

Human-Centered Innovation in Water Resources Management Education

A Co-Creation Approach to Developing VR Learning Experiences

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Abstract—Virtual Reality (VR) adoption in higher education is hindered by development costs and producing curriculum-aligned educational contents that meet learners’ needs. Whilst co-creating VR educational experiences with learners can mitigate these challenges - as it ensures content relevance and reduces development time and costs - involving learners as co-designers is challenging, especially if they lack coding expertise. This study contributes a practice-based approach to the co-creation of immersive learning experiences, that involved a design thinking workshop with learners, teaching staff and developers. The findings illustrate how a layered prototyping approach can support co-creation participants in progressing from scenario content design with detailed storyboards to immersive prototypes. The study concludes that integrating no-code immersive tools and generative Artificial Intelligence (AI) into the co-creation workflow can make VR pre-production accessible, efficient and shaped by learners’ needs – opening up potential for greater VR adoption in higher education.

Keywords-Virtual Reality; co-creation; Design Thinking; no-code prototyping; Artificial Intelligence.

I. INTRODUCTION

Virtual Reality (VR) has emerged as a transformative technology with applications that span education, healthcare, engineering, and entertainment [1]. Whilst its potential to offer immersive, experiential and collaborative learning in higher education is gaining recognition, VR adoption in higher education is constrained by development costs and limited availability of curriculum-aligned content [2]. Co-creation approaches hold a promise to mitigate these challenges, as they ensure that bespoke content development will meet learner needs and curricular goals, saving VR development time and cost later in the development process [3]. At the same time, end-user involvement in co-creating VR learning is not straightforward, particularly due to learners’ potentially limited VR expertise.

In this article, we propose a co-creation process that involves learners throughout defining learning contents, designing and developing a VR learning scenario. Measures are adopted to make VR accessible to learners and empower them to contribute meaningfully in the co-creation. In Section II, we review relevant co-creation literature in the contexts of education, software development and VR learning. These perspectives inform the methodological design of our study, described in Section III. In Section IV we present the findings, followed by a discussion in Section V. We conclude with lessons learned and implications for future work in Section VI.

II. RELATED WORKS

In this section, we review existing literature on co-creation in education, software development and VR learning contexts.

A. Co-creation in educational contexts

The teacher-centered paradigm has been challenged by learner-centered pedagogy that emphasizes among other, active engagement, autonomy, and focus on learners’ individual needs [4]. Learner-centered approaches are rooted in constructivist, emancipatory and experiential learning theories, from Dewey and Freire to Vygotsky and Piaget. They propose that learners develop deeper understanding and more critical thinking skills, when they actively shape their learning processes and when learning contents are adapted to their needs [5].

Extending from the learner-centered pedagogy paradigm, more recent research has increasingly emphasized the value of co-creating learning experiences with learners [6][7]. Co-creation advances learner-centricity to another level that goes beyond merely adapting to learners’ needs to engaging them meaningfully as equal partners in the design of learning contents and experiences [8][9]. Reported benefits of co-creation in educational contexts include increased motivation and engagement, agency and collaboration [9][10]. Co-

creation has been conceptualized as a human-centered design approach that emphasizes collective creativity [11], empathetic exploration into the lived realities and challenges of those, for whom value is being created [12] and iterative development [13]. Co-creation is especially well-suited for tackling wicked, ill-defined problems – challenges that lack straightforward solutions and require context-sensitive inquiry and collaborative solving [14][15]. Despite the growing conceptual literature on co-creation in education, there is a lack of empirical studies that offer insight into the methods used to co-create learning experiences [7][16]. Only few case studies, such as Laugaland et al. [16] and Hatsikas-Schroeder et al. [17] offer such methodological detail. Insight into methodological procedures is important for improving the quality and consistency of co-creation initiatives.

B. *Co-creation in software development*

The emphasis on collaborative design in educational contexts reflects an orientation towards human-centric principles, that also guides many practices in software development. Human-centered approaches are perceived to play a key role in increasing product innovation and improving usability, user satisfaction, software quality and successful adoption [18]-[21].

Whilst inviting user feedback during the process is a recommended practice in software development, it is often limited to two stages of the process: during requirement elicitation at the outset (mainly through user interviews), and after design solutions have been pre-defined by the design team (to provide feedback in the form of usability or user experience testing) [22][23]. By limiting user involvement to these two stages, users are essentially positioned as subjects or informants rather than as equal partners in the development process [22].

