Youth and Extended Reality: An Initial Exploration of Augmented, Virtual, and Mixed Realities

SPOTLIGHT SERIES

Youth and Extended Reality:

An Initial Exploration of Augmented, Virtual, and Mixed Realities

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SUGGESTED CITATIONS

APA

Cortesi, S., Hasse, A., Eigen, M., Maddens Toscano, P., Malik, M. & Gasser, U. (2021). *Youth and extended reality: An initial exploration of augmented, virtual, and mixed realities.* Youth and Media, Berkman Klein Center for Internet & Society. https://cyber.harvard.edu/publication/2021/youth-extended-reality

Chicago (Bibliography)

Cortesi, Sandra, Alexa Hasse, Melyssa Eigen, Pedro Maddens Toscano, Maya Malik, and Urs Gasser. "Youth and Extended Reality: An Initial Exploration of Augmented, Virtual, and Mixed Realities," Youth and Media, Berkman Klein Center for Internet & Society (2021), accessed on [Month Day, Year], https://cyber.harvard.edu/publication/2021/youth-extended-reality

Chicago (Footnote)

Sandra Cortesi, Alexa Hasse, Melyssa Eigen, Pedro Maddens Toscano, Maya Malik, and Urs Gasser. "Youth and Extended Reality: An Initial Exploration of Augmented, Virtual, and Mixed Realities," Youth and Media, Berkman Klein Center for Internet & Society (2021), accessed on [Month Day, Year], https://cyber.harvard.edu/publication/2021/youth-extended-reality.

MLA

Cortesi, Sandra, Alexa Hasse, Melyssa Eigen, Pedro Maddens Toscano, Maya Malik, and Urs Gasser. "Youth and Extended Reality: An Initial Exploration of Augmented, Virtual, and Mixed Realities." Youth and Media, Berkman Klein Center for Internet & Society, 2021. Web. [Day Mon. Year]. <https://cyber.harvard.edu/publication/2021/youth-extended-reality>.

Bluebook

Sandra Cortesi, Alexa Hasse, Melyssa Eigen, Pedro Maddens Toscano, Maya Malik, and Urs Gasser. YOUTH AND EXTENDED REALITIY: AN INITIAL EXPLORATION OF AUGMENTED, VIRTUAL, AND MIXED REALITIES (2021), *available at* https://cyber.harvard.edu/publication/2021/youth-extended-reality

KEYWORDS

Youth, young people, children, adolescents, teenagers, high school, middle school, digital media, Internet, online, extended reality, augmented reality, virtual reality, mixed reality, learning, education, physical health, mental health, social issues, funding.

PUBLICATION DATE

October 2021

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ACKNOWLEDGEMENTS

We are very appreciative of all the members of the Berkman Klein Center's Youth and Media team for their support of the project upon which this spotlight is based. Special thanks to Euan Brown, Felix Diaz (cover illustration), Rebecca Smith, and Claudia Thomas for their wonderful illustrations integrated in this paper.

Additionally, we are deeply grateful to Jeremy Bailenson, Cindy Ball, Marquis Cabrera, Mark Griswold, James Hairston, Sameer Hinduja, Lexi Kellison, and Leah Plunkett for reading a draft version of this report and providing comments and feedback, as well as their important work in this field.

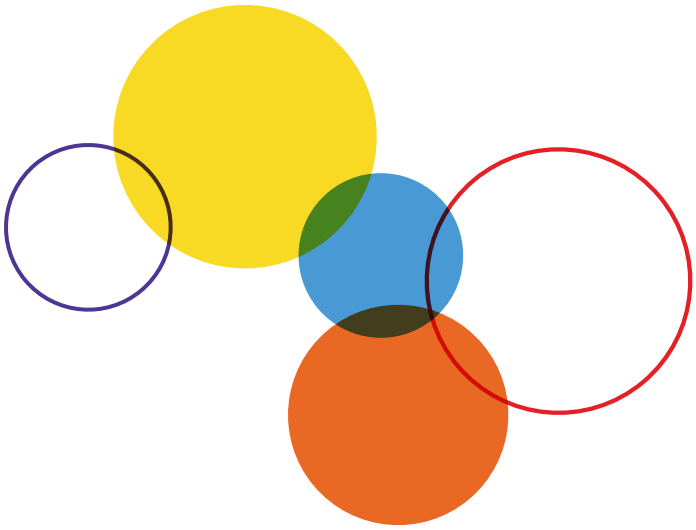
We would also like to thank Alex Edgerly for the creative layout and design of the spotlight.

This report is also a contribution to the World Economic Forum's Global Future Council on Virtual and Augmented Reality, of which Urs Gasser (co-chair) and Sandra Cortesi are members. The Council's mission is to explore and raise awareness around the positive and negative aspects of XR technologies and to translate findings from research and practice into tangible outputs for decisionmakers in this space. The authors are grateful for Council members' inputs and feedback on an earlier draft of this paper.

Youth and Extended Reality: An Initial Exploration of Augmented, Virtual, and Mixed Realities

By Sandra Cortesi, Alexa Hasse, Melyssa Eigen, Pedro Maddens Toscano, Maya Malik & Urs Gasser.

Extended reality (XR) technologies are becoming increasingly pervasive in the lives of young people today, entering homes, classrooms, and museums. These immersive technologies hold great promise for learning, creativity, and self-expression, while coming with risks connected to accessibility, privacy, and safety. This report seeks to showcase some of the Youth and Media team's initial learnings and questions around the potential benefits and challenges extended reality technologies may present for youth (ages 12-18), as well as concrete XR examples in domains such as learning, physical and mental health, and diversity, equity and inclusion. The piece also highlights examples of ways youth may design their own XR experiences, creating pathways for them to contribute to the societal discourse around these systems. This paper is not meant as a comprehensive overview of all youth-relevant XR experiences and their risks and benefits. Instead, the piece seeks to inspire further research and dialogue in the XR space and encourage a variety of stakeholders — including policymakers, international organizations, educators, and parents and caregivers — to discuss how we can, together, empower youth to meaningfully engage with XR technologies to promote learning, well-being, and inclusion, while addressing key concerns.



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I. INTRODUCTION

Extended Reality (XR) technologies are increasingly becoming a part of people's lives. With the help of XR, people can visualize a new piece of furniture[1] in their living room, solve engineering problems, or train medical practitioners.

XR is a multimodal technology with the capability of merging the physical world with virtual worlds by combining already existing aspects of augmented reality (AR), virtual reality (VR) and mixed reality (MR) into one environment — people can overlay virtual effects in their physical world, use their real objects in virtual settings, and/or completely immerse themselves in entirely virtual worlds. Increasing interest in XR, in part, attributed to reduced costs to access XR and large-scale mobile technology production that advanced the technology associated with XR, have helped to create the space for these technologies.

While there are a number of more publicly known use cases in the context of young people and XR — youth (ages 12-18) can, for instance, use overlay filters on their faces or play XR-based games — there is relatively little knowledge about young people's specific engagement with XR technologies. Even less guidance is being provided to those stakeholders (e.g., educators, parents/caregivers, those working at non-governmental organizations (NGOs) and international organizations) interested in maximizing the opportunities XR may offer.

This paper is not meant as a comprehensive overview of all youth-relevant XR experiences and their potential, as well as the challenges and concerns associated with them. Instead, it seeks to present the Youth and Media (YaM) team's initial learnings around these systems, concrete XR examples[2], and emerging questions that may, taken together, help inspire further research and dialogue. The examples shared highlight a number of opportunities worth further exploration. As described in part II, within the domain of (formal and informal) learning, which represents the centerpiece of our spotlight, XR technologies — such as virtual classrooms, and experiences that allow learners to explore different parts of the world, or learn about inaccessible processes (e.g., how organs function) — may provide a number of opportunities for youth. Some XR experiences in the educational context have the potential to increase the retention of information, foster skill-based learning, and provide opportunities to learn concepts in new ways.

In terms of physical and mental health, as highlighted

[1] N.B.: For Perma.cc links, for full site functionality (e.g., to be redirected to secondary links and view embedded videos), please click "View the live page" in the top right corner.

[2] In the majority of cases, we copied and pasted the text for these examples from their respective websites into his piece. In some instances, we made modifications to highlight the relevance of the experience in the context of youth.

