





Article

Extended Reality in Higher Education, a Responsible Innovation Approach for Generation Y and Generation Z

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Abstract: This study aims to provide a comprehensive overview of the XR challenges, opportunities, and future trends that will impact higher educational institutions. The article discusses (using observation, participatory observation and as well as document analysis) the potential for augmented reality to be used in higher education, having in mind characteristics of Millennials (Generation Y) and Post-Millennials (Generation Z) and raises issues about responsible innovation, the future of work, and formal education. Additionally, survey research was completed among students in Serbia and Romania (103 respondents) within selected generations regarding their knowledge of extended reality and their attitudes towards opportunities and challenges of extended reality in Higher Education Institutions, and thus this paper also utilises quantitative analysis. A correlation matrix, composite reliability, and regression model were used to code the data and extract knowledge. A thorough review of the existing literature on one hand and primary research as well, using the chosen scientific methods, the planned purpose of the research will be obtained: to gain a better understanding of the education needs of Generation Y and Generation Z and the potential use of XR as a response to the needs observed. The results of the quantitative analysis confirmed our starting assumptions: XR is an excellent technology facilitating the teaching processes allowing learners to more actively control their learning strategies and supporting the interactivity and connectivity that students and faculties experience. Furthermore, Generation Z students are more applicative for stating XR's opportunities (instead of challenges) in higher education institutions.

Keywords: extended reality (XR); higher education institutions (HEI); generation Y; generation Z; Innovation; personalised learning

1. Introduction

Higher education currently addresses generations Y (Millennials) and Z (Centennials), characterised by early, constant, and diverse interaction with technology. Apart from entertainment, electronic devices are extremely popular today, particularly among millennials and centennials who use them for educational purposes, experimentation, and gaming. Simultaneously, mobile devices significantly contribute to social alienation, particularly among the young, who are more likely to develop an addiction. While educational systems may struggle to prevent students from using such devices in class, they can increase their attractiveness and reform curricula by integrating educational tools such as mobile devices, games, virtual reality immersion, and simulation. In addition, we are witnessing today an

increase in the commercial use of virtual reality. Virtual reality's underlying technology promises numerous changes in how we perceive and interact with information, friends, and the rest of the world. In general, virtual reality is a computer-generated simulation of a three-dimensional environment that appears to the user to be real. Virtual reality's objective is to persuade the user that it is as real as a physical reality [1].

Today's virtual reality equipment enables a broad range of people to experience this technology. For example, sightseeing is accomplished by directing the head in the desired direction while walking using control sticks or motion sensors. In this way, virtual reality attempts to occupy all human senses, bringing the experience as close to reality as possible. It is as if the user is transported to a completely different location and time, namely the virtual world. All of the fundamental research has already been completed, which means that this technology is now accessible to a much larger population than was previously the case. In addition, there is a sizable developer community with experience developing 3D games and mobile applications. The technology must be widely accepted in classrooms, and its readiness must be tested among students and learners [2,3].

VR's enhanced attention and presence can benefit all online interactions and user experiences, including engineering, socialising, shopping, marketing, entertainment, and business development. For example, it may become common to visit 3D websites via VR in the near future, just as it is now to visit 2D websites via a screen. Virtual reality (VR) is progressing rapidly, with all related technologies benefitting from this rapidly changing virtual world. It has significant potential and is indispensable in several fields, including education and training. MR is a hybrid system in which both physical and virtual elements are involved. The results on secondary students' learning attitudes and effectiveness are positive, but research on university students is lacking [4].

For HEI, the use of technological resources is a solution to increase the attractiveness of this level of education, given that statistics show that many young people give up pursuing higher education [5]. Thus, identifying solutions for the application of XR in higher education as a favourite tool for Y and Z generations can increase the attractiveness of academic and practical training activities. At the same time, autonomy and a sense of competence can be encouraged, which will increase the students' motivation for learning [6].

The failure to research usage XR (MR, AR, VR) on university students, particularly in Serbia and Romania (both in total and in each country), is a critical reason for the study conducted.

Therefore, the problem statements of the research presented in this article are how to ascertain the current state of HEI and needs of Generation Y and Generation Z, how to ascertain the benefits and drawbacks of XR in higher education, and what recommendations on how to seize opportunities and overcome challenges to give to HEI especially in mid-income countries such as Serbia and Romania.

2. Higher Education Challenges

Today's higher education institutions face increased pressure to deliver outstanding learning experiences to an increasingly diverse student population, as well as exceptional, technology-enhanced teaching. Given that XR has gained traction in educational settings, it is well-positioned to address some of these issues.

However, the opportunities and challenges associated with students and teachers using virtual tools are all examples of evaluation opportunities (e.g., virtual lab instruments and materials) [7]. Speaking of the virtual, it is essential to emphasise that this term refers to virtual reality (VR), augmented reality (AR), and mixed reality (MR), which are all terms that are used to explain the same thing. Even though they provide significantly different experiences and capabilities, the relative merits and drawbacks of these systems must be weighed against the requirements of any particular application before they can be considered [8].

Without a doubt, technology has improved education over decades in the digital age. The fact that collaborative computer networks were widely adopted in the late

1980s and 1990s quickly gave way to internet-based learning delivery. This new XR interaction between visualisation technology and human perception is enthralling and can fundamentally alter teaching and learning dynamics [9]. As teaching and learning models are continually being tested during the educational path, these ulterior motives that can significantly alter our perceptions of self, time, and free will, should be further examined. However, using emerging technologies such as XR in higher educational systems raises many ethical and philosophical concerns about data collection, control, and exploitation in the XR ecosystem. This paper will focus on a higher educational personalised learning experience, an essential part of the XR ecosystem.

