MERIDIAN TREEHOUSE

AN INTRODUCTION TO LEARNING IN THE METAVERSE

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WHAT'S INSIDE

Letter from the Authors

You've likely seen the word *Metaverse* in the media. The opportunities for this "next iteration of the internet" are exciting, especially for learning. In the Metaverse, we imagine students building skills and exploring in shared virtual spaces without the boundaries of the physical world.

As we bring the promise of new technologies into education, however, history is our greatest teacher. We've seen patterns of poorly implemented, underused technology in learning environments, so how can the Metaverse be different and fulfill its potential?

To address the range of needs among learners, educators, and other stakeholders, we must understand the limitations of emerging technologies – as much as their affordances – and engage diverse perspectives and areas of expertise. Bridging divides between designers of cutting-edge technologies and educators who will use them is imperative. We need everyone who is eager to advance learning in the Metaverse to draw on evidence-based strategies as we pave the way forward.

You might be an educator, a caregiver, a museum designer, or an administrative decision maker wondering how the Metaverse might affect your work and your learners. Or, you might be a technology developer who wants to apply their skills and products to learning environments. We are a team of educators, scientists, and entrepreneurs who believe in the power of technology for intellectual, professional, social, and emotional growth. We created this document to provide a useful overview of the Metaverse, its components, its potential for education, and for those wanting to dive in – a starting point.

Our work and this conversation is ongoing, so please reach out with feedback and ideas (we are particularly interested in hearing how you use immersive technology for learning). You can reach us at xrlearning@meridiantreehouse.com.

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What is the Metaverse?

Imagine standing in your living room but feeling as though you are exploring the ocean floor alongside a friend who lives on the other side of the world. This is possible in the Metaverse.

Meta is Greek for beyond, and *verse* represents the totality of something. In this way, the Metaverse alters the human experience, using technology to go beyond our physical reality. The term was originally coined by science fiction author Neal Stephenson in his 1992 novel "Snow Crash"; in it, he describes the Metaverse as a virtual world composed of unique environments, each with a specific purpose: to entertain, socialize, educate, and more.[1] Using head-mounted displays (HMDs), smartphones, and other media technology, people could enter these shared spaces and engage with one another regardless of their location.

> **A decentralized network of computer-generated worlds where users feel a genuine sense of being in these spaces for work, leisure, and learning.**
>
> — Neal Stephenson

Three decades after Stephenson's social allegory, advances in computational science and communication technology are making the Metaverse more of a reality.[2]

In plain terms, ***the Metaverse is the next iteration of the internet***; a decentralized network of virtual spaces where users can socialize, learn, and play. Leveraging other emerging technologies (5G, blockchain, artificial intelligence), and shifting from 2D graphics on flat screens to 3D graphics in HMDs, the Metaverse will enable the creation of an interactive and virtual equivalent of our physical world (in terms of people, places, and things) that we will be able to explore through extended reality (XR) platforms.[3]

What is XR?

XR, which stands for "extended reality," or "cross reality," is a catch-all term for immersive technologies used to access the Metaverse: augmented, mixed, and virtual reality. XR also represents a spectrum where each of these technologies is situated between a completely computer-generated virtual environment (high *virtuality*) on one end and the physical reality on the other (no *virtuality*).[4] Physical reality constitutes any sensory experience naturally available to us in an environment. When such environments are perceived or processed in real-time using audiovisual hardware like smartphones or headsets, users are then placed along the XR continuum based on the degree of virtuality, or the ratio of virtual versus physical content being experienced.[5]

LOW — **SPECTRUM OF VIRTUALITY** — HIGH

Augmented Reality (AR)	Mixed Reality (MR)*	Virtual Reality (VR)
Tool: Mobile device or see-through head-mounted display to superimpose digital content onto the physical world from the view of the user.	**Tool:** See-through head-mounted display to merge virtual content with the user's physical environment.	**Tool:** Head-mounted display to enter and interact with a computer-generated virtual environment.
Description: Interactions between virtual and physical objects can be limited. For example, 3D objects may be semi-transparent and cannot hide behind physical objects.	**Description:** Interactions between physical and virtual objects are more natural. For example, virtual characters can hide behind physical objects, and vice versa.	**Description:** Audio and visual stimuli from the physical world are replaced with those of the virtual world.
Scenario: Two students in the same room use smartphones to scan an image of a fish, which then overlays text information and an animated 3D model of the species. A person in an AR head-mounted display can view that same 3D model from their perspective.	**Scenario:** Two students in different rooms use an MR device to scan their unique physical space and embed a virtual coral reef onto it where a virtual fish can swim around the furniture and each learner.	**Scenario:** Two students in separate rooms put on a VR device and are now on a virtual coral reef. They look down at their new virtual body of a scuba diver (avatar) and can interact with the fish and one another in that space.
Hardware: Smartphone, tablet, AR head-mounted display like Hololens, Realear devices, Magic Leap 1, or ThinkReality A3	**Hardware:** Hololens, Magic Leap 1, Varjo XR3, Lynx	**Hardware:** Meta Quest 2, HTC Vive
Application: Snapchat, Instagram, Pokémon Go	**Application:** Destination: Mars, Undersea	**Application:** theBlu VR, Human Anatomy VR

* While there is collective ambiguity around the difference between AR & MR, we rely on conceptualizations and distinctions provided by industry and academic practitioners in the field of human-computer interaction.

Shaping of the Metaverse

2021 saw the term *Metaverse* surge in awareness,[6] sparking global discourse centered around simple albeit important questions: *What is the Metaverse? How will it impact us as humans? Is its impact grounded in reality, or is this just hype?*

Metaverse technologies are not necessarily new. Their origins trace back centuries to rudimentary sensory illusions and, more recently, to advancements in computing in the late 20th century. For decades, XR and 3D technologies have contributed to advancements in medicine,[7] chemistry,[8] and engineering,[9] among other fields. Back then, these technologies were incredibly expensive, bulky, and served an industry-specific purpose. Today, with the availability of high resolution mobile screens, accurate motion sensing devices, and highly efficient mobile processors, XR is poised to make the jump from industry laboratories to our living rooms, offices, and classrooms. Put simply: ***XR is here to stay, and is transforming how humans work, socialize, play, and learn.***

EMERGENT TRENDS

Societal	Technological	Industrial	Legal
Virtual Lives: Humans are spending more time in virtual environments than ever before, increasing the importance of their virtual identities (avatars). Popular platforms include Roblox (over 200M users), Snapchat (over 300M users), Fortnite (over 350M players), and Meta's Horizon Worlds.	**Manufacturing:** Costs of XR hardware to access the Metaverse has been steadily declining, meaning XR adoption is likely to continue to increase over time.	**Corporate Investment:** Companies are creating positions that require workers to understand how to leverage XR effectively. Roblox users spent over $1B in 2020.	**Cybersecurity:** Local and national governments are investing in, and preparing for, legislation that will govern human activity within the Metaverse.
	5G: The ubiquity of high-speed internet connectivity will improve accessibility to the Metaverse globally.	**Non-Fungible Tokens (NFTs):** Companies are increasingly creating and selling virtual goods, from virtual Nike shoes for your avatar, to unique digital paintings. In 2021, companies sold over $24B in NFTs.	