The limited user involvement can be justified by the tight schedules and budgets of software development projects [19]. It might also be explained by the technical nature of software development, where end-users may lack understanding of the technology required to provide meaningful insights and express requirements [23]. Whilst human-centered approaches, such as agile methods advocate the benefits of user involvement throughout the product development lifecycle, user involvement is mainly perceived relevant for eliciting and validating requirements [23], rather than for truly co-designing software.

C. *Co-creating VR learning experiences*

The potential of VR to enrich education and training is increasingly recognized [24]. VR may offer immersive, experiential and engaging learning experiences that stimulate hands-on engagement [25]-[28]. It may facilitate the comprehension of complex or abstract concepts – for instance, in disciplines like anatomy [29]. In addition, VR allows collaborative learning by simulating physical co-presence and enabling learners to engage in joint tasks [30].

Despite the promising immersive qualities of VR that can address the need for visualization and active, hands-on learning, VR adoption in education remains limited [2][26][28][31]. In addition to the learning curve of VR and the potential discomfort or risk of experiencing motion sickness, higher education institutions face unique barriers that inhibit the adoption of immersive technologies [2][26]. Specifically, despite the growing accessibility of VR, limited university budgets inhibit adoption in academic teaching [28], not only due to hardware costs, but also due to the costs involved in purchasing VR content or developing bespoke content. Available VR content for purchase is limited in comparison to other educational resources, making it difficult to find relevant content that aligns with the university's curriculum [28]. Developing bespoke VR content ensures close alignment with the curriculum, but it requires considerable time and cost investment, and it lacks scalability, as it is unlikely to be used by several educational institutions with different specializations and curricula. Even if contents are relevant for several institutions, bespoke contents are not necessarily available for sharing as open educational resources.

Beyond these adoption challenges, VR does not automatically lead to positive learning outcomes. Its effectiveness in supporting positive learning outcomes might depend on how well-designed a VR learning application is [2][32], including interaction and immersion aspects [24][32], content relevance, positive user experience and reduced friction [24][26]. Whether purchasing existing content or developing bespoke content, a well-designed and user-friendly VR application that is closely aligned with learning needs could potentially contribute towards embracing the technology in higher education [33].

Whilst human-centered approaches may enhance content relevance and user experience, the barriers of involving end-users as co-designers is perhaps even stronger compared to 2D software: VR is a less mainstream technology, it involves a steeper learning curve and users may lack the technical expertise to participate meaningfully in the co-creation of VR prototypes [34]. Some researchers like Nguyen et al. [34] and Flobak et al. [35] have explored strategies to enable strong user participation in the co-creation of VR learning and to make the prototyping process more accessible to them. For instance, Flobak et al. [35] involved 15- to 17-year-old pupils as co-designers of a VR scenario for exposure therapy. The pupils brainstormed ideas, created a storyboard of their scenario, which they enacted in a role-play. The role play was then recorded with a 360° camera, rendered, and subsequently made accessible via Head Mounted Display (HMD). The study showed that non-developers can contribute creatively to VR content through accessible tools like 360° video.

However, the development of fully interactive VR environments requires advanced software development skills. The study by Nguyen et al. [34] proposed a co-creation process using LEGO® bricks to develop training

scenarios with police officers. The approach enabled co-creation participants with no VR design expertise to create 3D storyboards, establishing the foundation for more detailed VR scenarios to follow later on. Yet, the transfer from artefact to VR scenarios was beyond the scope of the study.

D. Research aim

The present study considers the following gaps in research and practice, as discussed previously:

- The need for deeper methodological insight into co-creating learning experiences with learners.
- The restricted user roles in software development, where users act as informants rather than as co-designers.
- The VR development challenges (pedagogical and technical) to create relevant, well-designed VR learning experiences in a time and cost-effective manner.

In response to these gaps, this study presents a co-creation process that involved learners as co-designers of a VR learning experience. It explores how to streamline early-stage development, potentially reducing development costs and time later on, and how to collaboratively create contents that genuinely meet learners’ needs and align with the academic curriculum.

III. METHOD

In this section, we describe the methodological approach employed in our study, structured along the Design Thinking process stages.

