IEEE SA
STANDARDS ASSOCIATION

INDUSTRY CONNECTIONS REPORT

THE IEEE GLOBAL INITIATIVE ON ETHICS OF EXTENDED REALITY (XR) REPORT

EXTENDED REALITY (XR) ETHICS IN EDUCATION

Authored by

Eleni Mangina

Chapter Leader

IEEE

TRADEMARKS AND DISCLAIMERS

IEEE believes the information in this publication is accurate as of its publication date; such information is subject to change without notice. IEEE is not responsible for any inadvertent errors.

The ideas and proposals in this specification are the respective author's views and do not represent the views of the affiliated organization.

ACKNOWLEDGEMENTS

Special thanks are given to the following contributors of this paper:

Athanasios Christopoulos

Didier Contis

Georgia Livieri

Farzin Matin

Mathana

Meredith Noelle

Nathalie Mathe

Rebekah Davis

Samira Khodaei

Stylianos Mystakidis

Thommy Eriksson

Tobias Loetscher

The Institute of Electrical and Electronics Engineers, Inc. 3 Park Avenue, New York, NY 10016-5997, USA

PDF: STDVA25107 978-1-5044-8201-1

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF IEEE SA INDUSTRY CONNECTIONS DOCUMENTS

This IEEE Standards Association ("IEEE SA") Industry Connections publication ("Work") is not a consensus standard document. Specifically, this document is NOT AN IEEE STANDARD. Information contained in this Work has been created by, or obtained from, sources believed to be reliable, and reviewed by members of the IEEE SA Industry Connections activity that produced this Work. IEEE and the IEEE SA Industry Connections activity members expressly disclaim all warranties (express, implied, and statutory) related to this Work, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; quality, accuracy, effectiveness, currency, or completeness of the Work or content within the Work. In addition, IEEE and the IEEE SA Industry Connections activity members disclaim any and all conditions relating to: results; and workmanlike effort. This IEEE SA Industry Connections document is supplied "AS IS" and "WITH ALL FAULTS."

Although the IEEE SA Industry Connections activity members who have created this Work believe that the information and guidance given in this Work serve as an enhancement to users, all persons must rely upon their own skill and judgment when making use of it. IN NO EVENT SHALL IEEE OR IEEE SA INDUSTRY CONNECTIONS ACTIVITY MEMBERS BE LIABLE FOR ANY ERRORS OR OMISSIONS OR DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS WORK, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Further, information contained in this Work may be protected by intellectual property rights held by third parties or organizations, and the use of this information may require the user to negotiate with any such rights holders in order to legally acquire the rights to do so, and such rights holders may refuse to grant such rights. Attention is also called to the possibility that implementation of any or all of this Work may require use of subject matter covered by patent rights. By publication of this Work, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying patent rights for which a license may be required, or for conducting inquiries into the legal validity or scope of patents claims. Users are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. No commitment to grant licenses under patent rights on a reasonable or non-discriminatory basis has been sought or received from any rights holder. The policies and procedures under which this document was created can be viewed at https://standards.ieee.org/about/bog/iccom/.

This Work is published with the understanding that IEEE and the IEEE SA Industry Connections activity members are supplying information through this Work, not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought. IEEE is not responsible for the statements and opinions advanced in this Work.

TABLE OF CONTENTS

THE IEEE GLOBAL INITIATIVE ON ETHICS OF EXTENDED REALITY (XR) REPORT

EXTENDED REALITY (XR) ETHICS IN EDUCATION

ABSTRACT

This report is the result of work within the IEEE Global Initiative on Ethics of Extended Reality (XR), a multidiscipline group of industry practitioners, ethicists, academics, researchers, educators, and technology enthusiasts. It has been written to focus on a wide range of ethical issues related to XR and the ownership of second lives. This report builds on work outlined in the "Extended Reality" chapter of the IEEE's seminal ethics-focused publication *Ethically Aligned Design*. XR is a term used to broadly refer to a suite of immersive technologies including virtual reality, augmented reality, and spatial computing. The scope of this report is the exploration of ethics-related issues to support the development, design, and deployment of XR applications in education and the aim is to initiate expert-driven, multidiscipline analysis of the evolving XR Ethics requirements, with a vision to propose solutions, technologies, and standards in future updates. The set of recommendations within this report will hopefully contribute to industry conceptualization of socio-technological issues, highlight concreted recommendations, and lay the groundwork for future technical-standardization activities.

MONIQUE J. MORROW & MATHANA

CHAIR & VICE CHAIR

IEEE GLOBAL INITIATIVE FOR ETHICAL EXTENDED REALTY

1. INTRODUCTION

Immersive technologies (XR) in education offer a number of opportunities (e.g., facilitating Authentic Learning Experiences; empowering learners as creative designers and makers; integrating immersive storytelling in learning; integrating immersive learning in STEM; fostering collaboration with Social VR and other XR technologies; cultivating immersive and blended-reality learning spaces and laboratories; developing the capabilities of the future workforce) [1], but the convergence with artificial intelligence (AI) can have a profound impact on ethics considerations for applications at all levels [2]. Utilizing AI in XR can reshape human experience and social interactions in education, but one of the barriers for adoption is the lack of policy on XR ethics for education [3], [4]. Ethics XR for education is a broad topic that needs to be present within the different levels of education. Some of the sections within this paper are intertwined with the rest of the separate papers that make up the report as a whole (i.e., privacy, social harassment, accessibility). This paper describes the most important issues for XR ethics in education at all levels and proposes an initial set of recommendations in this space with a view to further develop a more detailed policy on ethics XR for education for reference from all levels [5].

2. LEGACY ACCESS AND PLANNED OBSOLENCE

Generally, schools move very slowly in adopting new Information Communication Technologies (ICT) tools due to the lack of evidence-based results of XR systems' impact in education and the large-scale investment needed from governments. However, the most important factor is severely limited resources, such as time. For many teachers, finding a new ICT tool or a new set of learning material is a major investment in time, considering how little time is available for teaching-related tasks involving researching, learning, and planning for new tools [6]. Therefore, when practitioners eventually find ICT tools that work well for their classrooms, they might keep using that technology for years or even decades beyond which these tools can be supported. This slow ICT adoption and tendency to use specific tools and content for a very long time are in conflict with a typical schedule of planned obsolescence [7] of both hardware and software, as well as the speed at which content platforms become legacy systems [8].