In addition to these transformations brought on by the Metaverse, rapid societal change occuring in the 21st century is placing new demands on education systems. Many characteristics of education today are legacies of the 20th century system that emphasized the "three Rs"- reading, writing, and arithmetic - and prepared people for stable jobs performing routine tasks. In our increasingly complex and technology-driven society, however, the future of work is uncertain and requires people to be adaptive, lifelong learners.[10] Other aspects of society are also in crisis, including increased globalization, persistent inequality, environmental degradation, public health concerns, and political turmoil.[11] For all people to thrive in the future of work and tackle these global challenges, they need skills like critical thinking/reasoning, creativity/creative thinking, problem solving, metacognition, collaboration, communication, and global citizenship.[12]

This points to an urgent need for education to prepare young people to thrive amidst rapid technological, economic, and social change. Metaverse technologies may be useful in re-imagining how learning is done, if grounded in the realities of what they can and cannot do. Collectively, a more informed community of educators, content creators, and developers will enable institutions of all sizes to broaden learning opportunities regardless of subject matter or teaching methodology and prepare our societies for what is to come.

Building a Meaningful Learning Experience with XR

When designed well, technologies like XR can support effective learning that is difficult to achieve otherwise. Some features of XR that are especially important when applied to educational contexts are:

Immersion: XR hardware can leverage stereoscopic imagery and spatial audio to create the illusion of depth and space. Users can place 3D content (e.g., objects) in their environment from a first-person perspective, and feel as though they are sharing the space with the content itself.

Interactivity: XR allows people to actively engage with digital environments by enabling responses to users' movements and actions, making it an interactive medium that can invoke their full bodies and encourage creation and expression.

Invisibility: Because it uses realistic 3D imagery and blends the digital with physical, XR can visualize phenomena that are invisible to the human eye such as change over time or microscopic particles.

Together, these characteristics can facilitate a strong sense of presence, or the feeling of "being there," in a place different from your physical location,[13] as well as a strong sense of agency, which may be powerful for enabling learning.[14] Additionally, the technologies can engender a sense of presence in a different body, known as *virtual body ownership*,[15] and of being with other people, termed *co-presence*.[16]

Given these characteristics, XR is particularly good for certain learning goals and processes, and less effective for others. The affordances and limitations of XR for learning are described in the following lists.

Affordances: What Is XR Good For?

XR has some characteristics that align well with certain learning goals and processes because they enable learners to engage in certain tasks. We refer to these characteristics and their resulting potential for learning as *affordances*.

Increasing Interest and Motivation to Learn: Studies consistently find that using XR learning environments increases learners' enjoyment, interest, and motivation to learn.[17-19] Additionally, studies show that learners' self-efficacy, or their belief in their own capabilities, increases from using immersive learning environments by providing realistic hands-on or observational experiences.[20, 21] These motivational constructs are important for facilitating learning, and are important educational goals in themselves.

Personalization: XR platforms can adapt to each user's environment for a personalized learning experience that situates their learning within a relevant context.[22] Using spatial mapping techniques, AR/MR platforms can create a 3D mesh of the user's space, where virtual content can interact with the environment.[23] Additionally, geolocation features can detect the user's location and display relevant content, such as 3D models of local biodiversity.

Visualization: XR can help learners see things that are impossible or difficult to see in the physical world. This can support learning more accurate spatial representation, such as understanding the structure of cells,[24] and making abstract concepts more concrete[25], like visualizing the theory of relativity.[26]

Active Learning: XR can provide learners the opportunity to interact with real-looking objects and environments, which can enable them to actively participate in what they are learning, and connect their mind and body, too.[27] Learners can create with virtual objects in computer-generated and physical environments, facilitating new ways of learning-by-building.[28] XR is also useful for technical training and skill building, especially providing opportunities to practice high-cost, high-risk scenarios like medical dissections[29] or operating machinery.[30]

Game-Based Learning: Gaming is perhaps the most prevalent application of XR.[31] Games can engage learners by adapting difficulty based on need and proficiency, providing a scaffolded opportunity for repeated practice.[32, 33]

Virtual/Augmented Field Trips: XR's immersive capabilities can support or facilitate learning situated in more authentic contexts than the classroom.[34] VR can transport users to places impossible to visit in real life, and AR can help provide information or context onto an environment during a physical field trip.

Role-Play and Perspective-Taking: XR can also create a sense of virtual body ownership, or a sense of presence in a different body.[15] This can facilitate role-play and perspective-taking, effective pedagogical tools for identity exploration which can help people learn social and emotional skills or develop their self-beliefs.[35,36]

Immersive Storytelling: Stories are powerful for learning, and immersive storytelling can put a learner "inside" a story to provide more context and deepen their understanding; for example, by immersing them in a news story.[37]

Novel Social Interactions: Increasingly, XR applications allow people to interact with others through virtual meetings, games, and social networks. They open up the potential for collaborative learning, and connect people across distances that are difficult to orchestrate.[38]

Limitations: What Is XR *Not* Good For?

XR has some characteristics that make it difficult to achieve certain learning goals, which we refer to as *limitations*.

Cognitive Load: XR experiences provide learners with a lot of visual and auditory stimuli which can increase their cognitive load as they process what they see, hear, and read.[19] This may explain the mixed results of learning with immersive technologies in terms of what content knowledge is retained.[39, 40] More research is needed to understand optimal instructional methods in XR to maximize learners' comprehension [41, 42] and how it is best integrated into learning design,[43] something that is more well known with other materials like books, slides, and lectures.