A. Methodological overview

The objective of this research was to co-create a VR learning experience about water resource management, complementing existing university teaching practices. The co-creation brought together students pursuing a Master of Science (MSc) degree in ‘Sustainable Management – Water and Energy’, faculty members, and VR developers of the Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen University, Institute of Hydrology, in Germany.

In collaboration with the university, seawater desalination was selected as the overarching co-creation theme, as one of the topics covered by the study program. The students were presented with an open-ended design challenge: *What should a VR scenario look like that students can use to acquire the specialist knowledge and skills they need to plan a seawater desalination plant?* The design challenge of the VR learning scenario was intentionally left open for the students to define together more specifically during the co-creation. Given the complexity and open-ended nature of the design challenge - a “wicked” problem with multiple possible solutions - the design thinking approach [36] was selected to structure the co-creation.

The co-creation involved exploratory interviews and a two-day workshop. The interview discussion guide and the workshop structure are provided as supplementary material on the online platform Zenodo [37]. As the students that participated in the workshop had no previous experience with VR, the *Empower* stage was integrated into the design thinking process to familiarize them with the technology. Table I presents the design overview, illustrating the key stages and steps carried out during the process. These are described in detail in the following sections.

B. Empathize Stage

In line with design thinking, initial emphasis was placed on problem exploration and understanding students’ needs. Individual interviews were conducted with three university professors and seventeen MSc students across seven German universities. Professors were identified via word-of-mouth and students were recruited via LinkedIn and selected based on their enrollment in MSc level programs with a water resource management focus. The sample consisted of seven female and ten male students. The students’ age range 23-35 years. Interviews varied in format (telephone or video call) and duration (30-60 minutes). With the interviews participants’ perspectives of current teaching methods at their university and their associated challenges for teaching / learning were explored.

TABLE I. DESIGN OVERVIEW – DESIGN THINKING STAGES AND KEY PROCESS STEPS







Stage	EMPATHIZE 	EMPOWER 	DEFINE 	IDEATE 	PROTOTYPING 	TEST 
Methods/Tools and Output	<ul style="list-style-type: none"> • Interviews with university professors and students • Thematic area alignment with professor (curriculum fit) • Facilitator immersion into topic • Empathy maps • Challenges and needs analysis 	<ul style="list-style-type: none"> • VR introductory session to familiarize with the medium 	<ul style="list-style-type: none"> • Synthesis of interview findings • Group mind map to identify key knowledge gaps 	<ul style="list-style-type: none"> • Brainstorming ideas to address content needs and clustering 	<ul style="list-style-type: none"> • User stories • LEGO® Serious Play® 3D storyboards • VR prototypes 	<ul style="list-style-type: none"> • VR prototype testing with students
	Interviews	Co-creation workshop				

TABLE II. INTERVIEW SAMPLE WITH PROFESSORS AND STUDENTS IN THE FIELD OF ENGINEERING HYDROLOGY

Role	n (total: 20)	Type of higher education institution	Interview format	Interview duration
Professor	1	University of Applied Sciences	Telephone	30min
Professor	1	University	Telephone	30min
Professor	1	Technical University	Video call	30min
Students	3	University of Applied Sciences	Video call	60min
Students	14	Technical University	Video call	60min

Table II provides an overview of the interview sample, including participants' type of higher education institution, interview format and duration.

The key interview insights were synthesized into empathy maps, capturing students' learning styles and into a summary of their pain points and needs as learners. To deepen her contextual understanding, the researcher immersed herself in the subject during this research stage, by attending three online lectures given at RWTH Aachen University and studying the university's massive open online courses about seawater desalination.

C. Empower Stage

Following the interviews, a two-day design thinking workshop was held at RWTH Aachen University to collaboratively conceive the VR learning experience. The workshop brought together MSc students, teaching staff, and VR developers of the RWTH Aachen University. A total of 13 participants attended: eight MSc students (four female, four male), all of which had already been interviewed, two faculty members, and three VR developers. While the faculty members and developers accompanied the workshop, students acted as the main designers, contributing their perspectives as learners and shaping the goals and contents of the learning experience.

Notably, 7 of 8 students had no prior experience with VR. To support meaningful participation, the workshop began with an introduction to the task and an overview of the design thinking principles guiding the process. Students were given a 2.5-hour hands-on VR session to familiarize themselves with the medium. The VR team provided a tutorial on headset controls and setup, followed by guided exploration of two VR applications. This session allowed students to experience key VR affordances - such as spatial presence, depth, spatial audio, scale, embodied interaction, and multiplayer functionality and to familiarize themselves with navigating VR spaces.