There is a wider issue than just the individual teachers struggling to keep old systems working and finding new tools and content. Funds for new technology are often lacking in schools, which slows the spread of new ICT in educational institutions. From a societal perspective, it is a waste of resources to develop specific learning material that could have been giving returns on investment for many years or even decades, but is instead used only two to three years before it becomes unusable. There is also a historical perspective in which developing content and designing experiences are to a very high degree based on designers' experience of previous products. This is a natural part of inspiration for a design process [9]. In the production of, for example, music, movies, and literature, a movie maker might become inspired by watching old movies, and there may be many other sources of inspiration. Within XR development, designers have access to a comparatively limited canon of XR products, especially those intended for educational use.

Another important issue is the existing policies on privacy laws that impact education, which have not kept up with the pace of technology [10], [11]. Any instructional activities in which students create data, or during which data is recorded about students, will fall under Family Educational Rights and Privacy Act (FERPA) or General Data Protection Regulation (GDPR). An aspect of relevance here is the problem of persistence of the data created with integrity and ownership of said content, especially that which is created through scanning of the physical world and that which is created in any collaborative XR platforms [12]. XRSI has released a novel privacy framework version 1.0 (Title VI and Title IX with potential impact on universities trying to adopt XR), which sets a baseline set of standards, guidelines, and best regulation-agnostic practices [13].

3. RECOMMENDATIONS

Policies and recommendations on Digital Learning 2020 exist that are related to reporting on practice in early learning and care; primary and post-primary contexts, with minimum reference to the prospect of XR educational systems. The focus within practices of digital learning for adoption of ethically XR should focus on the following:

- XR Digital Strategy for Schools
- XR Digital Teaching and Learning Framework
- Ethically approved XR Teaching and Learning methodology
- XR technologies to ethically encourage active and collaborative learning
- XR technologies to ethically create new knowledge, content, and 3D artifacts
- XR technologies supporting effective teaching and learning assessment strategies

Within XR for education, consideration must be made for the effect XR technologies would have on students and their learning process outcomes. Which XR factors should be under the control of policy makers to produce the best performance outcomes, while at the same time ensuring ethical integrity and respect users' control? Although within the current educational system spectrum there are predefined factors for the progression of an individual student, specific factors must be considered depending on the level of education at which the XR technology is to be adopted:

- Impact of educational policies and resources for the adoption of XR in education
- Definition of educational equality and equity within XR in education
- Level of impact of XR toward the contribution to quality and equity in student performance
- The structure of differentiation within education systems and the applicability of XR within those systems
- Decentralization of ethically approved XR educational systems

4. CHALLENGES

Potential challenges are as follows:

- **Equity**: Will XR Educational systems increase the educational divide?
- **Acceptance**: What level of readiness do stakeholders have for XR technology adoption?
- **Safety**: What is safe use of software—in terms of both physical health and mental health and data analytics within XR education? And what unintended consequences may arise?
- **Privacy**: How do students retain control over their biometric and psychometric data within educational context when using XR technology? How can students be ensured that their use of XR technology will be prejudiced opportunities for advancement?

5. STAKEHOLDERS AND LEADERSHIP

An important aspect impacting the ethical use of technology in teaching and learning is the different groups of stakeholders involved (e.g., students, teachers, administrators, parents) and the hierarchical leadership structure in schools and school systems. This varies quite a bit among educational levels and individual countries and regions, but generally a hierarchical power structure can be assumed. The autonomy of different stakeholders, especially with the grass-root teacher, varies almost infinitely when it comes to choosing and using ICT in the classroom. An example of a teacher with very low autonomy is a lower grade teacher with low interest in using technology, as well as with a low level of ICT literacy [14]. On the other hand, a teacher with a typically high level of autonomy would be a university teacher with high interest in technology. The former often use whatever is handed to them, while the latter may often decide on their own equipment and tools with no regard to top management decisions whatsoever [15]. The following stakeholders are listed:

- **National (or state) central administrative authority for the public school system**: Typically controls regulations, resource distribution, and sometimes central implementation of IT infrastructure.

- **School top management** (e.g., headmaster or principal): Typically controls staffing, resource distribution, and strategy. Their interest and engagement in ICT for learning may vary widely from school to school. A significant risk at this level is that this group can be misled by quick fixes and magic bullets promised from technology and content providers.
- **Providers of hardware, software, platforms, and content:** The large scale of the school system provides these companies with a potentially very lucrative market and not all providers can be regarded as serious. For this group, skill and insight in pedagogy may be especially low. Textbook companies, proctoring software developers, and consumer electronic manufactures may find their tools and services being procured for the classroom without due diligence for unintended negative externalities.
- **School-based IT department:** Typically controls set-up of all computers at the school. Usually is responsible for regulating the settings of firewalls, what software can be installed, etc.—and may be quite rigid with this. These stakeholders tend to prioritize a safe computer infrastructure before experimentation with new ICT tools.
- **ICT pedagogy experts:** Whether from technology associations, local institutions of higher education, or within the school system, these individuals can have a major influence on how ICT is used at a school, if this role exists at all, especially if they have proper mandate from top management.
- **Learning material curators/Purchasers:** The actual role of these individuals varies. This role may or may not exist at each specific school.
- **Teachers/Instructors:** Within the complex and sometimes limiting constraints, created by the stakeholders above in the hierarchy, the teachers have much control over what and how technology is used in the classroom, especially how often and for what purpose.
- **Learners:** Learners typically use what the school provides, especially in the lower grades. In Higher Education the students can, in some situations, be highly autonomous when it comes to selection of ICT tools and learning material. At this level they often bring their own devices to the educational setting.
- **Parents and guardians:** Typically have very low insight or control over devices or programs, but in some parent-owned or private schools this might be different.