Time Constraints: HMDs used for VR and MR can make people uncomfortable or nauseous in as little as 10-15 minutes with worsening effects during long exposures,[44] indicating they are best used in small doses rather than as the instructional mode for a full lesson. Other technologies like mobile-based AR, computer applications, or low-tech solutions may be better suited for longer-term interventions.

Accessibility: Current XR technologies are not easy to use for many people. For example, someone with limited mobility in their hands might struggle to use controllers. Even something as common as wearing glasses can make using a HMD difficult. Additionally, some technologies are not equally accessible for people from varied backgrounds and identities. For example, headsets often cannot be worn over head coverings or many hair styles, like religious headscarves and natural Black hair styles.

Affordability: XR technologies remain more expensive than other learning resources such as computers and books, and often require a high-speed internet connection. Additionally, content is more expensive to create, requiring specialized equipment and skills to create the interactive virtual environments necessary for effective learning.

Lack of Educational Content: There are not yet many programs for learning, nor is there a platform that makes it easy to search for content based on learning goals, subject area, or age group. Additionally, few educators have the ability or capacity to create their own XR learning materials, much less teach learners how to make their own.

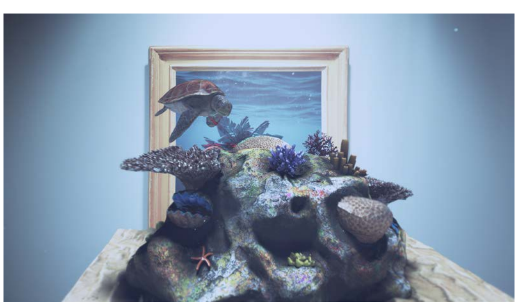
Privacy and Safety: XR technologies are being developed by corporations whose business models rely on collecting an increasingly detailed and wide range of data on every user. XR technologies have the potential to track people's movement and emotions, which can reveal personal and sensitive information about them,[45] raising the question of how to keep learners' data safe and their identities secure.

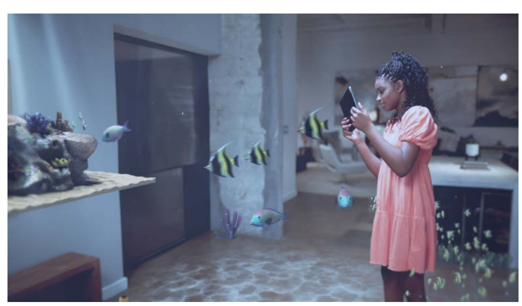
Difficult to Assess Learning: XR can afford a more individualized and unstructured learning experience, and is well suited to teaching skills, competencies, beliefs, and attitudes that may not be captured by multiple-choice learning assessments. And while XR offers the possibility of collecting diverse forms of user data (e.g., movement, eye tracking), this type of data has not yet been translated into meaningful learning assessments.

Note: The above lists of affordances and limitations are not exhaustive, and are intended to illustrate what we see as powerful (and not-so-powerful) applications of XR for learning. Also, while based on our understanding of the literature, research remains thin as the implementation of XR in educational contexts is nascent and the evidence base is likely to shift over time.

CASE STUDY

AR Reef is a mobile-based AR application that teaches learners about how their actions on land impact ocean health. Using a smartphone or tablet, the learner can "place" a digital picture frame on a vertical surface, from which the reef and its inhabitants emerge. This visualizes an underwater environment that is difficult to visit in real life, and animates coral biology and the impact of ocean stressors. Learners can move around the digital reef and view it up close from different angles. This interactive visualization was designed to support learning about the complexity of the ocean ecosystem, but data on learning outcomes has not yet been collected. Further, accessibility is limited based on the need to download an application onto the learner's device.





See the Appendix for additional examples of XR learning experiences.

Learning from the Past

In order to learn how to use XR effectively in education, we must first study the pitfalls that have hobbled past endeavors to revolutionize education with tech. By reviewing the sometimes unsuccessful history of tech in education, we can begin to understand why educators are oftentimes wary of new technology and the companies behind them. By building empathy with educators, we can better learn how to address their concerns with XR and optimize the impact that XR can have on the education space.

While learning is a complex and multifaceted phenomenon, XR has a lot of potential to contribute to formal and informal education. Yet, we can't overlook the fact that XR is not the first technology with promises of transforming education. History presents us with plenty of pitfalls to be avoided if we want to harvest the potential of XR for learning. A century ago, Thomas Edison enthusiastically argued that motion pictures would be a game changer for the educational system. He even suggested that this revolutionary technology would replace textbooks, and that videos would obtain one hundred percent efficiency for learning![46] Now let's fast forward to 2021, when similar optimistic claims were made about the Metaverse, describing it as a place where anyone "could learn about anything in the world just by bringing it closer to them."[47] Of course, it is fair to wonder if these two examples are outliers, or if there is, indeed, a long history of utopic expectations concerning technology in education. Unfortunately, these two examples, a century apart, look nothing like outliers.However, by understanding these pitfalls, we can begin to build better moving forward.

CASE STUDY

One Laptop Per Child is a famous illustration of the hype cycle. In 2005, two MIT professors had an ambitious vision to build sturdy computers that cost only $100 to be distributed in developing countries. The project received support from tech and design communities, as well as the United Nations. Despite the idealistic intentions, problems started piling up. The cost rose to $180 while still cutting corners. Infrastructure was often inadequate, with lack of electricity or internet access rendering the computers useless for many students. Moreover, most implementations did not have technical or pedagogical support. As a result, most evaluations of these programs found no impact on students' learning, aside from their increased skills at using the laptops.[56,57]

When we deploy technology for education, it cannot end when a piece of equipment is handed over to a school, teacher, or student. Instead, implementation should be done in accordance with the local practices, context, and culture.

Education and Technology: A Tumultuous History

In the late 1980's, it was believed that "the educational system had a history of becoming a burial ground for new technologies."[48] Living up to this reputation, school systems in the 1990's and 2000's fervently adopted and integrated the latest technologies, from televisions and interactive whiteboards, to the iPad and other tablets. Even computers were supposed to "blow up the school",[49] though despite the prediction that computers would render schools obsolete, the world's classrooms are still very much standing.

Put simply, *techno-utopians* have claimed that technology could be the ultimate solution to enhance academic performance and help fix some of the educational system's issues. Unfortunately, these predictions show a simplistic view of the otherwise complex phenomenon known as learning.

