Responsible XR

Public values for XR in education and research

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Introduction

As technologies continue to digitalise our educational and research world, the time is now to guide and shape their influence responsibly. Many educational institutions are diving into XR technologies, and the surge of innovation and experimentation is exciting. However, as we navigate through technical concerns, order headsets, and expand their virtual experiences to new domains, we should ensure that these advancements align with our shared public values.

In this document, we present the main parts of the discussion on the use of eXtended Reality (or XR) technologies in education and research. The first step is to understand XR use in particular case examples, and raise new questions regarding XR from a public values perspective.

Case example 1 focuses on VR-based digital laboratories (labs) located in the Netherlands. This is followed by asking questions about the technology in context, empowering both users and developers to take the role of responsible technology seriously.

Case example 2 will be on VR-Powered Virtual Presentation Training. This is followed by asking critical questions about the technology in context, empowering both user and developers to take the role of technology in their personal situation(s) seriously.

3 conclusions

1. XR in training has shown **to be effective in specific uses and applications**, leading to **new transformations in both lab training and communication.**
2. Public values as a basis for serious reflection on XR technologies lead to **new, more critical questions for educators and researchers alike** to ask when considering these new technologies in their situation.
3. To put these public values into action, the XR technologies must be aligned with our public values through **responsible practices**.

To understand how XR is being used in practice, the case examples describe unique cases and the subsequent research.

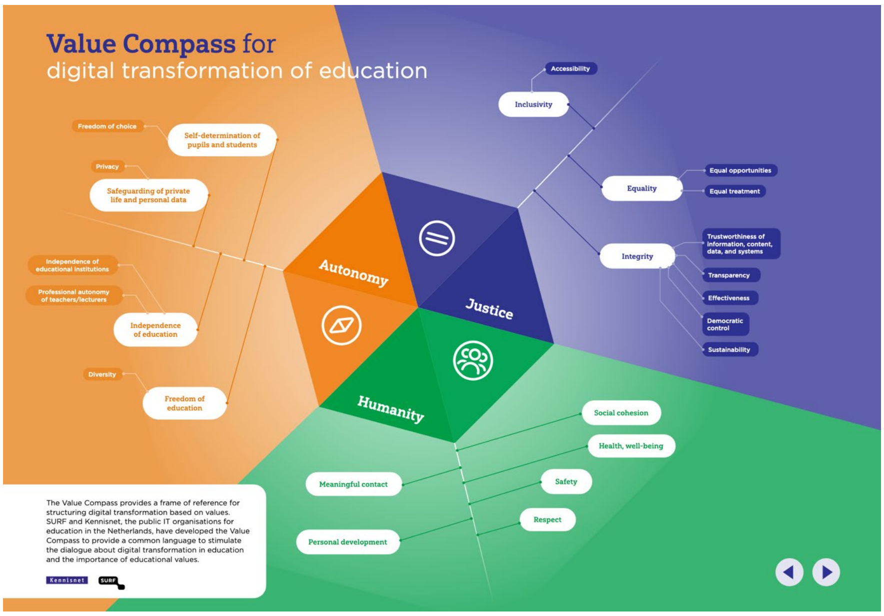
Understanding XR and public values

XR (eXtended Reality) is a term that encompasses all immersive technologies that expand our perception of reality, such as Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR) (See appendix A for more). VR creates a completely computer-generated environment that replaces the real world. There has been a growing interest in these technologies from educational institutions and research organisations alike, which have looked to better understand how they can benefit from the use of XR technologies in their work. To learn more about these technologies, check out "What is XR and what can it do".

Public values

XR technologies are able to set learners and instructors in new (digital) experiences. Public institutions in the Netherlands have also begun to acknowledge the impact of XR technology, and the discussion continues to grow (Kennisnet, 2022; Snijders et al., 2019). The virtual experiences of these new devices are not to be taken lightly, as they can induce intense emotions and physical reactions, and collect data on almost every movement made by the user. In turn, XR technologies have capabilities that extend to affecting different emotional states, bringing people together and influencing social behaviour (Nikiel, 2020).