The VR session was followed by a facilitated discussion during which, students reflected on their impressions of VR, its potential for learning, and its limitations. This initial exposure to VR was designed to empower students to develop an awareness of the potential and barriers of VR and to engage confidently in the subsequent ideation and prototyping phases, despite their lack of technical expertise.

D. Define Stage

The workshop continued with a collaborative mapping of the eight students' existing knowledge about seawater desalination. A group mind map exercise was used to surface prior understanding and identify gaps and was followed by a group discussion to reflect on missing knowledge and

learning needs. These materials were introduced into the workshop to support reflection and deepen understanding of the broader learning context. The interview insights (general learning needs) and the mind map (specific knowledge gaps) were used to re-define the design challenge.

E. Ideate Stage

The ideation session focused on generating ideas to address students' specific learning needs, whilst also considering the types of learning activities that the VR environment could enable. The ideation was a structured activity to encourage individual reflection and rapid idea generation. Participants were given Post-it® notes and a few minutes to write down as many ideas as possible. Students were split into two breakout groups. Each group was facilitated by a faculty member, who was tasked with clustering students' ideas. The clusters from the two groups were merged and refined into overarching themes.

F. Prototype Stage

To manage the complexity of designing a VR learning experience, a layered prototyping strategy was employed. This approach separated *learning content*, *narrative storyboards*, and *VR implementation layers*, allowing students to contribute meaningfully to content and structure. The three layers were implemented to progressively concretize ideas and build a detailed learning scenario that reflected the group's needs. This strategy is in line with Klafki's didactical model, which posits that didactic goals precede methodological implementations [38].

The content prototyping layer involved the development of user stories. Students worked on two user story templates, using pen and paper: the first required to reflect and elaborate on their proposed topic, learning objective, and expected learning benefit. The second asked students to formulate their concept of the same topic in a single, clear sentence: "*As a learner, I want to learn about...* (learning topic), *because...* (expected benefit)". The stories were presented and discussed in the group, establishing a foundation for framing the learning scenarios.

The narrative prototyping layer was developed using the LEGO® Serious Play® Method [39]. With LEGO® Serious Play®, students were encouraged to move beyond the reflections that were previously expressed on paper to more tangible prototypes that they built with their hands. The process started with a skills building phase that was used to get students accustomed to thinking with their hands, building using metaphors and storytelling. This phase gave learners confidence in representing their ideas without overthinking how their models look, removed barriers to

building prototypes of complex or abstract concepts (for instance, energy or sustainability) using symbolic thinking, and introduced *focused* storytelling – sharing their ideas by explaining the symbolic meaning of each brick. The process continued with the building phase, where students had the opportunity to build individual prototypes of learning scenarios, followed by building a collective learning scenario. To build the collective model, each student proposed elements from their individual prototypes to be included. This process involved negotiating and voting to ensure consensus. The resulting collective model was a 3D storyboard, where students presented their scenes in detail.

The VR implementation prototyping layer involved the transfer from analogue to VR prototyping with ShapesXR [40], a VR tool, designed for simple 3D prototyping and real-time co-creation. The RWTH Aachen University VR developers had received an online training ahead of the workshop to familiarize themselves with using the tool. To establish a workable starting point, the VR team selected one of the individual scenario ideas and produced a preliminary mock up with ShapesXR during the workshop. The entire collaborative LEGO® scenario will be developed in VR at a later stage. Following the workshop, the researcher continued developing the prototype in VR using ShapesXR. As a novice in VR production and without coding expertise, she relied on Artificial Intelligence- (AI-) based guidance using Microsoft CoPilot [41] for step-by-step instruction on sketching the desalination plant and creating animations.

G. Test

The complete ShapesXR prototype will be tested with MSc students at RWTH Aachen University in spring 2026. The testing phase will involve structured feedback collection through observation, reflection and discussion sessions. Students' feedback will be synthesized and reported to the VR development team to inform the next stage of technical implementation. Further iterations of the VR experience will be conducted once development begins, ensuring that the design remains aligned with students' learning needs and expectations.

IV. RESULTS

A. Interview insights into learners' needs

The co-creation process led to defining the learning goals and contents, and detailing scenarios of the VR environment. The exploratory interviews uncovered students' and professors' challenges and needs about teaching and learning water resource management-related study topics.