The expected measurable improvements in academic performance have not been as straightforward as many had hoped for. Moreover, technology has been proven over and over again to be an unviable strategy to fix problems in education. In fact, it has more often created new problems, especially around issues of equity.

Of course, we cannot deny that technology has transformed how we learn, both in and outside of school. However, the history of technology failing to live up to unreasonable expectations has repeated itself so many times that researchers have coined the term "rhetoric-reality gap"[50] to describe this phenomenon, doing so as a perpetual warning against blind support of technology in education.[51-54] But why does this keep happening? And how does it negatively affect learning?

The list of ingredients for this "oversold, underused" cocktail[51] is long and complex.[50] The risks begin with unrealistic promises made by biased stakeholders with personal interest in the success of the technology.[51] These false promises, made to buoy interest in the tech, then influence decision-makers with a naïve vision of the relationship between technology and education. Once implemented at great cost in schools, teachers face an uphill battle. Many are not provided with proper training or agency to acquire the technological, pedagogical, and content knowledge needed to successfully embed the technology in their teaching practices.[55]

For teachers, time is also not on their side when implementing new learning tools. Teachers need to adapt their lesson plans to accommodate the new technology. After the first implementation, teachers need to reflect on how things went and start an iterative process. This process requires time that most teachers, already burdened with heavy workloads, simply do not have. Thus, it is crucial that XR project managers and developers design and build the teacher's user story into their product roadmap, and that any initiative led by a company to bring XR into the classroom has sustained teacher support built into marketing and launch plans.

The technology might also lack appropriate design to fit into the reality of the educational system, contributing to negative attitudes from the implementer and also impeding students' learning. Simultaneously, poor initial planning can result in a lack of financial support to maintain the technology in working condition. This can result in the technology being abandoned, collecting dust on a shelf as the next hyped device joins the other obsolete pieces of equipment. This kind of vicious cycle can leave educators with feelings of resentment and frustration toward new technology implemented by decision-makers who, despite good intentions, lack expertise necessary to cultivate the soil on which technology is supposed to flourish.

Though the history of technology in education can be discouraging, vision and optimism for the future are crucial. When creators and educators are aware of the potential pitfalls in technology in education, they are better equipped to thoughtfully build and implement new tools in teaching practices.

RECIPE FOR SUCCESS — HOW TO AVOID THE "OVERSOLD, UNDERUSED" PARADIGM

1. Define your learning goals *then* see if XR could help you achieve them
2. Be realistic concerning what XR *can* achieve
3. Allocate time for educators to implement, experiment, and iterate their teaching practices with XR
4. Take into account the culture, context, and practice in which XR will be embedded
5. Make sure your budget includes all costs (e.g., maintenance, training) along with the cost of the XR platform(s) itself
6. Create or find high quality learning content in XR
7. Recognize that XR is a tool, not a panacea
8. Provide adequate training to your educators
9. And finally....***Don't use XR for the sake of using XR***

Tech as a Tool, Not a Silver Bullet

Teachers are often unfairly blamed for poor implementation of tech in the classroom. Technology is not the silver bullet to fix struggling systems of education. Technology is merely one of the tools available in the educator's toolbox. Moreover, a tool is only as good as its ability to serve a specific goal. After a century of this vicious cycle, propelled by naïve conceptions of the role of technology in education, it is time to change the course of history and break the cycle by learning from past mistakes.

Let's make sure that XR is seen for what it is; not a goal in itself, but a means to a carefully thought out end. In education, the goal concerns what needs to be learned. Once learning goals are clearly defined, then it is time to judiciously think about which strategy educators can use to achieve their objectives.

To give an example, let's say your learning goal is to inquire about the tidal zone ecosystem with your students. If you happen to live inland, XR might indeed be a useful tool that would allow your students to feel virtually immersed in this remote environment. On the other hand, if you happen to live close to the shore, benefit from safe access to a local beach, and can take students on a field trip, using XR would keep students away from an outdoor experience with nature, unnecessarily substituting it with a virtual proxy. In other words, if you can get your feet wet, do so; if you cannot, XR can be a valuable solution.

A rule of thumb is to use VR for experiences that otherwise would be Dangerous, Impossible, Counterproductive or Expensive (also known as the DICE acronym).[58]

- **Dangerous:** Train how to put out a fire instead of risking injuries with real fires.
- **Impossible:** Walk on Mars even though this is probably impossible during your lifetime.
- **Counterproductive:** Cut trees in a virtual forest to learn about deforestation, something that in real life would go against what you are trying to achieve.
- **Expensive:** Become a diver in the remote location you have always dreamt to visit (but are still saving money for).

While VR can transport you somewhere you couldn't go otherwise by taking you away from reality, AR and MR add to the user's surroundings. With AR, you can clean a virtual penguin covered in oil in your own sink, or you can get help identifying the plants you encounter during an outdoor hike.

We know that XR and the Metaverse will not fix systemic problems in education, and might even create new problems. However, understanding the strengths and weaknesses of XR will allow for thoughtful reflection on how we use these tools for specific learning goals and contexts.

