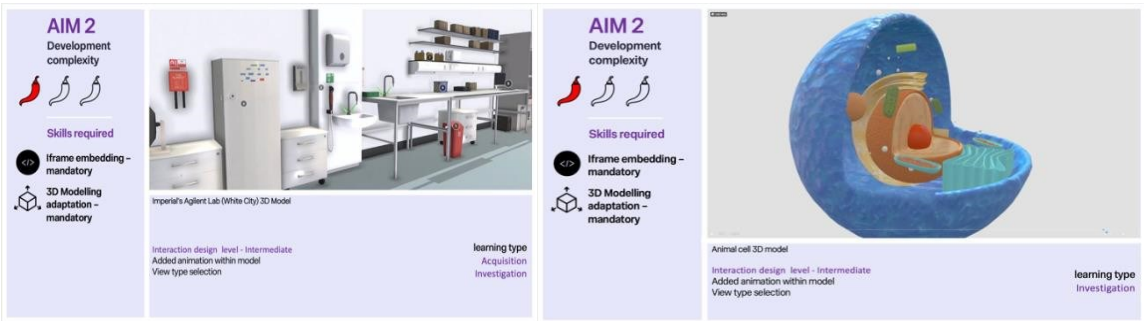

Fig. 5. AIM2 (DML).

This project includes detailed wiki-like technical instructions for developers alongside resources for academic and EdTech (professional services) colleagues wishing to experiment or use any of proposed AIM solutions.

Identifying both tools and workflows in service of the project's pedagogical aspirations is pointing to exciting, scalable, low-cost ways of ideating and delivering interactive 3D simulations and activities for online students and learners. This suggests further exploration and student-facing pilot projects would be constructive.

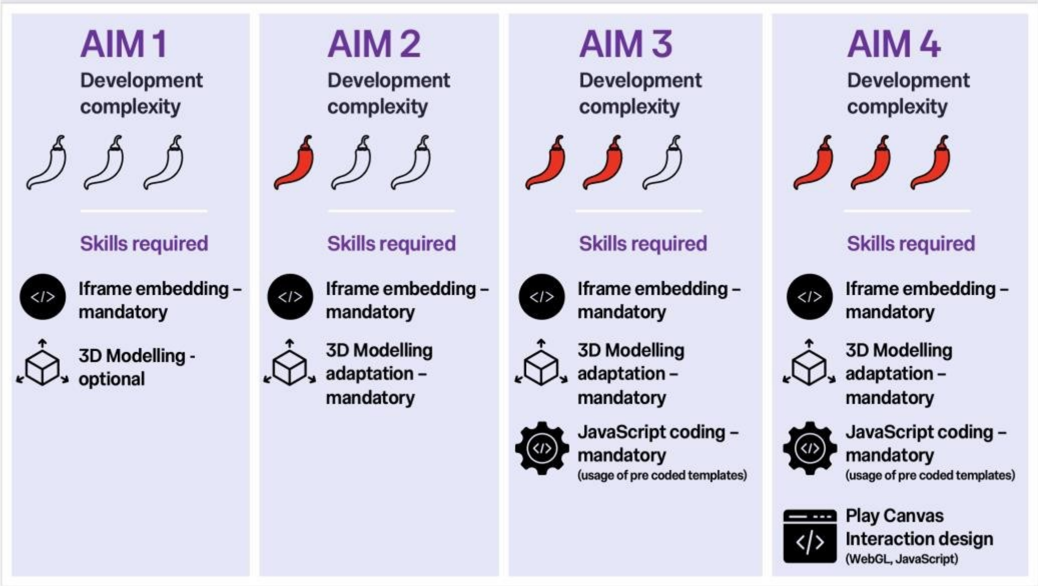

Fig. 6. recap of four AIMS tested (IETL, DML).