The United States and Spain have pioneered research on virtual reality and augmented reality in physical education. XR is used to train physical educators, increase user motivation through gamification in physical education, and teach physical educators using a variety of technological instruments [10]. According to [10], in the field of augmented reality and virtual reality, three Spanish researchers have had a significant impact: Arribas-Cubero, Gallego-Lema, and Muoz-Cristobal. It was determined that this last author was one of the most influential in VR in education by Aznar Daz et al. mainly because there were a large number of articles published by this author. The three authors were all associated with Spanish academic institutions, particularly the University of Valladolid, and as a result, Spain has the most scholarly output on the topic. Additionally, these three scientists were included in a list of the most influential people in general search as well as in their specific field.

Virtual reality and connected stimuli to the body, and the application of constant feedback can assist students in developing their motor skills and experimenting with various postures/movements without jeopardising their health. Due to the replication of movement (“learning-by-doing effect”) and engagement of all senses during simulated reality, students have been found to associate VR and AR in education with deep, comprehensive learning [11]. Due to VR technology’s interactive and exciting presentations and constant feedback. This practical approach enables tracking changes and reactions in the neural system, resulting in a more profound learning experience [12]. Nearpod VR, EON creator AVR, Audio Response Systems from the Technical University of Graz, and Facebook’s Social VR enable realistic, three-dimensional student-teacher interaction in virtual worlds [13,14].

Although the shift in computational capabilities used in Higher education is always welcome, ethical guidelines for XR systems that do not jeopardise an individual’s rights through various methodologies should always be further discussed. Social conditioning and the physical environment significantly affect people’s personal biases and ideas about social connections and self-identity and how they perceive themselves. As a result of digital technologies and information access, our perception of reality has been fundamentally altered [15]. To mitigate the possibility of increased XR impacts, proactive measures such as identifying solutions, establishing standards, and implementing governance-friendly approaches are required. Rather than waiting to see what the future holds, society should consider practical ways to improve the Higher Educational systems right now.

2.1. Millennials and Centennials

Generally speaking, professionals agree on the generation birth date-based classifications as such [16]:

- The Silent, or Mature Generation, (the builders) (1925–1946)
- The Baby boomers, the hippies, the idealists (1943–1964)
- Generation X, the post-Baby boomers, the TV generation, the latchkey kids (1961–1981)
- Generation Y, the Generation of the Millennium, or the Millennials (1978–2000)
- Generation Z, the post-Millennials or Centennials (1995–2010)
- Generation Alpha, the touch-screener (2010–)

Modern technologies have exposed younger generations to a constant barrage of sociological and technological challenges in their immediate environment, necessitating

acquiring new skills and knowledge required to access most information systems. Furthermore, complete automation of processes, the use of artificial intelligence systems, and digitalisation have become pervasive in all spheres of production and service processes and consumers' daily lives [17].

Generation Y, or the Generation of the Millennium or commonly known as the Millennials, is a generation that is beginning to occupy increasingly important positions in society and the economy. Millennium generation, also known as I generation, the "I" generation, digital, net, e-generation, has specific preferences, requirements, and desires [18].

Millennials represent the generation "born for technology". They brought technology into the economic and cultural focus and cannot understand their life without it [19].

According to a group of authors, the close connection of the millennial generation with different technologies during the entire period of their growing up led to the fact that this group of people is used to achieving results quickly. Millennials are often given credit for sparking the drive for gamification [20].

According to research conducted by Deloitte, less than four in ten millennials (38%) say that their organisations have automatable workflows or analysis processes that do a significant job or even a fair one of mechanical tasks and analyses previously handled by humans. Although nearly half (47 per cent) of respondents say their employers use Industry 4.0 technologies to increase staff or tasks or study efficiency, only 13 per cent believe this improves employee work. A significant number of millennials in Generation Z understand how Industry 4.0 is already making changes in the workforce and can see even more significant changes [21].

According to the results of the MASMI research, millennials in Serbia make up about 25% of the total population, with 34% of millennials being highly educated, 38% employed full-time, of which 72% work in the private sector [22].

Millennials believe things that appeal to their sense of uniqueness will be well-rewarded [23]. Additionally, Millennials spend around 10,000 h playing video games each year with "winning" as their slogan [24].

The people part of the Millennial generation learns to play video games naturally because that is how the generation was formed [25,26].

Generation Z describes a generation that uses technology such as manufacturing equipment and uses technology that does not exist yet, such as virtual communication. The fact that businesses now can offer long-term sustainable growth through the IoT is significant. It is possible that educating Generation Z could teach them how to have good relationships with both people and machinery, allowing the economy to grow over time. However, finding a suitable response to the demands of new technologies while accommodating the expectations of younger generations is a huge challenge for employers in both the private and public sectors [27].

Gen Z is the first generation to have never known a world without the internet, and its members are classified as digital nomads [28]. This generation is the first in a series to have access to information technology from an early age, which has had a revolutionary effect on its members' lives—ranging from various social interactions to mental health, as well as their personal and professional behaviour [29]. This also implies that Generation Z cannot be technologically reliant, for the simple reason that information technologies have been an integral part of their lives since their infancy.

Generation Z is also referred to as "post-millennials," "centennials", "the digital generation," "dot-com generation," "e-generation," and "switchers." Additionally, it is referred to as Generation C. Additionally, members of this generation are more adept at utilising various information gadgets. Children prefer electronic gadgets, cosmetics, and branded clothing over traditional toys [30]. They are a subset of digital immigrants, communicating in almost all spheres of their activities in a digital language. They spend a significant amount time in front of a screen (computer, laptop, or mobile phone), primarily communicating via chat rooms and various forms of social media. They prefer Internet-based content, spending considerable time surfing and watching YouTube videos. They are

proponents of online education, preferring to learn through short educational videos and online workshops [31]. Thus, computer use has become ingrained in their daily lives, even at home.

