XR ASSOCIATION DEVELOPERS GUIDE:
AN INDUSTRY-WIDE COLLABORATION FOR BETTER XR

CHAPTER 4: DESIGNING IMMERSIVE LEARNING FOR SECONDARY EDUCATION

XRA

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DESIGNING IMMERSIVE LEARNING FOR SECONDARY EDUCATION

This new chapter of the Developers Guide continues to focus on those developing platforms and applications for XR through establishment of an evolving set of best practices – this time with an emphasis on the importance and necessity of creating programs that are tailored for the classroom.

XR hardware is evolving rapidly, and while there are facets of XR hardware that are unique to each manufacturer, all are working to transform the way that students learn and reduce the barriers for learning in conjunction with software development partners. As software developers look to develop applications for use in the XR enterprise space, this guide is intended as a baseline of best practices for bringing XR to the education domain.

The guide is not meant as an exhaustive source on designing for XR in the classroom, and we recognize that these best practices must continually evolve. This will require ongoing input from relevant stakeholders, including standards setting bodies who are also working to establish industry standards in education.

Additionally, many countries around the world have established laws governing software for education, and we urge software developers to follow all education related laws and regulations in their applicable jurisdictions as they create innovative designs for XR.

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INTRODUCTION

WHAT IS THE VALUE OF XR IN SECONDARY EDUCATION?

The past few years have seen XR[1] use in education expand exponentially, in part, because the COVID-19 pandemic forced students into virtual learning, which, in turn, forced educators and school administrators to innovate in how to deliver curricula and other educational information to students of all ages. That led to an accelerated interest in alternative ways of delivering classroom instruction digitally, including through XR.[2]

Because most XR hardware manufacturers recommend users be at least 13 years of age, this chapter will focus on the use of XR in secondary education classrooms. Secondary education in the United States refers primarily to grades 9-12, also known as high school or senior high, and where children's ages are primarily between 13 and 18.

Research on XR use in the classroom is still emerging, and most of the research conducted to date has focused on adults and/or college-age students. While authoritative studies on the impact of XR-facilitated learning on children aged 13 to 18 years old may still be developing , many studies on adults have shown promising results supporting the value of XR for education and training.

A 2021 World Bank meta analysis[3] of studies looking at the effect of the use of VR simulations in adult education concluded that "VR training is, on average, more effective than traditional training as a mechanism to develop students' technical, practical, and socio-economic skills." The World Bank's analysis further revealed that students exposed to VR instruction reported 30 percent higher scores in socio-economic skills assessments and were up to 30 percent more "efficient in using inputs, time, and/or avoiding performance errors than students exposed to traditional training."

INTRODUCTION

As the World Bank analysis pointed out, the various benefits of VR use for education include the ability to embed gamification, performance metrics and collaborative features, as well as providing educators and students with a standardized, reproducible environment for repeated and optimized instruction.

Many of the aforementioned benefits are also relevant to AR and MR educational and training experiences. Multiple studies on the usefulness of MR training for medical students learning human anatomy[4] show that adult students found it as effective as traditional learning methods, that test scores were comparable to training on cadavers, and, in some instances, that MR training promoted teamwork.

Similarly, Education Corner noted[5], AR programs "promote interactive experiences with coursework, encourage collaboration between students, improve motivation, and increase learning gains. These benefits all rely on effectively implementing augmented reality into the class."

Effective implementation is key given that challenges remain in expanding XR for education in both secondary and higher education environments. As noted, many developers in the field are still experimenting with the most effective ways to use XR in secondary education. Even the World Bank meta analysis notes that it is "important to continue to assess the pros and cons of using VR for pedagogical instruction for different subjects as well as its cost-effectiveness and scalability."

Additionally, it's important to recognize that initially XR technologies will most likely be used as supplementary tools by educators, rather than as replacements for traditional methods of classroom instruction.

When exploring the use of XR in education, it may be beneficial to apply the DICE evaluation method, which is primarily used

to evaluate VR applications. Coined by the founding director of Stanford's Virtual Human Interaction Lab Jeremy Bailenson[6], the DICE method suggests that applications in XR can be useful when replacing real world experiences that are:

Dangerous, such as experiences that come with inherent risk such as firefighter training;

Impossible, such as taking a tour through our solar system;

Counterproductive, such as trying to teach a lesson with impractical or undesirable results. For example, teaching about the effects of deforestation by having a person actually cut down trees;

Expensive (and rare), such as experiences that are too costly or unique for the average person to experience, like scaling Mount Everest or visiting the Mona Lisa at the Louvre Museum.