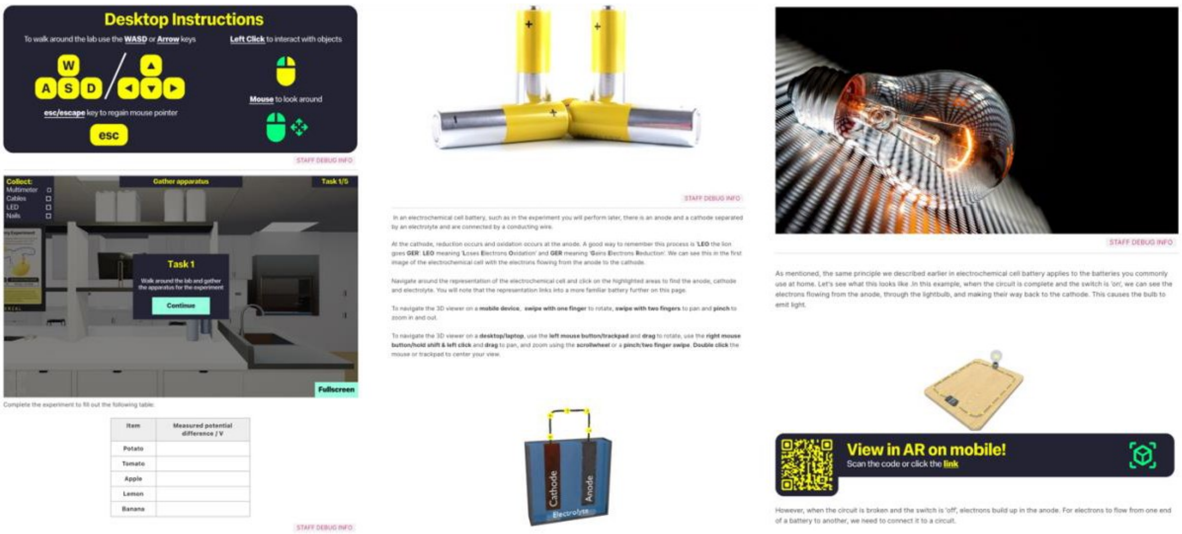

Fig. 7. Images from the edX platform.

2.2 Pedagogic Approach Explored

As discussed in this paper, the spark for this project has been technological in essence. However, the typical educational design challenge remained: how can we best solve or respond to an identified educational problem? A first step was to jointly consider this project's specific educational challenge in more depth, and then to offer space for a 'pedagogic interrogation' aimed at assessing whether there is good reason to develop the 3D interactions further. This pedagogic interrogation was loosely based around Postman's [4] inquiries from 1998:

A. How do you achieve effective pedagogy in the online asynchronous context?
B. What pedagogical challenges are we solving with this technology (Headgear-free 3D technology)?
C. Does the technology help meet learning outcomes? And/or does it encourage different types of learning?
D. What problems are we creating?

These questions were addressed through inquiry-based workshops and by generating a useful ideation framework for designing 3D activity level interactions.

How do you achieve effective pedagogy in the online, asynchronous context?

In considering how best to co-create the 3D interactions as a multidisciplinary team, the learning designers reflected on macro ideation components which enable pedagogic effectiveness and quality within a learning experience, learning intervention, or solution. The 'vertices' illustrated below in what we've termed the '3D Multimedia Ideation Framework' aim to highlight the vital integration of pedagogy, technology and content, and how this integration is a key component in approaching educational design and addressing educational challenges [5] for online, asynchronous learners.

In the case of our initial project, this framework allows us to ideate and co-create activity-level, 3D interactions in a robust yet scalable manner. As shown in the diagram, the emphasis is on ensuring balance across the 3 vertices. Yet, in terms of developing the proof of concept, we required an ideation method which was not reliant on specific content or new course concept being available to work with - i.e. could we design and develop a feasible, pedagogically-sound 3D activity type that acts as inspiration to academics/educators and helps online learners learn?