They prefer independent learning styles in which reading is relegated to a secondary role (with new reading strategies) and encourage physical activity. As a result, they are structured around images, with the text taking a back seat, with reading occurring “between the lines,” making them faster and more efficient. Thus, Generation Z members are further confirmed to be capable of receiving text simultaneously—they can process a large amount of information concurrently [17]. Generation Z, like the generation before it, aspires to education but also entrepreneurship [17].

Generation Z has a unique perspective on relationships, communication, and cooperative activities compared to previous generations. Why is it critical to distinguish between different generations of consumers? Simply put, it is because all generations are entwined, linked in daily life by living and working together and communicating with one another. Finally, there are distinctions in the motivational wheel as the initiator of the communication process, not only when it comes to major life decisions but also other purchases. These distinctions are evident in the behaviour of consumers of various age groups [32]. Members of each generation are believed to be connected primarily through shared experiences, customs, diverse cultural events, economics and politics, and popular culture. Their combined experiences in routine and emergencies distinguish them as a distinct group, not by age, but in a sociological sense [17].

2.2. Extended Reality

Cross Reality or Extended reality (XR) is a catch-all term for technologies that include virtual reality (VR), augmented reality (AR), and virtual worlds (VWs) [5]. Augmented reality (AR) is a technology that is very similar to virtual reality; it combines computer-generated images (CGI) with real-world scenes. AR on smartphones has recently gained popularity, thanks mainly to Apple’s ARKit and Google’s ARCore. This technology works quite simply on mobile devices: a layer with the computer-generated image is superimposed on the video captured directly by the camera sensor [1].

Augmented reality (AR) combines a physical image of the physical world with a digital image of the virtual world so that digital content is created in a physical or actual location and a new virtual space is created that is enriched with digital content. While both AR and VR have a bright future and potential applications, they differ in some ways from virtual reality. For example, augmented reality encourages users to interact with their environment, compared to virtual reality, which seeks to completely isolate the user and transport them to a different location or world. Additionally, some devices combine the characteristics of VR and augmented reality technology, allowing for seamless transitions between the two [33].

Mixed reality (MR) is a fusion of the physical and digital worlds that explores the relationships between human, computer, and environmental interactions. This new reality results from technological advancements in computer vision, graphics processing, display technology, and input systems. Paul Milgram and Fumio Kishino coined the term in 1994 with their paper “Taxonomy of Mixed Reality Visual Representations” [34]. The spectrum of mixed reality is the relationship between the physical and digital worlds and between virtual reality, augmented reality, and mixed reality [34]. Mixed reality combines the physical and digital worlds; these two realities define the polar opposite ends of the virtuality continuum. A spectrum of mixed realities is a collection of realities. On the left is a physical reality with people, while on the right is a digital reality with no people. The spectrum of mixed reality [34] represents the connection between the physical world and the digital world via augmented reality and virtual reality.

2.3. Sustainable Innovation in Higher Education

Innovative thinking equips students at postsecondary institutions with new functional abilities, which frequently results in developing entrepreneurial skills. As a result, it promotes the establishment of new businesses, thereby creating new job opportunities and ensuring their economic prosperity in the future. As the development of penicillin, safe drinking water, and sanitation demonstrates, our innovativeness has also benefited us economically [35]. Numerous benefits can be seen among both students and teachers as a result of educational system innovations.

Simović and Domazet also emphasise the critical nature of digital entrepreneurial abilities. The paper proposes establishing a concept or template for assessing entrepreneurial cognitive abilities in the context of digital technologies to develop an appropriate methodology that will serve as the foundation for the development of software or tools for assessing entrepreneurial intellectual abilities in the digital industry. This tool would directly assess students' digital entrepreneurial cognitive abilities in academic or vocational studies in Serbia. It would simplify the approach to analyse the factors underlying the fundamentally distinct levels of digital entrepreneurial intellectual abilities. Factors relating to a student's personality traits are considered and contextual, i.e., socioeconomic, factors [36,37].

Whether or not these innovations in higher education are acceptable will depend on how we employ these technologies that we have today. Therefore, we must take responsibility for our creations and recognise that technology is never neutral. There are a variety of social implications associated with each new technological development, both positive and negative. Even though it is acknowledged that it is necessary to conduct a critical and systematic examination of our technologies' commitment to sustainability, privacy, and accountability, our future innovations must not only contribute to solving the most pressing problems in Higher Education, but they must also be projects that foster consensus around universally held moral values. Technology and the scientific foundations upon which it is built are far too important to be ignored at this point. It is insufficient to focus solely on the outcomes of decisions. To foster responsible innovation, we must be proactive in ensuring that the values embedded in today's technologies are made explicit and communicated to those using them [35].

Even though students can currently participate in XR projects in their spare time, institutions should provide XR access on campus to enable these projects to be successful. In some cases, projects included everything from short-term research projects like developing an augmented reality app for a journalism class project to long-term educational endeavours like developing an app that can teach students to be responsible innovation drivers. Learning that is initiated and directed by the learner is frequently the most effective type of learning. Student access to virtual reality headsets and powerful computers is only possible if educational institutions make these tools available. Students who do not have direct access to these technologies can still access this technology through university computer labs or studios. Having access to technology through a technology lending program is even more advantageous for these individuals. Accessibility and assistance are essential requirements for encouraging development in the XR field while students are on their formal education path [38].

Students' participation in extracurricular activities can also be an excellent way to pique their interest in XR technology when organising an event that will draw a large number of people, such as a virtual reality game night, because students are more likely to get involved in this kind of event, rather than attending seminars or webinars in the age of global pandemic. As with any new medium, it is necessary to develop new methods of evaluating student work. In order to incorporate self-directed learning into assessments, instructors must rethink their course assignments and program outcome assessment criteria.