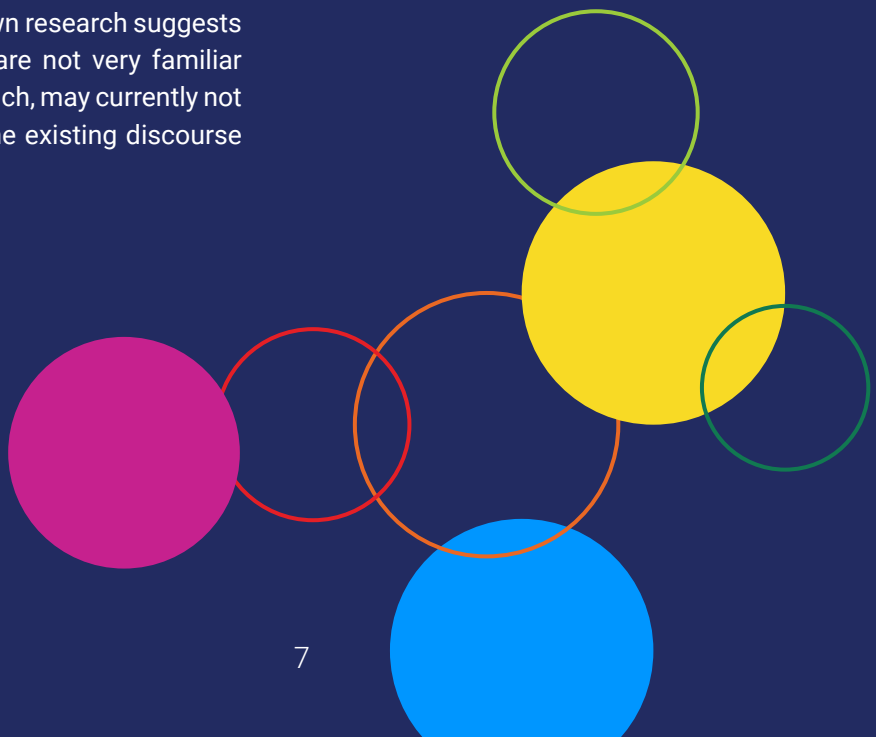
in part III, XR technologies may help open up the potential for the diagnosis and treatment of physical and mental health conditions among youth, and provide more accessible entry points to the healthcare system. In addition to creating opportunities for more accessible healthcare, as showcased in part IV, XR has the potential to promote equity and inclusion by, for instance, helping youth learn more about different communities, celebrate their identity, and cultivate empathy for those of different backgrounds.

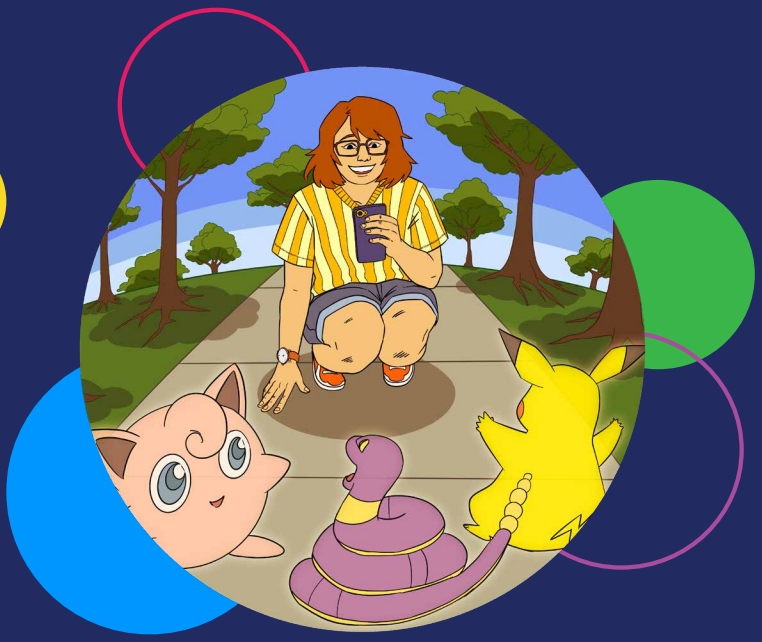
However, as described in part V, XR technologies also pose a number of challenges for young people and those who care for them that must be addressed. One area highlighted by the World Economic Forum is that of privacy and how XR technologies may collect and store personal data. For example, the use of AR applications in the home environment, which often capture individuals' surroundings (e.g., the people in the room, what the people look like, what they are wearing, other items/products in the room), raises questions around what data is collected, and how it is stored and used. There is a risk of undermining young people's privacy if those creating XR technologies are not clear and ethical about how they collect user data, where that data is stored, who can access it, and what can be done with it.

Additionally, looking ahead, it will be important to further cultivate young people's knowledge in the XR space. XR technologies have the potential to shape young people's lives, for better or for worse, yet anecdotal evidence from our own research suggests that youth (like many adults) are not very familiar with XR technologies, and, as such, may currently not be fully able to contribute to the existing discourse about the ethical, societal, and privacy- and safety-related questions the technologies may raise. A possible entry point may be involving youth in the design of XR experiences. Part VI provides several examples of opportunities where youth can create their own experiences aligned with their specific interests and needs, and, in the process, gain valuable knowledge about XR technologies and the skills to use them.

Given the potential impact XR technologies may have on young people's lives, it is also crucial to help make these systems more accessible to youth from different communities. Many of these technologies (especially the equipment needed to take full advantage of a given experience) are costly and thus mostly only accessible to more privileged youth. Without thoughtful interventions (e.g., making the experiences available in schools and public spaces, across cultures and contexts, to young people at different skill and developmental levels), XR technologies may amplify existing social inequalities. Against this backdrop, XR funding opportunities for stakeholders such as researchers, educators, and other entities are discussed in part VII.

Extended Reality (XR) is an umbrella term that includes virtual reality (VR), augmented reality (AR), and mixed (i.e., VR and AR) reality environments.





Virtual Reality

VR is defined by the Merriam-Webster dictionary as “an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer and in which one’s actions partially determine what happens in the environment.” Sony’s PlayStation VR, Oculus Go (a subsidiary of Facebook, Inc.), and HTC Vive are some of the more common and more costly VR devices. More affordable options include Google Cardboard, Cleanbox, and Merge. These are devices that are mounted on a user’s head and in which the user is completely immersed in the environment. An example of a virtual reality experience is in the historic city of Pula, Croatia’s Walking Tour, which uses VR to allow visitors to experience Pula in Roman times and visit the Amphitheatre, the Small Roman Theatre, the Triumph Arch, and the Forum Romanum.

Augmented Reality

AR is defined by the Merriam-Webster dictionary as “an enhanced version of reality created by the use of technology to overlay digital information on an image of something being viewed through a device.” Users can use their own devices to create an AR experience. An example of an augmented reality experience is Nintendo’s Pokemon Go app where users can “catch” Pokemon. Users look through their phone at their surroundings and superimpose virtual images and effects.

II. LEARNING

XR educational technology in formal learning environments (e.g., schools), informal learning environments (e.g., libraries or museums), or for vocational training may provide youth with new and engaging learning experiences. A metaanalysis involving 26 studies of AR in the education domain, for instance, suggests that such experiences can enhance learning outcomes, such as increased content understanding, improved long-term memory retention, and increased motivation to learn. It's important to note, however, that while there is an increasing evidence base around using AR and VR for learning purposes, a great deal of the literature focuses on using these technologies to teach a certain course or topic area. As the following report indicates, however, far fewer studies examine the efficacy of XR technologies compared to the use of non-XR tools in the educational space. As such, our team envisions XR technologies as one possible tool educators might consider integrating in the classroom — depending upon the affordability and accessibility of these technologies, further discussed in part V of this spotlight.

Preliminary evidence indicates three key areas with respect to potential ways XR technologies may be integrated in the classroom. First, XR technologies can be used to foster skill-based learning, such as learning a language. Research demonstrates that immersion may be helpful in learning a second language, and that VR, for example, can effectively simulate an immersive language experience. Second, XR can expand the possible activities youth can learn from in a hands-on manner. Such technologies can, for example, allow young people to travel inside the human body and explore cells for a biology course, or, for a physics class, examine how charged particles can interact with each other. Thus, XR has the potential to increase the topics young people can learn from by turning abstract concepts into concrete experiences. And third, XR can allow for new functionalities, or affordances, that offer opportunities for young people to learn in ways that have not yet been possible with other technological tools. For students taking vocational

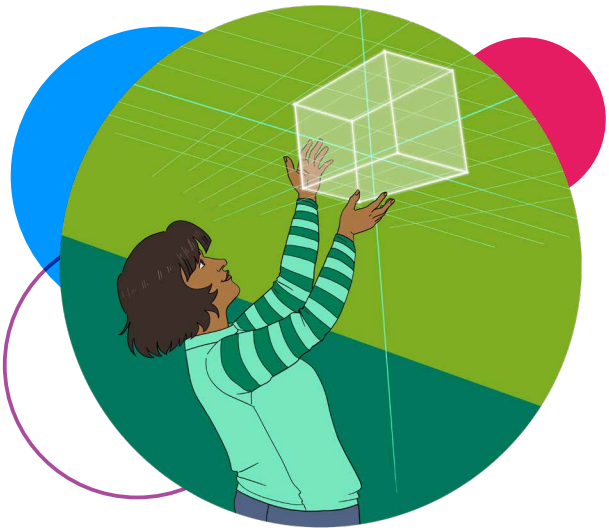
classes connected to architecture or construction, for instance, XR can simulate architectural designs that are more realistic that computer-aided designs — allowing individuals to walk through a space and explore various objects in it.