6. XR ETHICS IN EDUCATION—REQUIREMENTS

Educators must remain mindful that Immersive Virtual Reality (IVR) and generally XR can amplify and multiply challenges of traditional media (though there remains a pacing gap with XR used for teaching and learning between innovation, regulation, and policy [16], [17], [18]. Privacy issues concerning users' data, XR's potential impact on physical and psychological well-being, along with possibilities for surveillance abuse are some essential concerns [19], [20].

6.1. PRIVACY

Privacy, from the perspective of XR **ethics in education,** can help developers, teachers and enterprises establish and improve their code of conduct when it comes to privacy from an ethical point of view. Establishing a code of conduct makes all individuals utilizing XR technologies within educational frameworks accountable for protecting valuable data. Although the Children's Online Protection Privacy Act (COPPA) [21] imposes certain requirements on operators of websites or online services directed to children under 13 years of age and on operators of other websites or online services that have actual knowledge that they are collecting personal information online from a child under 13 years of age, there is still no specific guide and policy on requirements for ethics of XR applications used in education. The types and amount of personal information that could potentially be gathered by an XR device or application demands particular attention when it comes to children, and even students in higher education who are adults, yet under the direction of instructors with power to determine their success or failure in education [22], [23].

In addition to privacy issues, XR applications in education need to establish a sustainable methodology for interactive technologies utilization within different levels of education as technology directly mediates personal perception of and interaction with the physical world. From the perspective of how XR might be used for educational purposes, this presents exciting opportunities, but also creates security and safety concerns much more pressing, and potentially dangerous, compared with any issues raised by other existing technologies that do not directly affect our view of reality.

Furthermore, XR as a surveillance mechanism within education could have an impact on students: "'High-Surveillance' Schools Lead to More Suspensions, Lower Achievement" (EdWeek) [24], which the surveillance-enabled pedagogy could inflict harm to students (Reject Test Surveillance in Schools) [25]. Remote proctoring is already incredibly invasive [26], and the use of XR in proctoring could bring about even more granular (e.g., volumetric, biometric) surveillance in homes and classrooms [27], [28].

6.2. REGIONAL ETHICS LAWS IN EDUCATION

It is important for XR education products to **respect citizen rights** (as required by the Lisbon Treaty—European Charter of Fundamental Rights—which came into force 1 December 2009), as well as societal relevance. Ethics requirements enable better design and a methodology for standardized ethics requirements for XR Education will transform the ways in which people learn and teach within XR environments.

6.2.1. UNITED STATES

In the United States, individual states set forth codes of ethics for educators employed by the government (examples 505-6-.01 and QP-C-014). A wide variety of education organizations such as the NEA (like many other content/level associations) have also published ethics guides for their members. These policies and documents are rarely specific enough to provide recommendations or guidelines for technology use, much less for the most current iterations of XR technologies. However, particular ethical considerations that might be applied directly to the topic of XR in education include those regarding the health and safety of students in an educators' charge, maintaining appropriate relationships with students, and maintaining in confidence information related to the students' work [29]. That last point aligns with the previously mentioned law(s) typically applied to ICT in education in the United States, FERPA. FERPA is the Family Educational Rights and Privacy Act (FERPA) (20 U.S.C. § 1232g; 34 CFR Part 99). It is a federal law that protects the privacy of student education records for schools funded from the U.S. Department of Education. FERPA gives parents certain rights with respect to their children's education records. These rights transfer to the student when he or she reaches the age of 18 or attends a school beyond the high school level. Students to whom the rights have transferred are "eligible students."

6.2.2. EUROPE

EUROPE—The EU General Data Protection Regulation (GDPR), in force since 25 May 2018, replaced the existing data protection framework under the EU Data Protection Directive [11]. The EU GDPR is intended to protect the fundamental rights and freedoms of individuals in the context of technological development and also to help achieve policy objectives linked to the digital single market. In order to protect personal data, XR educational products should consider the following two new procedures introduced by the GDPR:

— **Data Protection Impact Assessments (DPIAs):** Operators and authorities that collect and use ("process") personal data are required to implement such assessment procedures any time their processing operations is evaluated to be a high risk to the rights and freedoms of humans. This is a requirement under Article 35 of the Regulation.

— **Data Protection by Design and by Default (DPbD**): Requires identification of ways of engineering and integrating safeguards for personal data into technology and its settings. This procedure is introduced by Article 25 of the Regulation.

The EU GDPR and its articles refer to the processing of Personal Data, which for the purposes of the regulation refers to any data relating to an identified or identifiable 'data subject.' Thus, the EU definition of personal data is very broad; whereas, in the United States the processing of personal information is generally permitted and subject to a patchwork quilt of laws in the U.S. that define specific data elements as personal information (e.g., name in combination with SSN). These include sectoral laws and regulations (e.g., FERPA, HIPAA, state data breach notification laws). In the EU (and in many other countries around the world) processing of personal data is generally prohibited unless certain requirements are satisfied [30].

6.2.3. EAST ASIA

6.2.3.1 CHINA

China's data privacy system is built through the combination of EU and U.S. laws. China seemed hesitant between the EU approach, which supported comprehensive data privacy law, and the U.S.'s approach, where rules are scattered through narrow-scoped laws [31]. To be more specific, in the beginning China decided to follow a sector-specific law model, much like the one in the United States. However, at the time of this writing, the country is on the way to establish strict data protection laws. Due to political contradictions, the mainland of China was set apart from the privacy breakthrough that has been noticed elsewhere globally and locally. Only with the Constitution from 1982 [32] China has brought out privacy and data protection rights, protected under Article 40 [31] and since 1986, the General Principles of the Civil Law (GPCL) [33] to protect "the right to reputation" (basis for privacy protection) [34].

In December 2012, the Decision on Strengthening Information Protection on Networks (the 2012 NPC Decision) [31] has led China to important evolution with regard to the development of personal data protection, including values, principles, and ethical requirements as part of new rules. Special attention should be placed on China's Cybersecurity Law, which was entered into force on 1 June 2017 and added a broader, even global, horizon that put emphasis on the non-binding guidelines—the so-called 2018 Specification [35], [36]. What is of high significance is the late awakening of China to the issue of privacy, which has opened the dialogue for deeper analysis. The similarity with the U.S. can be summarized as follows:

— **Requirements for Data Collection and Processing:** Both countries do not seem to require explicit informed consent, which profoundly constitutes the requirements for data collection and processing at a low level.

