Alliance4XR

Innovation alliance to infuse Extended Reality skills into Higher education and Vocational Training

D1.2 Analysis of institutions' available and missing skills, curricula and members' needs

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Abbreviations

Term	Explanation
AR	Augmented Reality
AV	Augmented Virtuality
BoK	Body of Knowledge
DoW	Description of Work
EC	European Commission
HEI	Higher Education Institute
MR	Mixed Reality
TL	Task Leaders
UDL	Universal Design for Learning
VET	Vocational Education and Training
VR	Virtual Reality
WP	Work Package
XR	eXtented Reality

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CONTENTS

Contents 5
Executive Summary 7
1 Introduction 8
1.1 Project objectives 8
1.2 Objectives of this report 9
1.3 Achievement indicators 9
1.4 Structure of the document 9
2 Methodology 10
3 Draft XR taxonomy of concepts and terms 11
4 Industry requirements as specified by use cases 12
5 Desk study of course syllabi 13
5.1 Analysis of desk study results 15
6 Questionnaire on current and future provision of XR-related education 19
7 Analysis of supply and demand 21
7.1 Supply of XR courses per industrial sector 22
7.2 Supply of XR courses per XR topic 23
8 Topics considered to be addressed by the Alliance4XR project 26
9 Conclusions 28
Annex 1: Detailed results of desk study on course syllabi 30
Desk study results of Greece 31
Desk study results of Spain 33
Desk study results of Cyprus 45
Desk study results of Ireland 51
Desk study results of Portugal 55

Desk study results of Sweden 57

Desk study results of Ukraine 60

Annex 2. Summary of responses from the questionnaire on current and future provision of XR-related education 62

Potential benefits of using XR in education 62

XR topics addressed in current and future teaching 68

Annex 3: Design of questionnaire and privacy policy 85

Questionnaire design 85

Privacy Policy 87

EXECUTIVE SUMMARY

The objective of this report is to describe the status of education institutes in construction engineering, energy & grids and marine engineering, with respect to the usage of XR technologies. The objective is also to describe the gap between supply and demand of XR skills and knowledge.

The demands of education and training in XR technologies are described in D1.1 (XR – state of play, market needs, training trends). The supply side is investigated by two different studies, one desk study of course syllabi being published, and one questionnaire submitted to teachers in XR technologies.

To compare the supply and the demand of education and training, a draft XR taxonomy has been created, where the most important XR topics are specified.

The main conclusions of this study may be summarised as follows

- The findings highlight the growing importance of incorporating XR technologies into educational programs to meet the evolving needs of the industry, in topics such as "Basic Principles of XR", "Advanced Technologies for Mixed Reality", "Usage of XR Technologies", "3D Visualisation," and "Virtual Navigation Techniques".
- Within the VET sector, there is a need for low-cost solutions aiming to guide the learner in performing operational tasks and making real-world decisions. Simple simulators and gaming applications may be one way forward.
- As the XR industry continues to expand, the importance of integrating practical applications and emerging trends into HEI educational programs is likely to grow.

1 INTRODUCTION

Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR) represent various types of virtual experiences, ranging from views of the real world to completely artificial environments. These technologies are positioned along what is known as the virtuality continuum[1]. According to Mann et al[2], the term eXtended Reality (XR) can encompass the technologies of the virtuality continuum and may be defined as 'technologies that extend/augment/expand human sensory capabilities through wearable computing'. The technology is intended to combine or mirror the physical world with a "digital twin world" able to interact with it, giving users an immersive experience by being in a virtual or augmented environment.

The fields of VR and AR are rapidly growing and being applied in a wide range of areas such as entertainment, cinema, marketing, real estate, training, education, maintenance and remote work. Extended reality can be used for joint effort in the workplace, training, educational purposes, therapeutic treatments, and data exploration and analysis."

1.1 Project objectives

Many studies and surveys[3] are underlining an existing gap between the supply and demand of well-educated persons in XR theories and applications. This means that current training modules within engineering schools and vocational training centres do not fully meet the needs of the employers / industry with respect to skills and knowledge in XR. This gap is causing a continuous shortage of relevant skills within a booming industry and thus, hindering faster and better development of commercial products and services.

The overall objective of the Alliance4XR project is to create and test learning methodologies and materials, to empower Higher Education Institutions (HEI's) and Vocational Education and Training (VET) providers to successfully address the challenge of XR digital skills in the engineering sector in a sustainable way. The project is primarily addressing the needs within engineering sectors such as

[1] Milgram, Paul & Kishino, Fumio. (1994). A Taxonomy of Mixed Reality Visual Displays. IEICE Trans. Information Systems. vol. E77-D, no. 12. 1321-1329.
[2] Mann, S., Furness, T., Yuan, Y., Iorio, J., & Wang, Z. (2018). All reality: Virtual, augmented, mixed (x), mediated (x, y), and multimediated reality. *arXiv preprint arXiv:1804.08386*.
[3] https://www.researchnester.com/reports/extended-reality-market/4863

structural engineering and construction, grids and energy, and maritime professions.

1.2 Objectives of this report

WP1 of the project deals with a gap analysis between the current educational needs as requested by the employers and the skills and knowledge provided by the education institutes. This work package is divided into three tasks, namely

- T1.1 Digital and green skills state of play for XR
- T1.2 Institutions' current status and needs analysis
- T1.3 Mapping the challenges and good practices in the knowledge flow and innovation.

The objective of this report is to describe the status of the education institutes in the three targeted sectors, with respect to the usage of XR technologies. The second objective is to describe the gap between supply and demand of XR skills and knowledge, based on the demands as expressed in D1.1 (XR – state of play, market needs, training trends).

This gap analysis will then form the basis of the future developments within the project, where learning material, a collaborative platform and training courses will be developed.

1.3 Achievement indicators

The achievement indicator being pre-specified relates to the number of education institutions analysed in terms of needs and missing skills. The target here is that at least 3-5 education institutes shall be analysed.

1.4 Structure of the document

This document is structured as follows. Chapter 2 describes the methodologies being applied for capturing and analysing the data. Chapter 3 describes the draft XR taxonomy, which is the model used for analysing the supply and demand. Chapter 4 then analyse the use cases as specified in a previous report (D1.1), with respect to the draft XR taxonomy. The main study of this task consists of a desk study, where existing syllabi are analysed, and a questionnaire sent to the education institutes. Details about the collected data are described in the annexes, while chapter 5 and 6 are condensed descriptions of the main results. Chapter 7 then analyses the gap between supply and demand of education and training in

XR. The validity and quality of the findings are then discussed in chapter 8 and the main conclusions of the work are described in chapter 9.

2 METHODOLOGY

The objective of this report is to

- describe the current supply of education, specifically within the three targeted sectors, with respect to the usage and/or development of XR technologies.
- describe the gap between supply and demand of XR skills and knowledge, based on the demands as expressed in D1.1 (XR – state of play, market needs, training trends).

The supply of education is studied by two different activities. As a start, a desk study was carried out, where the course syllabi at selected educational institutes were analysed with respect to XR related content. As a second activity, a survey based on a questionnaire was carried out, where teachers at different education institutes were asked to state their current and future provision of XR-related education and training.

To describe this gap between the current educational needs as requested by the employers and the skills and knowledge provided by the education institutes., a model of the skills and knowledge is needed. The term "body of knowledge" (BoK) often refers to a set of concepts, terms and activities that make up a professional domain, as defined by the relevant learned society or professional association. In many cases, this type of knowledge representations is organised in domain ontologies and may be formally described using semantic web standards such as OWL (Web Ontology Language). However, for the time being, no suitable BoK related to XR technologies has been found, which could support the project in describing the knowledge and skills gaps. As a result, a hierarchical taxonomy has been created as a substitute for a full-fledged BoK, where the most important topics (concepts and terms) in the XR domain are identified. As compared to a full BoK, a hierarchical taxonomy is limited to "part-of "-relationships between the concepts (super-concepts and sub concepts). An ontology-based BoK may have additional relationships for instance "uses", "is related to" etc. This proposed draft XR taxonomy is described in chapter 3.

3 DRAFT XR TAXONOMY OF CONCEPTS AND TERMS

The main aim of WP1 is to describe the gap between the current educational needs as requested by the employers and the skills and knowledge provided by the education institutes. To describe this gap, a taxonomy of XR-related concepts and terms is needed.

As a start, a first draft XR taxonomy was created, mainly based on the experiences of Universite Paris-Saclay and Novogit AB. By analysing the use cases described in D1.1 and the desk study and survey of existing courses reported in chapter 5, additional concepts and terms were identified. The XR concepts and terms are presented in Table 1.

Table 1: Concepts and terms of the draft XR taxonomy

1st level topics	2nd level topics	3rd level topics
1 Fundamentals of XR	1.1 XR Definitions	1.1.1 Virtual Reality (VR)
		1.1.2 MR, AR and AV
		1.1.3 XR
	1.2 Concepts and founding technologies	1.2.1 Perceptive and cognitive concepts
		1.2.2 Simulation modelling
		1.2.3 Computer science technologies
	1.3 XR equipment	
2 Tracking technologies		
3. 3D visualisation		
4. 3D Audio		
5. Kinematics		
6. Haptic senses		
7. Mixed reality	7.1 MR equipment	
	7.2 MR calibration	
	7.3 Image alignment	
8. Multimodal interactions in immersive environments		

9. Virtual navigations techniques		
10. Human factors and ergonomics in XR	10.1 User centred design	
	10.2 Dimensions in XR applications	
	10.3 Criteria on XR application ergonomics	
	10.4 Ergonomic evaluation	
	10.5 Evaluation based on questionnaires	
	10.6 Evaluation of usability	
	10.7 User-centric evaluation methods	
11. XR for business development		
12. XR in process and product development		
13. XR usage		

4 INDUSTRY REQUIREMENTS AS SPECIFIED BY USE CASES

D1.1 is describing the industry requirements of XR-based education in detail. One important result is the set of use cases, collected through a desk study. In table 2, these use cases are mapped on the draft XR taxonomy, in order to describe the industry needs.

