University of Glasgow

WHITEPAPER

XRED: PREPARING FOR IMMERSIVE EDUCATION

Professor Neil McDonnell

Dr Lavinia Hirsu

Dr Gabriella Rodolico

Dr Sarune Savickaite

Dr Imants Latkovskis

Dr Lysette Chapronniere

WORLD CHANGING GLASGOW

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We are the Scoping Extended Educational Realities (SEER) research group within the University of Glasgow. We believe that XR technology will transform education.

This transformation will introduce a 3D medium into learning spaces, enable widescale virtualisation of hitherto impractical experiences within lessons, and lead to dramatic changes in *how* and *what* it is possible to teach and learn. It will also change the world of work that we prepare our learners for.

Such change could be quick, safe, and equitable if we make the right decisions today, or it could be slow, carry risk, and be inequitable if we do not. Our ambition in this work is to catalyse the positive and responsible adoption of XR technology in education. We will call such widespread adoption **XRed**.

This Whitepaper document condenses our work into key takeaways. The associated Report document lays out our research, thinking, and argument in detail and provides Case Studies, an Illustrative Example of how we see a future lesson which makes use of XR technology, and a Glossary.

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WHAT IS XR TECHNOLOGY?

XR technology – sometimes extended reality – is a collective term for a group of technologies:

Virtual reality: VR intervenes on the senses to represent a completely virtual environment to a user.

Augmented reality: AR intervenes selectively on the senses to represent virtual elements *as if* they are in the real world, but lets the user still engage with the real world directly.

Mixed reality: MR uses virtual reality technology to re-present the real world to the user so that virtual elements can appear to be in the user's real environment.

VR is perhaps the best known of these technologies today. It is the most dramatic and affecting for the user as it separates them from experiencing their real-world environment.

AR is currently encountered via mobile phones which allow users to see the real world on their phone screen with virtual objects (e.g., Pokémon, furniture, measuring tapes) overlaid realistically. Notice that this is technically mixed reality by the now-standard definitions we use in the boxes. This is just one example of how the terminology in this area has changed over time, and how it continues to be confusing (See our Report for the glossary).

Hence we focus on the general term XR which encompasses VR, MR, and AR technologies. Our observations are not limited to the technology as it is today, but how we anticipate it will evolve – see our Illustrative Lesson in the full Report.

WHAT CAN XR DO?

XR technology has been enabled by the progress in computer vision and games engines which has made it possible for a user to put on a headset and have their own movements tracked well enough (computer vision) to realistically match a virtual environment (games engine) so that they can feel like they are really there (VR) or so that the virtual objects look like they belong in the real world (MR/AR).

This lets users:

Visit places they could not otherwise visit

- Places that are Dangerous, Impossible, Counterproductive or damaging, or Expensive[1] to visit, or places rendered inaccessible by physical or psychological barriers.

Do things that they could not really do in the real world

- Dissect patients, throw lightning, shoot bacteria, build mountains, mix combustibles, divide cells. Then repeat many times without cost or fear of failure.

Experience situations that they never could in the real world

- Return to the womb, handle a deadly pathogen, fly a spitfire.

See objects or environments from a perspective they could not occupy in the real world

- Look down on a galaxy, up at an atom, stand in the Mariana Trench.

Process 3D information via a 3D medium

- The shape of a hydrocarbon, the scale of a blue whale, the structure of the Sagrada Familia.

In sum: XR bypasses many of the physical and causal constraints of the real world.

[1] This is Jeremy Bailenson's DICE criteria for effective use of VR. Bailenson J. (2018). Experience on demand: *What virtual reality is, how it works, and what it can do*. W. W. Norton & Company.

WHAT CAN XR DO FOR EDUCATION?

Imagine if teachers and learners had superpowers that could let them take lessons *anywhere* and do *anything* when they got there. How would educators teach with these powers? What would they teach that they couldn't before? How would learners engage and collaborate in new ways? We think they would do almost everything differently and it would transform education.