- **Data breach notification:** In China, according to the Cyber Security Law, information about the incident should be reported. In advance, data subjects are required to be informed promptly, although this is not clearly defined. In EU the data controller has only 72 hours to notify the supervisory authorities, after becoming aware of a security breach, whereas in the U.S. there is a large timeframe for notification within a reasonable time [37].
- **Supervisory authorities:** The Cyberspace Administration of China is responsible for the data privacy enforcement, similar to that of the U.S., and the allocation of competence is not always clear [38].

On the other hand, the Chinese data privacy laws converge with the EU model [31], [39] in terms of data minimization; sensitive data; the right to be forgotten; data portability; and automated decision-making and profiling.

6.2.3.2 JAPAN

Japan's data protection law, one of the first data protection regulations in Asia in 2003, is the Act on the Protection of Personal Information (APPI) [40]. In September 2015 due to a high number of profile data breaches, it was proved that the APPI had not satisfied the requirements; therefore, an amendment on May 2017, one year ahead of the EU GDPR, was the next step. The establishment of the Personal Information Protection Commission (PPC) followed, which was of great significance [40]. APPI applies to all business operators (apart from government organizations and agencies) even to those with offices outside the country [40]. The type of data being protected under the APPI includes any personal identifiable information and any information that can be the basis for discrimination or prejudice, and prior consent is needed [41]. Under APPI, data subjects have the rights to request all information related to their personal data, amend, and delete and of their records [42], [40]. Finally, in case business operators fail to answer their APPI-based requests within two weeks, the data subjects can sue them for having collected their personal information. Companies should have set up structures and processes to handle with the requests of the data subjects. What is more, under APPI there have been restrictions on data transfers outside Japan, and specific contract agreements are in place with overseas partners [40]. In case of data breach, the PPC will directly contact the business operator asking to rectify the violation as an informal request. But if the company fails to comply with this, then a formal notice is issued and if the company continues its non-compliance, then they face imprisonment of up to one year and a penalty of $4600.

6.2.3.3 SOUTH KOREA

South Korea's Personal Information Protection Act was initiated in September 2011 [43]. It is one of the strictest privacy acts worldwide and applies to all organizations with strict penalties [43]. The laws have been divided into the following specific sectors [43]:

— The Act on Promotion of Information and Communication Network Utilization and Information Protection (IT service providers)

— The Use and Protection of Credit Information Act (Credit providers)

— The Act on Real Name Financial Transactions and Guarantee of Secrecy (Financial services)

What is worth mentioning is the fact that on 30 June 2017, South Korea joined the APEC Cross Border Privacy Rules as the fifth member along with the U.S., Japan, Canada, and Mexico. Regarding child data protection legislation in South Korea, the Korea Communications Commission requires explicit consent from all organizations responsible for the collection of personal data (for children ages 14 and under, parents or legal guardians provide the consent) [44].

6.3. PRIVACY IN EDUCATION REQUIREMENTS

Recommendation #1	Standardized methodology on ethics' considerations for governance on XR Educational systems (both stakeholders and companies need clear law governance and obligations regarding ethical XR data).

Recommendation #2	Management of sensitive information from ethics' perspective: All the data gathered from users' interaction with an XR ecosystem and in XR collaborative settings.

Recommendation #3	Knowledge perception's alteration and ethical concerns on the validity of new knowledge derived from XR environments.

Recommendation #4	Personal contact details: Such as name, address, phone number, email, etc., will also be a subject of protection (see Privacy paper).

Recommendation #5	Location information: When relevant, it could also be the subject of ethical concerns (see Tracking Geo-Location paper).

Recommendation #6	Biometrics and psychometrics: Any and all data (e.g., physical benchmarking and psychological profiling) that could be used to identify a student should be expunged after use (see Privacy paper).

6.4. USER REQUIREMENTS [45]

Recommendation #7	Educational Awareness and student-centered engagement.

Recommendation #8	Usability and affordances of XR within educational systems (what interactions are/are not allowed; what modalities are supported).

6.5. HARDWARE REQUIREMENTS

Recommendation #9	Hardware requirements should be as low as possible, as device and operating system agnostic as possible.

Recommendation #10	Remapping hardware requirements' preferences to be mobile and transportable across a range of hardware devices and software.

Recommendation #11	XR educational systems' providers should consult with stakeholders and integrate their feedback into hardware design (UX design) and data collection, use, and sharing.

Recommendation #12	XR educational systems' providers should have clear guidelines to avoid physical risk to stakeholders.

Recommendation #13	XR educational systems' providers should have clear guidelines on data associated with input (speech, keyboard, switch, gesture, eye tracking) and output modalities (tactile, visual, auditory, olfactory, gustatory).

There is a lack of research on the safe VR use. It is established that some children do not tolerate head-mounted VR and report symptoms of cybersickness such as nausea, fatigue, imbalance, visual disturbance, and general discomfort. Moreover, concerns have been raised that the use of VR may negatively affect the developing visual system in children. In the Health and Safety warnings, VR manufacturers indicate that the headset should not be used in children under 13 years of age [46]. VR headsets are typically not sized for children and hence may lead to discomfort or adverse health effects [46].

While the research is sparse and not yet conclusive, recent findings do not raise immediate concerns related to VR use in children [47]. However, it should be noted that these findings hold true on a group level. It is to be expected that some individual children will not tolerate VR and may not be able to complete a VR session. It is possible to take precautions to reduce the likelihood or severity of cybersickness symptoms (e.g., seated VR exposure, avoidance of content with high visual motion levels), but these precautions may not work for all susceptible individuals [48].

6.6. SOFTWARE REQUIREMENTS

Recommendation #14	If possible, the XR experience should not require software installment. The software should require a minimum of plug-ins, third-party software, and drivers. Provision of XR educational platform with minimum technological knowledge requirements from the stakeholders (i.e., minimum of plug-ins, third-party software, and drivers) and/or fit into stakeholders' existing technological educational practices.

Recommendation #15	XR educational systems' providers should consult with stakeholders and integrate their feedback into software design (UX design) and data collection, use, and sharing.