Table 2 Number of use cases per industrial sector and XR topic

XR topic	Construction	Energy	Marine	Other
XR Fundamentals	7	7	9	25
Tracking technologies	3	1	0	2
3D Visualisation	4	1	0	10
3D Audio	0	0	0	3
Kinematics	4	5	0	4
Haptic senses	1	0	0	1
Mixed reality	7	3	2	9
Multimodal interactions in immersive	1	0	0	5

environments				
Virtual navigation	3	6	0	10
Human and ergonomics	5	1	2	17
XR business development	3	3	10	12
XR process and product development	3	2	1	18
XR usage	6	7	10	10

Since the number of use cases are different for each sector, the content of table 2 should be read column by column. Doing such a reading, the following observations may be made.

In the construction sector, most use cases are related to XR fundamentals, mixed reality and XR usage. In the energy sector most use cases are related to XR fundamentals, virtual navigation and XR usage. In the marine sector, most use cases are related to XR fundamentals, XR business development and XR usage.

Most use cases in total are addressing other industrial sectors. For these sectors, most use cases are related to XR fundamentals, human and ergonomics and XR process and product development.

5 DESK STUDY OF COURSE SYLLABI

In the evolving landscape of higher education, XR technologies are increasingly being integrated into the curricula of Higher Education Institutions (HEI) and Vocational Education and Training (VET) centres. XR technologies that include Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) are expected to extend the user's experience by blending the physical and virtual worlds in various ways. This integration is anticipated to make learning experience more realistic, effectively bridging the gap between training and practical application in various engineering fields. On the other hand, incorporating XR technologies into the educational framework can enhance learning outcomes as educators can have at their disposal advanced technological tools that are more accessible and well-received by students.

As *Alliance4XR* seeks to identify the gaps between the educational needs demanded by employers and the skills and knowledge provided by educational institutions, a desk study was conducted across the countries of the *Alliance4XR*

partners. This study aims to describe and analyse the current landscape of XR courses offered by higher education institutions and provide a comprehensive overview of how widely these cutting-edge technologies are being adopted in the academic settings.

In order to ensure comprehensive and accurate analysis, the first step was to define important key pieces of information that should be collected from this desk research. First, the courses that are related to the targeted sectors of *Alliance4XR* (Grids & Energy, Marine and Construction) and to XR technologies should be identified within the countries of the *Alliance4XR* partners. Information on the academic level of these courses and programs, whether they are undergraduate, postgraduate, or part of continuing education programmes, is also crucial. For this purpose, a list was created and distributed among *Alliance4XR* partners for completion. Each partner provided a brief report on the educational institutions offering courses within their curricula that target the *Alliance4XR* primary sector(s) and the academic level at which they are offered (HEI/VET).

In total, course syllabi of 38 education institutes were investigated and their geographical distribution is described in figure 1. Figure 2 describes the academic level of the courses and programs being investigated, with respect to higher education institutes (HEI) and vocational education and training (VET) institutes.

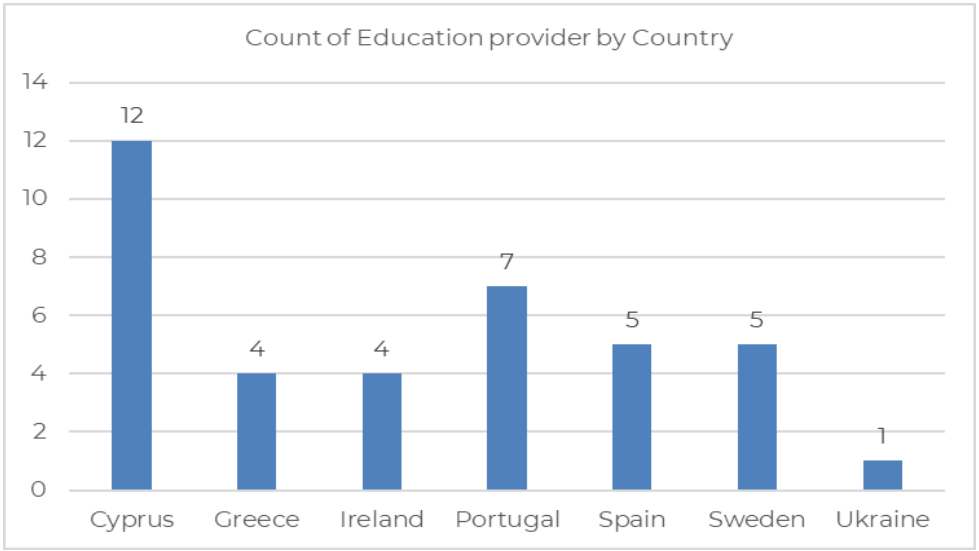


Figure 1. Number of analysed educational institutions offering courses that target the Alliance4XR primary sector(s), sorted by country

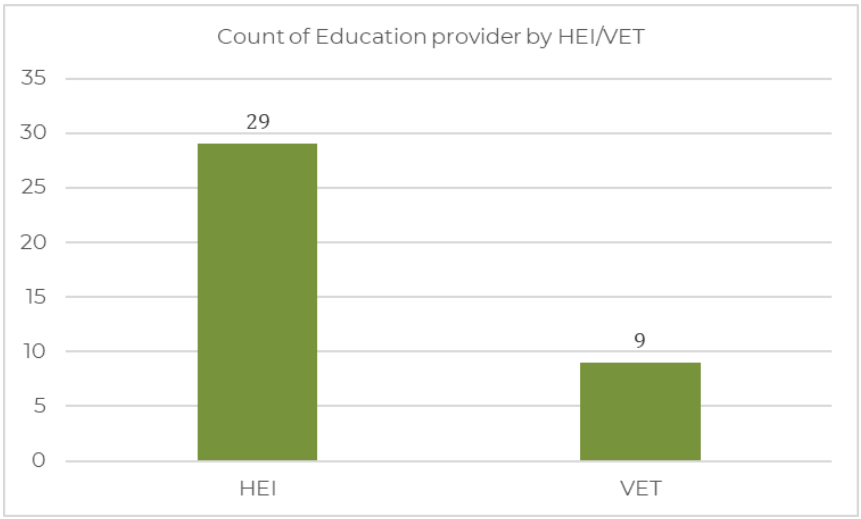


Figure 2. Number of educational institutions offering courses that target the Alliance4XR primary sector(s), sorted by academic level

In order to describe the scope and content of each course or program, course syllabi were accessed and analysed. To allow the forthcoming analysis, a predefined template was used in order to compile the findings into a structural format. The data about each course and program were entered by the *Alliance4XR* partners through Google forms, to ensure that the process was user-friendly and accessible. The following section presents the analysis of the results, while more detailed information about the results of the desk study is given in Annex 1.

5.1 Analysis of desk study results

60 out of 87 Modules were studied by the Alliance4XR partners within their countries that include XR courses in their curricula. These Modules mainly focus on acquiring knowledge of fundamental techniques to produce VR and AR applications. The majority of these Modules is part of the undergraduate programs offered by the educational institutions (See figure 3).

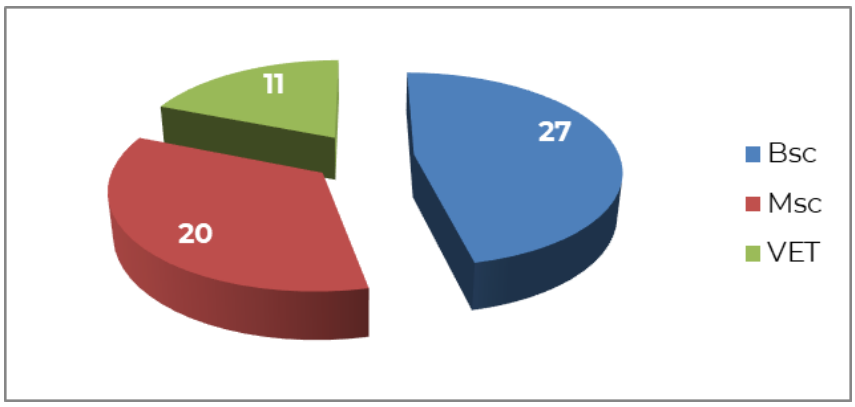


Figure 3. Number of modules offering XR courses, sorted by academic level

The following paragraphs summarise the basic findings of the desk study for every country.

Greece

In Greece, there are 4 MSc and 3 BSc courses that offer learning in XR technologies. Their basic learning objectives are introducing students to Principles of VR and related scientific disciplines and to familiarise themselves with VR and AR applications. Information regarding external funding for course development, if they are connected to green aspects, the level of satisfaction, the number of available places per course and if they are connected to an Alliance4XR use case could not be found online. Notably, none of these courses are provided by the Engineering Schools; all reported Modules come from Schools of Computing and Informatics. The online resources for Greece were limited to Bachelor's and Master's degrees focused on developing XR material, rather than recording the entire range of Modules of Greek Higher Institutions that cover the Alliance4XR sectors.

Spain

In Spain, there are 19 Modules that encompass the Alliance4XR sectors and offer XR related courses. In detail, there are 10 BSc courses, 6 MSc courses and 3 VET courses that offer learning in XR technologies. Their basic learning objectives are knowledge and application of fundamental principles and basic techniques of intelligent systems and their practical application, creation of virtual landscapes (video games, augmented reality scenarios, virtual reality, immersive experiences)

and creation of audio-visual content and in multimedia developments. Information regarding external funding for course development were found only for 5 out of 19 courses, 2 out of 19 courses are reportedly connected to green aspects, and the level of satisfaction was reported for 7 out of 19 courses with high score (e.g., 8/10 4,9/5). 9 out 19 courses provide online the number of available places with an average number of places to be 60. Finally, 1 BSc and 2 MSc courses are linked to an Alliance4XR use case.

Cyprus

In Cyprus, there are 10 BSc courses, 5 MSc courses and 7 VET courses that offer learning in XR technologies. Their basic learning objectives are lectures and use of simulators. Information regarding external funding for course development, if they are connected to green aspects, the level of satisfaction, the number of available places per course and if they are connected to an Alliance4XR use case could not be found online. There is a clear lack of curricula using XR methods in educational institutions related to maritime, energy, and structural engineering. The resources found online were limited to Informatics bachelor's and master's degrees, which are more related to developing XR material than using it to enhance learning.