Professors felt that students appear disengaged during lectures, with limited interest in active participation or deeper understanding. Opportunities for hands-on learning were described as rather restricted, primarily due to the university's financial constraints. For instance, the high cost of laboratory equipment prevents students from conducting

experiments themselves. Instead, a lab technician typically performs the experiments, while students observe passively. Similarly, site visits and field trips are rare, as the university's limited budget does not allow for regular excursions that could enrich practical understanding.

Student interviews echoed professors' views and revealed further challenges. Similar to professors, students reported feeling disengaged during lectures. They noted a strong emphasis on theoretical content and memorization, often without sufficient visualization or practical application. They felt that they lack opportunities to visualize complex systems, collaborate with peers, and especially practice decision-making. The rapid pace of instruction was generally seen as compromising deep understanding of the study materials, with success mainly defined by exam performance. To pass, students must memorize large volumes of content, much of which, is quickly forgotten after the assessment. A strong need for more active and experiential learning opportunities to complement theory was voiced by all students. As one of them explained: *"Theoretical lectures alone are not helpful. Practical exercises and implementation in the form of field trips, field measurements, lab experimentation are essential for us. Visualization is so important for us engineers. Equations are not just data – it's good to visualize information to make sense of it!"*

The summarized interview insights were presented in the workshop, allowing participants to develop a common awareness of their expectations of the VR learning environment, addressing the gaps in current teaching formats. After gaining first experiences with VR, students noted how their needs and expectations for active, visual, and collaborative learning aligned with the affordances of the medium, reinforcing their support for its use.

B. Mapping out knowledge and learning interests

Having explored students' pain points and needs during the interviews, the workshop started by focusing on mapping out their existing knowledge about seawater desalination, gauging specific learning topics they were interested to deep-dive into. Students already possessed theoretical knowledge about different desalination methods, energy and brine management methods, as well as about environmental, societal and economic issues that are raised due to desalinating water. Mapping out their knowledge, helped to define the key gap that might be addressed in the VR space: moving from fragmented theoretical knowledge about various aspects of desalination towards synthesizing and applying this knowledge to design an efficient, cost-effective, and at the same time sustainable seawater desalination plant. Planning a desalination plant involves managing trade-offs between energy use, environmental impact, cost and technical constraints. Even though students