2.4. Cutting Edge Technologies Potential of XR and Future of Work and Formal Education

Obviously, students and teachers at higher educational institutions are already influenced by virtual and augmented reality innovations. In other words, XR. Implementation

can be seen in various other industries, including health-care education, among others. More advanced virtual reality platforms and technologies, such as virtual reality (VR), have been implemented in nursing and medical schools, allowing these devices and platforms to be used to their full potential. Of course, the student's motivation and willingness to work hard are critical to the success of this learning method. Institutes and teachers will understand an increasing number of natural learner profiles through advanced data analytics and the development of highly personalised, enhanced pedagogy. In conjunction with edge computing, immersive visualisation will soon enable this type of personalised learning experience—even live—to be delivered directly to a student's vision.

It is not unusual for new methods, products, and technologies to gain widespread acceptance before becoming widely used. For example, Allcoat and von Mühlénen (2018) recently investigated various learning methods, including virtual reality (VR), traditional, and video media, and discovered that they were all effective. In addition, they discovered that virtual reality enhanced learning, increased engagement, and elicited a higher level of positive emotions in participants [6].

Furthermore, a positive mood may affect learning by increasing cognitive flexibility [39]. Additionally, the researchers discovered in a study that both positive emotion and high immersion had a significant effect on knowledge acquisition [40].

Regarding the facilities for XR and E-learning, E-learning has a significant impact on many aspects of the learning process and learners acceptance [41]. However, also professors must develop their competencies to offer the students acquired knowledge [42]. By integrating collaborative e-learning, augmented reality (AR), virtual reality (VR), and mixed reality (MR), the potential of extended reality (XR) can easily be seen. Immersive VR/AR applications combined with collaborative learning enable the "learning-by-doing effect" on deep, comprehensive learning and simulations that engage all five senses [43]. In the Internet of Things era, e-learning technology offers several significant benefits to organisations [44]. Thus far, the best description of XR has been that it enables spatial localisation and experimentation in various subject matter areas while also promoting innovative practices such as informal and ludic activities. It motivates learning and establishes new value scales. When it comes to collaboration and deeper learning, XR has an additional advantage due to its capacity to provide broad education. Respondents' perceptions of e-learning and XR immersion were gleaned from an online survey that elicited responses regarding respondents perspectives on the impact and influence of virtual technologies on work, study, and social life. The study enrolled all Serbian, Romanian, and Hungarian college students from public and private higher educational institutions. The study collected data on students' perceptions of XR in the context of online learning in three Eastern European countries. Millennials, like their teachers, are enthusiastic about new technologies. Students are busy, constantly moving, and eager to learn and expand their horizons through new experiences. However, these universities have not yet adopted XR technologies [43].

The fact is that researchers from a wide range of disciplines are becoming increasingly interested in the potential of extended reality as a learning tool. In engineering, computer science, and astronomy, measuring learning outcomes and experimenting with virtual reality (VR) are becoming more common [45]. Medical education is currently being evaluated for its potential to aid in comprehending anatomy and the intricate interrelationships between organs [46]. Further research is needed to determine whether or not extended reality is practical for teaching and learning and how to design practical learning applications [47]. The inconsistency of previous XR learning outcome measures may be due to the program's design rather than the medium itself, as previously suggested [45]. For positive educational outcomes to be achieved, improved guidance on best practices in virtual reality design must be developed [48].

By leveraging XR in lifelong learning, the educational system is being transformed in a way that is complementary to the rapid adoption of online and hybrid learning, both of which are critical to the future of work [49]. Blended and remote learning and working

will become more prevalent in the future, with augmented and virtual reality solutions providing unprecedented opportunities for training and community engagement in this environment. It is possible to practice difficult situations and high-risk skills safely and repeatedly by utilising XR technology [50]. From higher educational institutions, working students can use the most of XR (and 3D modelling) that allows them to collaborate with colleagues in the office from a distance by connecting to the office network and gaining access to the computer of another XR device while being able to do all the curriculums and exams [50]. To put it another way, higher education institutions and industry partners committed to ethical innovation and long-term workplace sustainability are seeing unprecedented opportunities for collaborative efforts in the workplace.)

The research gap, formulated after the literature review, include the questions: how to overcome the challenges of implementing new technologies? Which technologies should be chosen to satisfy the needs of primary students as stakeholders, but also educators, society, and HEI. The adequate recommendations applicable in low and mid-income countries are insufficient in the available literature.

3. Problem Statement

The literature review noted several advantages and challenges regarding HEI XR implementation and no potential solution (research gap). The existence of this information compelled us to take an exploratory trip to Serbia and Romania in order to investigate the effects of XR implementation in HEI. Considering that this is the future of our society, young people are eager to embrace technology, and so we designed a survey to provide Serbian and Romanian HEI managers and authorities with information about the adoption and implementation of XR in their HEIs. Belgrade and Bucharest are the locations for our student survey research. At the same time, we also researched what opportunities and challenges they may face in XR. Research examining student perceptions of using XR in higher education: A Study of Student Perceptions of Extended Reality Ahmet Ustun and Siba El Dallal [51]; paper Artificial Intelligence in Higher Education: Promises, Perils, and Perspective [52] and other sources [53–58].

We address the following critical issues in this article:

1. Shared knowledge and stance of research bases regarding extended reality in Higher Education;
2. Best practices regarding usage of extended reality in High Education;
3. Students' knowledge of extended reality;
4. Students' attitudes regarding extended reality opportunities and challenges in Higher Education Institutions.