Ireland

In Ireland, there are 5 BSc courses that offer learning in XR technologies. Their basic learning objectives are learning fundamental techniques to produce virtual reality (VR) and augmented reality (AR) applications, demonstrate an in-depth knowledge of digital / immersive technology and identify opportunities to utilise these effectively in industry. Information regarding external funding for course development were found only for 1 out of 5 courses, 3 out of 5 courses are reportedly connected to green aspects, and the level of satisfaction can be found by requesting access to course evaluation; 2 out 5 have been found to have positive feedback. All courses provide online the number of available places with an average number of places to be around 25. Finally, 3 out of 5 courses are linked to an Alliance4XR use case.

Portugal

In Portugal, although 15 Modules were reported that encompass the Alliance4XR sectors, only one MSc Module offers a course in XR technologies, and it is not currently running; it will start in September 2024. Its basic learning objective will be indoor application for digital design and outdoor application for site work instruction and real scale anchoring of bridges. Information regarding external funding for course development, if it is connected to green aspects, the level of satisfaction, the number of available places and if it is connected to an Alliance4XR use case are not applicable since the Module has not started yet.

Sweden

In Sweden, although 13 MSc Modules were reported that encompass the Alliance4XR sectors, none of them offers a course in XR technologies. Information regarding external funding for course development, if they are connected to green aspects, the level of satisfaction, the number of available places per course and if they are connected to an Alliance4XR use case are not applicable.

Ukraine

In Ukraine there are 3 MSc courses, 1 BSc and 1 VET course that offer learning in XR technologies. Their basic learning objectives are getting basic knowledge of VR/AR technology, learning to create virtual and augmented reality applications and providing students with the knowledge, skills and abilities necessary to work with virtual, augmented and mixed reality technology. Information regarding external funding for course development, if they are connected to green aspects, the level of satisfaction, the number of available places per course and if they are connected to an Alliance4XR use case could not be found online.

An interesting remark from this desk study is that none of the reported courses integrates XR technologies in enhancing learning. This suggests that there is stronger emphasis in the current academic landscape on creating virtual and augmented reality content and tools, rather than using and integrating XR technologies and best practices into educational frameworks to improve student learning outcomes. There is a potential area for further research and development, emphasising the need for educational institutions to balance the creation of XR technologies with their effective pedagogical use.

6 QUESTIONNAIRE ON CURRENT AND FUTURE PROVISION OF XR-RELATED EDUCATION

To reach out also to organisations not covered by the desk study and to collect opinions on future provision of XR-related courses, a questionnaire was distributed to the partner's networks. The questionnaire was distributed through LimeSurvey[4], to ensure that it was user-friendly and accessible. As a first step, the target audience of the survey was identified, mainly including academic experts. The next step was the design of the questionnaire and ethical approval. The full version of the questionnaire, along with the privacy policy, can be found in Annex 3 of this report. As a next step, the questionnaire was distributed to various distribution channels, which include, but are not limited to:

- **Email**: Personalised emails to identified stakeholders with a link to the questionnaire.
- **Professional Networks**: Distribution through professional networks such as LinkedIn to reach a broader audience.
- **Industry Associations**: Collaboration with industry associations and professional bodies to distribute the questionnaire to their members.
- **Social Media**: Promotion of the questionnaire on the project's social media platforms to increase reach and participation.

In total, the survey collected 28 responses from academia stakeholders. A summary of the responses is provided in Annex 2 of this report. The questionnaire is divided into two sections, where the first section deals with questions about the potential benefits of using XR in education. The second part deals more specifically with the topics of the draft XR taxonomy, to what extent its topics are included in the current courses or considered to be included within the next few years. This section also deals with opinions about the importance of the different topics in the draft XR taxonomy. All questions are of multiple-choice nature except for one, which is a free text question. Figure 6 below illustrates the industrial sectors the respondents are targeting with their teaching.

[4] https://www.limesurvey.org/

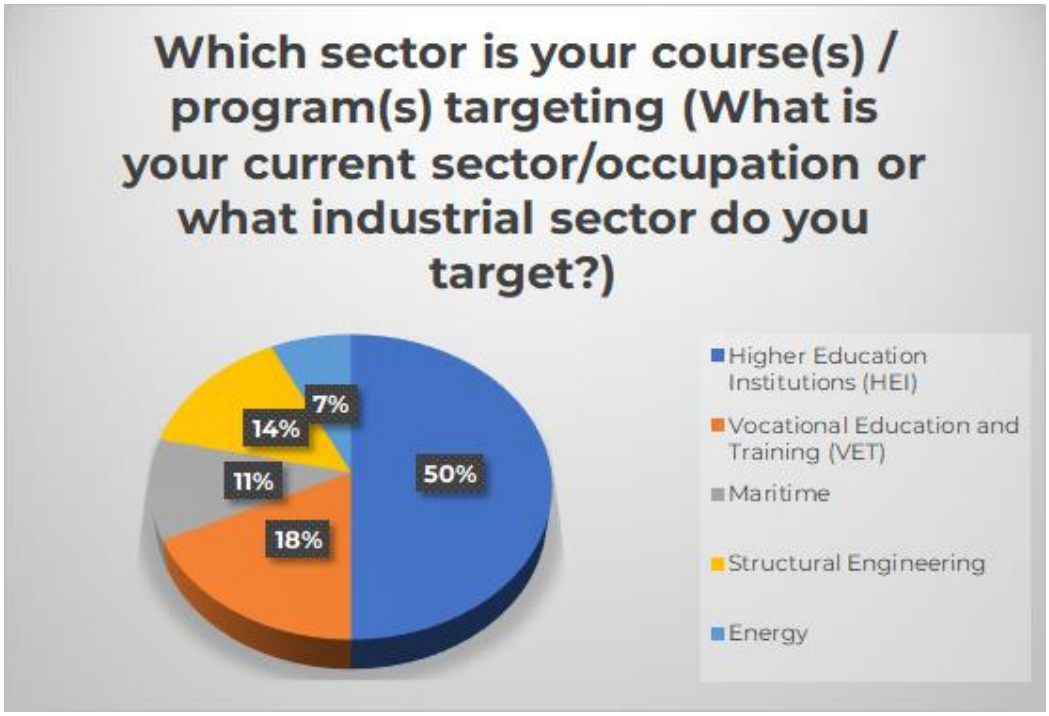


Figure 4 Which sector is your course(s) / program(s) targeting (What is your current sector/occupation or what industrial sector do you target?)

The free text question reads: "How do you think XR technologies can or cannot address the diverse learning needs of students/trainees within your sector?".

The responses regarding the potential of XR technologies in addressing diverse learning needs highlight several key advantages and challenges. Many believe that XR can significantly enhance the learning experience by providing immersive and practical illustrations of theoretical concepts, thus helping students contextualise their knowledge. The technology's ability to offer personalised and self-directed learning paths, adapt to individual learning paces and styles, and simulate real-world scenarios without real-world risks are seen as major benefits. XR is also recognized for facilitating experiential learning, which can be particularly beneficial in fields like operations, maintenance, and medicine.

Respondents also emphasise the collaborative and engaging nature of XR, which can foster motivation and active participation among students. The potential of XR to support Universal Design for Learning (UDL) is noted, as it can offer multiple means of engagement, representation, and expression, thus catering to diverse learning needs. Additionally, XR is praised for its capacity to bring near-actual lessons to life, stimulate creativity, and improve collaborative group work.

However, there are concerns about the high costs associated with developing and preparing XR content. Some respondents point out that while XR can address specific learning needs, it may not be as effective for conveying disciplinary knowledge or complex theoretical concepts. The technology's current limitations in fields such as mechanical engineering and fundamental medical understanding are noted.

7 ANALYSIS OF SUPPLY AND DEMAND.

The current demand of XR knowledge and skills is described in D1.1 - XR state of play, market needs, training trends. In that report, a collection of 57 use cases, describing real and potential usages of XR technologies in various application domains. These use cases are further analysed in chapter 4 of this report.

The D1.1 report highlights how XR technologies are contributing to professional training, for instance VR assisted training for pilots and AR assisted training of assembly processes. In addition, remote collaborative development is also mentioned as an example of XR usage with high potential. Several barriers have also been identified, for instance high initial costs for hardware, software, and content development, technical complexity in integrating XR with existing systems and ensuring compatibility, user resistance and lack of expertise, the need for high-quality and engaging content, infrastructure requirements such as robust internet and processing power, health and safety concerns like eye strain and motion sickness, and data privacy and security issues in handling sensitive information.

The objective of this report (D1.2 - Institutions status and needs analysis) is to specify the gaps between current supply of education and training and the demands of the industry, specifically the three target industrial sectors construction, energy & grids and marine. Based on the gaps being identified, learning material is to be developed, as well as supporting software solutions and training actions. This will be developed and implemented in later stages of the project.

To support the analysis of supply and demand, a draft XR taxonomy has been prepared, consisting of topics to be addressed in future stages of the project, see table 1 in chapter 3.

The use cases specified in D1.1 have been mapped to this draft taxonomy, see chapter 4 of this report. The conclusion drawn is that all topics in the draft taxonomy are addressed by the use cases and are consequently to be considered in the remaining analysis. It should be noted that there is no evidence that the list of use cases is representative for the entire set of XR usages. This means that the amount of use case matchings cannot be used for prioritisation, when selecting topics to be considered in the future stages of the project. Instead, other results reported in D1.1 indicate that there is a need for additional XR tools in professional training (VR and AR). To realise this, a larger pool of XR developers is required together with data science experts, being able to streamline data processing and product development processes.

7.1 Supply of XR courses per industrial sector

The desk study of existing XR-related courses deals with two major questions about the current supply of courses, see tables 3 and 4, namely the industrial sectors the courses are addressing and to what extent they cover the topics specified by the draft XR taxonomy. As mentioned, the desk study covers main institutions in 7 European countries (GR, ES, CY, IR, PT, SE and UA).