XR technology makes such superpowers possible and we think that it could transform learner experiences, drive imagination and wonder, expand their boundaries, engage new modalities, stimulate creativity, and give them the freedom to fail and simply try again. It will achieve this through its distinctive expansion of learning affordances: interactivity, feedback, presence, agency, 3D, and immersion. The first steps have been taken already: see Case Study 2 in the full Report.

The widespread adoption of this technology—XRed—is not yet here but we think that it is coming, and that by thinking about it carefully today we can catalyse the positive and responsible adoption of the technology for the good of education tomorrow. We offer an Illustrative Lesson to demonstrate this in the full Report.

XRED: ROADBLOCKS AND OPPORTUNITIES

We organise our considerations into four categories: Classroom Deployment, Pedagogical Adoption, Access, and Safety. For each we identify a mixture of Roadblocks to XRed adoption, and Opportunities that it might bring. We mention recommendations along the way before summarising and categorising those recommendations in the Recommendations section.

Classroom Deployment

Space. XR will enable teaching in a range of non-classroom contexts, but deploying XRed in the classroom – where the majority of teaching takes place for logistical reasons today – will impact on how space is used. XR technology will require different types of space than traditional classrooms offer, but it will also allow us to use virtual space instead of physical space for certain tasks.

Classroom management. XR lessons can be extremely absorbing, but that means that learners can become distracted, especially by some of the stimulating experiences which XR will bring, and yet XR could help a teacher to manage classroom attention and guide behaviour (Illustrative Lesson) much like iPads already do (Case Study 2).

Transition. The transition between teaching using a whiteboard, a tablet, a physical object, physical movement, and XR technology may all happen in a single lesson in the future. These transitions to and from XR are difficult to enact with current devices and create a barrier to their integrated use.

Distance. XRed has the potential to change how learning over distance can happen through virtual co-location, and the sharing of 3D experiences.

Expertise. Teachers and learners largely lack the expertise to use XR technology today, and more importantly to author the experiences they need for XRed.

Standardisation. New technologies bring a proliferation of standards in the early years and XR is no different. This creates friction.

Takeaways:

Classroom flexibility; tech-assisted classroom management; improved distance learning; tech-assisted transitions.

Current classroom size layout; behaviour management barrier; on/offboarding friction; lack of XR expertise; hard/software standardisation.

Recommendations:

Develop an XRed apt Product – *Industry*

Build an XRed Ecosystem – *Industry*

Anticipate XR Adoption – *Education*

Pedagogical Adoption

Ambition. XRed does not just provide a new means of teaching what we already do, but it enables us to broaden the horizons of what is taught. That requires vision, imagination, and ambition.

Best practice. We do not yet know what best practice looks like for XRed at scale. We do know that aligning teaching methods to intended learning outcomes is vital for good education in general, and that aligning the technology to those learning outcomes is part of that process.

Equipping teachers. Teachers require access to the technology, to existing or prepared resources, and the skills and tools to make their own XRed resources.

Time and bandwidth. Educators need time and appropriate workload bandwidth to adapt to XRed.

Takeaways:

Vast new teaching possibilities.

Best practice not yet defined; equipment, training, and resources limited; teacher workload.

Recommendations:

Build an XRed Ecosystem – *Industry*

Build the evidence base for pedagogical efficacy – *Industry, Government*

Adopt early and evolve – *Education*

Access

Equality. Not every learner can access XR technology today and so access to the technology is limited and unequal, and yet XR could expand the access to education for remote or shielding learners.

Cost. XR technology may not cost as much as many assume at first glance as highly capable headsets are comparable in price to an iPad. And yet XR technology is expensive relative to the proportion of teaching it can contribute to today. Here XR compares unfavourably to those same iPads (Case Study 2).

Ability. XR devices are built for the typical user – with typical sight, hearing, mobility, dexterity, and neurology. But XR devices could be extraordinary enablers for the atypical user via the use of computer vision, spatial audio, and haptics. We do not yet fully understand how to use XR for such enhancement, or how such adaptations may also benefit more typical users too.