In addition to these three areas, there are several other areas connected to the educational space that appear promising in the context of XR. For example, XR technologies may be able to help fill in some of the gaps created by transitioning from in-person to remote learning. Against the backdrop of the global pandemic and disrupted education in regions around the world, field trips, which are often one of the most exciting aspects of formal education, are less likely to occur in the coming months. While not equivalent to an in-person experience, XR technologies, such as VR, can create the opportunity to explore places that have not been possible for many to travel to. For example, students can explore the depths of the ocean or even take a rocket to outer space. Instead of in-person field trips to museums, students can use XR technologies to explore exhibits — some museums have their own XR-based apps, such as the Louvre's "Mona Lisa: Beyond the Glass" VR app or the "Anne Frank House VR" experience. Additionally, some XR technologies allow young people to create their own AR and VR exploration experiences.

With respect to the adoption of XR technologies in the educational space, research in the context of higher education suggests two key factors are important. First, the XR technologies need to fit into current curriculum standards and educators' instructional methods. This finding aligns with research around the diffusion of innovations more broadly. For any innovation to be implemented in a given setting — from the workplace to the classroom — it must fit within systems currently in place. Second, as with the diffusion of other innovations, the adoption of XR is influenced by the cost of these technologies — not only in terms of the monetary value, but, for instance, the cognitive load of learning how to use XR.

As further discussed in part V of this paper, XR technologies also present challenges in the educational space (and across additional domains, such as physical and mental health, or diversity, equity, and inclusion). Making sure the technology is accessible to students (e.g., students from low-income homes and those who have limited Internet access); inclusive of students from varying demographics (e.g., addressing gender norms in formerly male-centric video game technologies); and taking into account privacy and safety concerns are important considerations in the XR space.

1. COMMON SCHOOL SUBJECTS (E.G., LANGUAGES, MATHEMATICS, BIOLOGY, ART)

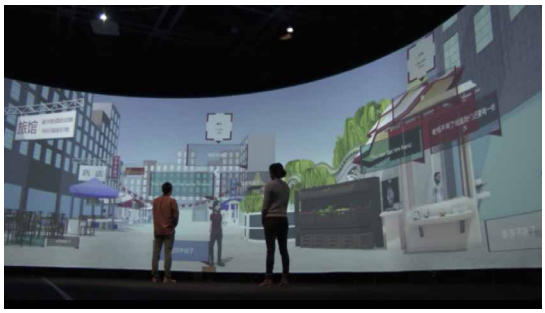


XR technologies can give students the capacity to be more creative in their day-to-day learning by bringing what they learn on paper into real life. With XR, students in design-related classes or activities, such as computer-aided drawing (CAD), robotics, and woodshop can interact with their ideas in 3D. In art classrooms, XR could act as a new medium for art projects, expanding the curriculum in diverse and collaborative ways, which may be particularly useful during remote learning. As illustrated by the concrete XR examples below under "Content Areas," XR can also foster learning in math, science, and history classrooms as well. Beyond its ability to make the educational experience more creative, XR

technologies can also give students and educators alike the ability to personalize a student's education. For instance, XR technologies may enable students to choose when learning happens, at what speed, and at what level of detail.

In addition to enhancing specific content areas, XR technologies also have the potential to promote teachers' pedagogical skills. For example, the Connect to Learn project, which aims to bring advances in technology to underserved schools in Myanmar, provides professional development for teachers through VR-based modules. The modules allow teachers to practice different pedagogical methods and learn how to integrate technology in their classroom. XR technologies also have the capacity to bolster students' pedagogical skills, such as public speaking.

CONTENT AREAS



Learning Chinese by IBM Research and Rensselaer Polytechnic Institute (RPI)

This VR experience teleports students to the busy streets of Beijing or a crowded Chinese restaurant. Students get to haggle with street vendors or order food, and the environment is equipped with different AI capabilities to respond to them in real time.

Access information about the experience here.

See a video about the experience here.

Type? MR

Publicly Available? No, currently created for institutional research

Cost? N/A

Geogebra AR by the International GeoGebra Institute (IGI)

This AR app lets students interact with math, specifically with geometry and graphs, in a unique way. Students can customize the inputs and functions they interact with and even screen record on their phones.

Access information about the experience here.

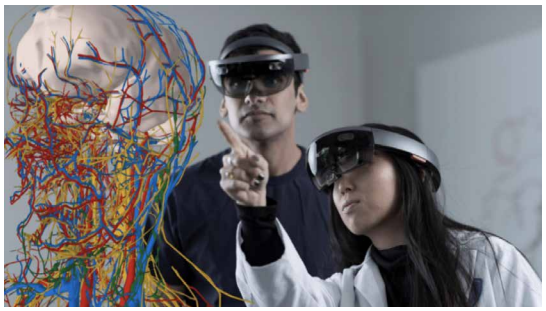
See a video about the experience here.

Access the experience here.

Type? AR

Publicly Available? Yes

Cost? Free



HoloAnatomy by Case Western Reserve University, the Cleveland Clinic, and Microsoft

The HoloAnatomy app allows students to engage with concepts in anatomy (e.g., visualize how blood flows through the heart).

Access information about the experience here.

See a video about the experience here.

Access the experience here.

Type? MR

Publicly Available? Yes

Cost? App is free, but headset is recommended

Merge Cube by Merge EDU

Merge Cube is an affordable foam cube and free app. The app generates a variety of interactive 3D objects in AR over the cube, allowing for tactile learning.

Access information about the experience here.

See a video about the experience here.

Type? AR

Publicly Available? Yes
Cost? Individual pricing at $9.99/month and school quotes available upon request

Quiver and Quiver Education by QuiverVision

QuiverVision is a 3D augmented coloring app. Users can download free or paid coloring packs from the Quiver app, print them out, color them in, and then scan the picture with the QuiverVision app for AR animations.

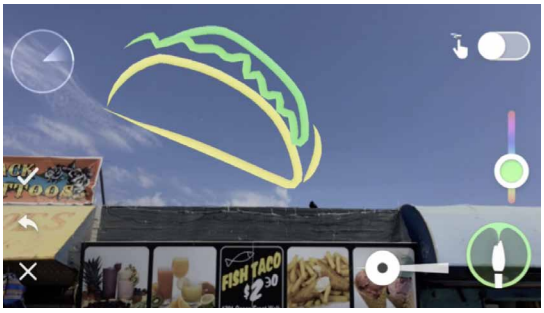
Access information about the experience here.

See a video about the experience here.

Type? AR

Publicly Available? Yes

Cost? Both free and paid coloring packs available



World Brush by Active Theory

This AR app allows users to paint using the world as their canvas. Users can upload their AR paintings anonymously with GPS tags. While it is not marketed to students specifically, it could potentially be used in art classrooms.

Access information about the experience here.

See a video about the experience here.

Access the experience here.

Type? AR

Publicly Available? Yes

Cost? Free

PEDAGOGY

VRsatility by Hassan Brown and Kevin Bryant

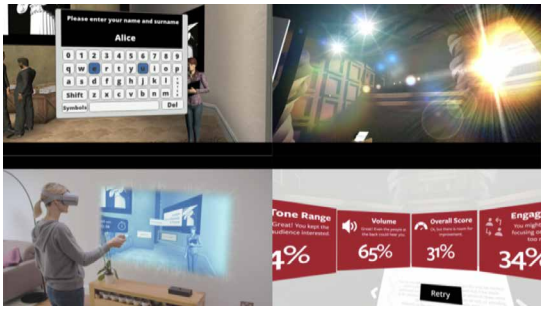
VRsatility seeks to provide educators with an immersive virtual space to practice their interpersonal and pedagogical skills prior to initial engagement with students in order to minimize potentially harmful interactions.

Access information about the experience here.