Recommendation #16	XR educational systems' software developers should provide transparent information to stakeholders on ethically approved XR data collection, use, and sharing.

Recommendation #17	XR educational systems' providers should provide platforms encouraging inclusion and collaboration and eliminate online harassment, digital vandalism, and fraud.

Recommendation #18	XR educational systems should provide feedback mechanisms to allow students to flag inappropriate content.

7. XR ETHICS IN EDUCATION—3D EDUCATIONAL CONTENT

Generally, the lack of resources to purchase learning material (content) is a big problem. It favors the production of learning material that is lacking in quality—it is mass-produced and often not pedagogically sound. It also opens for potentially unethical arrangements with, for example, ad-sponsored learning material. On the other hand, free, open-source content of high quality is often produced by different institutions such as museums and universities [49]. The problem with these is often that they do not always fit with a specific school curriculum and educational level [50], [51].

7.1. ACCESSIBILITY

Recommendation #19	Open-source platforms that support new model hosting and collection building with 3D objects ethically approved.

Recommendation #20	3D repository accessibility, based on ethically defined content based on specific educational taxonomy based on specific curriculum components of different level of studies.

Recommendation #21	3D repository metadata availability based on parameters defining the ethics requirements for 3D teaching and learning objects.

Recommendation #22	Relevance, social interactions, and standards based on specific curriculum needs.

Recommendation #23	Checklist guide for educators to utilize XR Educational toolkits in compliance with ethics' requirements.

Recommendation #24	XR systems (devices, content portals, etc.) should be designed barrier free. User disabilities should be considered for the accessibility of XR education systems with respect to the following: ▪ Auditory disabilities ▪ Cognitive disabilities ▪ Neurological disabilities ▪ Physical disabilities ▪ Speech disabilities ▪ Visual disabilities

7.2. TEACHING AND LEARNING

Recommendation #25	Teaching and Learning Process: Free or open-source content should be highly modular, so that teachers can easily adopt it to their own curriculum. It should be, also, clearly coded with keywords, category, and educational level (3D Learning Objects metadata) to make it easier for teachers to find. Generally, educational content should not be tailored for a specific pedagogical method such as problem-based learning or flipped classroom. Rather, it should be method neutral and modular, so that teachers can decide for themselves how the content is used.

Recommendation #26	Affordances of XR Education Ethics based on content preparation pre-requisites and evaluation of effectiveness in terms of applicability of Bloom's Taxonomy.

Recommendation #27	XR that generates the sense of presence demonstrates six of the eight key affordances of technology for teaching as posed by HPLII book [52]: interactivity, adaptivity, feedback, choice, non-linear access, and linked representations.

Recommendation #28	Assessment IVR that generates the sense of presence, demonstrates six of the eight key affordances of technology for teaching, as posed by HPLII book [52]: interactivity, adaptivity, feedback, choice, non-linear access, and linked representations.

Recommendation #29	Guidelines on the creation of Active Learning Strategies within the XR Educational system (Project/Problem based; Inquiry-based; Action-based and Connectivism Learning) and alignment of competence-based education principles with specific tasks within XR system.

7.3. AUTHORING TOOLKITS

Recommendation #30	Authoring tools should, if possible, be open-source, backward compatible, hardware and operating system agnostic, and must be designed with a very high attention to usability and user experience, especially for beginners and intermediate users. In many cases, it can be highly beneficial if they can be used by both teachers and children. At the same time, authoring tools need to be sufficiently secure when it comes to hacker attacks and exploits, and when it comes to moderation tools so that inappropriate behavior can be mitigated, especially in Social VR platforms.

Recommendation #31	Content curation—Using or sharing third-party or other people's content in an ethical, fair, and selective way through an open XR educational repository. This should be provided to the stakeholders in a quick, low-cost, and easy way. XR educational content can be within the following types: aggregation of content within specific learning outcomes; distillation of XR content to focus on key tasks and outcomes; elevation of XR educational content through provision of creative freedom within the XR educational toolkit; XR mashups when the content is created from merging different other content types; XR educational chronological content producing the evolution of an educational concept.

8. XR ETHICS IN EDUCATION—IMPACT

In recent years, interest in extended reality technology has been piqued, as affordability and more creativity pave the way for promising new developments in education and industry [53]. In essence, virtual and augmented reality are providing incredible experiences to extend the learning environment, from K-12 education all the way up to higher learning. XR offers experiences in 3D that involve experience-based active learning in scenarios that might not be available in real life for complex learning activities [54]. Education for Sustainable Development, or Education for Sustainability (EfS), is a process that develops people's awareness, competence, attitudes, and values, enabling them to effectively become involved in sustainable development at the local, national, and international levels, and helping them to work toward a more equitable and sustainable future [55]. In particular, it enables people to integrate social and cultural considerations with environmental and economic decision-making [56]. XR reality is by nature multidisciplinary through the intervention of sensors and has an impact to privacy and trust for the users [57], [58].

8.1. EDUCATIONAL [59]

Recommendation #32	Building a framework, including ethical guidelines, based on data protection and transparency, and setting technology standards and best regulation practices in XR educational systems. Expand the definition of what needs to be protected at all educational levels and what is the minimum viable solution in terms of personal data and effective XR educational system.

Recommendation #33	Encourage and support collaboration across institutions and industry to accelerate the development of a sustainable ecosystem for ethically approved XR educational systems. Promote constructive dialogue between academia and companies, aiming to exchange views and opinions and share ideas gained from the use of XR technology.

Recommendation #34	Standardize impact assessment of learning through XR in a sector that has been proven effective in transforming educational delivery (i.e., medicine).

Recommendation #35	Encourage the accessibility and availability of 3D content in order to increase capacity, deployment, and adoption.

Recommendation #36	Since the future of learning and working becomes remote, due to the new unprecedented situation of COVID-19, XR technology is laying the groundwork for enhancing soft-skills training in high-risk situations, promoting ethical innovation and sustainability in the future of work.

8.2. SOCIETAL [55] [60]

Recommendation #37	Ethical XR educational systems encourage educational institution to be adaptive and offer alternative educational content provision when certain challenges take place (i.e., pandemic).