Ongoing digital transformation in education offers many advantages, but at the same time puts public values under pressure. The Dutch education sector is increasingly debating the impact of digital technologies. Prompted by a 2019 call to action from all public university vice-chancellors, concerns were raised about what influence large tech corporations have on education and the need to uphold public values. This sparked a national debate on public values in education. The rise of technologies, including XR, is reshaping educational practices and creating dependencies on software providers, leading to new challenges and responsibilities for institutions. To help navigate these changes, Kennisnet and SURF developed a Value Compass — a framework for addressing public values in education, aimed at promoting a discussion beyond functionalities and costs to shared ambitions for the future of digital education.



Case example 1:
Virtual labs in virtual reality

The introduction of virtual labs with VR is a new experimental step for institutions like the University of Groningen, Wageningen University and Research, University of Twente, and University Eindhoven. These institutions have used this virtual experience for a variety of scenarios found in labs and with varying educational methodologies, including challenge-based learning.

This VR organic chemistry labs experiment was introduced to cope with both training students on new lab equipment, their feelings of preparedness in the lab and give virtual access to it during closure times during COVID-19 lockdowns . Learning about the lab layout, its tools and what to expect before going into the real thing is helpful for new students, essentially providing a preparatory tool to boost student confidence and readiness as well as a virtual alternative for ensuring continuity in education.

Research context

The VR experiment Virtuele Practica is an example of the increased interest in the use of VR in laboratories and in STEM (Science, Technology, Engineering and Mathematics) research (Bitter & van der Kolk, 2021; Liu et al., 2020; Makransky et al., 2020). New ways of motivating students, teaching students, and experimenting with students on the possible added value of XR technologies in STEM learning are growing (SURF, 2023b). Findings focused primarily on negative feelings, such as anxiety or lack of confidence in the lab, show that students can become more confident or feel less anxiety when first incorporating VR laboratory experiences in their training. With learning being at the centre of the discussion, it may be important to consider the simulation environment as more engaging than informative. For instance, research has found that learners feel a greater sense of presence when they are using a high-immersion VR science lab simulation involving a head-mounted display while learning less when compared to the low-immersion version of a desktop simulation (Makransky et al., 2019; Liu et al., 2020).

The findings from the research completed in VR labs have been quite encouraging, with students perceiving the virtual lab as a positive experience. Moreover, studies like these have provided evidence that virtual chemical laboratories are not only viable as a complementary tool, "but that they provide better results in learning outcomes" than using a traditional lab first for onboarding (Gungor et al., 2022, p. 7). As these systems continue to become more realistic and enriched with detail, new questions arise as to how students and instructors should interact in the virtual laboratory, indicating that future curriculum will be prepared not only for a physical but also for the simulated lab experience as well. In fact, labs at TUDelft have already begun taking the first steps to implement a VR laboratory in education (Interactive Virtual Reality Laboratory, 2018).

Public values: A foundation for better questions

Taking the role of technologies in education seriously involves recognising technologies as having an impact on our norms and ways of living. XR technologies are no different, but are unique in their increasingly disruptive capabilities. Various public values and their components could be considered for virtual labs in VR and their unique capabilities in modelling chemistry labs.

For this case, one component of each public value has been selected. The components chosen were: personal development (Humanity), inclusivity (Justice), and the self-determination of students (Autonomy). These components were chosen because of their direct connections to reasons why virtual labs are often implemented in educational settings.

Personal development and inclusivity are namely seen as benefiting from the implementation of VR virtual labs, and their capabilities often improve inclusiveness in the course by removing obstacles for learners to get into lab training. Self-determination of students was considered for this section, as much of the training in VR virtual labs requires the students to do so in their own time and interest. Engaging with public values as a basis for serious reflection on XR technologies will lead to new, more critical questions for educators and researchers alike to ask when considering XR technologies in their context.

Personal development (Humanity)

Education should encourage self-development by incentivising the expression of the learners' character and their relation to the world (Bok et al., 2021). Thus, technologies should not only facilitate this value, but help ensure that learners can find or create opportunities for personal development. In other words, when VR labs enter the educational context, it could be considered as impacting personal development. Virtual labs challenge learners and instructors alike to think differently about their training and (learning) environment. From here, new questions arise regarding personal development and the use of VR-based laboratory training.