4. Research Methodology

4.1. Research Design and Process

Regarding the methodology, we combined qualitative [59] and quantitative data collection. The planned methodology was represented by:

- Empirical research: it included observation (phase I) and participatory observation (phase 2). All study authors are university professors involved in applying new technologies within HEI in Romania and Serbia. In addition, they have initiated the implementation of XR (and AI&ML) technologies in educational institutions in which they are employed or own.
- Desk research was represented by the document analysis (phase 3). The document analysis process [59] used the following model: acquire access to relevant documents, create an organisational chart, verify document authenticity, and detect document content. A wealthy literature review in phase 3 has helped us verify our findings with more data sources and search for alternative explanations. Based on the literature, we found that XR is a modern, helpful tool that can enhance teaching and learning in HEI.

- Field research was represented by the online survey based on the questionnaire. (phase 4). Based on this grounded background within phases 1, 2 and 3, we designed survey research and used different statistical analyses to ensure the results (phase 4). We have maintained objectivity and avoided bias with qualitative data analysis by using multiple people to code the data. Furthermore, we allowed participants to review our results. Further elaboration of the methodology was performed by presenting the research design and research process.

First, quantitative data collection and analysis gathered was coded and analysed. In our analysis, we used Correlation Coefficient to see the link between our variables. Then, a composite reliability analysis was conducted to see if we could design a sustainable regression model. We used Smart-PLS software, version 3.0. Based on composite reliability, we designed a regression model that emphasised the opportunities and challenges brought by XR in HEI.

We designed an online survey applied in Serbia and Romania on 103 students. First, quantitative data collection and analysis (phase 4) gathered was coded and analysed. In our analysis, we used Correlation Coefficient to see the link between our variables. Then, a composite reliability analysis was conducted to see if we could design a sustainable regression model. We used Smart-PLS software, version 3.0. Based on composite reliability, we designed a regression model that emphasised the opportunities and challenges brought by XR in HEI.

We have formulated the following research questions we seek to provide a response to the following questions:

1. What are relevant standpoints regarding the use of XR in HEI?
2. What are higher education challenges?
3. What is cutting edge potential of XR technologies?
4. How will be the future of work and formal education?

4.2. Research Hypothesis

Our research verifies the validity of the following hypothesis for which we will use primary and secondary data:

Hypothesis 1 (H1). *XR is an excellent technology facilitating teaching processes, allowing learners to more actively control their learning strategies and supports the interactivity and connectivity that students and faculty experience.*

Hypothesis 2 (H2). *Generation Z students are more applicative for stating XR's opportunities (instead of challenges) in higher education institutions.*

4.3. Research Tool

The survey research among Generation Y and Generation Z students in the Republic of Serbia (former and the current) and Romania was conducted online with a Google Forms questionnaire. This was done to get a general sense of how much knowledge of Extended Reality is held by the student population and, in particular, to understand both opportunities and challenges involved in Extended Reality in HEI. The questionnaire was built on four segments, first informed consent of respondents to participate in the research, then Social-demographic questions segment (age, gender, education, work status, country of origin); third Extended Reality (XR) general knowledge and usage; and forth Extended Reality (XR) in HEI perceived opportunities and challenges. The survey contains many questions regarding student opinion on XR. For this study, only two questions were selected as relevant: (a) Opportunities of integrating XR in HEI and (b) Challenges brought by XR in HEI. These two questions have multiple choice answers evaluated on a 1 to 5 Likert scale, where 1: not at all and 5: very representative [60]. The survey therefore contains two main categories of questions of interest for this research study: one category refers to opportunities engaged by XR in the higher education process, and the second

category refers to opportunities brought by the XR technology in the educational and learning process. It results from two main variables OXR and CXR, with fifteen sub-variables presented in Table 1. Table 1 shows codes of indicators that follows our model and indicators names.

Table 1. Variable analysed.

Code	Variable Name
OXR1	XR supports learning
OXR2	XR facilitates teaching processes
OXR3	XR systems permit learners to more actively control their learning strategies
OXR4	XR motivates and engages students
OXR5	XR allows students to learn complex subjects in a simplified way
OXR6	XR allows students to practice the learning content directly in a realistic environment
OXR7	XR supports the interactivity and connectivity that students and faculty experience
OXR8	XR tools encourage the development of students' creative thinking process
OXR9	XR systems facilitate effective learning, encouraged by learning by doing
CXR1	Expensive content creation for XR technology
CXR2	A constant need to buy new equipment, as updated models are constantly being released
CXR3	Problem with data protection among students and teachers
CXR4	Need for protocols establishment, without generally approved frameworks
CXR5	XR software and hardware is mainly designed for the consumer market
CXR6	Scalability and sustainability have limited broad adoption of XR.

4.4. Processing the Data

We performed an extensive data collection and coding process to generate the data that can answer to H1 and H2. Correlation matrix, composite reliability, and regression model were used to code the data and extract knowledge. To obtain the variables, Smart-PLS3 was employed [61–71]. Once the data was analysed, we concluded that H1 was correct and constructed a regression model based on that assumption.

We have coded variables with a code of indicator regarding whether they are part of opportunities (OXR) or challenges (CXR), adding their numbers linearly as ordered in the fourth segment of the questionnaire. Table 1 shows codes of indicators that follow our model and indicators names.

5. Survey Method

5.1. Research Sample

We used Stratified sampling (we divided the population into strata according to students of a particular age generation). Thus, the student population refers to Generation Y and Generation Z.

Regarding the description of the sample, Table 2 shows the social-demographic characteristics of 103 respondents regarding their age, country of origin, education (schooling), and student status (activity). Regarding the age group and belonging of respondents to Generation Z or Generation Y, we choose reference [72], and 51.46% percent was in the age group belonging to Generation Z, and 48.54% of respondents were members of Generation Y. We can find almost equal gender distribution of respondents: male 50,49% and female 49.51%. Regarding the country of origin, 58.25% of respondents are from Serbia, while 41.75% are from Romania. Regarding education, 73.79% of respondents have finished high school and are students of the first level of studies, while 26.21% are students at the second level of studies.