Table 3: Industry sectors targeted by XR courses

Industrial sector	Number of countries	Number of courses
Construction	4	7
Energy	1	1
Maritime	2	12
Computer engineering	5	22
Education	1	15
Other	3	3

The industrial sectors being addressed by XR-related courses are summarised in table 3. It should be highlighted that there is a significant variation in the credits awarded across different courses. In addition, the course syllabi being studied did not always reveal enough information about the number of credits related to XR. Due to these limitations in the data, a comparison of credits is not meaningful to perform. In addition, in some countries, especially in the VET sector, national or

regional credit systems are used, not easily translated to European standards like ECTS and ECVET.

The overall conclusion is that the marine sector seems to be well supplied by training courses using XR, but this supply is limited to two countries, primarily Cyprus but also Spain. The construction sector has a wider geographical supply of XR-related courses, covering 4 of the 7 investigated countries. However, the supply is somewhat limited in terms of the number of courses provided. The energy sector is less addressed by existing XR courses and only one course was found in the seven countries being investigated.

Most XR-related courses address other industrial sectors outside the main priorities of the project, such as computer engineering/informatics and education. This conclusion is also supported by the results of the questionnaire, see figure 4 in chapter 6.

7.2 Supply of XR courses per XR topic

Questions related to the supply of XR courses are addressed by the desk study of courses at selected educational institutes and by the questionnaire sent out to the learning institutes.

The courses identified in the desk study have been mapped to the draft XR taxonomy see table 4 below. A hierarchical taxonomy as the one proposed here, is not sufficient for modelling an entire knowledge domain. Since a specific course may be addressing several topics, addressing various industrial domains and addressing concepts in various depth, the draft XR taxonomy needs to be extended to model the variations of courses properly. But since the aim of this study is mainly to identify gaps between supply and demand, the draft taxonomy is sufficient for this task. It should also be noted that the list of courses identified in the desk study is not complete. In addition, the content of the courses is not always described in sufficient detail in the public syllabi published. Consequently, a precise mapping to the topics of the draft XR taxonomy cannot be made. Since a quantitative analysis cannot be made, a weaker mapping to the draft XR taxonomy is made, based on an ordered scale (none, few, many).

Table 4: Number of courses in the desk study addressing the topics in the draft XR taxonomy

XR topic	Indicative number of courses
XR Fundamentals	Many
Tracking technologies	Many, probably included in VR courses
3D Visualisation	Many
3D Audio	Perhaps included in some VR, MR and game development courses
Kinematics	Many, probably included in VR courses
Haptic senses	Few
Mixed reality	Many
Multimodal immersive	Perhaps included in some VR courses
Virtual navigation	Many, probably included in MR, VR and game development courses
Human and ergonomics	Many, probably included in game development courses
XR business development	Few
XR process and product development	Many, primarily development of VR or gaming products
XR usage	Many simulators in the marine sector (CY). Few in the construction sector and none observed in the energy sector.

Considering the observed demand of education in all topics in the draft XR taxonomy, the gap between demand and supply then mainly relates to topics where few or no courses are observed. Table 4 indicates topics dealing with haptic senses, XR business development, process and product development in the priority sectors (construction, energy and marine) as well as XR usage within these sectors, may be examples of gaps to be addressed. It is also observed that there are many (short) courses where different marine related simulators are used, but these courses are available only in one country (Cyprus).

These findings are also verified by the questionnaire submitted to teachers in XR. In this survey, the respondents were asked about their current provision of courses related to the topics as specified in the draft XR curriculum. In addition, they were also asked about their expectations on supply of XR-related courses in the future.

The responses of the survey are described in detail in Annex 2 and summarised in table 5 below.

Table 5. Supply of XR-related courses according to the survey

XR topic	Current supply	Considered to be included	Not currently considered	Important within 5 years
XR Fundamentals	64%	32%	4%	96%
Tracking technologies	44%	40%	10%	77%
3D Visualisation	57%	40%	0%	87%
3D Audio	52%	24%	17%	61%
Kinematics	29%	39%	19%	73%
Haptic senses	26%	34%	27%	67%
Mixed reality	41%	44%	6%	81%
Multimodal interactions in immersive environments	38%	41%	9%	76%
Virtual navigation	38%	47%	6%	83%
Human and ergonomics	34%	40%	12%	70%
XR business development	34%	41%	11%	63%
XR process and product development	37%	33%	12%	63%
XR usage	37%	37%	12%	72%

The second column of table 5 specifies the topics which are taught in current courses, partially or fully. This column should correspond to the results of table 4. According to the desk study, a limited number of courses were found on topics dealing with haptic senses and XR business development, process and product development for the priority sectors (construction, energy and marine). The limited supply of courses in haptic senses is verified by the questionnaire, see table 5 But due to the limited number of responses from teachers in the three priority sectors, a limited supply of business development or process/product development courses in these sectors could neither be verified or denied. Another topic not well covered by existing courses is kinematics.

The third column of table 5 indicates the new developments being considered by the university teachers soon. The expected developments of new courses are in the

fields of virtual navigation, mixed reality, multimodal interactions in immersive environments and business development.

8 TOPICS CONSIDERED TO BE ADDRESSED BY THE ALLIANCE4XR PROJECT

The industrial impact of XR is already evident, with applications and use cases in training, field service, maintenance, and other processes through AR, as well as onboarding and upskilling through VR. The convergence of XR with other technologies like AI is expected to further enhance its adaptability and effectiveness in learning processes.

Based on the results of the supply and demand analysis, the following topics of high priority for further development are (in order)

1. Basic Principles of XR: Respondents overwhelmingly agree on the necessity of understanding the foundational concepts of XR. This indicates a need for comprehensive introductory courses that cover the basics of virtual reality (VR), augmented reality (AR), and mixed reality (MR).
2. Advanced Technologies for Mixed Reality: This topic reflects the growing interest in cutting-edge XR technologies. Curriculum development may include modules on the latest advancements in MR technologies, such as holography and advanced display systems.
3. Usage of XR technologies in various industrial sectors: There is a clear need for additional training tools such as simulators and response to various scenarios. More efficient development tools are needed to reduce the costs associated with the development of applications and products for XR usage.
4. Virtual Navigation Techniques: Effective navigation is key to creating immersive and intuitive XR experiences. Courses and learning material should cover the principles of spatial awareness, user orientation, and wayfinding in virtual environments. Hands-on projects involving navigation challenges will build practical skills.
5. Tracking Technologies: The strong support for this topic suggests that understanding how XR systems track user movements and interactions is crucial. It may be beneficial to include practical workshops or labs that allow students to work with various tracking technologies.

6. 3D Visualization and 3D Audio: The emphasis on these areas indicates that immersive experiences are essential for XR applications. Educational programs should incorporate projects that involve creating and manipulating 3D models and integrating spatial audio to enhance realism.
7. Applying XR technologies in process and product development: Such emphasis suggests that XR can streamline workflows and enhance productivity. Training programs should include simulations and project-based learning that allow students to apply XR technologies to real-world process challenges and product developments.

8. The role of XR for business development: The responses of the questionnaires indicate a strong belief in the role of XR technologies for business development in various industrial sectors. This suggests a need for case studies and real-world applications to be included in the curriculum, focusing on how XR can improve processes, training, and customer engagement in various industries and provide value to the organisation.

Among the emerging trends in XR technologies that also should be considered when specifying future development activities are

- Multimodal Interactions: The interest in "Multimodal Interactions in Immersive Environments" highlights the need for education on how users can interact with XR systems through various input methods (e.g., gestures, voice, and haptics). Training programs should focus on designing user interfaces that accommodate these interactions.
- Haptic Feedback: The inclusion of "Haptic Senses" in the curriculum is significant, as tactile feedback can greatly enhance user experience in XR. Educational institutions should explore partnerships with companies specialising in haptic technologies to provide hands-on experience.

Also, the diverse representation of countries (e.g., Greece, Cyprus, Ireland) may reflect varying levels of XR technology adoption and application in different regions. Educational institutions should consider tailoring their programs to address local industry needs and technological capabilities. When deciding to develop learning material, XR platforms or XR courses, it is recommended that proper value propositions are formulated, addressing the expressed needs of the target groups.

At last, with a significant number of respondents in the 45-54 age range and holding advanced degrees, there is an opportunity to leverage their expertise in XR technologies. Institutions could develop mentorship programs that connect experienced professionals with students to foster knowledge transfer and practical insights.

Thus, the educational programs under development should consider the following aspects:

1. In case VET is addressed, a clear focus on learning objectives adapted to the user needs is recommended. This to reduce the risk of unnecessary development costs and/or equipment.
2. Integrate essential XR subtopics into the curriculum, focusing on both theoretical knowledge and practical applications. This should include hands-on projects and practical assignments.
3. Collaborate with industry leaders in XR technologies to provide students with access to the latest tools and technologies, as well as real-world case studies.
4. Stay updated on emerging trends in XR, such as AI integration, advanced tracking systems, and haptic feedback, to ensure that educational offerings remain relevant.
5. Incorporate experiential learning opportunities, such as internships or co-op programs, to allow students to apply their knowledge in real-world settings.
6. Implement strategies to attract a diverse student body, ensuring that a wide range of perspectives and ideas are represented in the field of XR.

9 CONCLUSIONS

The conclusions of this study may be summarised as follows

- As the XR industry continues to expand, the importance of integrating practical applications and emerging trends into educational programs is likely to grow. Moreover, by fostering partnerships with industry leaders and providing students with hands-on learning opportunities, educational institutions can create a pipeline of skilled professionals ready to tackle the challenges and opportunities presented by XR technologies.

- The findings of the questionnaire highlight the growing importance of incorporating XR technologies into HEI educational programs to meet the evolving needs of the industry. The strong support for topics such as "Basic Principles of XR", “Advanced Technologies for Mixed Reality”, “Usage of XR Technologies”, "3D Visualisation," and "Virtual Navigation Techniques" underscores the need for comprehensive curricula that provide students with a solid foundation in XR concepts and applications.

- There is currently limited emphasis in using and integrating XR technologies and best practices into educational frameworks to improve student learning outcomes. There is a potential area for further research and development, emphasising the need for educational institutions to balance the creation of XR technologies with their effective pedagogical use. This means that the scope of the project may be widened to also include the educational sector in general, not only construction, energy and marine.