Emerging questions

- How can VR technology in our institution foster self-development and encourage learners to express their character? In what ways can VR provide a more enriched environment for this self-exploration compared to traditional in-person methods?
- How can the VR-based laboratory be enhanced to better facilitate self-development and a learner's connection to the world? Are there elements from the real world that might distract or detract from this goal if introduced into the virtual environment?
- Could XR immersion lead to feelings of isolation among students, hindering the sense of community that traditional educational settings provide?
- How might implementing XR technologies change the personal development goals of our students or staff? Will there be a new expectation we cannot facilitate?

Challenges

With personal development in consideration, there are many exciting possibilities for education and research, but also some concerns to consider. Based on public values, we see a need for future capabilities of detailed, tactile interaction in VR to capture more nuanced experiences of a real lab setting. There is potential for isolation, where self-development is hindered by not having learners work through building relationships, teamwork, and communication skills. If not designed thoughtfully, VR experiences can isolate learners in siloed environments, depriving them of opportunities to collaborate.

Inclusivity (Justice)

The value of inclusivity is found by keeping education open to all learners (Bok et al., 2021). Simulated laboratories have multiple benefits for learners. VR-simulated laboratories do not have limitations for height, such as shelves that are too high, nor do they ever close; they can be open 24/7. These virtual labs also enable students from around the world who have access to the internet and headsets to train within the virtual space, promoting possibilities for inclusive laboratories in the future (Kennisnet, 2022). Inclusivity as a value provides a starting point for new questions when implementing these VR laboratories.

Emerging questions

- Who cannot be included in a VR-based laboratory? Who is missing from the conversation or training?
- How will we be able to change the content of the simulated laboratory in the future to fit the individual user?
- What training or resources are provided to educators to help them foster an inclusive environment with XR technologies?
- How are our simulated laboratories and trainings designed to promote inclusive learning experiences for all? What pedagogical approaches are we employing to ensure every learner, regardless of their background, benefits from XR technologies?

Challenges

Inclusivity with VR may be more approachable for some learners and even educators, but limitations are still prevalent. Not everyone will have access to the required VR hardware and software, which creates a disparity between those who can afford and experience these immersive onboarding sessions and those who cannot. This disparity leads to technological accessibility issues. The same obstacle can occur for researchers, as not all researchers have equal access to the latest VR equipment and software, especially those in underfunded institutions or developing regions.

Self-determination of students (Autonomy)

Learners and their instructors often work together to share motivations and goals to better educational experiences. In the context of public values, students should have the right to choose the type of education that suits them through self-determination (Bok, et al., 2021). The VR labs experiment described as an example offers students not just a 24/7 available lab, but also a solitary space to explore the lab equipment with less distraction or noise. Moreover, the ability to use these tools allows students to learn without the need to go to a campus for every training session. These considerations lend themselves to new insights in VR-based laboratories when re-framed for this value.

Emerging questions

- What current challenges do VR-based laboratories resolve for students, and are there other technologies that could be viable instead?
- Can VR-based laboratories increase the freedom learners have to choose their learning paths and topics of interest?
- Does the VR-based training in virtual labs enhance the experience of current learning goals or pedagogy?

Challenges
The value of self-determination shows many facets of use in VR-based laboratories, but also new questions about impact. If institutions heavily adopt VR labs without maintaining physical labs, it could limit the choices for those learners and researchers who prefer hands-on, tangible experiences, leading to an over-reliance on the XR tools. VR simulations may also have limitations on how users can modify their approach or deviate from a set simulation path. This could hinder learners' and researchers' sense of agency and self-determination in their educational or investigative processes.

Conclusion

This case example focuses on understanding how XR technologies are currently being used in VR-based virtual chemical lab training and how public values can help inform better, more critical questions about technologies. The case example of VR-based laboratories sets the stage for both how XR technologies are applied to VR-based training and the research that surrounds their use. From the case example, public values are brought in to frame better, more critical questions about both application and common concerns with XR technologies in the VR-based laboratory context.

The public values considered in this case example show VR's potential is vast, yet concerns arise around authentic interactions, potential for isolation, and limited opportunities for collaboration. While VR can enhance inclusivity, accessibility challenges persist, with many learners and researchers potentially lacking the necessary hardware and software, especially in underfunded regions. Additionally, the principle of self-determination in VR-based laboratories raises concerns about over-reliance on VR, possible neglect of traditional labs, and constraints on learners' and researchers' agency to adapt their approach within VR settings. This emphasises the need for a balanced and thoughtful integration of VR in education and research.