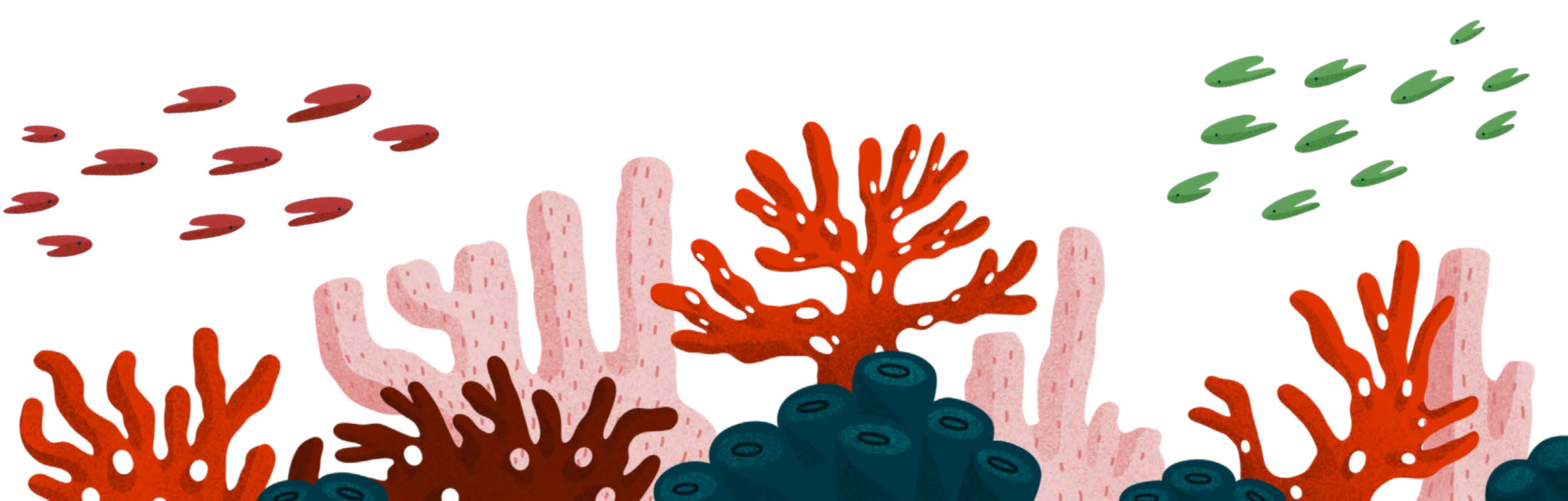
Inclusively Designing XR for Learning

The previous insights into XRs opportunities and challenges point to the importance of thoughtful XR design. To achieve this, we should ask:

1. **What are the learning goals?** Educators and designers need to be specific about their goals, because while XR can help achieve some learning goals, it may hinder others. For example, XR-enabled learning experiences can support learners' spatial awareness by providing rich 3D representations that are not visible in real life. On the other hand, the rich stimuli can cause a heavy cognitive load that interferes with their ability to remember factual information. Frameworks for instructional design emphasize connecting the activities learners engage in with their mental processes that lead to learning,[59] and frameworks like Universal Design for Learning are helpful to ensure all media and activities are accessible for all learners.[60] Again, before any headset is donned, educators should articulate the goals and determine whether and how XR supports them.

2. **Who are the learners?** When designing learning experiences and deciding which XR technology and applications to use (if any), it is crucial to consider who the learners are. Hardware and applications are not accessible or inclusive to every population of learners, in part due to who is designing them. Most XR content, as well as hardware, is created by a sliver of the world's population– typically by companies based in Silicon Valley, at the top of the world's income distribution, by people who have historically had the most privilege. Though diversity among XR developers, content creators, and leadership is increasing, representation skews male, able-bodied, and white.[61-63] This has resulted in XR hardware and content that is not equally accessible or beneficial for all. For example, several studies have shown that while in VR, women suffer more from motion sickness than men.[64-68] One of the potential culprits seems to be the inter-pupillary distance (the distance between your pupils, a crucial measurement for comfort and vision in VR), which is generally smaller in women than men. Though most VR headsets have the option to adjust this distance, women and people with smaller faces are less likely to fit the headset to their eye morphology, resulting in motion sickness.[64]

   In addition, some VR experiences are aimed to highlight tragedies and difficult living conditions, which may be eye-opening and empathy-inducing for privileged populations, but could be triggering and harmful for those closer to the subjects.[69] We just don't know yet how learners from diverse backgrounds experience various types of XR applications, so designers must use caution and consider their audience carefully. Long term, the XR industry should also aim to diversify their ranks so the voices and talents of underrepresented groups are included from the beginning.

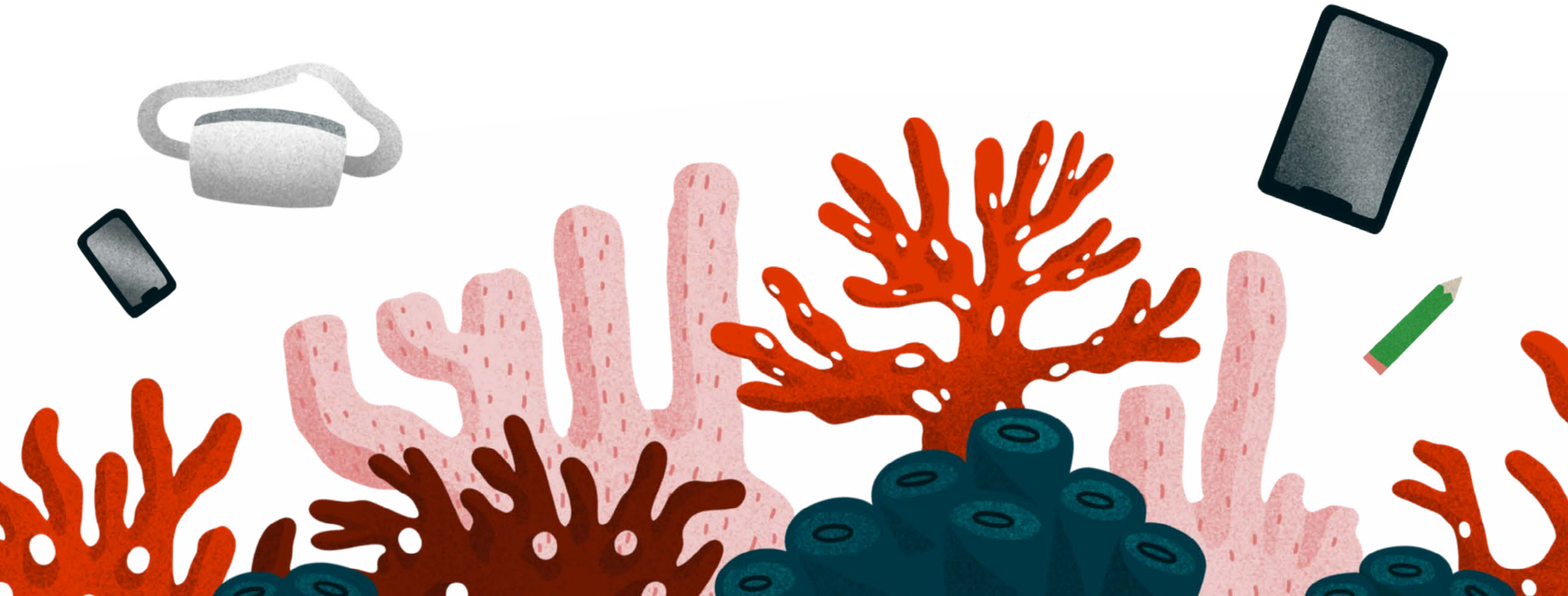


3 **What is the context?** XR technologies have not yet been designed with a range of potential learning contexts in mind. Some considerations include the skills and time of the educators who will be implementing the technology and learning experience, the infrastructure and characteristics of the space, the amount of time learners and educators will have, and the resources available to them. For example, designing a learning experience in a museum where individual learners engage in a brief, one-time experience is far different than designing an experience for a semester-long class with 30 learners. Choosing the right technology to deploy the experience also depends on the context, such as availability of electricity, internet, and devices.