Type? VR

Publicly Available? No, still developing the program

Cost? N/A



VR for Online Learning by the London School of Business and Finance

The London School of Business and Finance integrated XR technologies into their distance learning platforms as of October 2019. One feature of the technology allows students to practice their presentation skills.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Available to students at this school

Cost? Free for students at this school

HP Reveal by HP

HP Reveal is a mobile app that can help students create more innovative and exciting presentations for the classroom. It lets users create "auras" (or trigger points) in order to overlay audio and video to enhance still images.

Access information about the experience here.

See a video about the experience here.

Type? AR

Publicly Available? Yes

Cost? Free

VR Debate Championships by the Democracy Builders Fund

Democracy Builders has partnered with a number of technology companies to bring VR to a unique education forum: debate. Recently, a few debate leagues from across the U.S. were able to compete over VR, experiencing debate in new ways.

Access information about the experience here.

Type? VR

Publicly Available? No, still piloting the technology

Cost? N/A

Figment AR by Viro Media

Figment AR is a free AR app that lets users place 3D emojis, animals, and other objects into scenes, along with environmental effects like snow or fireworks.

Access information about the experience here.

See a video about the experience here.

Type? AR

Publicly Available? Yes

Cost? free

2. THE ARTS AND CULTURE

XR technologies can also be applied in informal learning spaces such as museums, parks, and libraries. XR applications in museums can bring art to life and provide historical context, as is the case at the Louvre, and let users experience art using new forms and mediums. Extended reality can also be implemented in spaces such as museums to teach traditional school subjects, such as mathematics, in an engaging way. There are also use cases of XR in informal learning environments that are designed to not only promote discipline-specific knowledge, but serve as social spaces for young people to experiment with emerging technologies and learn from and with each other.

Beyond the Walls by the Smithsonian American Art Museum

This VR experience allows museum visitors to learn about specific pieces of art and engage with those pieces directly. Each piece of artwork has its own unique accompanying experience.

Access information about experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes

Cost? Free

Mona Lisa: Beyond the Glass by the Louvre

This exhibition, which is part of the commemorations of the 500-year anniversary of the death of Leonardo da Vinci in France, allows visitors to experience the Mona Lisa in a novel way and see the vivid details of the painting. There is an app which allows an in-home experience.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes

Cost? Free

Titanic VR by Immersive VR Education

This experience allows users to learn about the Titanic. Users can step in the shoes of an Associate Professor of Maritime Archaeology at the fictional University of Nova Scotia and dive the wreck of the Titanic.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes, on Oculus, Playstation or Steam

Cost? $19.99

Anne Frank House VR by Force Field Entertainment

This VR experience recreates the "Secret Annex" where Anne Frank and her family hid from the Nazis during WWII. Users can learn about Anne's thoughts and the events that took place while they were in hiding.

Access information about the experience here.

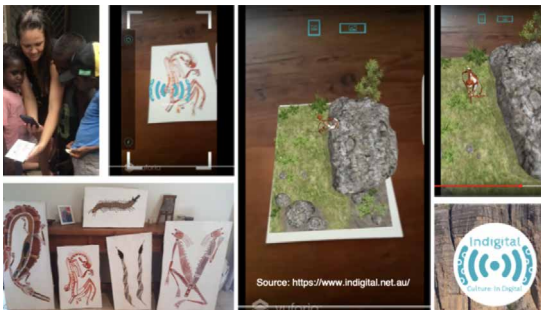
See a video about the experience here.

Access the experience here.

Type? VR

Publicly Available? Yes, but only works with Oculus and other compatible platforms

Cost? Free



Indigital VR/AR by Indigital

Indigital aims to bring Indigenous cultures digitally alive in the landscape.

Access information about the experience here.

See a video about the experience here.

Type? AR and VR

Publicly Available? Yes, to classrooms in Australia

Cost? Must contact for pricing details

3. NEW PLACES, SPACES, AND TERRITORIES

Irrespective of the specific learning setting — whether in the classroom, museum, or at home — through XR technologies, students may explore places otherwise impossible to visit (e.g., ancient Rome, shipwrecks, or space), situations invisible to the human eye (e.g., exploring the inside of a cell, seeing microscopic chemical reactions, visualizing Newton's Laws), or use cases often less accessible to most students (e.g., examining organs in the body, witnessing simulations of medical procedures).

Pula Virtual Reality Walking Tour by Virtual Reality Croatia

The city of Pula in Croatia uses VR to allow visitors to experience Pula in Roman times and visit historic monuments such as the Amphitheatre, the Small Roman Theatre, the Triumph Arch, and the Forum Romanum.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes, in Pula, Croatia

Cost? 26-49 euros per person

Expeditions by Google

Google Expeditions allows students to go on over 900 VR expeditions, ranging from a trip to the North Pole to Namibia, and over 100 AR expeditions. These experiences are accessible using a purchased kit (e.g., by Aquila Education) a home made kit, or simply by using a phone.

Access information about the experience here.

Type? AR and VR

Publicly Available? Yes

Cost? Free

Parallel Parks by New Horizons

Parallel Parks enables people, especially those with a disability and those with mobility issues, to access previously inaccessible parts of national parks in Australia, including the Great Barrier Reef, Kangaroo Island, the Murray River, and Uluru.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? No, still in its early stages

Cost? N/A

SummAR Reading Augmented Reality Storywalk by the Baltimore County Public Libraries

This experience allowed people to explore the solar system through 14 brightly-colored panels equipped with animated 3D holograms that can be viewed through a mobile device.

Access information about the experience here.

See a video about the experience here.

Type? AR

Publicly Available? Yes, in Baltimore area as part of exhibit

Cost? Free

Mission: ISS by Magnopus

With Mission: ISS, users can travel to the International Space Station in VR, experience zero-gravity, and explore what it's like to be an astronaut.

Access information about the experience here.

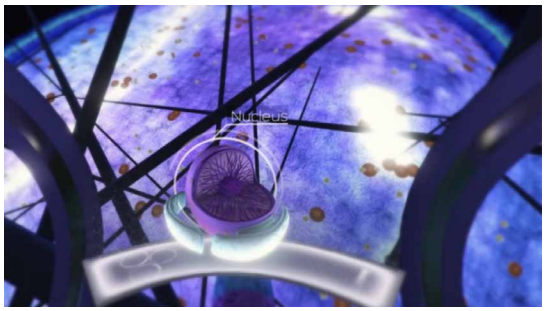
See a video about the experience here.

Access the experience here.

Type? VR

Publicly Available? Yes, on Oculus and other supporting platforms

Cost? Free



Journey Inside a Cell by The Body VR

This VR experience allows students to interact with a human cell by traveling through the bloodstream and discovering how blood cells work to spread oxygen throughout the body. Students then enter one of the billions of living cells inside our body and learn how organelles work together to fight deadly viruses.

Access information about the experience here.

See a video about the experience here.

Access the experience here.

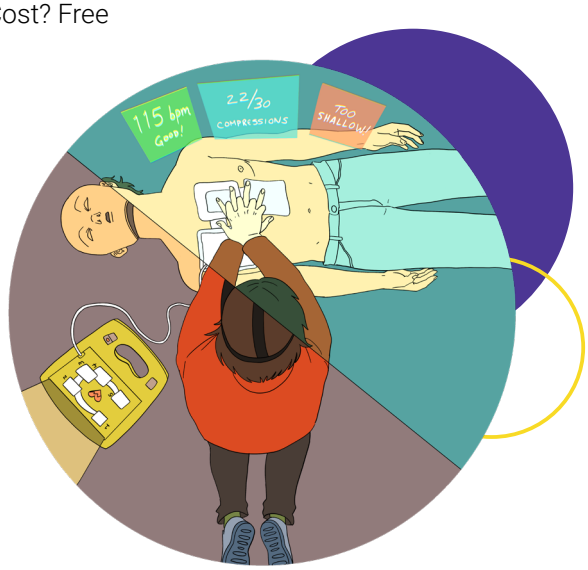
Type? VR

Publicly Available? Yes, on Oculus and other supporting platforms

Cost? Free

4. SIMULATION OF CHALLENGING SITUATIONS

While not always designed specifically for youth, XR technologies are increasingly used to simulate scenarios that may otherwise be too dangerous or challenging. By way of example, XR can enable learners to familiarize themselves with emergency situations (e.g., a fire earthquake, or robbery) or practice a risk-intensive task relevant to a specific job (e.g., putting out a fire on an oil truck).



VR Safety Training by Asian Pacific Disaster Resilience Centre (APDRC)

APDRC uses VR to raise public awareness about disasters and train everyday people in how to safely respond to and escape such scenarios..