The DICE method does not apply in all possible education use cases, but, for some, it may serve as a useful tool for teachers and administration when evaluating the efficacy of XR in education. For example, some high schools have had great success teaching technology and design principles to students through the use of VR in career and technical education classes where design principles are the subject matter and learning how to develop VR applications is the project.

SECTION TWO

ACCESSING THE CURRICULUM

WHAT TEACHERS AND STUDENTS WANT AND NEED FROM XR IN THE CLASSROOM

A 2022 XR Association survey[7] of teens found that 2 in 5 high schoolers report already having used either VR or AR in school. Additionally, they reported that the top areas in which VR and AR are currently being used in school are in tech and media, science, art, and after-school activities. Eighty percent also reported being excited about the future of XR.

In May 2022, the XR Association and the Joan Ganz Cooney Center at Sesame Workshop[8] sponsored a forum to explore the use of XR technologies in high school settings. This event brought together a broad spectrum of participants including academic researchers, educators, manufacturers, policymakers, and developers. One of the core understandings was that to successfully bring XR applications into classrooms they must be designed such that all students can participate.

To that end, it is beneficial for developers to understand that students have different needs. Those needs range from different levels of academic preparation, exposure to technology and attention spans, varying language abilities, and access to culturally relevant content .[9] Taking these into consideration when developing tools for educational experiences will be useful to the adoption of the application in the classroom.

ACCESSING THE CURRICULUM

In addition, the applications should be accessible to students and teachers with disabilities. The users' age and familiarity with interactive technologies should be taken into consideration.

There should be multiple physical modalities for how a student can interact in the immersive experience to support the aim to have all students participate regardless of ability.

Lastly, given the low likelihood that devices will be 1:1 in classrooms anywhere in the near future, providing teachers and students with multiple ways of experiencing and accessing the same educational materials in alternate formats — such as 2D, written, and other techniques — will improve the overall utility and longevity of the application.

Developers can listen to a panel of educators discuss how they are currently using XR in the classroom and their needs for the future, here.[10]

RECOMMENDATIONS

Developers should expect that parents and teachers will want information on how effective any particular app is at creating positive student outcomes.

Developers should include subject matter experts in the development of apps to ensure the integrity and validity of the educational information included in the app.

Developers should test apps with their intended audience and age-appropriate testers. Ideally they should have third-party research investigate and validate any learning efficacy claims.

Developers should participate in or conduct research studies on their content with educators and educational institutions early and often. When feasible, developers should begin conducting randomly-controlled trials (RCTs) in classrooms with learners to further test and validate whether their content is having the intended outcome and efficacy.

Developers should consider creating content that aligns with teacher grade-level objectives and local or state standards to ensure that they have a meaningful impact on learning.

CURRENT XR APPS FOR EDUCATION

Biology
Apps that allow students to go inside the human body and explore anatomy, such as AnatomyX or HoloAnatomy.*

History
Apps that immerse students in a historical event or place as if they were actually present, such as experiencing the birth of the ancient Roman Empire or seeing the Egyptian pyramids. Examples include Our Worlds, which helps learners explore Native American artifacts on tribal lands, and Movers and Shakers NYC, which helps users explore Black history monuments in New York City.*

Math
Apps that allow students to view and/or create graphs, curves, vectors and other math functions in 3D for high school-level math subjects, such as algebra, calculus, and geometry. Examples include PrismsVR and CalcFlow.*

Astronomy
AR apps that can virtually place the entire solar system in the classroom or VR apps that allow the exploration of other celestial bodies. Examples include SkyView and SolAR.*

Foreign language studies
Apps that allow students to visit foreign locales to learn and practice vocabulary in virtual settings. Examples include Immerse and Mondly.*

Art
Apps that allow students to draw with virtual paint brushes or pens to create virtual artworks. Examples include Tilt Brush and ShapesXR.*

See disclaimer on page 22

SECTION THREE

ONBOARDING AND TRAINING

Both teachers and students will need time to acclimate to the app environment, and developers are encouraged to build in onboarding mechanisms to ensure the app can be used as intended and effectively. This can be a training session in the application, guidance on hardware setup and usage, or classroom planning and pacing guides for introducing the new technology to students. Strong consideration should be given to the limited time teachers have with students and to reducing user friction when launching the experience.