CASE STUDY

KaiXR is a student-friendly platform of immersive experiences providing a safe pathway to the Metaverse with educator resources and implementation support. The platform contains over one hundred 360-degree virtual field trips ranging from the US presidential portraits of the Obamas to learning about CRISPR's DNA editing by a female Nobel Prize winning biochemist. The 360-degree videos are accessible on a range of devices including laptops, smartphones, and VR headsets, creating a low barrier to entry for practitioners and learners. The library prioritizes culturally-relevant content that can be hard to find. Although less expensive and easier to use, these 360-videos are not as interactive as more expensive and higher-end XR experiences, hence limiting the potential for hands-on learning. The company continues to research methods to demonstrate its effectiveness on learning outcomes across a wide range of learners.





Now that you have an understanding of learning in the Metaverse, you may be wondering if XR is right for your learning objectives and students.

What follows is a series of questions to help you think judiciously about embedding XR into your teaching practice. No matter your role in education, it is imperative to keep the students, your learners, front and center.

First, take some time to generate an initial learner profile that you will reference throughout the rest of this section. For instance, you can use the following worksheet to fill in the blanks:

_______ is _____ and lives in _________. He/She/They is ____________________________ ,
Name — Age — Location — Describe their background

enjoys learning about _______________ , and has trouble _______________________ .
Topic(s) — Challenge(s) they are experiencing

Here are some sample learners we have used in the past:

- **Ivan,** a first-generation, low-income student, attends a Title I school with limited access to technology. He has a strong curiosity but is unable to access libraries as his parents work two to three jobs to sustain their family.
- **Andrea,** a Spanish-speaking high school student in Panama, lives near the Smithsonian Tropical Research Institute and loves to snorkel. She is a woman of color who loves exploring, but fails to identify with the ocean researchers depicted in the media she's consuming.
- **Jessie,** who identifies as non-binary, is a college sophomore who is changing their major from social sciences to STEAM, is shy, and prefers small group learning. They are anxious about the future and wonder what careers are available to them.
- **Mia**, a millenial looking to work in tech, is searching for training programs that teach user research skills. However, she lives in a rural area in the southwestern U.S. and has limited opportunities to engage with experts in the field.

As you think about what your learners need (you know them best), remember that research in the field of XR and education can also complement your own experiences as a practitioner.

In order to effectively reflect about the role XR could play in your learning practice, progress through these four reflective levels, which we'll take you through below.

Level 1	Level 2	Level 3	Level 4
Explore the Desired Learning Experience	Search for Existing XR Materials	Begin Designing New XR Content, If Needed	Deliver a Measurable Experience

LEVEL 1: EXPLORE THE DESIRED LEARNING EXPERIENCE

Questions to ask yourself about learning

What will XR give me that is not available in the teaching tools that are currently available to me?

What are the learning objectives?

- What specific things do I want students to learn or achieve by the end of each day?

What are the learning outcomes?

- What do I want students to achieve overall once they reach all objectives?

What are the needs of my diverse learners?

Acknowledge other parameters, or organizational limitations, capable of shaping those key outcomes such as:

- The technologies your learners need and can access
- The cost of these technologies
- The age requirements of hardware and software
- The physical environment in which your learners are learning
- The IT protocols to which the school or district must adhere

To prioritize, here are some questions to help you think about your learners:

Background: How do your learner's experiences and their unique circumstances impact how they perceive learning?

Learning Modality: What is your learner's preferred way of learning (e.g., in person, virtual, or hybrid)?

Support: What community of support (educators, family, tutors) does your learner have access to while they navigate the Metaverse?

More questions will come up as you continue to reflect. The purpose of this exercise is to empathize with the targeted learner and inquire about who they are, how they learn, and what they want to get out of an XR-focused experience.

LEVEL 2: SEARCH FOR EXISTING MATERIALS

To avoid reinventing the wheel, be intentional about identifying existing resources. To get started, take a look at the **Appendix at the end of this guide for a list of educational XR experiences**. You can also check out the **Educational VR Apps database** by the Stanford Virtual Human Interaction Lab.[70]

Starter questions

- What learning objective would benefit most from XR?
- Is pre-existing XR content that supports this objective available?
- How can I leverage my existing lessons to build upon or connect to the resources available to me?
- How do I leverage subject matter experts to help me build an immersive experience or just help me understand how to begin?
- What are the resources I can use to understand the differences between AR, MR, and VR education?

As we search for existing materials, how can learner preferences and needs impact our XR development and material sourcing?

Background: What experiences has your learner had with XR?

Learning Modality: What formats does your learner prefer when learning? Do they enjoy reading text, 2D visualizations, short-form videos, project-based work, etc.?

Support: What kinds of support can we scaffold for your learner? Do they prefer learning ontheir own, collaborating with peers, or working with a guide?

If, after reflecting on the questions above and using the resources we've provided, you haven't found XR experiences that address your learning objectives, you may consider creating your own content. Note: creating your own content can be a challenging endeavor and the next level should be considered as optional.

LEVEL 3: BEGIN DESIGNING NEW XR CONTENT, IF NECESSARY

Whether you build XR content yourself or outsource it to a third party, this section provides some questions to get you started.

Consider the following questions:

- What kind of content do you have in mind? How long would the experience last?
- How do you want the content delivered (i.e. in person, self-paced, AR or VR)?
- What accessibility features does your content need to offer (e.g., closed captioning)?
- What do you want the learner to create to demonstrate comprehension?
- How will the content be culturally relevant and respectful for your diverse learners?
- In what ways will XR enhance learning, if at all?
- Who can you learn from (i.e. consult an expert to help you navigate future issues)?
- What tools and resources do you have available to create your own XR content (e.g., 360o cameras, game engine software, content building tools, hardware, programming support)?