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Information not available

Cost? Information not available

VR Training by Immerse

This VR experience, created in collaboration with an oil company, allows people to learn how to respond if there is a fire on an oil truck.

Access information about the experience here.

Type? VR

Publicly Available? No, partnership recently announced, still developing

Cost? N/A

Discussion questions:

- How can we equip educators — especially those in low-resource communities — with the skills and support to implement XR-based technologies in the classroom in a thoughtful manner? What kind of training would educators require? How does privilege manifest itself in the means of education chosen by different groups/ stakeholders? What is the prevailing narrative about XR technologies in the classroom, and who shapes it?
- How can educators and students be included in the design process of XR educational technologies?
- To what extent are remote XR experiences, such as HoloAnatomy, equivalent or better than in-person class experiences?
- What classroom settings would benefit the most from XR technology (e.g., small versus large classes, specific subjects, etc.)?
- How will XR technologies impact the workplace? To what extent will the job market shift to using XR technologies? What are some of the cybersecurity measures companies should foresee when moving to XR training?
- How can XR be most effectively implemented in informal learning settings, like museums, to teach school subjects, such as math – especially for those falling behind in such subjects?
- How can we create informal learning spaces that allow youth to not only experiment with XR technologies, but collaborate with each other and learn valuable social skills in the process?
- How can we leverage XR technologies to promote education in regions of the world where education is challenging for the general population, including youth, to obtain? How can we ensure that these tools are meaningful for the youth who use them — in other words, how can these systems take into account learners' regional and cultural context?
- How can XR technologies be leveraged to close the digital education divide?
- How will the COVID-19 pandemic affect the introduction of XR technologies in an educational context?
- What kinds of safeguards would best mitigate potential privacy concerns related to using XR-based technologies in the classroom? How can we balance XR systems' need for data while safeguarding the privacy and security of sensitive student data, both at the individual and cohort levels?
- Are there educational functions — either inside or outside of the classroom — that XR ed tech is uniquely positioned to fill in a positive manner? Are there functions it should not fill, for privacy, security, or ethical reasons?
- As highlighted by the various examples showcased in this paper, XR technology has the potential to bring more learners online in an interactive and attractive way. However, the often cost-prohibitive nature of these technologies reduces their accessibility. How can prices be lowered to make these technologies more accessible?
- If schools purchase VR equipment, will there be a way for students to rent or borrow them for the purpose of homework, projects, or presentations?
- How can formal and informal learning environments accommodate those students who experience physical effects from these XR technologies, such as motion sickness, without hindering their educational experience? Will the use of XR be voluntary or have a way for students to opt-out? Will students be at a disadvantage if they choose not to use XR?

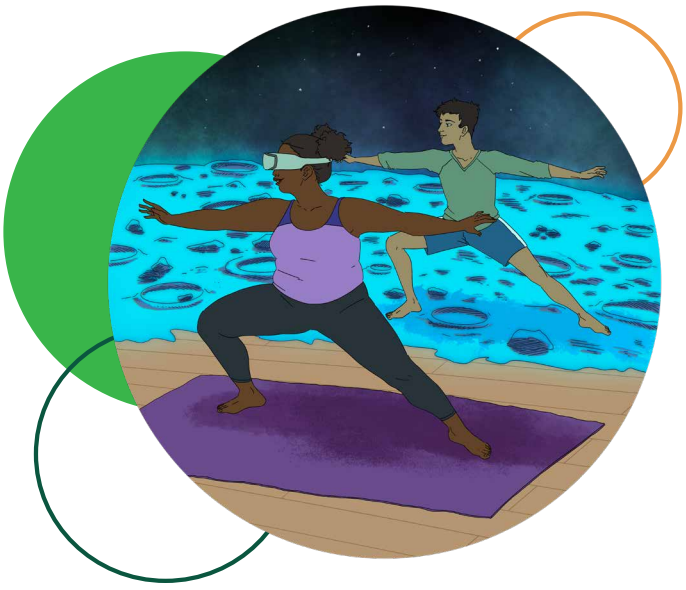
[3] The meaning of terms such as "better" or "best" exist on a spectrum subject to multiple variables determined by relevant stakeholders (e.g., in the educational space, such variables might include the extent to which the experience is mindful of those from different contexts and abilities, or learners' performance on subject-specific assessments).

III. PHYSICAL AND MENTAL HEALTH

In the health domain , XR technologies have been used for the diagnosis and treatment of mental and physical health disorders. As demonstrated in part I, section 4, XR systems have also been used for educational purposes related to health. For example, in medical school, some VR applications allow students to interactively learn about human anatomy and practical surgical operations. These technologies can also be used to promote physical health through engaging fitness experiences and applications. Additionally, XR technologies have been used for mental health applications, such as the diagnosis, understanding, and treatment of different mental health conditions.

1. PHYSICAL HEALTH

XR technologies are being used in creative ways to promote physical health. Both AR technologies and VR technologies have been integrated into fitness apps to make physical activity a multimodal experience with real and virtual elements. In the context of youth, these technologies have turned fitness into games that can be used both in school gym classes or at home. Given the popularity of video games, which are now being recognized as school sports in some U.S. states, XR technologies could be a unique solution to keep young people active and address the high rates of obesity among youth.



In addition to promoting a healthy lifestyle, XR technologies can act as a diagnostic tool for a number of medical conditions (e.g., concussion testing for school sports), making these technologies an accuracy-improvement tool and potentially a more accessible means of medical care. XR systems can also be used in the telehealth space, which may be particularly beneficial to those in remote or underserved regions.

QuasAR Arena by HappyGiant

This AR experience brings lasertag right to a user's phone. It is a two-player game that can be used in gym class or at home.

Access information about the experience here.

See a video about the experience here.

Access the experience here.

Type? AR

Publicly Available? Yes

Cost? Free

EYE-SYNC by SyncThink

EYE-SYNC is a mobile VR technology for concussion diagnosis. It has the potential to help athletes at all levels, even in school sports, by making concussion testing more efficient.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes, to healthcare providers

Cost? Must contact for demo and pricing

Supernatural by Supernatural

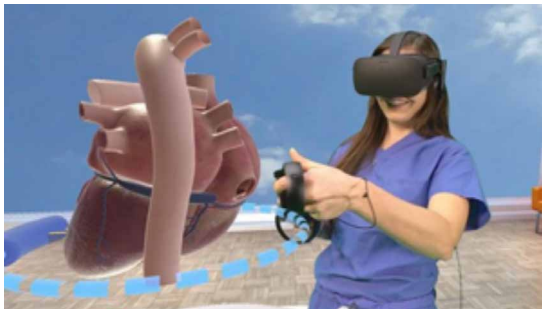
Supernatural is a VR experience that combines music, fitness coaches, virtual destinations and movements into a home workout.

Access information about the experience here.

Type? VR

Publicly Available? Yes, with headset and membership

Cost? 30 day free trial, then $19 per month or $179 per year



The Stanford Virtual Heart by Lucile Packard Children's Hospital

The Virtual Heart is a VR experience that allows users to see the heart and 12 congenital heart defects in 3D. It can be used for medical training, but also helps with diagnosis and allows patients and their families to visualize complex issues up close.

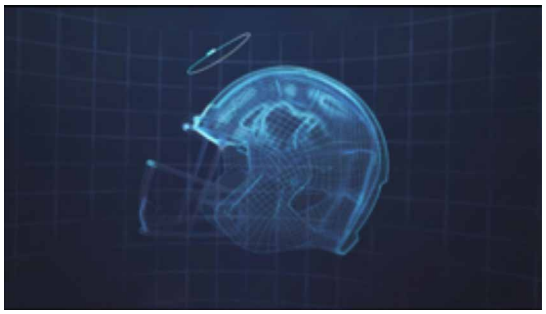
Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? No, currently available at specific location alone

Cost? N/A



CrashCourse | Concussion Education by TeachAids

CrashCourse is an interactive VR educational experience that allows users to learn about concussions through the setting of a school football game. The experience can be implemented into health or gym class curriculum in schools to better educate students about sports-related injuries.

Access information about the experience here.

See a video about the experience here.

Access the experience here.