Often schools aren't working with the latest technology. Developers should understand the limits of available school support technology, such as the relative network speeds available at schools and the age and condition of tablets, computers, and other devices, among other things. Being conscious of these potential limitations when building apps for educational use may increase the utility of the application.

To ensure usability and feasibility as a learning tool, developers should carefully consider how their XR programs might fit within the time limit of a teacher's class, providing enough time to ensure equitable pacing for the entire lesson of instruction, including setup time. In addition, developers should consider creating natural breaks at regular intervals and allowing students and teachers to stop and pause the program periodically to enable teachers to check-in with students and/or to reduce any fatigue from using the device or program.

ONBOARDING AND TRAINING

👍 RECOMMENDATIONS

Provide training materials with instructions showing how to use the built-in safety features of the hardware and software.

Provide tutorials that are accessible on demand and in both 2D and 3D environments so that teachers can select which is best for sharing with their students.

Consult with intended customers and/or a representative group of teachers/students to understand onboarding needs regarding training and implementation.

Consider that typical high school classes last less than an hour, around 45 to 50 minutes.

Consider that schools even in the same school district may have different technology budgets, needs, and preferences. Developers may not be able to predict what kind of hardware any given school may have, so designing apps that can deploy on multiple devices (e.g. VR or AR headsets, tablets, smartphones, desktop computers) should be the goal, where feasible.

Image provided by Transfr/West Alabama Works

Image provided by Haptix Studio

SECTION FOUR

ASSESSING LEARNING OUTCOMES

Teachers need to assess whether a student has actually learned new information from their lesson plans and curricula, whether it comes from books, videos, interactive and/or immersive technologies, or other materials.

Many educators will opt to create assessment tools or tests outside of any XR app they may be using to augment their lessons. Others may want to gain insights into student learning or have students complete assessments while using the XR app.[11]

Additionally, developers should consider that there is no universal third party classroom management software that allows teachers to "peer into" a student's VR stream to ensure a student is staying on task while maintaining a student's physical safety. However there is a need for teachers to ensure that students remain engaged in the activity and have awareness when students are no longer using the application as intended. Developers should consider supporting casting or streaming functions when feasible.

Developers should understand that school budgets often limit the number of students who can simultaneously participate in an immersive experience. Moreover, teachers may vary in their pedagogical approaches to how students participate in an immersive experience. For example, teachers may send subsets of their classes to XR "stations" to use and experience the programs in shifts during the class time.

# ASSESSING LEARNING OUTCOMES

RECOMMENDATIONS

Consider allowing teachers to be administrators on the apps and provide the ability for teachers to see how much time each student spent on each part of the experience, including whether a child missed or skipped a part of the experience.

Because not every student in the class will be participating in the immersive experience at one time, consider creating both collaborative and individual experiences that meet the educational needs of the curriculum and/or classroom.Examples of such experiences include asynchronous cooperative experiences that could be adapted to the classroom to support specific learning objectives.

Consider supporting casting or streaming functions so teachers can have the opportunity to view the students' level of engagement.
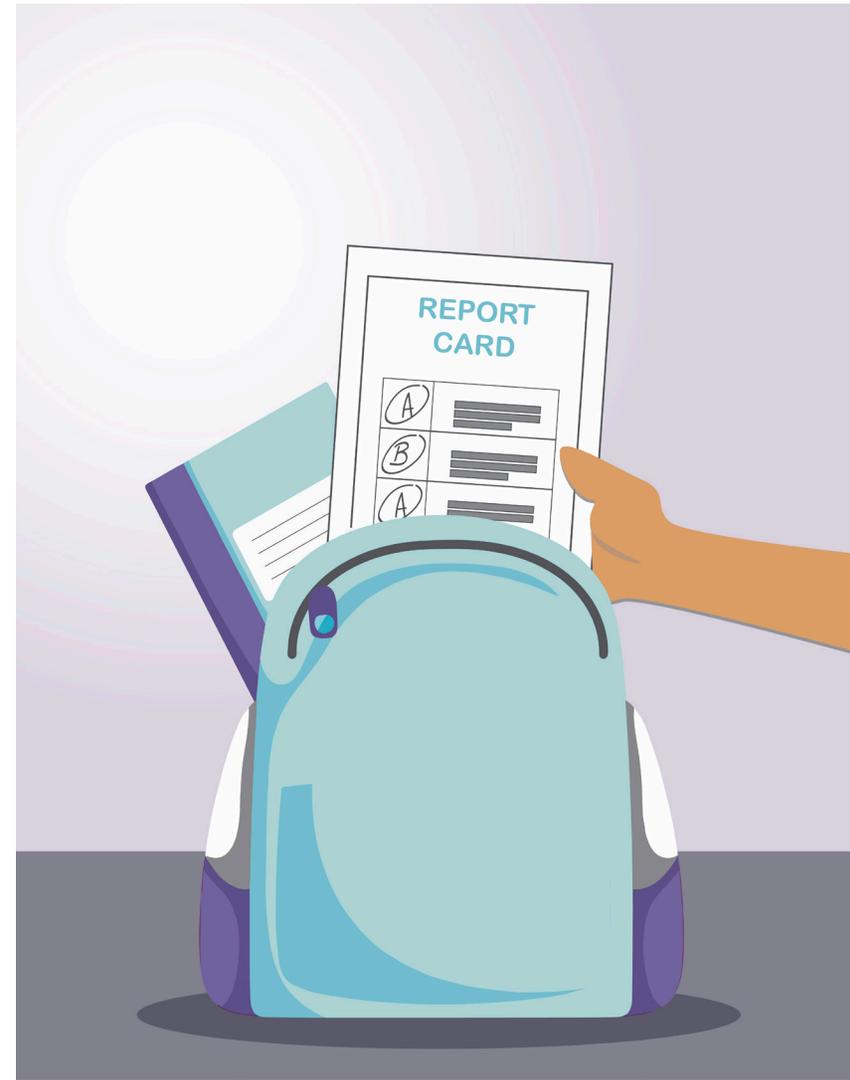
SECTION FIVE