- Within the VET sector, there is a need for low-cost solutions aiming to guide the learner in performing operational tasks and making real-world decisions. Simple simulators and gaming applications may be one way forward.
- Although there are limitations in the studies of supply being performed, they arrive at similar conclusions, strengthening their validity.
- The pre-specified achievement indicator of this activity states that at least 3-5 education institutes shall be analysed with respect to needs and missing skills. In total 38 education institutes were investigated by the desk study and 28 responses were obtained through the questionnaire. The target has been superseded.

ANNEX 1: DETAILED RESULTS OF DESK STUDY ON COURSE SYLLABI

A total of 87 courses and programs were studied in the *Alliance4XR* countries. These modules address the targeted sectors of *Alliance4XR (*Grids & Energy, Marine and Construction), although not all of them necessarily offer XR technology courses. In addition, courses in Computer Engineering were also studied. More specifically, 27 out of 87 reported Modules are not offering XR technology related courses.

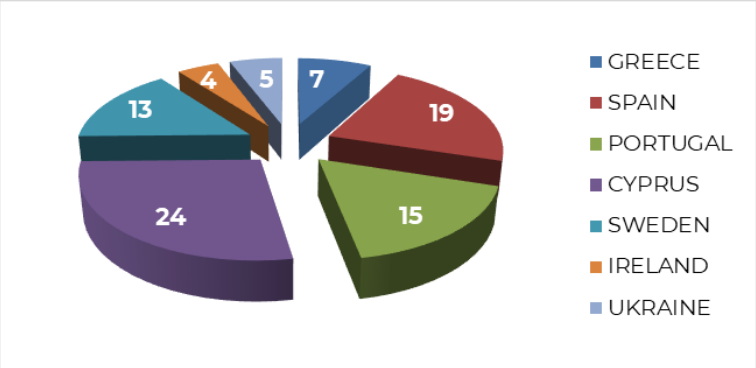


Figure A1.1. Number of studied modules encompassing the targeted sectors of Alliance4XR sorted by country.

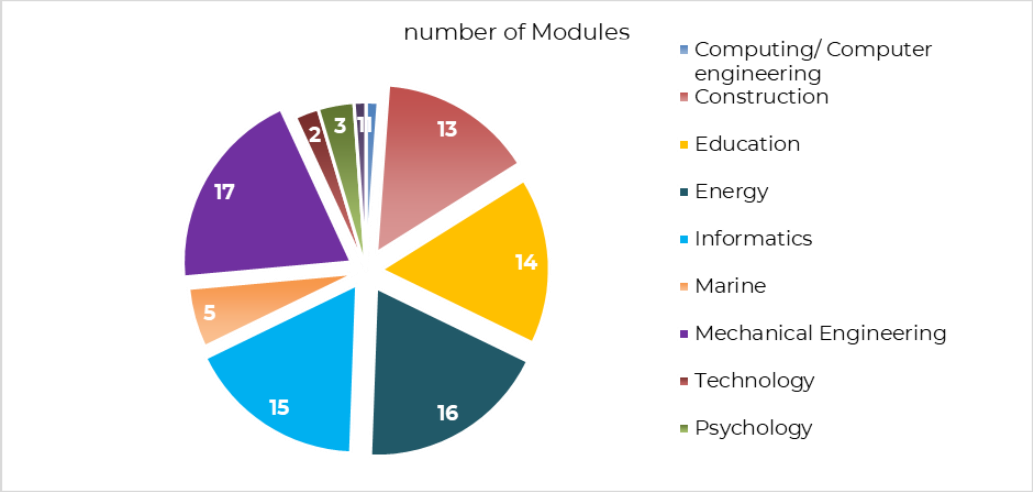


Figure A1.2. Number of modules per sector within Alliance4XR countries

In the following section, the detailed information collected is presented for each country individually

Desk study results of Greece

Table A1.a: Summary of XR Courses in Greece

Greece						
Education institute	**Industrial sector**	**Course name**	**Total credits for the course**	**Level (VET, BSc, MSc, PhD)**	**Included in program (name)**	**Credits related to XR (if deductible)**
AUTh	Computer engineering	Virtual Reality	7.5 ECTS	BSc	Faculty of Sciences- School of Informatics Elective Course belonging to the selected specialization	7.5 ECTS
AUTh	Computer engineering	Virtual Reality	7.5 ECTS	MSc	Faculty of Sciences- School of Informatics Elective Course belonging to the selected specialization	7.5 ECTS
AUTh	Computer engineering	Virtual Reality Systems	5 ECTS	MSc	Faculty of Sciences- School of Informatics Elective Course belonging to the selected specialization	5 ECTS
AUTh	Computer engineering	Virtual Reality	5 ECTS	BSc	Department of Computer, Informatics and Telecommunications Engineering	5 ECTS
International Hellenic University - IHU	Computer engineering	Virtual Reality	7.5 ECTS	MSc	Department of Computer, Informatics and Telecommunications Engineering- Postgraduate study Program in Robotics	7.5 ECTS
University of Patras	Computer engineering	Computer Graphics & Virtual Reality	7.5 ECTS	BSc	Department of Electrical Engineering	7.5 ECTS
University of Ioannina	Computer engineering	Virtual Reality and Augmented Reality	6 ECTS	MSc	Department of Informatics and Telecommunications- Msc Informatics and Network	6 ECTS

Table A1.2: Learning Objectives per course in Greece

Greece			
Education institute	**Course name**	**Level (VET, BSc, MSc, PhD)**	**Learning Objectives**
AUTh	Virtual Reality	BSc	Historical overview. Principles of VR, related scientific disciplines, VR applications. Tracking devices, navigation devices, gesture interfaces. Augmented reality (applications and taxonomy, AR devices, tracking for AR). VR application development using Unreal Engine or Unity.
AUTh	Virtual Reality	MSc	Principles of VR, related scientific disciplines, VR applications
AUTh	Virtual Reality Systems	MSc	To familiarize students with VR/AR devices and to provide them with abilities for designing and developing VR/AR and mobile AR applications using visual, haptic and aural rendering technologies.
AUTh	Virtual Reality	BSc	The course introduces students to mixed reality application development techniques
International Hellenic University - IHU	Virtual Reality	MSc	Basic Concepts: Introduction in computer graphics and virtual reality Advanced topics: virtual reality simulations, Virtual, augmented and mixed reality
University of Patras	Computer Graphics & Virtual Reality	BSc	Knowledge on the computer graphics pipeline, information visualization and virtual reality Knowledge on virtual reality systems, projections, interaction, feedback
University of Ioannina	Virtual Reality and Augmented Reality	MSc	Virtual Reality Hardware Computer 3D Graphics Virtual Reality Application Architecture Augmented Reality Augmented Reality Features VR Application Development Software AR Application Development Software

Desk study results of Spain

Table A1.3: Summary of XR Courses in Spain

Spain						
Education Institute	**Industrial Sector**	**Course Name**	**Total Credits For The Course**	**Level (VET, Bsc, Msc, Phd)**	**Included in Program (Name)**	**Credits Related to XR (If Deductible)**
Universidad Católica De Valencia / Valencian Catholic University	Education/Knowledge	Bachelor's Degree in Animation and Video Game Design and Narration	240 ECTS (Module outline)	BSc	N/A	8 ECTS
Universidad Autónoma De Barcelona	Education / University	Bachelor's Degree in Interactive Communication	240 ECTS (Module outline)	BSc	N/A	6 ECTS
Universidad De Alicante / University of Alicante	Education /Knowledge	Virtual Reality	6 ECTS	BSc	Multimedia Engineering	6 ECTS
Universidad Jaume I (Castellón) // Jaume I University (Castellón)	Education/Knowledge	Bachelor's Degree in Video Game Development and Design	240 ECTS (Module outline)	BSc	N/A	54 ECTS
Unie Universidad	Education/ Knowledge	Bachelor's Degree in Audio-visual Communication	240 ECTS (Module outline)	BSc	N/A	12 ECTS
Universidad Politécnica De Valencia	Education/Knowledge	Bachelor's Degree in Digital Technology and Multimedia	240 ECTS (Module outline)	BSc	N/A	24 ECTS

Universidad De Valencia // University of Valencia	Education/Knowledge	Master's Degree in Web Technologies, Cloud Computing, And Mobile Applications	60 ECTS	MSc	N/A	8 ECTS
Euneiz (Vitoria-Gasteiz)	Education/Knowledge	Bachelor's Degree in Art and Animation for Video Games	240 ECTS (Module outline)	BSc	N/A	48 ECTS
Ceu-Cardenal Herra (University)	Education / Knowledge	BSc Degree in Engineering of Industrial Design and Product Development	240 ECTS (Module outline)	BSc	N/A	60 ECTS
Institut D'educació Secundària Álvaro Falomir	Education/Knowledge	VR & AR	N/A	VET	Game Development and Virtual Reality	180 ECTS
ESCUELA SUPERIOR DE ARTE Y TECNOLOGÍA //High School of Art and Technology	Education/ Knowledge	3D Design for VR	Private (No Credits)	VET	No	160 ECTS
Florida Universitaria (University)	Education/Knowledge	Online High Technician In 3D Animation, Games, And Interactive Environments	N/A	VET	N/A	N/A
Colegio Oficial De Arquitectos De Valencia //Official College of Architects of Valencia	Construction	PRACTICAL COURSE IN VIRTUAL AND AUGMENTED REALITY WITH UNITY3D	N/A	MSc	No	N/A