Type? VR

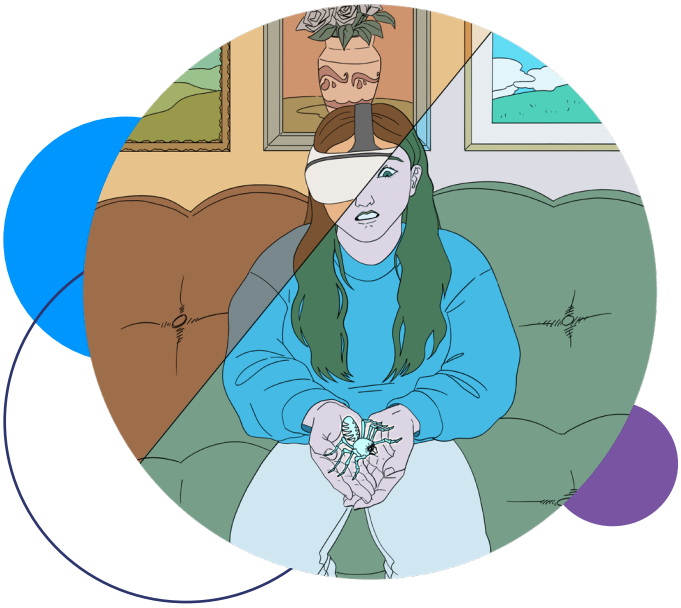
Publicly Available? Yes, with Oculus and other compatible platforms

Cost? Free

2. MENTAL HEALTH

The World Health Organization estimates that one in four people are affected by mental or neurological disorders in their life. Among youth specifically, mental health conditions affect one in six young people ages 10 to 19 globally. Moreover, half of all mental health disorders begin by the age of 14, but the majority of cases go undiagnosed and untreated.

In the youth context, virtual reality, for instance, has been used to detect drug use among teens and treat substance use disorders that are particularly prevalent among young people. In the U.S., e-cigarettes, for example, are the most widely used nicotine-containing product used by adolescents. A recent study demonstrated that youth playing a VR-based e-cigarette prevention program showed significant increases in important determinants of e-cigarette use, including increased knowledge about the detrimental impact of this product and reduced likelihood of trying e-cigarettes in the next year.



Manic VR by Katrina Bertin

This VR experience explores the experiences of the creator's siblings who suffer from bipolar disorder. Viewers are immersed in a visual world of animation that presents the heightened senses, hallucinations, and frightening imagination that may accompany manic depression.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? No, was available at select screening events

Cost? N/A

Smileyscope by Evelyn Chan

Smileyscope uses VR to improve clinical procedures involving needles. It aims to keep children more relaxed during such procedures.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes, available to clinicians

Cost? Clinicians must contact Smileyscope

BehaVR by BehaVR

This system includes programs that aim to address mental health issues using techniques such as exposure therapy and mindfulness.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes, available to clinical providers

Cost? Pricing depends on the specific therapeutic program

Psious VR by Psious

Psious is a VR platform that seeks to treat mental health conditions, ranging from phobias to anxiety.

Access information about the experience here.

Type? VR

Publicly Available? Yes, available to mental health professionals

Cost? Must contact Psious for demo and pricing

AltspaceVR by Microsoft

AltspaceVR seeks to foster social connections by providing spaces for users to play games, participate in exercise classes, stream content, and engage in other social activities.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes, available on a variety of headsets and PCs

Cost? Free

Tripp by Nanea Reeves and Zack Norman

Tripp is advertised as an employee wellness benefit to support employees' mental health and overall well-being.

Access information about the experience here.

Type? VR

Publicly Available? Yes, with membership

Cost? Free trial, then $4.99 per month or $15.99 per year

Oxford VR by Daniel Freeman, Jason Freeman, and Barnaby Perks

Oxford VR creates simulations of scenarios in which psychological difficulties occur (e.g., fear of heights), providing a safe space to try new behavior.

Access information about the experience here.

See videos about the experience here.

Type? VR

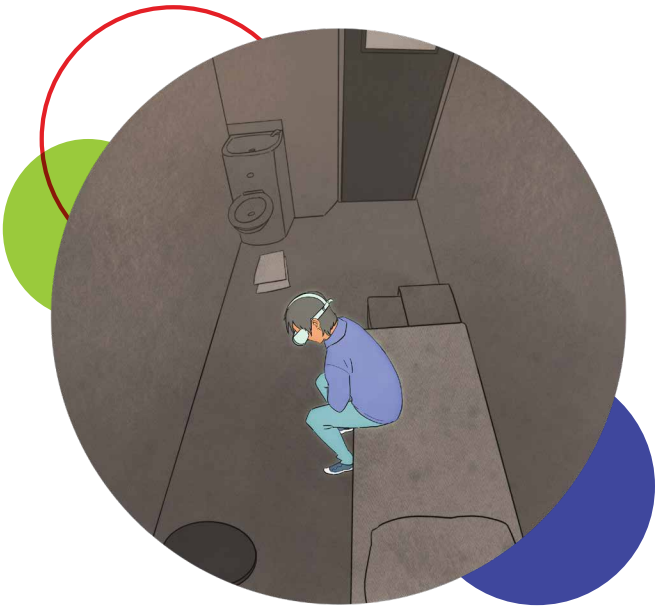
Publicly Available? Yes, available to select health care settings

Cost? Must contact for more details

Discussion questions:

- How can XR technologies offer a pathway towards affordable mental health care solutions?
- How can XR systems be applied towards public health issues, such as drug use, to better reach vulnerable youth?
- In developing XR technologies in the health space, how can we make sure that the technologies account for cultural nuances in how youth express mental and emotional distress? How can we also make sure that XR systems consider child development issues?
- How can XR technologies be designed to reduce stigma around mental health service-seeking behaviors among youth — particularly youth from communities where mental illness and treatment-seeking are highly stigmatized?
- As XR technologies may help those living with physical and mental health issues by providing them with access to interventions and therapy, how do we reduce the risks of violations of privacy to avoid discrimination based on existing mental health issues?
- How can XR technologies be developed to teach people about health concepts, such as the spread of infectious diseases, in an engaging way?
- How can we involve youth themselves in developing XR technologies to provide accurate health information to young people in an engaging, interactive way?
- Particularly in the context of COVID and its aftermath, can XR technologies be incorporated into telemedicine to provide at-home diagnoses and treatment for those who have limited access to healthcare? Can XR experiences take the place of physicals required by schools and youth sports teams, as well as other more "routine" doctor's visits?

IV. DIVERSITY, EQUITY AND INCLUSION



An additional application domain area centers around the question of how XR can be leveraged to help build a better, more inclusive, equitable, and diverse world. For example, how can XR technologies include the diverse voices, perspectives, cultures and contexts, and experiences of often underrepresented populations — whether in terms of age, ethnicity, race, gender and sexual identity, religion, national origin, location, skill and educational level, and/or socioeconomic status? A number of multimodal XR experiences highlighted here suggest that XR may help young people learn more about different communities, celebrate their identity, and cultivate empathy in a specific scenario. The experience may be as simple as a Snapchat filter or as involved as a fully immersive experience (e.g., a VR-based solitary confinement simulation).

100,000 New Trees in Oslo by the Oslo School of Architecture and Design, The Municipality of Oslo, and Udaru

This project focuses on exploring how AR can foster youth participation in the context of urban planning. In the study, young people ages 14-16 used an AR application to simulate the planting of trees in Oslo, Norway. A next step will be to coordinate the AR-based youth designs with physical tree planting.The research is commissioned by Oslo City Hall and their "100,000 new trees in Oslo by 2030" project.

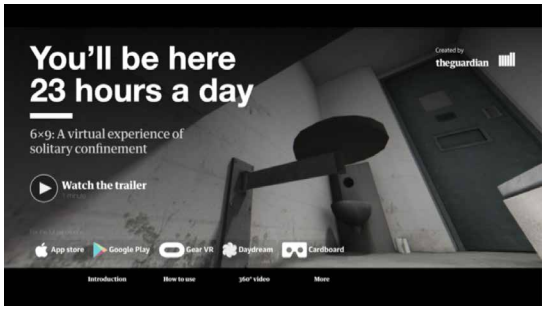
Access information about the experience here.

See a video about the experience here.

Type? AR

Publicly Available? No, AR application used for purposes of study

Cost? N/A



6x9: A Virtual Experience of Solitary Confinement by The Guardian

This experience allows users to be placed inside a U.S. solitary confinement prison cell and tells the story of the psychological damage that can ensue from isolation.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes

Cost? Free

VR Action Lab by Harmony Labs

This experience explored how virtual reality might activate young people as upstanders and address the precipitous drop in efficacy of middle school anti-bullying efforts. It produced three VR experiences embedded in a pilot-tested six-lesson curriculum, along with other resources, like an impact design toolkit for VR media makers and mission-driven organizations and an issue briefing book.

Access information about the experience here.