AGE-APPROPRIATE CONTENT

As of publication of this chapter, there are no XR-specific education standards for children of any age, but there are useful, equivalent resources that can still help developers measure whether their content is appropriate for specific grade levels and age groups.

For example, Common Sense Media has a rating framework[12] based on age-appropriateness that developers can use as a guide. Similarly, Digital Promise, which offers EdTech certifications for educational technology, has resources that may help guide developers in creating age-appropriate content for high school. Their Learner Variability Project has white papers, webinars, and the Learner Variability Navigator web tool, all of which are designed to help developers understand the holistic needs of students and classrooms as well as evidence-based strategies to meet those needs.[13] The International Society for Technology in Education (ISTE) also has developed standards and courses for educators related to STEM content on how to "create high-impact, sustainable, scalable and equitable learning experiences for all learners."[14] Additionally, developers should investigate which additional content standards may be applicable,   such as the Next Generation Science Standards (NGSS), Common Core Standards for Math and English, and/or any state equivalents.

To align with students' grade-level objectives, developers may also want to consult lexile and quantile charts to determine whether their content is developmentally appropriate for the grade and age-level of the students for which they are designing. Lexile levels refer to language content, while quantile levels refer to math content.

AGE-APPROPRIATE CONTENT

Developers should be mindful that many high school educators are limited in their choices of educational content by school or district rules that bar some types of content (such as those that include weapons like virtual guns) or by technology that blocks content that has been deemed inappropriate for certain age groups on the Internet.

👍 RECOMMENDATIONS

Consult with intended customers and/or a representative group of teachers/students about any potential content restrictions that may preclude a school or educator from using certain apps.

Be transparent if the content touches on sensitive topics, such as references to smoking, drug use or weapons, so that educators can decide whether it is appropriate for their students.

To ensure educators can help control the content their students are exposed to, consider giving teachers authoring tools to create or help shape the types of immersive learning environments and curricula they need and want.

With teachers as a supervisory presence, developers should also provide a mechanism for collaborative creation tools in which students can participate in the content creation.

SECTION SIX

USER COMFORT AND SAFETY

To ensure user safety and comfort in the classroom, developers should consult the full list of considerations included in Chapter One of the XR Association's Developers Guide; Fundamental Design Principles for Immersive Experiences[15] , including tips on creating subtle clues that denote safe play areas, user breaks, and design choices that can limit visually-induced motion sickness and eye strain, among other things.

There are also some issues specific to the classroom that developers should take into consideration when designing educational apps for high school.

RECOMMENDATIONS

Consider that existing gesture commands and other modalities such as body motion and voice controls may need to be altered for high school users because those modalities have been designed with adult users in mind.

Depending on the app, consider that students aged 13 to 18 may be most familiar with physical and virtual buttons, rather than the use of hand gestures, particularly because many of them are accustomed to using tablets and/or smart phones.