5.2. Research Results

In this study, the results are split into two sections. In the first section, known as Correlation Matrix Results, the results of the correlation matrix are described and then, in the section composed of regression analysis, the composite reliability is examined.

Table 2. Social-demographic characteristics of respondents.

Characteristics	Category	Frequency	Percent
Age	from 18 to 24 years old (gen. Z)	53	51.46
	from 32 to 40 years old (gen. Y)	50	48.54
Country	Serbia	60	58.25
	Romania	43	41.75
Gender	Masc	52	50.49
	Fem	51	49.51
Schooling	Higher education	27	26.21
	Highschool	76	73.79
Activity	Student	71	68.93
	Former student	32	31.07

5.2.1. Correlation Matrix Results

Within the matrix correlation, we may see a strong correlation between OXR1 and OXR2, OXR4, OXR5, OXR6, OXR7 and a strong correlation between OXR1, OXR8, and OXR9. The correlation coefficient is higher than 0.7 in these cases. XR facilitates teaching processes, allow learners to control their learning strategies more actively and supports the interactivity and connectivity that students and faculty experience (Table 2). Another powerful correlation might be observed between CXR1 and CXR2, CXR4 and a strong one with CXR3. In general, the content creation for XR technology is expensive because of the constant need to buy new equipment, as updated models are constantly being released, a problem with data protection among students and teachers and the need for protocols establishment without generally approved frameworks. Thus, we may assume that Generation Z students are more applicative for stating XR's opportunities (instead of challenges) in higher education institutions. Correlation between variables are presented in the Table 3.

Table 3. Correlation between variables.

	OXR1	OXR2	OXR3	OXR4	OXR5	OXR6	OXR7	OXR8	OXR9	CXR1	CXR2	CXR3	CXR4	CXR5	CXR6
OXR1	1.00														
OXR2	0.73	1.00													
OXR3	0.68	0.76	1.00												
OXR4	0.76	0.64	0.71	1.00											
OXR5	0.69	0.69	0.68	0.75	1.00										
OXR6	0.72	0.72	0.73	0.81	0.76	1.00									
OXR7	0.70	0.60	0.64	0.80	0.75	0.75	1.00								
OXR8	0.69	0.63	0.62	0.71	0.82	0.72	0.73	1.00							
OXR9	0.67	0.65	0.63	0.74	0.83	0.76	0.71	0.82	1.00						
CXR1	0.48	0.36	0.42	0.49	0.49	0.50	0.49	0.45	0.45	1.00					
CXR2	0.45	0.42	0.37	0.40	0.54	0.47	0.48	0.45	0.41	0.78	1.00				
CXR3	0.35	0.35	0.24	0.38	0.33	0.40	0.30	0.30	0.37	0.62	0.54	1.00			
CXR4	0.42	0.35	0.33	0.33	0.38	0.31	0.32	0.30	0.35	0.71	0.69	0.65	1.00		
CXR5	0.33	0.41	0.32	0.29	0.37	0.29	0.31	0.31	0.35	0.43	0.52	0.46	0.52	1.00	
CXR6	0.48	0.40	0.41	0.47	0.46	0.32	0.46	0.48	0.41	0.49	0.57	0.46	0.65	0.68	1.00

5.2.2. Composite Reliability Results

The composite reliability shows a very strong model because all the OXR and CXR factors (subindices) values are very high (greater than 0.7). In Table 4, we may observe that all the criteria of the validation process are met; thus, we may design a consistent regression model. Furthermore, the inner model is statistically significant because its standardised track coefficient (0.568) has a high value. Therefore, we may conclude that CXR has a relatively significant effect on the variable OXR. This means that the challenges of implementing XR in HEI affect the opportunities brought by XR in online teaching and learning (Table 4, Figure 1). The Universities still struggle to face these challenges in their

approach to provide high-quality education.

Table 4. Regression model statistics.

Reflexive Construct	Composite Reliability	Alpha Conbrach	AVE	R Square
	(>0.7)	(>0.7)	(>0.5)	(>0.5)
OXR	0.965	0.959	0.755	0.568
CXR	0.919	0.894	0.656	—

Notes: The LV CXR does not have an R² value, as it precedes the other variables in the SEM (Structural Equation Modelling).

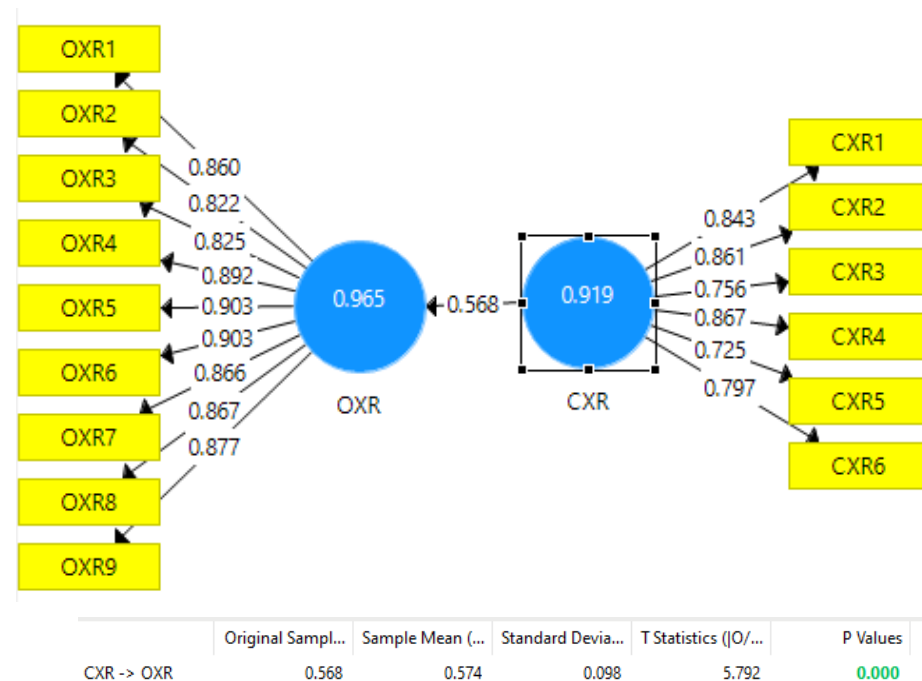


Figure 1. Composite Reliability Model.