Type? VR

Publicly Available? No, piloted in four states — lessons and curriculum are available here

Cost? N/A

1,000 Cut Journey by Courtney Cogburn

This VR experience puts users in the shoes of a black man, Michael Sterling, at four different stages of his life. It is an attempt to simulate the racism faced by a Black male, for non-blacks to experience.

See a video about the experience here.

Type? VR

Publicly Available? No, previously viewable at select film festivals and locations

Cost? N/A

Four Walls: Inside Syrian Lives by the International Rescue Committee (IRC) and Rashida Jones

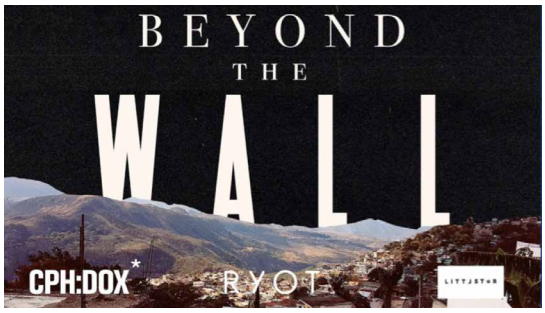
This experience allows the user to accompany Rashida Jones on her visits to numerous dwellings of displaced Syrians.

Access information about the experience here.

Type? VR

Publicly Available? Yes

Cost? Free



Beyond the Wall by SHIFT Media

Beyond the Wall tackles the tensions in U.S./ Mexican relations at the border during the beginning of the Trump Administration.

Access information about the experience here.

See a video about the experience here.

Type? VR

Publicly Available? Yes

Cost? Free

#LGBT Free Hug in Beijing by VeeR TV

VeeR VR, an entertainment platform based in China, engaged in social experiments with the LGBTQ community to celebrate pride month. Videos of the experiences were made available to watch on VR headsets to help others understand the triumphs and struggles of the community. The experience has even been brought to classrooms.

See a video about the experience here.

Type? VR

Publicly Available? No, this was an experiment conducted in Beijing

Cost? N/A

I Am A Man by Derek Ham

"I Am A Man" is an interactive VR experience that allows individuals to see historical events of the Civil Rights Movement through the lens of Black Americans. Users see the events leading up to the assasination of Martin Luther King Jr., as well as the 1968 Memphis Sanitation Workers Strike.

See a video about the experience here.

Access the experience here.

Type? VR

Publicly Available? Yes, available on Oculus and other compatible platforms

Cost? Free

THE KEY by Celine Tricart

The Key is a VR experience that allows users to experience the journey of a refugee and the challenges they face as they leave their homes.

See a video about the experience here.

Access the experience here.

Type? VR

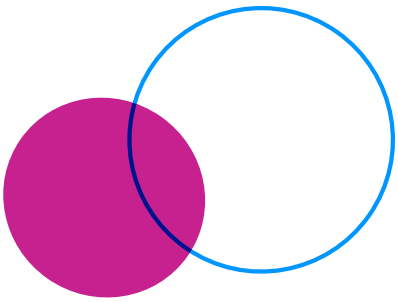
Publicly Available? Yes, available on Oculus and other compatible platforms

Cost? Free

Discussion questions:

The uneven access and the lack of skills and opportunities to use XR technologies — especially for youth from underrepresented communities — runs the risk of amplifying digital inequalities. How can different stakeholders — such as policymakers, companies, international organizations, and educators — reach these communities to promote access to these technologies and cultivate the skills needed to use them?

- How can we empower youth from underrepresented communities to actively drive (or at least actively contribute to) the design, development, and deployment of XR technologies to counter the dominance of Western values within the XR discourse?
- To what extent should we be looking at technical solutions for social problems?
- XR is often reliant on individuals' ability to control their physical motions (e.g., quickly moving one's hand). How can these technologies be made more accessible for those with limited mobility?
- How can XR technologies enhance a sense of belonging and community?
- Research indicates that harassment in XR, such as VR, may take different forms, such as environmental (e.g., throwing virtual objects) or physical (e.g., unwanted physical contact). How can we most effectively mitigate and prevent these forms of online harassment?
- There are two types of depth cues that individuals depend upon to determine how far away objects are: shape-from-shading (this provides the brain with a sense of how far away an object is depending on the light that is cast on it), and motion parallax (this tells the brain that if an object appears larger, it is getting closer). Since motion parallax is simpler to reproduce, XR technologies such as VR systems often rely on these cues. The dependence on motion parallax, however, does not take into account possible physiological differences in terms of gender – preliminary research indicates that men often depend more on motion parallax, while women on shape-from-shading. How can future research help determine the extent to which biology plays a key role in how one experiences VR?
- How can XR systems best accommodate those with visual and auditory impairments? Can XR technologies be used to enable greater accessibility? On the contrary, would mass use of XR make those individuals' lives more difficult?
- Are there specific XR tools that different advocacy groups recommend to promote cultural/community learning experiences (e.g., Derek Ham's "I Am A Man" VR experience that teaches users about Martin Luther King Jr. and the Civil Rights movement)?
- How can we use XR technologies to teach about gender identity and promote greater tolerance and understanding in this space?
- How can we bring XR technologies to low-income classrooms and communities (e.g., through funding programs geared towards teachers[4])?



[4] Learn more about funding opportunities in the XR space in part VII of this spotlight.

V. OVERARCHING CHALLENGES AND CONCERNS

While XR technologies may offer innovative and enriching experiences within an array of domains, there are still a number of obstacles that these technologies must overcome to address issues around accessibility, privacy, and safety. It's important to note that these concerns do not represent an exhaustive list of all challenges associated with XR technologies, but, instead, offer examples of some issues that are particularly salient. There is a growing body of literature around the concerns related to XR systems, and this part V of the spotlight is meant to provide a high-level overview of some of these challenges.

In terms of accessibility, in order to take advantage of the affordances of XR, as with other digitally networked technologies, Internet connectivity is needed. This may prevent a significant number of people from leveraging the technology. Further, we often associate XR with expensive VR headsets, which can be financially burdensome and inaccessible to many. These barriers are real. At the same time, less costly VR headset options, such as Google Cardboard, as well as free and low-cost VR and AR apps have become available, which students can use on their phones without further equipment.

Additionally, as with many other networked technologies, such as artificial intelligence, there are concerns around the extent to which the design of XR incorporates the voices and perspectives of underrepresented groups. In terms of additional issues around inclusion, XR is more reliant (compared to other digital technologies) on individuals' ability to control their physical motions (e.g., quickly moving one's hand). How can these technologies be made more accessible for those with limited mobility?

Second, there are numerous challenges around privacy, data and data protection, and commercial risk, some of which are resonant with general concerns that come with digitally networked technologies, while others are specific to XR. For example — like many digitally connected systems — XR has the ability to collect, aggregate, analyze and monetize users' data — data which is "durable, searchable, and virtually undeletable." Given that children and youth are often pioneers in exploring emerging technologies, they may experience XR-related privacy and data protection risks before adults enact strategies to mitigate such concerns. Moreover, the unprecedented amount of data that networked technologies such as XR are able to collect can be sold to third parties, including companies that can target marketing to youth. These targeted messages may put youth at risk for commercial

exploration and exposure to content that may impact their perspectives and behaviors in ways not optimal for healthy development.

Moreover, research shows that young people (like many adults) generally lack an adequate understanding of the processes of data collection and resultant commercial profiling and marketing to which they can be subject. In addition to collecting information such as young people's product preferences and location, XR technologies also have the potential to gather large amounts of data about nonverbal behavior, such as gestures, facial expressions, and eye gaze — even if one is only using the system for short periods of time. Indeed, spending a mere 20 minutes within a VR simulation may capture slightly under two million recordings of one's body language. In the context of education, researchers have used nonverbal data gathered through VR to predict test scores, and estimate the number of mistakes made while learning a specific task. A young person's future — from the university they are admitted to, to their employment opportunities and quality of working life — could be (positively or negatively) impacted by the nonverbal data that XR technologies collect. The data captured through XR will also strengthen companies' efforts to target advertising to youth — a study shows that data about one's head movements in VR is associated with how positively someone rates the content in a simulation. Legal protections against these and related privacy risks vary across jurisdictions and application areas. When it comes to student privacy issues in the context of formal education in the U.S., this publication (pages 4-5) by authors from the YaM team and the Cyberlaw Clinic at the Berkman Klein Center for Internet & Society at Harvard offers both a general point of entry into the privacy analysis, as well as a roadmap for exploring additional information and engaging with decision-makers who might be involved in determining whether, how, with which students, and for what purposes XR technologies can be employed, and what privacy safeguards need to be put in place.