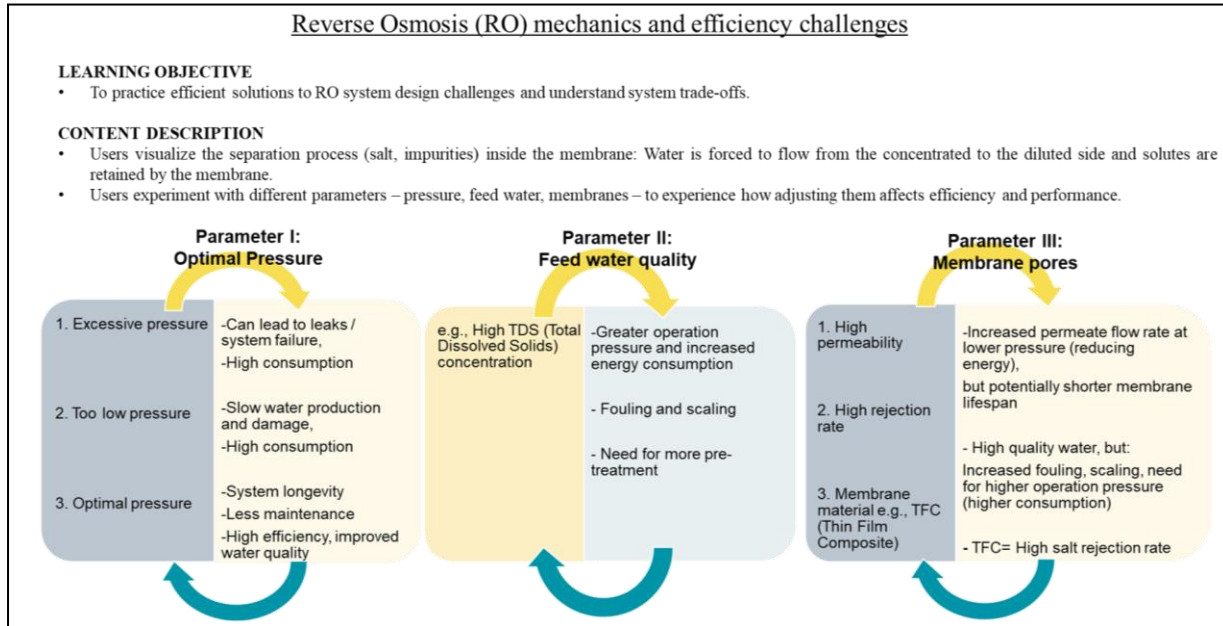


Figure 1. Exemplary user story for VR prototyping

know how a desalination plant works, they lack experience in applying their knowledge to developing innovative, sustainable and efficient solutions. Based on these insights, the design challenge evolved: *“How might we design a VR learning environment about seawater desalination that allows us to actively learn and gain experience in making various decisions needed, when planning a sustainable, cost-effective and efficient desalination plant?”* Having defined the design challenge, multiple ideas were brainstormed. These were clustered under two major themes: selecting a method (desalination method, energy and brine disposal methods or combining multiple methods) and experiencing the trade-offs of their decisions (in terms of cost-effectiveness, efficiency and sustainability).

C. Prototyping – from user stories to LEGO® models and rapid VR prototypes

User story development allowed students to assemble and expand on the rapid ideas generated during the earlier brainstorming session into coherent possible solutions. It supported reflective thinking on the rationale and the contents of the learning experience and it ensured that all voices and diverse learner insights were considered. A total of eight user stories were developed and pitched. Figure 1 presents an example of one of the user stories.

During the LEGO® Serious Play process, the students created learning scenario prototypes, first individually and then collaboratively. The collective scenario is summarized in Figure 2.

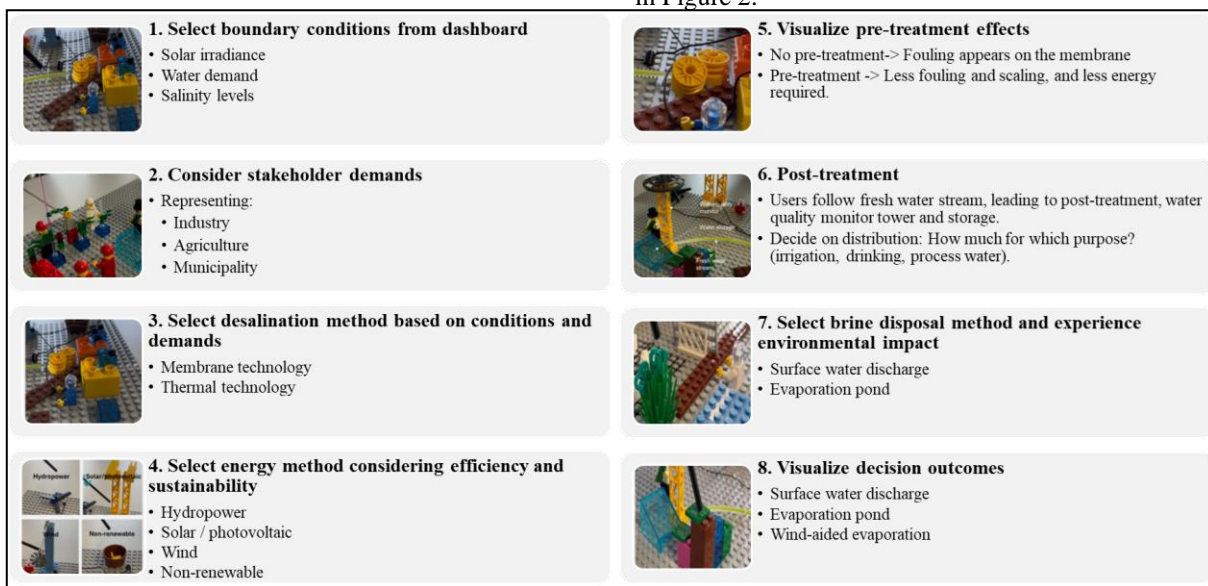


Figure 2. Collaborative storyboard of the VR scenario

The students felt that this scenario bridges their theoretical knowledge with the real-life constraints and situations they are likely to face in their future workplace. Beyond technical skills and engineering knowledge, further skills were perceived essential to effectively tackle complex engineering projects, including project management and social skills, involved when planning a desalination plant. For example, an understanding is needed in terms of how to manage different stakeholders' requirements and expectations, whilst considering specific conditions, such as water demand and cost. Moreover, by making different decisions in terms of desalination method, pre-/post-treatment, energy and brine disposal methods, learners would experience the impact of their decisions on the plant's efficiency, cost-effectiveness and sustainable management.