5.2.3. Regression Model Results

Our anterior findings are supported by the model below. In the regression model, XR is an excellent technology facilitating teaching processes, allowing learners to control their learning strategies more actively and supporting the interactivity and connectivity that students and faculty experience. Overall, the model is representative (R² is 0.65), meaning that OXR brings many benefits to HEI. The variation of the independent variable (OXR2, OXR3, and OXR7) explain 65% of the variation of the dependent variable (OXR1). The other percentages should be explained by other variables such as OXR4, OXR5, OXR6, OXR8, and OXR9.

Regression model equation:

$$\text{OXR1} = 0.705 + 0.402 \times \text{OXR2} + 0.11 \times \text{OXR3} + 0.360 \times \text{OXR7}$$

The ANOVA test confirms the before mentioned findings because $F > F_{\text{crit}}$ and $\text{Sig } F < 0.01$. Moreover, the Anova test assumptions are met: the dependent variable is measured on a continuous scale, the independent variables are made of four different categorical, independent groups, the observations are independent (which means that there is no relationship between the observations of each group or between the groups themselves), there are no extreme values, the variable is distributed normally in each group of the independent variable, and there is a homogeneity of variants (Table 5).

Table 5. Regression analyses.

Regression Statistics						
Multiple R	0.808					
R Square	0.652					
Adj. R Square	0.642					
Standard Error	0.593					
Observations	103					
ANOVA	Df	SS	MS	F	Significance F	
Regression	3	65.3	21.77	61.94	1E-22	
Residual	99	34.79	0.351			
Total	102	100.1				
	Coefficients	Standard Error	<i>t</i> Stat	<i>p</i> -value	Lower 95%	Upper 95%
Intercept	0.705	0.262	2.686	0.008	0.184	1.225389
OXR2	0.402	0.089	4.508	2E-05	0.225	0.578913
OXR3	0.11	0.099	1.115	0.267	−0.09	0.306093
OXR7	0.369	0.077	4.816	5E-06	0.217	0.520787

The Multiple R coefficient is 0.80, which has a high value. The *p*-value shows probability (F-statistic), representing the F-test marginal significance level. In a *p*-value less than 0.05 (significance level), H1, the alternative hypothesis is accepted. The new model results can be seen in the table above. The *p*-value is 0.26 for OXR3, meaning that the coefficient of this variable is not very well estimated, but, overall, the model is reliable. The *p*-value for the intercept, OXR2 and OXR3 variables is smaller than 0.05, meaning that the coefficient is well estimated (Table 5). The R2 coefficient of this model is 0.80 indicates that the variation of causal variables determines 80% of the OXR1 variable variance, and the model cannot explain 20% of this influence.

6. Discussion

Following the statistical test *t*, the resulting coefficient for the OXR2 variable was 0.402, with a probability of guaranteeing results (Prob) of 2E-05 (less than the sensitivity threshold of 0.01), so this variable's coefficient is very well estimated with a deficient standard error (0.08), and with 95% likelihood, it will be found in the interval [0.225; 0.578913]. The coefficient for the OXR3 variable is 0.11 with a deficient standard error (0.09), and with 95% likelihood, it will be found in the interval [−0.09; 0.306093]. The coefficient for the OXR7 variable is 0.369, with a probability of guaranteeing results (Prob) of 5E-06 (less than the sensitivity threshold of 0.01) so this variable's coefficient is very well estimated and with 95% likelihood, it will be found in the interval [0.217; 0.520787]. The intercept value was estimated to be 0.705 with a probability of guaranteeing results (Prob) of 0.008, and with 95% likelihood, it will be found in the interval [0.184; 1.225389]. The T-test for each variable generated validates the model and contributes to the predictive power of the regression. Probability, the significance threshold of the variables should be less or around 0.05 (Table 4).

As shown in the matrix correlation, XR is an extremely useful learning aid because it allows students to control their learning strategies while supporting the interactivity and connectivity they enjoy with their classmates and professors. However, there is a problem with data protection among students and educators and the requirement for protocols establishment without generally approved frameworks, as shown by matrix correlation. XR's opportunities (rather than challenges) in higher education institutions are more applicable to Generation Z students, and we presented our assumption as H2. The composite reliability shows a strong model because the OXR and CXR factors (subindices) have extremely high values. As we saw in Table 5, all of the validation criteria have been met, allowing us to create a valid regression model. The inner model has a high standardised track coefficient making it statistically significant. From this, we can deduce

that CXR has a sizable impact on OXR. By this, we mean that XR implementation challenges in HEI impact XR's opportunities in online teaching and learning. In their efforts to provide high-quality education, universities are still grappling with these issues. The ANOVA test confirms the before mentioned findings.

In conclusion, following the above results, we can state that regression analyses allowed us to confirm our hypothesis (Table 5).

These findings verify our starting assumptions and allow us to be firm in recommendations to HEI in Romania and Serbia regarding the introduction of XR facilities in teaching processes.