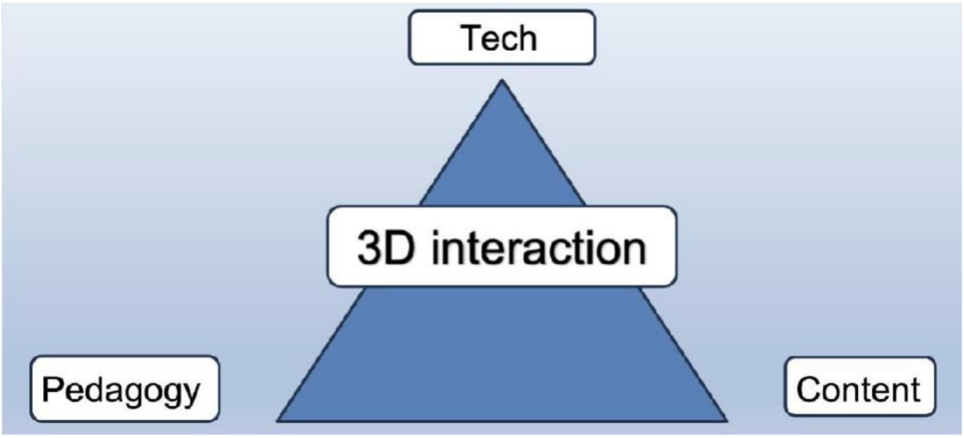

Fig. 8. 3D Multimedia Ideation Framework utilised for collaboration.

What pedagogical challenges are we solving with this technology (Headgear-free 3D technology)? Does the technology help meet learning outcomes? Does it encourage different types of learning?
Applying a well-known learning design tool and taxonomy, 'Laurillard's learning types' [6], namely - acquisition, investigation, practice, production, collaboration and discussion - to a chosen 3D model, the project team interrogated the viability of designing a 3D interaction to achieve each learning type. For the purpose of the exercise, we used the metaphor of 'buckets' to reflect depth and ensure the flow of ideas among team members. Please see an image of this below:

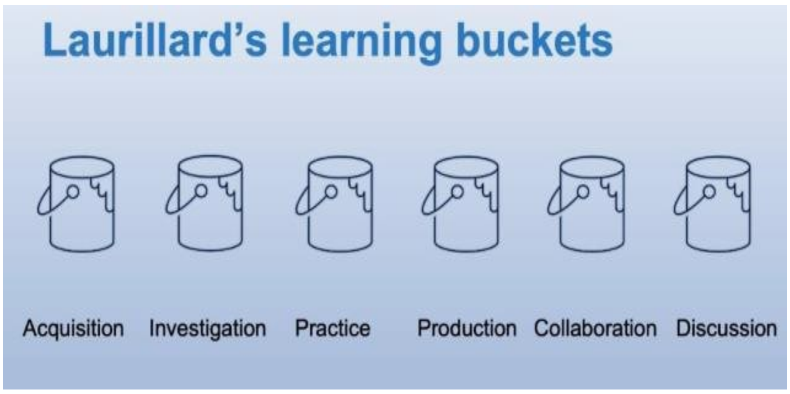

Fig. 9. This image helped us reimagine Laurillard's 'Learning Types'; shown here as 'buckets'.

The brainstorming took the form of a collaborative, storyboarding exercise within a workshop facilitated by one of the learning design team members; the exercise resulted in us rejecting the learning types 'collaboration' and 'discussion' and choosing the other 4 as in-scope for our initial, proof-of-concept development stage.

Subsequent to the collaborative exercise, the learning designers focused on applying the chosen learning types to storyboarding specific activities for 2 separate 3D models (also chosen by the project team). The aim of this exercise was to ascertain whether the technology could a) support online asynchronous learners in meeting imagined psychomotor-driven learning outcomes and b) be a valuable activity option for educators to co -develop when making a fully online asynchronous learning experience. We feel the authored activity sets for the 2 chosen 3D models provide successful worked exemplars for potential learning scenarios, simulations, or games.