Public values provide both a common vocabulary, and some familiar values to consider when implementing technologies into educational or research-based contexts. Following these questions are new open opportunities to act. Where the framework of public values may not be sufficient to give direct answers to the serious questions it raises, responsible XR enables action and direction through guided conversation and consultation.

Impact

Acting on public values requires open dialogue, budding from individuals and/or communities that take a first step into these complex conversations. New tools to discuss, debate and re-frame the impact of technologies and the plurality of beliefs, ideas and values that come from it have been designed and offer some guidance. These dialogues can also stem from case examples like this, which try to set a stage with which technology is observed and analysed for its role in and impact on education or research. XR technologies further embed digitalisation into education and, in turn, impact how public values are discussed, prioritised, and acted upon.

Public values as a discussion tool and framework continue to actively drive and shape conversation. Moving beyond public values may require looking beyond discussion and more towards practice-based approaches. Some of these practices may be found in discussions revolving around the communities of responsible technologies. Responsible XR is one branch of responsible technologies that can offer new insights into not only the public values involved, but also the implementation and design of such technologies.

Case example 2:
VR-powered virtual presentation training

Simulations for learning are popular for training procedural knowledge, step-by-step interactions and industry-focused skills. The work in Hogeschool Utrecht sheds light on a new way of considering social skills for simulations; and that is as a virtual audience for practicing speeches (Boetje & van Ginkel, 2021; van Ginkel, 2019; Van Ginkel et al., 2020).
In this case, there is a virtual audience that has been created in simulations to seemingly watch, listen, and sometimes annoy the practicing presenter. The simulations are generally simple; presenters are placed in a room or boardroom with an audience to fill the seats with different virtual persons, some paying attention, others not. With this, the presenters are placed in an artificial scenario that depicts potentially real events, with the likelihood that they will act and respond appropriately or as they would in real life (Valls-Ratés et al., 2022). Much of the interest in the use of these simulations with VR technologies comes from the presence (or feeling) of being a speaker that VR can offer.

These simulations offer learners an audience that is always available and easy to organise with. The use of public-speaking skills continues to be vital in both industry and academic work, but public-speaking experts may be limited in availablity, making them hard to find and schedule. Here, VR simulations offer not only an existing audience, but also one that can give feedback based on eye tracking, motion tracking, speech rate and more (Ginkel, 2019). Continual use of these simulations has been researched thoroughly to ascertain the benefits of presenting in a virtual world.

Reducing public speaking anxiety, or PSA, has been given special attention in many studies, and results show a reduction in PSA in as little as 3 training sessions over a five-week period (Valls-Ratés et al., 2022). Some simulations even allow for immediate messages that alert the presenter during their presentation that they need to maintain eye contact with audience members or slow/speed up their rate of speech (Boetje & van Ginkel, 2021; Van Ginkel et al., 2020).
Giving feedback to students in these simulations is not easy, and guaranteeing its effectiveness is still under investigation. Recent studies found that students enjoy getting immediate feedback from VR trainings, but a coach or instructor is still required for context-specific feedback (Magnée et al., 2022).

Feedback timing, placement in the simulation and moving from quantitative analysis to a qualitative approach requires innovative thinking and future research (S. van Ginkel, personal communication, 27 September 2022). Moreover, virtual presentations are still difficult to integrate into a more traditional educational space and therefore require a dedicated lab or workshop (Merchant et al., 2014; van Ginkel, 2022).

New opportunities

While many learners will continue to practice their presentations at home in front of a mirror or with their friends, VR presentation exercises continue to intrigue educators and industry entrepreneurs alike. It is difficult to ignore that the possibilities of scaling these VR exercises and instant feedback on various details of any presentation may lead to greater benefits and new creative routes. A technology like VR presentations also impacts our public values as its implementation becomes more and more widespread. To consider the impact this technology application may have on public values on education, three sub-values from the broader three areas of public values will be discussed.