Universidad Politécnica De Valencia	Education / Knowledge	Bachelor's Degree in Interactive Technologies	240 ECTS (Module outline)	BSc	Bachelor's Degree In Interactive Technologies	21 ECTS
TECH School Of Design	Education	Módulo 8: Immersive VR Game Módulo 9: Professional 3D Audio for VR Video Games	60 ECTS	MSc	Máster En Animación 3D Y Realidad Virtual (Online)	N/A
Unir (The Internet University)	Education/Knowledge	Extended Reality: Virtual, Augmented, And Mixed Reality	60 ECTS	MSc	All	60 ECTS
Universitat Politècnica De Catalunya (UPC)	Computer Or Product Engineers	INTERACTIVE DESIGN: VIRTUAL REALITY, AUGMENTED REALITY AND 3D	15 ECTS	BSc	What Is Augmented Reality (AR)? History Of the AR. AR Applications. AR Platforms and Technologies. Impact Of AR. Development of Augmented Reality Applications Introduction to AR Application Development. Tools And Sdks for AR Development. Design Of AR Experiences. AR Application Programming. Publishing AR Apps. Ethical And Legal Considerations Privacy and Security in AR. Ethical Problems of AR. The Future of AR.	1 ECTS

Communication@Euroxr-Association.Org	Marine	Master In Naval and Ocean Engineering	60 ECTS	MSc	Digital Twins	N/A
Universitat Politècnica De Catalunya (UPC)	Construction	master's degree in BIM management. digital transformation and new business models	60 ECTS	MSc	Virtual Reality.	10 ECTS

Table A1.4: Learning Objectives per course in Spain

Spain			
Education institute	**Course name**	**Level (VET, BSc, MSc, PhD)**	**Learning Objectives**
Universidad Católica De Valencia / Valencian Catholic University	Bachelor's Degree in Animation and Video Game Design and Narration	BSc	Learning to tell stories and portray them graphically forms the fundamental basis of the profession, as it involves acquiring the creative ability necessary to produce engaging work, along with the technical skills to execute it, thanks to the use of essential design and programming software.
Universidad Autónoma De Barcelona	Bachelor's Degree in Interactive Communication	BSc	To became a professional in the creation of interactive products and services: designing complex websites, communication interfaces, experiences adapted to different environments, applications that enhance user experience, analysis and visualization of big data, animation of objects and characters, and creation of virtual landscapes (video games, augmented reality scenarios, virtual reality, immersive experiences). Learn to integrate technological innovations and emerging digital production tools to lead and manage interactive communication projects.

Universidad De Alicante / University of Alicante	Virtual Reality	BSc	- Analyze, design, and build systems and applications that require parallel, concurrent, distributed, and real-time programming techniques. - Acquire and apply the principles, techniques, and technologies of Virtual Reality. - Understand and apply advanced audiovisual post-production techniques that integrate different types of content, both synthetically generated and sourced from capture devices.
Universidad Jaume I (Castellón) // Jaume I University (Castellón)	Bachelor's Degree in Video Game Development and Design	BSc	((Among others) - Knowledge and application of fundamental principles and basic techniques of parallel, concurrent, distributed, and real-time programming. - Knowledge and application of fundamental principles and basic techniques of intelligent systems and their practical application. - Knowledge and application of principles, methodologies, and life cycles of software engineering in the field of video games. - Ability to design and evaluate human-computer interfaces that ensure accessibility and usability for systems, services, and computer applications.
Unie Universidad	Bachelor's Degree in Audio-visual Communication	BSc	Direction of audiovisual and cultural projects. Production of audiovisual projects. Marketing and distribution of audiovisual content. Management of audiovisual companies. Editing and post-production. Television production. Development and supervision of audiovisual scripts. Operation of camera, sound, and lighting. Specialization in digital media and platforms (podcasts, augmented reality, streaming, social networks, etc.).

Universidad Politécnica De Valencia	Bachelor's Degree in Digital Technology and Multimedia	BSc	Planning, deployment, and management of networks; creation of audiovisual content; streaming platforms and content; administration of digital infrastructures; development of applications; user interfaces and usability; Industry 4.0 and IoT (Internet of Things); e-commerce; audiovisual production centers; entertainment.
Universidad De Valencia // University of Valencia	Master's Degree in Web Technologies, Cloud Computing, And Mobile Applications	MSc	Development of professional and research activities, as well as the use of equipment in the field of Information and Communication Technologies, with a special emphasis on modelling, design, implementation, evaluation, and management of network services, mobile applications, and cloud computing. This is achieved through knowledge of new trends and research lines in this area.
Euneiz (Vitoria-Gasteiz)	Bachelor's Degree in Art and Animation for Video Games	BSc	(Among a long list of them) Mathematical techniques and tools in multimedia developments. Programming languages and development, databases, and software methodologies related to computer science and multimedia. Computer structure and architecture, from hardware architecture to "Maker" methodologies present in this field of study. Creativity and innovation based on the foundations provided by technology, anthropology, culture, and the justification of ideas. Tools for digital illustration and photography, fundamentals of graphic design, typography, and multimedia content layout. Collaborative tools and application of agile manifesto principles and associated methodologies. User-centered design solutions focusing on UX, interface design, human-computer interaction, prototyping tools, and system testing. Process management mechanisms, memory resources, and file systems across different transmission media and networks. Signals, analog and digital systems, signal representation and modulation, transformations, and filtering.

Ceu-Cardenal Herra (University)	BSc Degree in Engineering of Industrial Design and Product Development	BSc	Several related to Industrial design
Institut D'educació Secundària Álvaro Falomir	VR & AR	VET	Video Game Programmer Video Game Tester Video Game Designer 2D and 3D Game Artist Independent Game Developer Developer of Virtual, Augmented, and Mixed Reality Applications Expert in Artificial Intelligence for Video Games
ESCUELA SUPERIOR DE ARTE Y TECNOLOGÍA //High School of Art and Technology	3D Design for VR	VET	Understand the proper workflow for developing 3D models for Virtual Reality. Comprehend the fundamentals of optimal topology and how to shape ideas with the aim of implementation in a VR environment. Understand the correct workflow required for creating models and scenes with the necessary optimization for the proper functioning of the VR scene, using a simple pipeline with 3DsMax and Substance Painter, and knowledge of topology and texturing. Create a navigable VR scene, 3D modelling and texturing, and have extensive knowledge in 3D design for VR.
Florida Universitaria (University)	Online High Technician In 3d Animation, Games, And Interactive Environments	VET	Utilize and master a selection of the most in-demand technologies in the market, while acquiring a set of skills that will facilitate your entry into the workforce: Use the leading software in the industry Model appealing characters, props, and environments Create fantastic animations in both 2D and 3D Set up characters and elements for animation (Rigging) Master Unity, one of the most powerful engines Design video games and create various mechanics

			Generate the necessary functions for in-game interaction Publish your games and applications on multiple platforms
Colegio Oficial De Arquitectos De Valencia //Official College of Architects of Valencia	Practical Course in Virtual and Augmented Reality with Unity3d	MSc	Understand and use the leading software in the market for the development of multisectoral Virtual Reality (VR) and Augmented Reality (AR) experiences. Leading Market Software Foundations: UNITY3D Design of levels. 3D Programming. Learn the basics of bringing our level designs to a mobile VR platform. Create a first Virtual Reality project for Android mobile.

Universidad Politécnica De Valencia	Bachelor's Degree in Interactive Technologies	BSc	Design and Implement Programs for Interactive Products Programming Electronic Data Acquisition Devices and Control Systems Programming electronic devices for data acquisition and control systems. Mobile Device Programming Development and programming of mobile applications. Application Communication Establishing communication between different applications. Information Storage and Management Techniques for storing and managing information. Graphical Interfaces, Including Web Applications Creating graphical user interfaces, including web-based applications. Algorithm Programming for Information Processing Developing algorithms for processing information, including games and artificial intelligence when required. Utilize Geographic Information Technologies (GPS, GIS, Online Cartography) Geographic Information Systems (GIS) Utilizing Geographic Information Systems (GIS) for spatial data management and analysis. GPS Technology Applying GPS technology for location-based services and data collection. Online Cartography Creating and managing online maps and cartographic resources. Understand and Use Network Architecture Concepts, Protocols, and Telematic Network Interfaces. Design and Operate Telematic Networks Network Architecture and Protocols Understanding network architecture concepts and telecommunication protocols. Telematic Network Design and Operation Designing and managing telematic networks for data communication.

			Develop Applications for Controlling Internet-Connected Devices IoT System Architecture Designing the architecture for Internet of Things (IoT) systems. IoT Device Programming Programming devices for IoT applications. Communication Networks and Protocols for IoT Developing communication networks and protocols for IoT devices and applications. Development of IoT Management Applications Creating applications for managing and controlling IoT systems. Traducción Completa en Inglés

TECH School Of Design	Módulo 8: Immersive VR Game Módulo 9: Professional 3D Audio for VR Video Games	MSc	Master 3D Max Organize the Workspace Professionally and Apply Best Practices Create Interactive 3D Environments Using Materials from the Master's Program Create Animated 3D Characters Learn Advanced Texturing Techniques and Brush Types Specialize in Digital Sculpting with ZBrush Master Cinematic Creation Learn to Create Facial Rigs and Lip Sync Use Unity 3D and Unreal Engine to Test Game Content Create 2D and 3D Game Prototypes with Mechanics and Physics Develop Prototypes for AR and Mobile Devices Efficiently Program Artificial Intelligence Apply Ragdoll Simulation Technology Use an Effective Version Control System Learn the Production Process and Project Management Basics Understand Why Agile Methodologies are Used in Professional Development
Unir (The Internet University)	Extended Reality: Virtual, Augmented, And Mixed Reality	MSc	Develop Extended Reality Applications Allowing Users to Interact with Virtual Elements. Apply Programming Tools and Development Engines to Build Dynamic Elements with Autonomous Actions. Use 3D Development Tools Adapted to the Needs of Extended Reality. Analyze Mobile App Interface Design and Its Applicability to Extended Reality. Evaluate Psychological and Cultural Factors Affected by Extended Reality, Focusing on Immersive Experiences.
Universitat Politècnica De Catalunya (UPC)	Interactive Design: Virtual Reality, Augmented Reality And 3d	BSc	Train students so they can work developing immersive and 3D reality projects. To equip students with a solid foundation in some of the technologies that will impact many sectors