In terms of safe spaces to experience an XR app, keep in mind that most teachers have limited ability to alter their classroom spaces to create specific XR-safe rooms. And it may be impractical for teachers to reconfigure their classrooms every 45-50 minutes to accommodate the needs of the different classes they are teaching during any given school day.

Consider that teachers are responsible for the safety of the students in their care, and therefore will likely look for apps that create immersive experiences with built-in guidance for physical safety measures to decrease any chances of student injury or harm.

SECTION SEVEN

DIVERSITY, EQUITY, INCLUSION, AND ACCESSIBILITY

Teachers have an imperative to create inclusive, welcoming environments for students of all backgrounds, ethnicities, races, genders, and abilities. Developers creating XR apps for use in high school settings should be mindful that teachers will take that imperative into consideration when choosing technology for their classrooms.

ACCESSIBILITY CONSIDERATIONS

The many ways in which software developers can ensure their apps are usable and accessible to users with disabilities can be found in detail in Chapter Three of the XR Association's Developer's Guide; Accessibility and Inclusive Design in Immersive Technology.[16] In addition to the suggestions in Chapter Three, public schools must comply with the federal Individuals with Disabilities in Education Act (IDEA), which generally requires schools to provide comparable educational opportunities for children with disabilities. Developers should be familiar with the requirements under this law and any state or local laws addressing education for people with disabilities, because those laws can impact the types of technology schools choose to use and/or purchase.

DIVERSITY, EQUITY, INCLUSION, AND ACCESSIBILITY

DIVERSITY AND IDENTITY CONSIDERATIONS

Research has shown that representation has a profound impact on a child's education. A 2021 analysis by Common Sense Media of the available research on the effects of representation in media on children found that, "Media representation is important to how kids build their perspectives on their own ethnic-racial group, as well as that of others."[17] Because of that, it is important to ensure that students and teachers of all backgrounds can see themselves reflected in the technology they use, through the creation of avatars and/or through representation within the content of the application.

The XRA's Developers Guide, Chapter Two: Creating Safe, Inclusive and Respectful Immersive Experiences[18] includes some helpful tips on promoting community safety and inclusion.

LANGUAGE CONSIDERATIONS

Developers should take into account the growing diversity of learners with different backgrounds and language proficiencies. For example, English language learners (ELLs) are the fastest-growing student population group, according to the National Education Association. By 2025, an estimated 25 percent of public school students will be ELLs.[19] With an increase in ELLs, building content that is both culturally relevant and culturally responsive is important to ensuring that the content meets this population's educational needs.

RECOMMENDATIONS

Utilize the guidance in Chapter Three of the XR Association's Developer's Guide: Accessibility and Inclusive Design in Immersive Technology to ensure applications are accessible and inclusive for persons with disabilities.

Where possible, give users the option to remain seated or to move around a safe space – both to ensure that the app is usable by low-mobility users, but also to accommodate potential space limitations in classrooms.

If avatar creation and representation tools are included in an app, include options for students of different races, ethnic backgrounds, gender identities, body-types, and those with disabilities, so that students have the option to accurately represent themselves if they so choose.

If the app includes exaggerated and playful avatar representations, be mindful to avoid potential ethnic, racial, gender, and non-disabled stereotypes when creating options to choose from. If avatars are not customizable, consider using neutral characteristics.

Consider how to provide access for culturally and linguistically diverse students so they can meaningfully engage within the content.
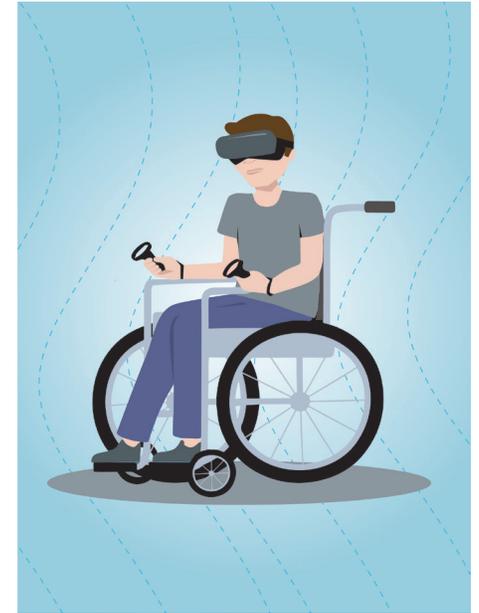
SECTION EIGHT

PRIVACY

Privacy should be built-in to provide school administrators, parents, and teachers with assurance that their students' information, personal identifiable information (PII), and other data will not be used for commercial or other non-educational purposes.