Public values: A foundation for better questions

Taking the role of technologies in education seriously involves recognising technologies as having impact on our norms and ways of living. XR technologies are no different, but are unique in their increasingly disruptive capabilities. Various public values and their components could be considered for VR-based presentation training and its capabilities in developing presentation skills.

For this case, one component of each public value has been selected. The components chosen were: Meaningful contact (Humanity), equal opportunities (Justice), and safeguarding of private life and personal data (Autonomy). These components were chosen to show the unique impact VR presentations can have on education in practice.

Meaningful contact is often associated with time-well-spent between learner and instructor. XR technology can give a new meaning to this notion. Equal opportunities in inclusivity are about more than just technical solutions. XR technologies are in a unique position in relation to equal opportunities, which are considered in this section. Lastly, safeguarding data is a critical discussion to have regarding XR technologies, as their many sensors can collect more data than people may be aware of.

Meaningful contact (Humanity)

Meaningful contact can be interpreted as an important and meaningful connection between students and teaching staff (Pijpers & Bomas, 2020, p. 19). These connections change as we continue to implement new technologies, especially headsets with VR capabilities. For presentations, instructor feedback becomes critical, but wearing the headset may also impact how learners direct their attention to specific things. Learners may feel overwhelmed by the scenario at first and need to come to terms with its features. From here, new questions arise regarding meaningful contact and the use of VR-based presentation training.

Emerging questions

- How does the headset or wearables impact the communication between instructor and learner? Is the instructor inside the virtual world?
- What new behaviours form in VR-based presentations? Are there habits that form from using the headset during presentations?
- Does a trainer or instructor need to be present at all VR-based trainings?
- How is feedback provided? Are peers part of the learning process?

Challenges

This use of VR in presenting offers new insights to communicative skills. It also has an impact that should be considered. While VR offers a simulated environment for presentation training, it may not capture the full spectrum of human emotions and reactions. Non-verbal cues such as body language, tone variations, and real-time feedback from an audience are integral to the process of communication. Moreover, feedback in a VR environment might be based on algorithms and predetermined metrics, which could lack the personalised touch and understanding that a human educator provides.

Equal opportunities (Justice)

Equal opportunities may be concerned with educational institutions offering equal opportunities to all students, without disadvantaging or excluding specific groups (Bok et al., 2021). The always available audience in VR-based presentation software allows students more time and flexibility to practice. Making appointments for timeslots on stage takes planning and sometimes luck. Not all learners have that luxury of time, and simulated presentations can help with that. However, these simulated audiences may vary and creating new simulations can be costly in both time and effort.

Emerging questions

- What kind of opportunities do students see in virtual reality? Will these skills be important for the future of their education or work?
- Can agreements be made to share simulations between institutions? Are open-source exercises/scenarios available?
- Are our simulated presentation trainings developed with pedagogy in mind? If yes, what are those pedagogies?

Challenges

Skills, opportunities, and the interaction between the two will be impacted by XR technologies. In this case, we can see concerns that not all students may have access to the necessary VR equipment and internet connectivity required for VR-powered presentation training, yet. Non-accessible virtual experiences and lack of features like closed captioning, voice recognition, or customisable interface settings could exclude certain students from fully benefiting from the VR training. For researchers using XR technologies, there is a risk that the VR environment might not be equally accommodating or intuitive for all users if a researcher's study involves participants from varied backgrounds.

Safeguarding of private life and personal data (Autonomy)

One component of autonomy in education is the ability to safeguard personal life and personal data, where learners and educators know their privacy is ensured when they use digital resources of their institution (Bok et al., 2021). For virtual presentations, the amount of data that headsets and their controllers can measure and collect is hard to comprehend. Data collected with these headsets can include mouth movements, eye tracking, location, walking style, and the list goes on (Kennisnet, 2022).

Emerging questions

- What data is necessary for proper feedback? How is this communicated to a learner?
- If taken away from the institutions, will the cameras of the headsets record the spaces of the learner? Who will have access to that data?
- What current challenges do VR-based presentations resolve for students and are there other technologies that could be viable instead?