Communication@Euroxr-Association.Org	Master In Naval and Ocean Engineering	MSc	Have a global vision of all stages of the life cycle of a naval project Possess and understand knowledge that provides a basis for the development of research ideas Conceive and develop appropriate technical and economic solutions for naval projects Develop the conceptual design that meets the shipowner's requiremen cost estimate and also a risk assessment Work and negotiate with the shipowner from the designer's point of vie define the mission of the ship, and help the ship owner define the ship according to their needs Apply the knowledge acquired and your problem-solving ability in new environments related to Naval Engineering Solve complex problems and make responsible decisions Acquire the basis of scientific and technological knowledge applicable i Naval and Oceanic Engineering and management methods Be able to organize and lead multidisciplinary work groups in a multilin environment Acquire fundamental knowledge of the project of a ship, its structure, machinery and facilities on board Know the scope of detailed engineering of structure, armament, electri authorization and air conditioning Know how to organize and control the construction, repair, transformati maintenance and inspection processes of naval projects Deepen the management of the shipyard, having a global and current v of all its departments Acquire knowledge of vessel operation throughout its flow line Know in detail the latest trends in innovation and development in the n market, at all stages of the project life cycle, from the beginning of the d to the operation and scrapping of the vessel or artifact

Universitat Politècnica De Catalunya (UPC)	Master's Degree in Bim Management. Digital Transformation and New Business Models	MSc	To understand BIM methodology, know how to apply it and be able to convey it by internalising its methodological and ideological principles. To undertake commissions for building, structures, facilities or civil work To undertake construction projects during the project execution phase. To use BIM during the operation and maintenance phase. To calculate the cost of executing the project and plan its construction. To manage projects using BIM, confirming compliance with the requirements of the assignment, analysing the content of the constituer models, and organising work processes that permit multidisciplinary coordination. To interpret bidding specifications with clauses related to BIM to correct size the resources needed to comply with them. To access new market niches.

Desk study results of Cyprus

Table A1.5: Summary of XR Courses in Cyprus

Cyprus						
Education Institute	**Industrial Sector**	**Course Name**	**Total Credits For The Course**	**Level (VET, Bsc, Msc, Phd)**	**Included in Program (Name)**	**Credits Related to XR (If Deductible)**
The Cyprus Institute	Computational Physics and Engineering	High Performance Computing and Machine Learning	90 ECTS	MSc	High Performance Computing and Machine Learning MSc or MSc/MPhil	N/A

Human Resource Development Authority of Cyprus (HRDA)	Construction	No XR course offered.	N/A	N/A	N/A	N/A
Cyprus Marine and Maritime Institute (CMMI)	Marine	No XR course offered.	N/A	N/A	N/A	N/A
Mediterranean Maritime Academy	Marine	BRM / BTM – Ship handling	N/A (duration: 5 days)	VET	Officers in Charge of a Navigational Watch - STCW Courses	N/A
Mediterranean Maritime Academy	Marine	ERM / ERS (Engine Resource Management/ Engine Room Simulator)	N/A (duration: 5 days)	VET	Officers in Charge of an Engineering Watch - STCW Courses	N/A
Mediterranean Maritime Academy	Marine	ECDIS (Electronic Chart Display & Information System)	N/A (duration: 5 days)	VET	Officers in Charge of a Navigational Watch - STCW Courses	N/A
Mediterranean Maritime Academy	Marine	GMDSS (Global Maritime Distress and Safety System)	N/A (duration: 18 days)	VET	Officers in Charge of a Navigational Watch - STCW Courses	N/A
Mediterranean Maritime Academy	Marine	ARPA (Automatic Radar Plotting Aid)	N/A (duration: 5 days)	VET	Officers in Charge of a Navigational Watch - STCW Courses	N/A
Mediterranean Maritime Academy	Marine	Cargo Handling Simulator	N/A (duration: 5 days)	VET	Officers in Charge of a Navigational Watch - STCW Courses	N/A

Mediterranean Maritime Academy	Marine	Ice Navigation Course	N/A (duration: 3 days)	VET	Officers in Charge of a Navigational Watch - STCW Courses	N/A
Cyprus Maritime Academy (CyMA) in collaboration with Intercollege and the University of Nicosia	Marine	Nautical Electronic Instruments	6 ECTS	BSc	Nautical Sciences Programme	1 ECTS
Cyprus Maritime Academy (CyMA) in collaboration with Intercollege and the University of Nicosia	Marine	GMDSS	7 ECTS	BSc	Nautical Sciences Programme	3 ECTS
Cyprus Maritime Academy (CyMA) in collaboration with Intercollege and the University of Nicosia	Marine	ARPA & RADAR – Watch Keeping	6 ECTS	BSc	Nautical Sciences Programme	2 ECTS
Cyprus Maritime Academy (CyMA) in collaboration with Intercollege and the University of Nicosia	Marine	Simulation BTM – BRM – BMS	6 ECTS	BSc	Nautical Sciences Programme	2 ECTS
Cyprus University of Technology (CUT)	Computer Engineering	Computer Graphics	5 ECTS	BSc	Computer Engineering and Informatics	N/A
University of Cyprus (UCY)	Computer Science	Human Computer Interaction	7.5 ECTS	BSc	Department of Computer Science (Specialization: Real World Computation)	N/A
University of Cyprus (UCY)	Construction	Construction Management II	5 ECTS	BSc	Civil and Environmental Engineering	N/A

European University of Cyprus	Computer Science	Human Computer Interaction	6 ECTS	BSc	Computer Science	N/A
Frederick University	Mechanical Engineering	Advanced Manufacturing Processes	6 ECTS	BSc	Mechanical Engineering	N/A
University of Nicosia	Informatics	Extended Reality	10 ECTS	MSc	Metaverse	N/A
University of Nicosia	Informatics	Virtual and Augmented Reality Development	10 ECTS	MSc	Metaverse	N/A
University of Nicosia	Informatics	Virtual World Architectures	10 ECTS	MSc	Metaverse	N/A
University of Cyprus	Informatics	Virtual Reality	7.5 ECTS	MSc	Master's in games	N/A
University of Cyprus	Informatics	Human-Computer Interaction	7.5 ECTS	BSc	BSc in Computer Engineering	N/A

Table A1.6: Learning Objectives per course in Cyprus

Cyprus			
Education institute	**Course name**	**Level (VET, BSc, MSc, PhD)**	**Learning Objectives**
The Cyprus Institute	High Performance Computing and Machine Learning	MSc	Theoretical with practically focused training through lectures and laboratory work, using state-of-the-art supercomputers.

Human Resource Development Authority of Cyprus (HRDA)	No XR course offered.	N/A	N/A
Cyprus Marine and Maritime Institute (CMMI)	No XR course offered.	N/A	N/A
Mediterranean Maritime Academy	BRM / BTM – Ship handling	VET	Lectures and use of simulators.
Mediterranean Maritime Academy	ERM / ERS (Engine Resource Management/ Engine Room Simulator)	VET	Lectures and use of simulators.
Mediterranean Maritime Academy	ECDIS (Electronic Chart Display & Information System)	VET	Lectures and use of simulators.
Mediterranean Maritime Academy	GMDSS (Global Maritime Distress and Safety System)	VET	Lectures and use of simulators.
Mediterranean Maritime Academy	ARPA (Automatic Radar Plotting Aid)	VET	Lectures and use of simulators.
Mediterranean Maritime Academy	Cargo Handling Simulator	VET	Use of simulator.
Mediterranean Maritime Academy	Ice Navigation Course	VET	Lectures and use of simulators.
Cyprus Maritime Academy (CyMA) in collaboration with Intercollege and the University of Nicosia	Nautical Electronic Instruments	BSc	Lectures, textbooks, in-class assignments, use of the above electronic instruments or Bridge simulator or other equivalent method.

Cyprus Maritime Academy (CyMA) in collaboration with Intercollege and the University of Nicosia	GMDSS	BSc	GMDSS simulation and theory (use of textbooks).
Cyprus Maritime Academy (CyMA) in collaboration with Intercollege and the University of Nicosia	ARPA & RADAR – Watch Keeping	BSc	ARPA simulation and theory (use of textbooks).
Cyprus Maritime Academy (CyMA) in collaboration with Intercollege and the University of Nicosia	Simulation BTM – BRM – BMS	BSc	Bridge simulator and theory (use of textbooks).
Cyprus University of Technology (CUT)	Computer Graphics	BSc	The module may have the form of an exercise, a tutorial, a workshop, a lecture, a seminar or a combination of all.
University of Cyprus (UCY)	Human Computer Interaction	BSc	N/A
University of Cyprus (UCY)	Construction Management II	BSc	Lectures, Laboratories, Textbooks.
European University of Cyprus	Human Computer Interaction	BSc	Lectures, Textbooks.
Frederick University	Advanced Manufacturing Processes	BSc	The material is mostly presented by lectures, through textbooks, although demonstration of some manufacturing methods and site visits are performed.