Schools and school districts may have their own rules about student privacy, so developers are encouraged to consult with their intended customers, when possible, on privacy restrictions.Some schools, for example, may not allow students to sign into existing social media apps or to create new accounts or user profiles for themselves in order to access educational content on tech devices.

Schools also have concerns about where, how, and for how long user data is saved, as well as about what borders the data may cross in that process. Developers should be prepared to provide answers or share resources to address these concerns.

PRIVACY

👍 RECOMMENDATIONS

Consider giving teachers and schools administrative control over the creation and/or use of student user profiles to allow the school to protect student privacy, when desired.

Consider asking schools to sign a Digital Privacy Agreement (DPA) to establish transparency in who has access to the data and where that data may travel.

Be mindful that several laws at both the federal and state levels may govern the collection and dissemination of student educational information and records. Examples of such laws include the Family Educational Rights and Privacy Act (FERPA)[20] at the federal level and the California Consumer Privacy Act[21] at the state level.

SECTION NINE

ADDITIONAL RESEARCH NEEDS

As noted previously, research on the impact and efficacy of XR educational content is still emerging. Because further discussion and research are needed, developers should take into account these unknowns if they choose to develop apps for high school education.

Developers and academics working on or with educational apps for high school students have the opportunity to add to the body of research, which will inform others working in this space and improve adoption of XR as an educational tool.

👍

RESEARCH TOPICS COULD INCLUDE:

Student and teacher attitudes on the use of XR in the classroom

Student and teacher comfort and safety using XR in the classroom

Student and teacher engagement in the classroom

Assessments of learning outcomes following the use of XR in the classroom

Equitable approaches to deploying and supporting XR in the classroom

ENDNOTES

1   XR is an umbrella term that encompasses augmented reality (AR), virtual reality (VR), mixed reality (MR), and other forms of alternate, expanded, or immersive reality applications.

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6   Learning Solutions, Julie Dirksen and Pamela Hogle, "VR Training Ideal for Dangerous or Impossible Experiences," April 24, 2019. https://learningsolutionsmag.com/articles/vr-training-ideal-for-dangerous-or-impossible-experiences?utm_campaign=lspub&utm_medium=link&utm_source=lspub&_ga=2.268844918.681861372.1657918731-504549605.1657918731

7   XR Association, "Teachers, Teens Agree Immersive Tech Has a Place in the Classroom," May 19, 2022. https://xra.org/teachers-teens-agree-immersive-tech-has-a-place-in-the-classroom/

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10   Immersive Learning for Media (sponsored by the XR Association and the Joan Ganz Cooney Center at Sesame Workshop), "What's possible with XR in high school education?" panel, May 17, 2022. https://www.youtube.com/watch?v=R6ZwCrz7e6Y&list=PLUsmpPIJgsXDKG-juRrJYsRQrAi4oSKMt&index=5

11   Immersive Learning for Media (sponsored by the XR Association and the Joan Ganz Cooney Center at Sesame Workshop), "Assessing Learning From Classroom Applications of XR," Lightning Talk from Sam Bindman (foundry10) May 17, 2022. https://www.youtube.com/watch?v=hpukg5SMzm8&list=PLUsmpPIJgsXDKG-juRrJYsRQrAi4oSKMt&index=4

12   Common Sense Media, "How We Rate and Review," https://www.commonsensemedia.org/about-us/our-mission/about-our-ratings

13   Digital Promise, https://digitalpromise.org/

14   International Society for Technology in Education, https://www.iste.org/iste-standards

15   XRA's Developer's Guide, Chapter One: Fundamental Design Principles for Immersive Experiences, https://xra.org/research/xr-primer-1-0-a-starter-guide-for-developers/

ENDNOTES

16   XRA's Developers Guide, Chapter Three: Accessibility and Inclusive Design in Immersive Technology. https://xra.org/research/xra-developers-guide-accessibility-and-inclusive-design/

17   Common Sense Media, Onnie Rogers, "Why Representation Matters in Kids' Media," Oct. 20, 2021. https://www.commonsensemedia.org/kids-action/articles/why-representation-matters-in-kids-media

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19   National Education Association, "English Language Learners Toolkit," July 2020. https://www.nea.org/resource-library/english-language-learners

20   U.S. Department of Education, "Family Educational Rights and Privacy Act (FERPA)" page, https://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html

21   State of California Department of Justice, "California Consumer Privacy Act (CCPA)" page, https://oag.ca.gov/privacy/ccpa

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