Once satisfied with the initial scenarios, we designed and created a learning experience and embedded 3D interactions where we identified learners could benefit from them. This was then transferred onto a learning platform to not only test the technology, but also test the examples within. We found that these continued to be aligned to Laurillard's learning types and offered the learner an opportunity to explore, experience and reflect. The next steps of the project are t o deliver AIM to an asynchronous student cohort to stress test the experience as well as evaluate and further interrogate it through the following lenses: learner-centrered, multimedia, and VR design (e.g. DICE/RIDE [7] framework).

What problems are we creating through this technology?

Technology can create its own problems [8] and as we have embarked on this project, the multidisciplinary approach has made this a foundational principle at the forefront of our thinking. This focus has highlighted the various challenges we face in the HE and digital education context but has also spurred the development of innovative solutions. This includes a need for better learning design toolkits, such as storyboard or scripting templates which enable 3D interactions to be described, conceptualised, and authored in an appropriate, co-creative manner.

There was the initial challenge of how well learning types of collaboration, and discussion fit into the asynchronous environment, creating new, innovative examples of how this could be done in future projects and exemplars of the technology.

3 Conclusion

The integration of interactive real-time 3D learning assets into online learning experiences within existing mainstream LMS and VLEs promises to transform the way we educate asynchronous learners, providing a more engaging, interactive, and purposeful experience for those not benefiting from synchronous instruction, and/or XR learning solutions. These tools not only foster engagement among this learning audience, but also offer educators unprecedented insights into student performance, creating a more authentic learning environment for achieving psycho- motor driven and, often, conceptual learning outcomes.

Deploying vetted solutions and workflows into Virtual Learning Environments already used for online learning enables some of the value-add currently available only in-situ and synchronously to be scaled, as this learning format does not rely on costly, individualized hardware. As this work-in-progress paper demonstrates, however, this requires the development of cost-effective solutions which not only comply with technical limitations and requirements of VLEs and learning experience platforms, but also deep understanding of the nature of online learning more widely. The solutions being offered by this group will, therefore, only be as beneficial as the underlying pedagogical rationale of their deployment. In this paper we explored workflows and solutions that would cater to the pedagogical potential. The subsequent phase will deploy the AIM framework to student-facing online modules on a LMS, delivering actionable insights and further opportunities to evaluate the approach

Acknowledgements

Kamyar Raoofi, Thomas White, Simon Pocock, Penn Davis, Christian Pask, Olesea Bortniac, Jorge Dubuc, Robyn Lowe, Nikos Mexis.

References

1. Morris, N.P., Ivancheva, M., Coop, T. et al.: Negotiating growth of online education in higher education. Int J Educ Technol High Educ 17, 48 (2020). DOI: https://doi.org/10.1186/s41239-020-00227-w
2. Khazanchi, D., Bernsteiner, R., Dilger, T., Groth, A., Mirski, P. J., Ploder, C., … Spieß, T.: Strategies and best practices for effective eLearning: lessons from theory and experience. Journal of Information Technology Case and Application Research, 24(3), 153–165 (2022). DOI: https://doi.org/10.1080/15228053.2022.2118992
3. Postman, N.: Building a bridge to the 18th Century: How the past can improve our future. 1st ed. Vintage, New York (2000).
4. Newhouse, C. P.: When does technology improve learning? In: Henderson, M., Romeo, G. (eds.) Teaching and Digital Technologies: Big Issues and Critical Questions, pp. 197–213. Cambridge University Press, Cambridge (2015). DOI: 10.1017/CBO9781316091968.021

5. Laurillard, D.: Teaching as a Design Science: Building Pedagogical Patterns for Learning and Technology. 1st ed. Routledge (2012). DOI: https://doi.org/10.4324/9780203125083
6. Bailenson, J.: Experience on demand: What virtual reality is, how it works, and what it can do. W.W. Norton & Company, Inc., London (2019).
7. Selwyn, N.: Education and technology: Key Issues and debates. 3rd ed. Bloomsbury Academic, Great Britain (2021).