And third, there are safety risks connected to XR technologies. As with many other networked technologies, such as computers and mobile phones, some users may experience eye strain using XR. Unlike many other Internet-enabled technologies, however, XR may induce side effects such as nausea, dizziness, seizures, and discomfort wearing the needed equipment. Recently, there have been efforts to make VR headsets, for instance, more comfortable to wear for those of different racial and ethnic backgrounds. Additionally, XR offers another online space for young people to be cyberbullied in. Research shows that harassment in XR, such as VR, may take different forms, such as environmental (e.g., throwing virtual objects) or physical (e.g., unwanted physical contact). Given the immersive nature of XR, will these types of harassment be experienced as more intense compared to bullying via text message or chat? And how can educators, parents, and other stakeholders most effectively reduce and prevent these forms of online harassment?

VI. PROGRAMS FOR YOUTH TO CREATE THEIR OWN XR EXPERIENCES

One way in which XR technologies can be made more accessible to young people is by providing means for them to create their own experiences aligned with their specific interests and needs. Like a number of the XR technologies highlighted in part II, section 1, some of these experiences can be implemented within the school curriculum. Additionally, in some cases, little technical knowledge is required to design an experience, providing a more accessible entry point for those interested in engaging with XR.

CoSpaces Edu by DelightX GmbH

This app is specifically designed for the classroom — it lets students create both AR and VR experiences by designing their own games, experiments, stories, museum expeditions, and more.

Access information and a video about the tool here.

Access the tool here.

Type? AR and VR

Publicly Available? Yes

Cost? Free

Tour Creator by Google

Tour Creator is a tool that allows people to create their own VR tools, letting them explore new locations in 3D. This tool could be useful to both teachers, in creating curriculum, and students in designing their own experiences.

Access information and a video about the tool here.

Access the tool here.

Type? VR

Publicly Available? Yes

Cost? Free

ARKit by Apple

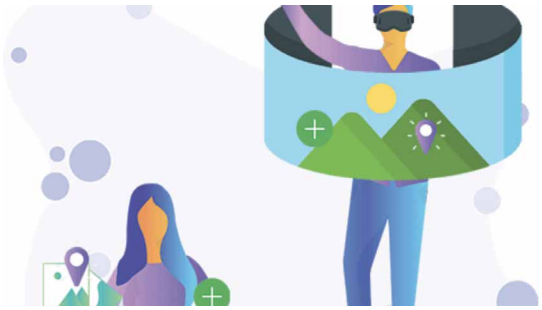
ARKit is not just one app, but an entire set of tools that lets users make their own AR creations. There are a wide range of applications and thus, potential users. The tools also provide the ability to work collaboratively with other users on an AR experience.

Access information about the toolkit here.

Type? AR

Publicly Available? Yes

Cost? Free



Viar360 by VIAR

Viar360 is an entire training program that teaches users to make VR. It was built for employee training, but it is a customizable platform that could also be applicable for student vocational training or even a school course on VR.

Access information about the program here.

See a video about the program here.

Access the program here.

Type? VR

Publicly Available? Yes

Cost? Free 14-day trial. Then, $99 for the first month and an extra $24 per month after that

Metastage by Magnopus

Metastage is a performance app that allows users to bring performance art to life in both VR and AR. Users can create videos, holograms and more using mixed reality formats.

Access information about the tool here.

See a video about the tool here.

Access the tool here.

Type? AR, VR, and MR

Publicly Available? Yes

Cost? Free

Vizor 360° by Oculus and Vizor

Vizor 360° is a paid drag-and-drop web app for creating and sharing immersive experiences.

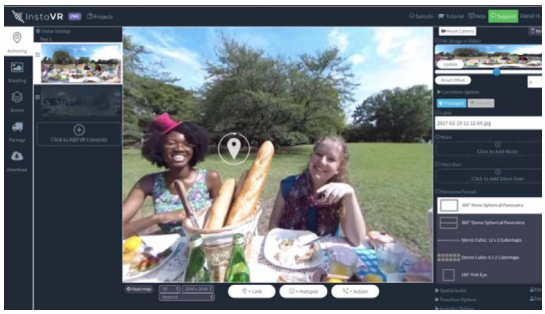
Access information about the tool here.

See a video about the tool here.

Type? VR

Publicly Available? Yes

Cost? Free trial then starting price at $2 per user per year after that



InstaVR by InstaVR Inc.

InstaVR is a paid drag-and-drop online tool for making VR apps, with support for panoramic images and movies.

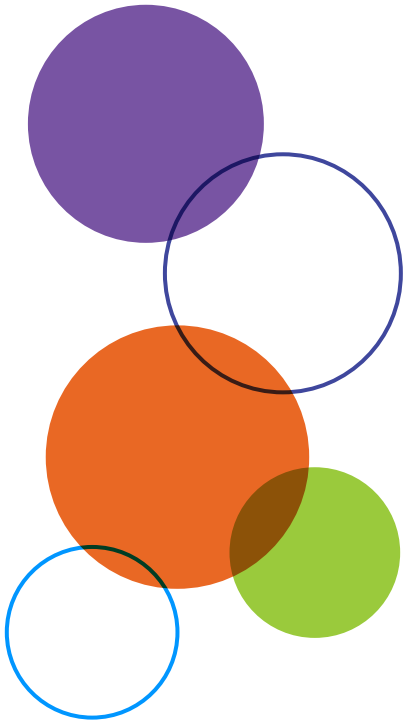
Access information about the tool here.

See a video about the tool here.

Type? VR

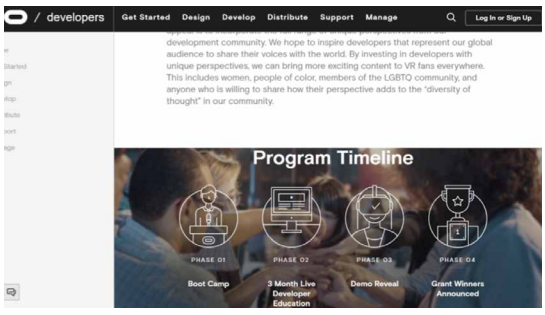
Publicly Available? Yes

Cost? $199 per month but with options for shared licensing in schools



VII. FUNDING AND DEVELOPMENT SUPPORT

Due to the expensive nature of VR and AR, many members of marginalized groups have been left out of the development of these technologies. There are a number of programs and funding streams from non-profits, private companies, and governments created within the last few years that aim to combat this inequity. This part VII showcases programs from around the world that seek to provide funding, technical support, mentorship, and leadership opportunities geared towards members of underrepresented communities trying to create VR and AR content to combat societal issues. Programs such as these will ideally make it possible for XR technologies to become more widely accessible.



Launch Pad by Oculus

An incubator with a Launch Pad program in the U.S. focused on supporting VR content creators of diverse backgrounds through training and development of their content.

Access information about the program here.

VR for Impact by HTC Vive

VR for Impact is an initiative developed in accordance with the UN's Sustainable Development Goals. The program will sponsor and provide funding for different VR projects aligned with the UN's goals in an effort to use innovative technology for global good.

Access information about the program here.

Electric Dream Factory supported by the University of Washington's CoMotion Labs

The Electric Dream Factory is a start-up-like content studio, which aims to provide support to people from diverse backgrounds who wish to tell their stories using VR and MR technologies.

Access information about the program here.

BPMplus by Black Public Media

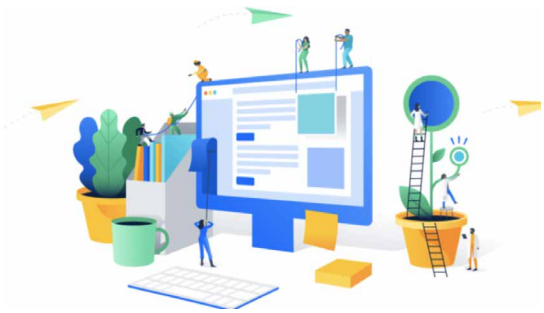
Black Public Media is focused on funding and creating content that supports the Black community. More specifically, they offer free training in XR to help Black content creators and educators learn more about the technology.

Access information about the program here.

Women Startup Challenges by Women Who Tech

Women Who Tech seeks to provide grant money to women-led startups through their startup challenges. In 2017, they launched a competition for women-led startups in VR and AI. Beyond funding, they also offer mentorship and networking opportunities.

Access information about the program here.



The Beacon Technology Teacher Grant by Verizon Fios

This grant program provides $1,000 for VR equipment in classrooms. Teachers can apply by describing how they could use VR to enhance creativity and learning in their classrooms.

Access information about the program here.