Recommendation #38	XR educational collaborative learning strengthens positive attitudes toward learning, improves performance in academic results, and provides a solution to help ensure sustainable education.

Recommendation #39	Ethical XR education reduces costs (i.e., transportation and health expenses).

Recommendation #40	Ethical XR education promotes higher creativity, innovation, and productivity of the employees in educational systems, which results in happier, healthier, and more responsible citizens.

Recommendation #41	Higher sustainable corporate responsibilities following the principles of a circular economy.

Recommendation #42	Trans-frontier collaboration in real time is being promoted through the XR education.

9. CONCLUSIONS

9.1. GENERAL

This paper provides a set of initial recommendations in terms of initiating the process of a policy on standards for XR Ethics in Education. The authors have recommended that a list of principles, values, and aspirations based on the desired code of conduct of XR applications in education need to be put in place for the stakeholders to safely perform education tasks within XR educational environments with integrity. Although there is no policy on XR Ethics for Education, in summary, the activities to be found in XR educational systems should include the following:

— Maintain ethical standards of practice in educational teaching, learning, and research.
— Protect human subjects from harm.
— Ensure that the practice of fully informed consent is observed from all individuals.
— Ensure that ethics requirements adhere to the ethical national legislations and directives for the utilization of XR in educational levels.
— Establish an External Ethics Advisory Board at each educational level for policy reform, with specific roles and responsibilities.
— Provide reassurance to the public and policy regulation bodies that all the above are done.

9.2. CHALLENGES

Potential challenges are as follows:

- **Legal concerns,** as the law has not advanced as fast as the technology. Consumer privacy and data security along with product liability and health and safety issues are the top three concerns reported in 2020. What happens when a student plagiarizes or harasses someone within an XR environment?
- **Legal concerns** about developing immersive technologies according to XR/AR/VR/MR industry experts in the United States in 2020 [60].
- **Ethical concerns,** as to what is acceptable within the XR educational environments. Ethical code of conduct with clear boundaries should be available to the stakeholders.
- **Data privacy concerns,** related to the collection, analysis, and storage of data associated with the XR educational systems' input (speech, keyboard, switch, gesture, eye tracking) and output modalities (tactile, visual, auditory, olfactory, gustatory).
- **Digital divide,** given the cost of purchasing XR hardware, can exclude from the experiences and educational advantages, disadvantaged schools, and further increase the social division. Policy makers should keep up with the potential of XR revolutionizing learning and enable the opportunity to reach everyone.

10. REFERENCES

The following sources either have been referenced within this paper or may be useful for additional reading:

[1] Lee, M. J. W., Georgieva, M., Alexander, B., Craig, E., and Richter, J., "State of XR & Immersive Learning Outlook Report 2021," *Walnut, CA Immersive Learn. Res. Network.*, 2021.

[2] M. C. Johnson-Glenberg, H. Bartolomea, and E. Kalina, "Platform is not destiny: Embodied learning effects comparing 2D desktop to 3D virtual reality STEM experiences," *J. Comput. Assist. Learn.*, 2021, doi: 10.1111/jcal.12567.

[3] S. Ligthart, G. Meynen, N. Biller-Andorno, T. Kooijmans, and P. Kellmeyer, "Is Virtually Everything Possible? The Relevance of Ethics and Human Rights for Introducing Extended Reality in Forensic Psychiatry," *AJOB Neurosci.*, 2021, doi: 10.1080/21507740.2021.1898489.

[4] M. Wang, J. Ryoo, and K. Winkelmann, "Preface to the special issue on Cross Reality (XR) and Immersive Learning Environments (ILE) in education," *Interactive Learning Environments*. 2020, doi: 10.1080/10494820.2019.1696845.

[5] E. Isidori and M. Cacchiarelli, "The Ethics of Education and Its Function Within Virtual Learning Environments," 2017, doi: 10.21125/inted.2017.1951.

[6] *How people learn II: Learners, contexts, and cultures*. 2018.

[7] R. Kurz, "Quality, obsolescence and unsustainable innovation," *Ekon. Vjesn. Contemp. Business, Entrep. Econ. Issues*, vol. 28, no. 2, pp. 511–522, 2015.

[8] I. UNESCO, "Mainstreaming Early Childhood Education into Education Sector Planning: The Rationale for Investing in Pre-Primary." UNESCO, 2019.

[9] K. Yang, X. Zhou, and I. Radu, "XR-Ed Framework: Designing Instruction-driven andLearner-centered Extended Reality Systems for Education," *arXiv Prepr. arXiv2010.13779*, 2020.

[10] "Family Educational Rights and Privacy Act (FERPA)," *US Department of EducationU.S. Department of Education*, 2021. https://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html.

[11] "What is GDPR, the EU's new data protection law?" *GDPR.EU*, 2021. https://gdpr.eu/what-is-gdpr (accessed Sep. 16, 2021).

[12] A. Vasilchenko *et al.*, "Collaborative learning & co-creation in XR," 2020, doi: 10.1145/3334480.3381056.

[13] "The XRSI Privacy Framework," *xrsi.org*, 2021. https://xrsi.org/publication/the-xrsi-privacy-framework.

[14] Q. Liu, Z. Cheng, and M. Chen, "Effects of environmental education on environmental ethics and literacy based on virtual reality technology," *Electron. Libr.*, 2019, doi: 10.1108/EL-12-2018-0250.

[15] K. Larson and R. Chambers, "AR in the computer programming classroom: A review of the literature," 2020, doi: 10.1109/TALE48869.2020.9368329.

[16] J. S. Aubrey, M. B. Robb, J. Bailey, and J. Bailenson, "Virtual Reality 101: What you need to know about VR and Kids," *Common Sense Media*, 2018.

[17] M. Rose, "Ethics of VR documentary." YouTube.com. https://www.youtube.com/watch?v=I7hVr4UrSL0 (accessed Oct. 27, 2020)." https://www.youtube.com/watch?v=I7hVr4UrSL0.

[18] M. Madary and T. K. Metzinger, "Real virtuality: A code of ethical conduct. Recommendations for good scientific practice and the consumers of VR-technology," *Frontiers Robotics AI*, vol. 3, no. FEB. 2016, doi: 10.3389/frobt.2016.00003.