The transfer to VR prototyping was challenging, given the time constraints of the workshop. The complexity of the collaborative scenario, required a more manageable entry point. Hence, the VR team began by creating rough initial VR prototypes of one of the students' individual scenario ideas (Fig. 1) during the workshop, as shown in Figure 3.

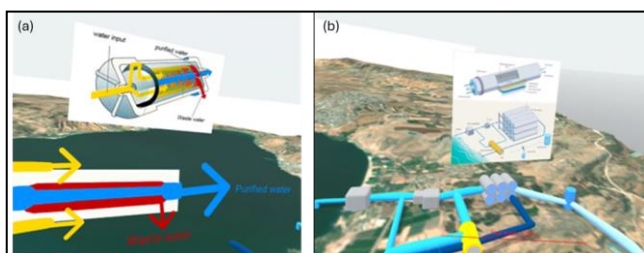


Figure 3. Impressions from the VR mock up during the workshop, simulating the salt separation process (a) and the placement of the Reverse Osmosis racks (b).

The selected learning scenario centered on visualizing the effects of adjusting pressure on water production, quality and energy efficiency in seawater desalination. It was developed further by the researcher after the workshop (Fig. 4).

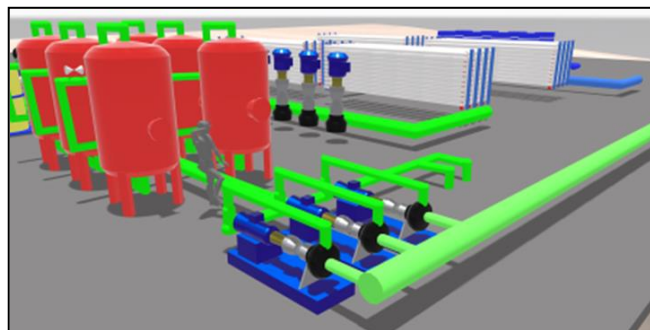


Figure 4. Impression of the VR prototype after the workshop, showing the water intake pumps and pre-treatment filters of the desalination plant.

AI provided step by step instructions for sketching components of the plant and it demonstrated how specific models, interactions and effects could look like in ShapexXR (Fig. 5).

V. DISCUSSION

The co-creation process resulted in detailed, collaboratively developed learning scenarios that aligned with the university's curriculum and were tailored to learners' needs, as students were actively involved throughout the design process. Given that the design challenge was initially ill-defined and represented a wicked, complex problem, the design thinking approach enabled a thorough exploration of the problem space.

To minimize expert-learner dynamic effects during the co-creation that could have inhibited students' voices, faculty members played a peripheral role in the workshop, whilst students were the main actors throughout the process. Two key methodological steps aimed to empower students as true co-designers:

The first step was the VR onboarding session, which helped students familiarize with the VR medium and experience its special affordances, before asking them to develop a VR scenario for a medium they do not know. On the other hand, we acknowledge that this approach had limitations: The VR session shaped students' perceptions of VR and may have influenced their ideas about a VR learning scenario. A different or more extensive sensitization process might have generated alternative ideas and scenarios. Had time not been a constraint, a broader range of VR applications could have been demonstrated, including more industry-relevant applications. Students' experiences with the medium could have also been enriched, by understanding various types of VR content and the differences between them (3D modeling, 360° content, Gaussian splat etc.) as well as different types of possible educational VR formats, such as games, virtual tours, or experiments. A more extended sensitization process may have also raised students' awareness of the technical constraints and effort involved in software development. This limitation led to the development of a complex learning scenario that complicates VR production. Moreover, the aim of involving students as equal designers was not fully achieved just by the VR onboarding. Students remain non-experts in VR and hence, were not fully capable of taking technical decisions about VR aspects.