Consider the following questions when designing new content:

Background: What kind of content does your learner enjoy consuming (i.e. social media, entertainment)?

Learning Modality: What scaffolding does your learner need to develop and apply their learning (i.e. timing, artifact creation, etc)?

Support: What scaffolding does your learner need to develop and apply their learning (i.e. timing, artifact creation, etc)?

Inclusivity*: What elements can you incorporate into the experience to make learning culturally competent and relevant**?

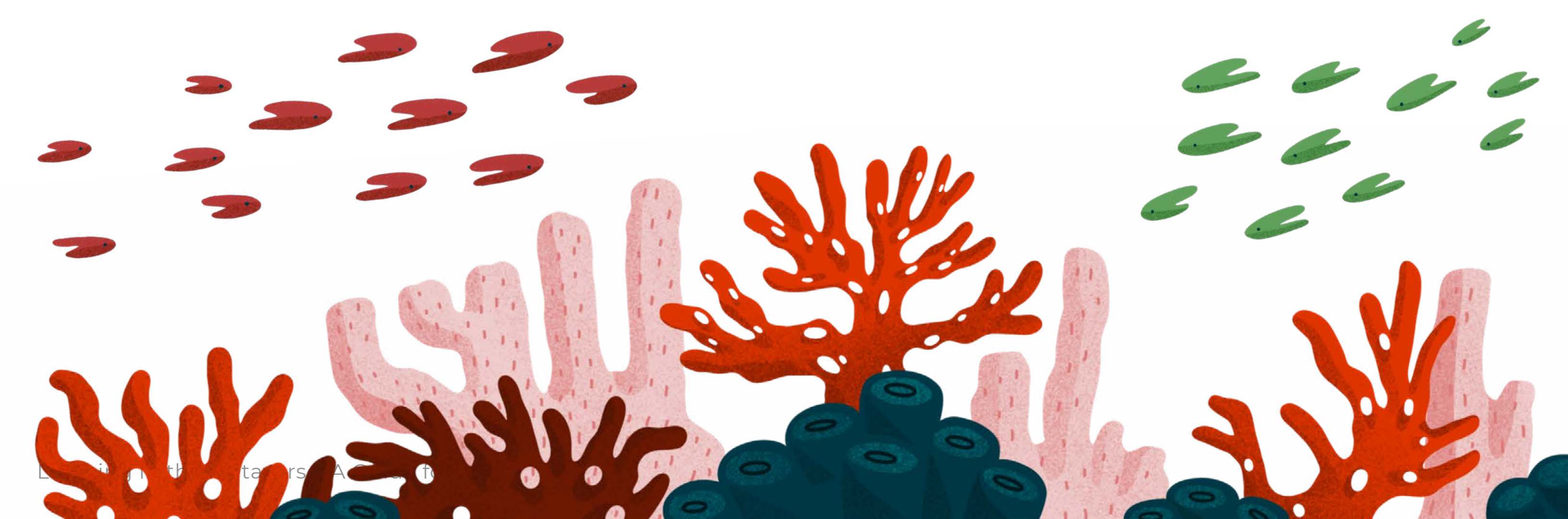
*Inclusivity: A practice of building equal access to learning opportunities and resources for people who might otherwise be excluded or marginalized, such as those having disabilities or belonging to other minority or socioeconomic groups.

**Culturally Competent: Containing a range of cognitive, affective, and behavioral skills that lead to effective and appropriate communication with people of other cultures and backgrounds. Intercultural or cross-cultural education are terms used for the training to achieve cultural competence and relevance.

As you begin to sketch out your content, think about the potential of XR to enhance your learning outcomes. For example, if you are teaching how to construct a persuasive essay, does adding XR help the learner write better? If not, maybe this topic is not the best candidate for XR. Remember, **XR is merely one tool in your pedagogy toolbox.**

If you continue down this path, we recommend you test an early prototype of your learning experience with your targeted learners before investing further time in content development. **Receiving feedback on early prototypes will be invaluable.** The more targeted feedback you collect and reflect upon (and identifying what feedback to discard), the more effective the content will become.[71]

Want to learn more about the mechanics of creating content? We are in the process of building resources to help guide you through this. To receive them when released, contact us at **xrlearning@meridiantreehouse.com**.



LEVEL 4: DELIVER A MEASURABLE EXPERIENCE

As you build out and make plans to deliver your curriculum, be sure to consider how you'll measure your learning outcomes. A recommended approach is to focus more on the process of learning, understanding, and reasoning instead of what content students know, do not know, or whether or not they reached a learning outcome.

Consider a few questions:

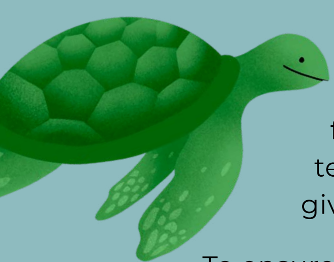
- Does your design and execution take into account what you want to measure?
- What can my learners understand and do?
- How are my learners assessing their own work and the work of their peers?
- How do we distribute content over time to reinforce learning?
- What will learners do before and after using XR to help them make the most of the experience and maximize their learning?

We encourage you to experiment, monitor, and evaluate the experience in order to quickly pivot and iterate.

Final evaluation questions:

- **Background:** What does success look like for your learner in the learning experience?
- **Learning Modality:** What metrics are important to consider through the learning experience of your learner (e.g., engagement, attitude, motivation, agency)?
- **Support:** What are the various measurement tools and protocols to check for your learner's knowledge understanding, reflection, and application?

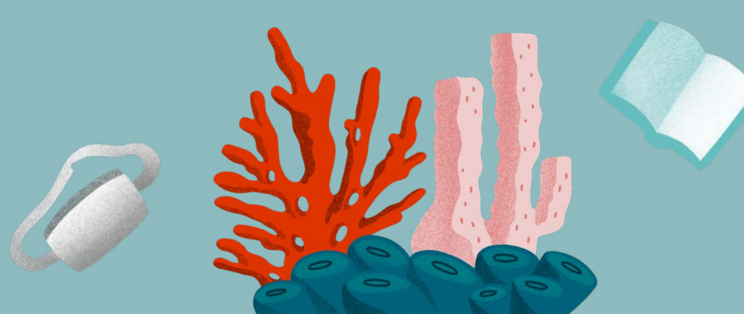
FINAL REFLECTION



This introductory guide is designed to serve as an onramp to learning in the Metaverse. Though you may have more questions than answers, we hope you feel confident to discuss and imagine the possibilities of XR in education. As new technologies emerge—impacting how people live, work, and learn—we are motivated to give every learner the opportunity to thrive in an increasingly complex world.