E-learning has a significant impact on many aspects of the learning process and learner acceptance [41]. However, professors must also improve their skills to teach students [42]. The potential of extended reality (XR) can be seen by combining collaborative e-learning, AR, VR, and MR. Deep, comprehensive learning and simulations that engage all five senses are possible with immersive VR/AR applications and collaborative learning [43]. In the age of the Internet of Things, e-learning has many advantages for businesses [44]. So far, the best description of XR is that it promotes innovative practices such as informal and ludic activities. A new value scale motivates learning. XR's ability to provide broad education gives it an edge in collaboration and deeper learning. An online survey asked about respondents' perceptions of virtual technologies' impact on work, study, and social life. The study included Eastern European college students, public and private. In three Eastern European countries, students' perceptions of XR in online learning were studied. Like their teachers, Millennials love new technologies. Students are busy, on the move, and eager to learn and broaden their horizons. Nevertheless, these universities have not yet adopted XR [43].

Increasingly, researchers from diverse fields are interested in the potential of extended reality as a teaching tool. Measuring learning outcomes and experimenting with VR are becoming more common in engineering, computer science, and astronomy [45]. Anatomy and the intricate interrelationships between organs are currently being evaluated in medical education [46]. More research is needed to determine whether or not extended reality is helpful for teaching and learning [47]. Previous XR learning outcome measures' inconsistency may be due to program design rather than the medium itself [45]. Improved guidance on best practices in virtual reality design is required for positive educational outcomes [48].

XR technologies in education will improve both the teaching and learning processes, which is an essential step in e-learning. Many studies presented in [50,51] have shown how XR technologies give their advanced participation in education through the use of different multimedia. In order to achieve the maximum expected achievements in the educational process, the basis of the integration of XR tools in education lies in the integration of communication design with students [48]. In order to explain XR as an excellent tool in the teaching process, it is necessary to apply multimedia focus (synchronous use of words and graphics) and the principle of modality (the way of presenting information depends on the complexity of the material presented to students).

Many educational XR applications work based on storytelling because, based on that, the engagement with students is more intensive, and they understand the taught areas more easily. A large number of XR applications are learned through the process of learning by doing (for example, a large number of educational processes in the field of mathematics are taught through the so-called non-symbolic math). Furthermore, in XR educational tools, students learn to go through specific teaching subject/character roles [73].

In the field of education, various research papers have emerged due to the design of XR tools in the educational process. Thus, approaches included game-based learning, role-playing, studio-based pedagogy, problem-based learning, participatory simulations [26,28,31].

Unlike many classical theoretical directions in terms of XR implementation in teaching, our research focuses on pragmatic models of XR in education with students.

The use of XR in lifelong learning is transforming the educational system, complementing the rapid adoption of online and hybrid learning, both critical to the future of work [49]. In the future, augmented and virtual reality solutions will provide unprecedented opportunities for training and community engagement. XR technology allows you to practice difficult situations and high-risk skills safely [50]. College and university students can use XR (and 3D modelling) to collaborate with colleagues remotely by connecting to the office network and gaining access to another XR device's computer while doing all curriculums and exams [50]. Those committed to ethical innovation and long-term workplace sustainability are seeing unprecedented opportunities for workplace collaboration.)

Although not yet fully implemented in the teaching process at higher education institutions, due to the nature of XR technologies and the enthusiasm clearly shown by the Z generation of students, it is necessary to include them in the learning process [36]. Furthermore, due to Generation Z mobility, XR technologies adapt to their habitat—whether on the road or a student campus, 24 h a day with all possible stimulating interactions and applications that fully suit this young generation. At the same time, the way of presenting XR simulations in learning will be significant because it is necessary for continuous complex study and not for superficial learning [30].

Our research shows that Z generation students prefer the use of new technologies in education, especially XR because this modern technology is closely related to the possibilities for simulation and experimentation. In that sense, higher education institutions must develop new learning methodologies that would align with the aspirations of new generations. Furthermore, in times of crisis, such as the current COVID-19 pandemic and the availability of MOOCs (Massive Open Online Courses), XR technology benefits the education system and higher education institutions.

7. Conclusions

Colleges, universities, other educational establishments, and EdTech companies can gain a competitive advantage by experimenting with new approaches in teaching. These establishments will have to implement XR methods to meet the growing demand for adaptive and personalised education. New technologies are causing revolutions and evolution in many industries, and we are here to see them. Higher education, on the other hand, especially in mid-income countries, is exempt from this rule. This groundbreaking research in the field sheds light on higher education in the era of XR and offers new perspectives. During these difficult times, the higher education system has taken a heavy hit. The pandemic spread, which is still difficult to stop in some parts of the world, has put colleges and universities under financial strain. Nevertheless, most universities and colleges have always wanted to be innovative to ensure their survival and improve their students' daily lives.

All of the characteristics of Generation Y and Generation Z students are critical for higher education institutions addressing educational challenges and wishing to share their values with their students. As a result, these institutions will recognise the critical method of adapting extended reality content of a particular everyday learning curriculum to capture the students' attention and improve the learning outcome. Due to the rapid advancement of information technology, this can be implemented in the present moment.

Based on the regression model, this study showed that XR is an excellent teaching aid because it empowers students to take charge of their learning by giving them greater control over their methods and enhancing the sense of interactivity and connectivity between them and their teachers. The regression model showed that OXR (opportunities of XR) has many advantages for HEI.

Furthermore, the research results and findings can be attractive to other mid-income countries (not only Serbia) because they demonstrate a good acceptance of XR among generation Z students.

The lack of research in using XR in HEI and among university students in general, especially in Romania and the Republic of Serbia, added value to this research. Making

effective learning analytics for Romanian and Serbian HEI could improve the whole academic system in these countries.

Research limitations. The facts presented in this study, as is the case in all research, are subject to limitations. One limitation of this research is the desire for social desirability, generalizability, imprecise measurements, and questions not asked. Other difficulties have to be considered when researching XR in higher education, such as the time it takes to search for resources on XR. Furthermore, the study only took into account the answers of the participants, not any other feature or behaviour of the students. Additionally, future research that incorporates the findings from this study must be recommended. Finally, future studies must target concrete ideas for colleges and universities.

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