[19] E. Southgate, "Conceptualising Embodiment through Virtual Reality for Education," 2020, doi: 10.23919/iLRN47897.2020.9155121.

[20] C. J. O. Fenandez, "Special Session-XR Education 21th. Are We Ready for XR Disruptive Ecosystems in Education?" 2020, doi: 10.23919/iLRN47897.2020.9155215.

[21] B. Heller, "Defining 'Biometric Psychography' to Fill Gaps in Privacy Law to Cover XR Data: Brittan Heller's Human Rights Perspectives," *Voices of VR*, 2021. https://voicesofvr.com/988-defining-biometric-psychography-to-fill-gaps-in-privacy-law-to-cover-xr-data-brittan-hellers-human-rights-perspectives (accessed Aug. 05, 2021).

[22] J. M. M. Ferreira and Z. I. Qureshi, "Use of XR technologies to bridge the gap between Higher Education and Continuing Education," 2020, doi: 10.1109/EDUCON45650.2020.9125346.

[23] M. Carter and B. Egliston, "What are the risks of Virtual Reality data? Learning Analytics, Algorithmic Bias and a Fantasy of Perfect Data," *New Media Soc.*, 2021, doi: 10.1177/14614448211012794.

[24] S. D. Sparks, "High-Surveillance" Schools Lead to More Suspensions, Lower Achievement. " EdWeek.org. https://www.edweek.org/leadership/high-surveillance-schools-lead-to-more-suspensions-lower-achievement/2021/04 (accessed Aug. 03, 2021).

[25] L. Barrett, "Rejecting Test Surveillance in Higher Education," *SSRN Electron. J.*, 2021, doi: 10.2139/ssrn.3871423.

[26] M. Chin, "XAM ANXIETY: HOW REMOTE TEST-PROCTORING IS CREEPING STUDENTS OUT. " TheVerge.com. https://www.theverge.com/2020/4/29/21232777/examity-remote-test-proctoring-online-class-education (accessed Aug. 03, 2021).

[27] M. Slater *et al.*, "The Ethics of Realism in Virtual and Augmented Reality," *Front. Virtual Real.*, 2020, doi: 10.3389/frvir.2020.00001.

[28] P. Steele, C. Burleigh, M. Kroposki, M. Magabo, and L. Bailey, "Ethical Considerations in Designing Virtual and Augmented Reality Products—Virtual and Augmented Reality Design With Students in Mind: Designers' Perceptions," *J. Educ. Technol. Syst.*, 2020, doi: 10.1177/0047239520933858.

[29] K. Adapa *et al.*, "Augmented reality in patient education and health literacy: a scoping review protocol," *BMJ Open*, 2020, doi: 10.1136/bmjopen-2020-038416.

[30] dataprotection.ie, "Data Protection Commission," *dataprotection.ie*, 2018.

[31] P.-L. E, "Pernot-Leplay E. China CyberSecurity Law: Comparison with the GDPR & US Laws." Published 2020. https://pernot-leplay.com/data-privacy-law-china-comparison-europe-usa/ (accessed July 14, 2021).

[32] "Constitution Of The People's Republic Of China," 1982 | US-China Institute. https://china.usc.edu/constitution-peoples-republic-china-1982 (accessed July 14, 2021).

[33] W. Jones, “General Provisions of Civil Law of the People’s Republic of China,” *Rev. Cent. East Eur. Law*, 1987, doi: 10.1163/187529887X00221.

[34] G. Greenleaf, *Asian Data Privacy Laws*. 2014.

[35] Admin, “China: TC260 publishes cybersecurity standards. Data Guidance.” Published 2020. Accessed July 28, 2021. https://www.dataguidance.com/news/china-tc260-publishes-cybersecurity-standards.

[36] “China’s Emerging Data Privacy System and GDPR,” *CSIS.org*, 2018. https://www.csis.org/analysis/chinas-emerging-data-privacy-system-and-gdpr.

[37] “Data Breach Notification Law.” 2020. Accessed July 29, 2021. https://www.scasecurity.com/data-breach-notification-law-in-california/.

[38] B. Zhao and G. P. Jeanne Mifsud Bonnici, “Protecting eu citizens’ personal data in china: A reality or a fantasy?,” *Int. J. Law Inf. Technol.*, 2016, doi: 10.1093/ijlit/eaw001.

[39] W. G. Shi M, Sacks S, Chen Q, Shi M, Sacks S, Chen Q, Webster G. “Translation: China’s Personal Information Security Specification.” New America. Published 2019. Accessed July 29, 2021. https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-chinas-personal-information-security-specification/.

[40] A. Coos, “Data Protection in Japan: All You Need to Know about APPI. Endpoint Protector.” Published 2019. Accessed July 30, 2021. https://www.endpointprotector.com/blog/data-protection-in-japan-appi/.

[41] K. V. Iserson, “Ethics of Virtual Reality in Medical Education and Licensure,” *Cambridge Q. Healthc. Ethics*, 2018, doi: 10.1017/S0963180117000652.

[42] M. Sholihin, R. C. Sari, N. Yuniarti, and S. Ilyana, “A new way of teaching business ethics: The evaluation of virtual reality-based learning media,” *Int. J. Manag. Educ.*, 2020, doi: 10.1016/j.ijme.2020.100428.

[43] A. Wall, “GDPR matchup: South Korea’s Personal Information Protection Act.” IAPP. Published 2018. Accessed July 30, 2021. https://iapp.org/news/a/gdpr-matchup-south-koreas-personal-information-protection-act/.

[44] “South Korea amends child data protection laws.” Accessed July 30, 2021. https://iapp.org/news/a/south-korea-amends-child-data-protection-laws/.

[45] “XR Accessibility User Requirements,” *W3C*, 2021. https://www.w3.org/TR/2021/NOTE-xaur-20210825/ (accessed Sep. 16, 2021).

[46] “Health and Safety Warnings of Oculus Quest 2,” *oculus.com*, 2021. https://securecdn.oculus.com/sr/oculus-quest2-warnings-english.