Ecology. XR devices allow virtual fieldtrips and simulated experiments and thus offer an opportunity to reduce carbon emissions and waste. At the same time XR devices generate carbon and waste in their manufacture and operation. We do not know the net effect on our environment of widespread adoption.

Takeaways:

Access improvements for some; potential for environmental gains.

New access barriers for some; current cost-benefit ratio; environmental costs.

Recommendations:

Research accessibility in XRed – *Industry, Government*

Adopt Universal Design for XRed – *Industry*

Develop an affordable XRed apt product – *Industry*

Research the ecological impact – *Government*

Safety

Safeguarding. Education is a gateway to important life outcomes, and at certain stages is mandatory, and that means that learners have less scope to opt-out of using XR technology than standard consumers do. It follows then that the safeguarding obligations concerning XRed are far greater for learners than for consumers.

Health & Safety. VR users are often unaware of their environment in a way that can expose them to hazards. But Computer Vision can help keep users safe by detecting and highlighting dangers.

Data. Computer Vision and eye-tracking are key to the successful operation of many XR experiences, but they create both new data opportunities for personalised experiences and new data vulnerabilities for those using the devices, and also those around them. This data can be social, personal, and can enable biometric inferences.

Wellbeing. We do not yet know the medium- or long-term impacts of extended XR use on perception, cognition, or behaviour.

Takeaways:

Tech-assisted safety; highly personalised experiences.

New safeguarding, health, and data challenges; unknown long-term impacts.

Recommendations:

Develop a secure and private XRed apt product – *Industry*

Research the impacts on perception, cognition, and behaviour – *Government*

Establish data handling protections – *Government*

XRED: RECOMMENDATIONS

Here we organise our recommendations by sector.

XR Technology Industry:

Build a product, build the path.

- We recommend that the XR Technology Industry build XRed products that are apt for classroom deployment. This requires that they enable safe and autonomous on/offboarding for classes and that they have integrated tools for classroom management to support educators, but it also requires that privacy and accessibility are not afterthoughts.
- We recommend that the XR Technology Industry build an XRed Ecosystem of standardised tools and platforms which allow educators to be trained and to be able to create content fit for their purpose.
- We recommend that the XR Technology Industry supports robust research into the demonstrable pedagogical benefits, and not mere "wow" or imagined gains, of XR use in education.
- When the evidence is strong, the products apt, and the ecosystem established, then the positive case for XRed will be compelling. Costs must be controlled to ensure the overall value proposition is too.

Government:

Anticipate, support and safeguard.

- We recommend that Government attends to the power of XR technology today before widespread adoption takes hold. Private interests and the natural evolution of the technology cannot be relied upon to safeguard XR users in general, but especially learners using XRed in mandatory or option-limited contexts.
- We believe that the Government's role is to support research which will inform strategy and regulation. Urgent research is required concerning the potential pedagogical benefits of XRed, the potential impacts on perception, cognition, learning, and behaviour of learners and educators, the potential accessibility implications (good and bad), the new data implications, and the net impact on our environment.

Education Sector:

Prepare, align, integrate, and lead.

- We recommend that the Education Sector anticipate widespread XRed and start early —now— in the process of preparing teachers, curricula, and classrooms for that future.
- We recommend that Educators engage with research and develop best practice guidelines. These should outline where and when there is alignment between learning outcomes and the capabilities of XR technology and identify where XRed can support new, ambitious, learning objectives that were not possible before.
- We recommend that educators develop techniques for transitioning in and out of XR within lessons, and integrate the technology into practice in an inclusive way.
- More generally we think that the Education Sector must take the lead to ensure XRed is built to enable and support those who know best: education practitioners.

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Laura Foster

Leticia Jauregui

Luca Ottonello

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Dr Mark Wong

Martin McDonnell

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