The second step taken to enable students' meaningful involvement in the co-creation, was the layered prototyping process (content, narrative, VR implementation prototypes), which allowed ideas and prototypes to be developed stepwise, rather than immersing learners in VR prototyping immediately - a step that might have distracted from reflecting on learning objectives and content before considering aspects, inherent to VR. Instead, prototyping began with tools that students are familiar with - pen and paper. User story development allowed individual reflection and elaboration on first ideas. These stories became more tangible when building LEGO® prototypes. The LEGO® process unleashed creativity, as it guided students to work with metaphors and symbolism to represent even highly abstract concepts (e.g., sustainability). This resulted in the development of multiple, tangible and detailed learning

How do I model a high-pressure pump?

Take me through making on of those with shapes XR

Absolutely! Let's build a **high-pressure centrifugal pump** for a **seawater desalination plant** in **Shapes XR**, step by step.

Step 1: Pump Body (Main Structure)

- **Shape:** Large Cylinder
- **How to Use:** This will form the **core of the pump**, where seawater enters and gets pressurized.
- **Positioning:** Place it horizontally for a centrifugal pump.

Step 2: Motor Section

- **Shape:** Smaller Cylinder
- **How to Use:** Attach this to one side of the main pump body to represent the **motor housing**.
- **Detailing:** Use **thin cubes** to add bolts and labels.

Step 3: Inlet & Outlet Pipes

- **Shape:** Long Thin Cylinders
- **How to Use:** Attach one **cylinder** to the front (seawater intake) and another to the back (pressurized output).
- **Positioning:** Angle them slightly to simulate flow direction.

Can you show me what a high pressure pump would look like in shapes xr if I followed these instructions?




Figure 5. AI-based instruction [41] on modeling a high-pressure pump in ShapesXR and a visualization of the result of following these instructions.

scenarios in a short time. The transition to VR mock ups during the workshop was a necessary step, as analogue prototypes might deviate from the final VR product, missing implementation aspects, specific to this medium. The real-time VR prototyping in the workshop had limited success, mainly due to time constraints. Whilst ShapesXR is a tool for real-time co-creation, more time and extensive experience with the tool was essential to build testable VR prototypes in real-time. Further work on the VR prototypes after the workshop resulted in more complete versions, showing that familiarity with the tool is needed for the creation of test-ready prototypes.

VI. CONCLUSION AND FUTURE WORK

Extending the VR prototyping experience after the workshop provided valuable insight and learnings for future studies. One key learning is that, rapid VR prototyping tools like ShapesXR, can offer a pre-production workflow, which results in a potentially more streamlined process, with ultimately lower development costs and accelerated iteration cycles. Production is postponed to a later stage, once the VR prototypes have been refined to closely match needs and user experience.

Secondly, as ShapesXR does not require coding expertise and includes easy-to-learn sketching tools, it is accessible to non-experts. AI can be used to guide the entire prototyping process, lowering barriers for non-experts even further. It is anticipated that integrating no-code, VR prototyping tools and generative AI into the co-creation process could empower educational institutions to prototype their own VR learning experiences in the future. This shift towards no-code immersive design tools combined with AI could democratize immersive education.

Emerging developments are likely to improve accessibility and lower design barriers for non-VR experts

even further. For instance, beyond 3D sketching in ShapesXR, the tool allows to import external 3D models, which typically need to be purchased. Generative AI is now close to overcoming this cost barrier, as it allows the generation of 3D models from 2D images - the quality of the 3D models is improving. Moreover, developments in the field are now also enabling the automatic generation of entire, navigable, 3D worlds from a single 2D image [42]. Figure 6 presents 3D desalination plants for users to navigate through, created from 2D images and by using a simple text prompt.



Figure 6. Navigable 3D seawater desalination plant generated by Marble Worlds AI [42].

The potential of leveraging generative AI for VR content creation is supported by recent literature. For instance, Vallasciani et al. [43] presented a user study, where participants created a VR virtual museum experience with the use of generative AI. Linares-Pellicer et al. [44] highlighted that generative AI can address the bottleneck in VR educational content creation, as faculty members can use it from initial idea generation to programming and creating high-quality immersive experiences without technical expertise.

Concluding, our study has proposed a co-creation methodology to empower learners as co-designers and has offered lessons about streamlining the VR production process with no-code immersive prototyping tools. We envision that building no-code VR prototypes with AI assistance - from asset creation, to world-building - will increasingly open up possibilities for learners and lecturers to create their own immersive educational contents, tailored to their needs.

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