[47] L. Tychsen and P. Foeller, “Effects of Immersive Virtual Reality Headset Viewing on Young Children: Visuomotor Function, Postural Stability, and Motion Sickness,” *Am. J. Ophthalmol.*, 2020, doi: 10.1016/j.ajo.2019.07.020.

[48] L. Tychsen and L. L. Thio, “Concern of photosensitive seizures evoked by 3D video displays or virtual reality headsets in children: Current perspective,” *Eye and Brain*. 2020, doi: 10.2147/EB.S233195.

[49] T. Matsuda, H. Nakayama, and K. Tamada, “Using 3D virtual reality technology in cyber ethics education:

How can we really evaluate and change students' attitudes?" in *Cases on 3D Technology Application and Integration in Education*, 2013.

[50] E. Mangina, "3D learning objects for augmented/virtual reality educational ecosystems," 2018, doi: 10.1109/VSMM.2017.8346266.

[51] R. C. Sari, M. Sholihin, N. Yuniarti, I. A. Purnama, and H. D. Hermawan, "Does behavior simulation based on augmented reality improve moral imagination?" *Educ. Inf. Technol.*, 2021, doi: 10.1007/s10639-020-10263-8.

[52] National Academies of Sciences, *Engineering, and Medicine. 2018. How People Learn II: Learners, Contexts, and Cultures.* Washington, DC: The National Academies Press. doi.org/10.17226/24783

[53] "Extended Reality in Education: Benefits and Examples." https://www.nextgyn.com/extended-reality-in-education-xr/ (accessed June 30, 2021).

[54] J. Pomerantz and R. Rode, "Exploring the future of extended reality in higher education." EDUCAUSE. 2020.

[55] R. Bucea-Manea-Ţoniş, V. E. Simion, D. Ilic, C. Braicu, and N. Manea, "Sustainability in higher education: The relationship between work-life balance and XR e-learning facilities," *Sustain.*, 2020, doi: 10.3390/su12145872.

[56] D. Tilbury, "Environmental Education for Sustainability: A Force for Change in Higher Education," in *Higher Education and the Challenge of Sustainability*, 2005.

[57] C. Y. Chang, C. L. Debra Chen, and W. K. Chang, "Research on immersion for learning using virtual reality, augmented reality and mixed reality," *Enfance*, 2019, doi: 10.3917/enf2.193.0413.

[58] S. Mann, T. Furness, Y. Yuan, J. Iorio, and Z. Wang, "All reality: Virtual, augmented, mixed (x), mediated (x, y), and multimediated reality," *arXiv Prepr. arXiv1804.08386*, 2018.

[59] J. DeVaney, "5 Reasons We Are Hopeful About the Future of Extended Reality in Learning," *INSIDEHighered.com*, 2021. https://www.insidehighered.com/blogs/learning-innovation/5-reasons-we-are-hopeful-about-future-extended-reality-learning (accessed Sep. 16, 2021).

[60] M. Slater *et al.*, "The Ethics of Realism in Virtual and Augmented Reality," *Frontiers in Virtual Reality*, vol. 1. p. 1, 2020, [Online]. Available: https://www.frontiersin.org/article/10.3389/frvir.2020.00001.

[61] T. Alsop, "Thomas Alsop. ''Legal concerns about developing immersive technologies according to XR/AR/VR/MR industry experts in the United States in 2020.' Statista.com. https://www.statista.com/statistics/829821/worldwide-vr-ar-technology-development-legal-concerns .

[62] J. Martín-Gutiérrez, C. E. Mora, B. Añorbe-Díaz, and A. González-Marrero, "Virtual technologies trends in education," *Eurasia J. Math. Sci. Technol. Educ.*, 2017, doi: 10.12973/eurasia.2017.00626a.

[63] S. Jiang, X. Huang, C. Xie, S. Sung, and R. Yalcinkaya, "Augmented scientific investigation: Support the exploration of invisible fine details in science via augmented reality," 2020, doi: 10.1145/3392063.3394406.

[64] D. Allison and L. F. Hodges, "Virtual reality for education?" 2000, doi: 10.1145/502390.502420.

[65] S. H. Hadi *et al.*, "Developing augmented reality-based learning media and users' intention to use it for

teaching accounting ethics," *Educ. Inf. Technol.*, 2021, doi: 10.1007/s10639-021-10531-1.

[66] A. Torda, "CLASSIE teaching—Using virtual reality to incorporate medical ethics into clinical decision making," *BMC Med. Educ.*, 2020, doi: 10.1186/s12909-020-02217-y.

[67] M. Al Zahrani and M. Fawzy, "Engineering Education Gaming: Case Study of Engineering Ethics Game Modeling," 2020, doi: 10.1109/ISEC49495.2020.9230280.

[68] B. Matthews, Z. S. See, and J. Day, "Crisis and extended realities: remote presence in the time of COVID-19," *Media Int. Aust.*, 2021, doi: 10.1177/1329878X20967165.

[69] J. T. McGuirt *et al.*, "Extended reality technologies in nutrition education and behavior: Comprehensive scoping review and future directions," *Nutrients*. 2020, doi: 10.3390/nu12092899.

[70] A. S. Perskey, "Anna Stolley Perskey, How Are Law Schools Using Virtual Reality Tools in Classrooms?" ABA Journal, https://www.abajournal.com/magazine/article/virtual_reality_augments_law_school_curricula.

[71] T. Higgin, "Five research-based ways to use VR for learning." CommonSense.org https://www.commonsense.org/education/articles/what-the-research-says-about-vr-in-classrooms (accessed Aug. 03, 2021).

[72] E. Gera, "Emily Gera. 'How VR Is Being Used to Help Children with Learning Disabilities, Autism.'" Variety.com.org https://variety.com/2018/digital/features/voiss-interview-vr-hmd-1203086576 (accessed Aug. 03, 2021).

[73] N. Michel, J. J. Cater, and O. Varela, "Active versus passive teaching styles: An empirical study of student learning outcomes," *Hum. Resour. Dev. Q.*, 2009, doi: 10.1002/hrdq.20025.

RAISING THE WORLD'S STANDARDS

3 Park Avenue, New York, NY 10016-5997 USA http://standards.ieee.org

Tel.+1732-981-0060 Fax+1732-562-1571