To ensure that learning experiences are impactful regardless of the tool or platform used, we need to understand the promise of these technologies and how they can fulfill their potential, instead of becoming another oversold and underused learning tool. If you remember one thing, it should be this: ***rigorously prioritize your learners***—and their place in the future—as you build, implement, and evaluate immersive products. The Metaverse will continue to grow and evolve, as will the opportunities to create impactful experiences.

Learning with XR is still in its infancy. We hope educators, content creators, developers, and researchers will continue to work together to create high-quality XR learning experiences, experiment with them, build the evidence base, and share our discoveries. Our work and this conversation is ongoing, and we want you to be a part of it. Please tell us what you are taking away from this introduction, what you want to see next, and what you are doing with XR. You can reach us at xrlearning@meridiantreehouse.com.



ABOUT MERIDIAN TREEHOUSE

Meridian Treehouse is an award-winning nonfiction storytelling and experiential agency that cultivates multidisciplinary collaboration and innovation. Its team of scientists, educators, storytellers and technologists is committed to using the tools of today and tomorrow to build accessible and inspiring lifelong learning resources. The firm specializes in developing multi-platform experiences, content and partnerships that educate and entertain – all with the goal of fostering curiosity, free from outdated spatial and logistical constraints. Because exploration is for everyone, everywhere.

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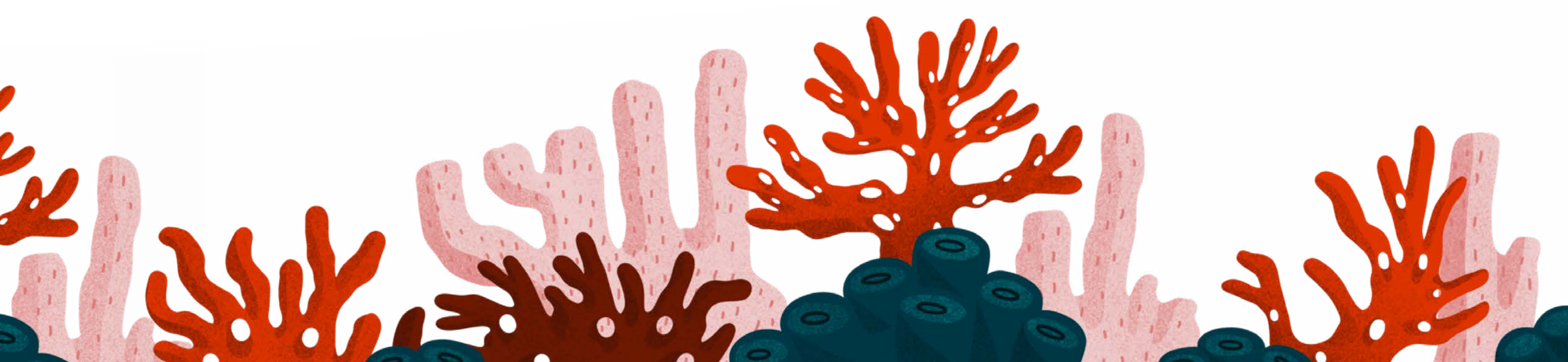

Existing XR Learning Experiences

This list is not exhaustive nor a form of endorsement, and is limited by the experience of the authors. We look forward to adding additional examples in future work.

- AR Reef: an interactive AR experience about coral reef ecology and biology.
- Anne Frank House VR: an interactive VR application of the Anne Frank House narrated by passages from her diary.
- The Book of Distance: an artist's interactive VR experience telling of his grandfather's experience in Japanese internment camps.
- Cellverse: a collaborative VR game that "shrinks" learners to fit inside a cell in the human body to identify cystic fibrosis.
- CRISPR Field Trip: 360-degree video that shows how to edit DNA with CRISPR.
- EcoMobile: a tablet-based AR app students can use when visiting a pond to hear from holographic park rangers and learn about the surrounding ecosystem.
- The Enemy: an AR app that puts the viewer between people on opposing sides of conflicts to hear their stories.
- ENGAGE: a platform for immersive learning, meetings, virtual events, company culture, training, and development.
- Expedition Everest: a VR film by National Geographic about a team of scientists, Sherpa, and storytellers studying the impacts of climate change on Mt. Everest.
- Explore: an interactive underwater VR experience that visualizes coral reefs from biological to global scales and teaches the learner to collect data as a marine biologist.
- In Protest: 360-degree films from inside the Black Lives Matter protests of 2020 around the United States.
- KaiXR: a student-friendly platform that offers over a hundred immersive experiences and provides support for educators.
- Mission:ISS: a VR experience on the International Space Station.
- Nanome: a VR platform to visualize nanoscale molecules.
- National Geographic Explore VR: a VR experience where the user searches for a colony of Emperor Penguins in Antarctica as a National Geographic photographer.
- Prisms VR: experiences that teach math through movement, experience, and discovery.
- Sketchar: an AR app that helps teach drawing techniques by augmenting physical sketches and surfaces.
- SMALLab: an MR multimedia laboratory that allows learners to visualize centripetal force with their bodies.
- The Stanford Ocean Acidification Experience: a VR activity showing the process by which the ocean becomes more acidic as it absorbs carbon dioxide emitted into the atmosphere and its impact on marine life.
- Strivr: VR training software platform to optimize workforce performance from procedural to soft skills.
- Teacher's Lens: an anti-implicit bias training for teachers.
- Traveling While Black: a VR documentary that immerses the viewer in the long history of restriction of movement for Black Americans and the creation of safe spaces in their communities.
- Tree: a VR experience that transforms the user into a tree to experience its life cycle in the rainforest.
- Wildeverse: an AR game creating a virtual forest where the users step into the shoes of scientists tracking apes and other wild animals and learn about what conservation organizations actually do.
- Zoe: a VR app that helps learners build their own virtual environments without learning to code.

Additional Collections of XR Learning Experiences:

- Educators in VR
- Educational VR Apps database
- XR Libraries
- XR Ecomap

Resources on Kids and XR

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