Challenges
The concerns raised for safeguarding personal life and personal data require new regulatory and data protections. Modern VR systems are equipped with sensors that track a variety of user metrics, from eye movement to body motion. While these metrics can be useful for presentation training – for instance, by analysing a presenter's gaze to ensure they are engaging with their audience – they can also be deeply personal. If mishandled, this data provides insights into a user's health, physical capabilities, or even emotional states. As with any digital platform, VR systems are vulnerable to cyberattacks. The unique and comprehensive nature of data collected by VR systems can make them attractive targets.

Conclusion

This case example focuses on understanding how XR technologies are currently being used in VR-based presentation training and how public values can help inform better, more critical questions about technologies. The case example of VR-powered presentation training is brought into the discussion to set the stage for both how XR technologies are applied to VR-based trainings and the research that surrounds their use. From the case example, public values are brought in to frame better, more critical questions about both application and common concerns with XR technologies in the VR-based trainings.

The adoption of VR in presentation training presents multifaceted challenges. While it offers a dynamic platform for skill development, VR may not fully replicate the depth of human interactions, lacking nuanced emotional cues and the personal touch of human feedback. Equally concerning is the digital divide, as not every student has access to required VR gear and high-speed internet, and without inclusive design features, certain groups may be inadvertently sidelined. Researchers also face challenges from VR environments that may one day be universally intuitive. Furthermore, the intimate nature of data collected by VR, from eye movements to physical gestures, coupled with potential cybersecurity threats, underscores the pressing need for robust data protection measures to guard users' personal and sensitive information.

Public values provide both a common vocabulary, as well as some familiar values to consider when implementing technologies into educational or research-based contexts. Following from these questions are new open opportunities to act. Where the framework of public values may be not be sufficient to give direct answers to the serious questions it raises, responsible XR enables action and direction through guided conversation and consultation.

Impact

Acting on public values requires open dialogue, budding from individuals and or communities that take a first step into these complex conversations. New tools to discuss, debate and re-frame the impact of technologies and the plurality of beliefs, ideas and values that come from it have been designed and offer some guidance. These dialogues can also stem from case examples like this, which try to set a stage with which a technology is observed and analysed for its role in and impact on education or research. XR technologies further embed digitalisation into education and in turn impact how public values are discussed, prioritised, and acted upon.

Public values as a discussion tool and framework continues to drive and shape conversation in an active way. Moving beyond public values may require looking beyond conversation and more towards practice-based approaches. Some of these practices may be found in discussions revolving around the communities of responsible technologies. Responsible XR is one branch of responsible technologies that can offer new insights on not only the public values involved, but also the implementation and design of such technologies.

Next steps

Using public values as a frame raised new questions, concerns, and opportunities for communities in education and research. The next step may be to act on these questions and tackle the complex discussions, designs, and implementation related to virtual experiences in education and research.

The SURF XR team has begun facilitating dialogues regarding important questions like the ones found in these cases. We believe that shaping a better future of research and education with this technology requires considerations for both the technical and social side of XR. In other words, it is a matter of ensuring that as we push the boundaries of what is technologically possible, we do so in a way that is ethical, respectful, and beneficial for all involved while guided by a strong commitment to public values.

Responsible XR addresses questions related to responsible application, virtual experience design and value alignment, while being framed by public values. We do this through fostering reflective practices, amplifying member voices, and embodying public values in our co-creation of virtual experiences.

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Appendix A: Definitions of extended reality technologies

AR (Augmented Reality):
- **Definition**: Refers to devices that overlay information onto the real world while being seen through cameras or other screens.
- **Example**: The popular game “Pokémon Go” takes advantage of AR by interacting with the real world through the lens of a user’s smartphone camera.
- **Reference**: Wingfield & Isaac, 2016

MR (Mixed Reality):
- **Definition**: Blends human perception with digital interfaces or holograms, merging the physical and digital worlds.
- **Example**: One application of MR includes digital overlays on construction sites showing blueprint work and building outlines in design. It often involves seeing the world through the cameras of a headset with simulated interfaces in view.
- **Reference**: Kennisnet, 2020

VR (Virtual Reality):
- **Definition**: Encompasses user experiences that are visually and auditorily distinct from the real world.
- **Example**: Often used with headsets, headphones, and haptics, virtual reality tools have applications in gaming, workplace training, and tourism.
- **Reference**: Ziker et al., 2021, p. 56

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