Desk study results of Ireland

Table A1.7: Summary of XR Courses in Ireland

Ireland						
Education institute	**Industrial sector**	**Course name**	**Total credits for the course**	**Level (VET, BSc, MSc, PhD)**	**Included in program (name)**	**Credits related to XR (if deductible)**
Technological University of Shannon	Computer Software	Software Design with Virtual Reality and Gaming – BSc (Hons)	240 ECTS (Module outline)	BSc	As a student on the course, you will work with the latest tools and technologies to enhance your skillset. Software development languages, tools and methodologies provide the backbone of this programme. These skills are critical to following a career in the VR game development industry, but they also have widespread application across many domains. https://tus.ie/courses/us713/	5 ECTS
UCD School of Computer Science	Computer Science	UCD School of Computer Science: Augmented and Virtual Reality (COMP3025J)	5 ECTS	BSc	The course will cover recent developments in the field and teach the fundamental foundations of Mixed Reality, which combines both fields. The course material includes: - History of Augmented and Virtual Reality (AR/VR) - Display technologies to produce AR/VR environment (Reality-Virtuality continuum) - Tracking technologies - 3D Reconstruction - 3D Printing - VR/AR Game Engines - Mobile AR/VR - CAVE VR Environments - VR HMD - 3D photogrammetry - Computer vision fundamentals - Case study on Medical VR/AR applications - Case study on Educational VR/AR applications Course overview: https://hub.ucd.ie/usis/!W_HU_MENU.P_PUBLISH?p_tag=MODULE&MODULE=COMP3025J&TERMCODE=202100	N/A

Chang'an-Dublin International College (CDIC & UCD)	Construction	Digital Construction (CVEN3006W)	5 ECTS	BSc	Chang'an Dublin International College of Transportation (CDIC) is a joint international college established in collaboration between University College Dublin (UCD) and Chang'an University (CHD). Students are awarded degrees by both Chang'an University (CHD) and University College Dublin. This module introduces digital modelling and information management in construction projects. The module provides a range of theory, and technical concepts associated with projects based on nD modelling. Students will evaluate and improve the management of construction projects by adopting Building Information Modelling (BIM) tools. Course overview: https://hub.ucd.ie/usis/!W_HU_MENU.P_PUBLISH?p_tag=MODULE&MODULE=CVEN3006W&TERMCODE=202300	N/A
Munster Technological University	Mechanical and Manufacturing Engineering	Bachelor of Engineering (Hons) in Mechanical and Manufacturing Engineering	240 (Module outline found here)	BSc	The REEdI (Rethinking Engineering Education in Ireland) BEng (Honours) in Mechanical and Manufacturing Engineering is a blended degree that brings in the best of manufacturing and mechanical engineering, culminating in flexible and adaptable engineers to meet industry needs. The REEdI student engineer will learn about the design and development of processes whilst also gaining an equally strong knowledge of the design, development and operation of products and equipment. Course Overview: https://www.mtu.ie/courses/mt834/#about-the-course	5 ECTS
Technological University of Shannon	Computer Software	Software Design with Virtual Reality and Gaming – BSc (Hons)	240 ECTS (Module outline)	BSc	As a student on the course, you will work with the latest tools and technologies to enhance your skillset. Software development languages, tools and methodologies provide the backbone of this programme. These skills are critical to following a career in the VR game development industry, but they also have widespread application across many domains. https://tus.ie/courses/us713/	5 ECTS

Table A1.8: Learning Objectives per course in Ireland

Ireland			
Education institute	**Course name**	**Level (VET, BSc, MSc, PhD)**	**Learning Objectives**
Technological University of Shannon	Software Design with Virtual Reality and Gaming – BSc (Hons)	BSc	Graduates of this programme will be able to: • Demonstrate technical, soft skill and transversal skill competencies work effectively and professionally as an individual or within multidisciplinary teams • Apply acquired skills and knowledge required to solve problems and collaborate with subject matter experts (SMEs)
UCD School of Computer Science	UCD School of Computer Science: Augmented and Virtual Reality (COMP3025J)	BSc	Acquire knowledge of fundamental techniques to produce virtual reality (VR) and augmented reality (AR) applications. The student will have knowledge of the latest developments in VR/AR and the competence to improve on this understanding in the future. They will also be exposed to the fundamental concepts of image processing used in VR/AR applications.
Chang'an-Dublin International College (CDIC & UCD)	Digital Construction (CVEN3006W)	BSc	• Define the concepts and process of information management and understand the difference between 3D modelling. • Investigate and practice BIM tools associated with the construction project stages. • Describe qualitative and quantitative construction management techniques, their uses, benefits and limitations. • Apply appropriate sources of information in construction projects and explain proper techniques to manipulate data in assessing the projects. • Evaluate the benefits of various management and technique skills by Performing a BIM case study.

Munster Technological University	Bachelor of Engineering (Hons) in Mechanical and Manufacturing Engineering	BSc	Graduates of this programme will be able to: • Demonstrate technical, soft skill and transversal skill competencies work effectively and professionally as an individual or within multidisciplinary teams • Apply acquired skills and knowledge required to solve problems and collaborate with subject matter experts (SMEs) • Research and develop potential solutions to problems • Interpret engineering drawings, SI units, specifications, engineering standards, regulatory requirements • Demonstrate implementation of principles and application of the concepts involved in operational excellence and lean 6-sigma • Demonstrate an in-depth knowledge of digital / immersive technology and identify opportunities to utilise these effectively in industry • Recognise good leadership attributes and look for continuous professional development (CPD) opportunities to develop these • Demonstrate awareness of the UN Sustainable Development Goals (SDGs) and the importance of the engineer's role in society

Desk study results of Portugal

Table A1.9: Summary of XR Courses in Portugal

Portugal						
Education institute	**Industrial sector**	**Course name**	**Total credits for the course**	**Level (VET, BSc, MSc, PhD)**	**Included in program (name)**	**Credits related to XR (if deductible)**
Escola Profissional do Fundão	Construction	N/A	N/A	N/A	N/A	N/A
Escola Profissional Gustave Eiffel	Construction	N/A	N/A	N/A	N/A	N/A
Escola Profissional Gustave Eiffel	Energy	N/A	N/A	N/A	N/A	N/A
Escola Profissional da Moita	Energy	N/A	N/A	N/A	N/A	N/A
Escola Superior Técnica Profissional (IPCA)	Energy	N/A	N/A	N/A	N/A	N/A
Instituto Politécnico da Maia (IPMAIA)	Construction	N/A	N/A	N/A	N/A	N/A
Escola Superior Náutica Infante D. Henrique	Marine	N/A	N/A	N/A	N/A	N/A
Escola Superior Náutica Infante D. Henrique	Energy	N/A	N/A	N/A	N/A	N/A
ISEC Lisboa	Energy	N/A	N/A	N/A	N/A	N/A
Instituto Politécnico de Tomar	Energy	N/A	N/A	N/A	N/A	N/A
Instituto Politécnico de Bragança	Energy	N/A	N/A	N/A	N/A	N/A
ISPGAYA	Energy	N/A	N/A	N/A	N/A	N/A

Politécnico do Porto	Energy	N/A	N/A	N/A	N/A	N/A
Instituto Politécnico de Castelo Branco	Energy	N/A	N/A	N/A	N/A	N/A
University of Minho	Construction	(From September 2024)	3 ECTS	MSc	Included in NORISK Erasmus + programme	N/A

Table A1.10: Learning Objectives per course in Portugal

Portugal			
Education institute	**Course name**	**Level (VET, BSc, MSc, PhD**	**Learning Objectives**
Escola Profissional do Fundão	N/A	N/A	N/A
Escola Profissional Gustave Eiffel	N/A	N/A	N/A
Escola Profissional Gustave Eiffel	N/A	N/A	N/A
Escola Profissional da Moita	N/A	N/A	N/A
Escola Superior Técnica Profissional (IPCA)	N/A	N/A	N/A
Instituto Politécnico da Maia (IPMAIA)	N/A	N/A	N/A
Escola Superior Náutica Infante D. Henrique	N/A	N/A	N/A
Escola Superior Náutica Infante D. Henrique	N/A	N/A	N/A
ISEC Lisboa	N/A	N/A	N/A
Instituto Politécnico de Tomar	N/A	N/A	N/A
Instituto Politécnico de Bragança	N/A	N/A	N/A
ISPGAYA	N/A	N/A	N/A
Politécnico do Porto	N/A	N/A	N/A
Instituto Politécnico de Castelo Branco	N/A	N/A	N/A

University of Minho	3 ECTS	MSc	Indoor application for digital design + Outdoor application for site work instruction and real scale anchoring of bridges

Desk study results of Sweden

Table A1.11: Summary of XR Courses in Sweden

Sweden						
Education institute	**Industrial sector**	**Course name**	**Total credits for the course**	**Level (VET, BSc, MSc, PhD)**	**Included in program (name)**	**Credits related to XR (if deductible)**
KTH	Marine	N/A	N/A	MSc	Master program, marine technology	0
Chalmers	Marine	N/A	N/A	MSc	Nordic Five Tech	0
Blekinge Tekniska Högskola	Marine	N/A	N/A	MSc	Civilingenjör i marin teknik	0
KTH	Construction	N/A	N/A	MSc	Transport and Geoinformation Technology	0
KTH	Energy	N/A	N/A	MSc	Masterprogram, miljövänliga energisystem	0
Luleå University of Technology	Construction	N/A	N/A	MSc	Civilingenjör Väg- och vattenbyggnad	0

Luleå University of Technology	Energy	N/A	N/A	MSc	Civilingenjör Hållbar energiteknik	0
Chalmers	Construction	N/A	N/A	MSc	SAMHÄLLSBYGGNADSTEKNIK, CIVILINGENJÖR	0
Chalmers	Energy	N/A	N/A	MSc	HÅLLBARA ENERGISYSTEM, MASTERPROGRAM	0
Lund University	Construction	N/A	N/A	MSc	Civilingenjör i väg- och vattenbyggnad	0
Lund University	Energy	N/A	N/A	MSc	Sustainable Energy Engineering - Master's Programme	0
Linköpings universitet	Construction	N/A	N/A	MSc	Masterprogram i digitaliserat byggande	0
Linköpings universitet	Energy	N/A	N/A	MSc	Civilingenjör i energi - miljö - management	0

Table A1.12: Learning Objectives per course in Sweden

Sweden			
Education institute	**Course name**	**Level (VET, BSc, MSc, PhD)**	**Learning Objectives**
KTH	N/A	N/A	N/A
Chalmers	N/A	N/A	N/A
Blekinge Tekniska Högskola	N/A	N/A	N/A
KTH	N/A	N/A	N/A
KTH	N/A	N/A	N/A
Luleå University of Technology	N/A	N/A	N/A
Luleå University of Technology	N/A	N/A	N/A

Chalmers	N/A	N/A	N/A
Chalmers	N/A	N/A	N/A
Lund University	N/A	N/A	N/A
Lund University	N/A	N/A	N/A
Linköpings universitet	N/A	N/A	N/A
Linköpings universitet	N/A	N/A	N/A

Desk study results of Ukraine

Table A1.13: Summary of XR Courses in Ukraine

Ukraine						
Education institute	**Industrial sector**	**Course name**	**Total credits for the course**	**Level (VET, BSc, MSc, PhD)**	**Included in program (name)**	**Credits related to XR (if deductible)**
Zhymoryr Polytechnic State University	Technical	Virtual and Augmented Reality	N/A but the course is optional	BSc	Information systems and technologies; Computer Science	N/A but the course is optional
Igor Sikorsky Kyiv Polytechnic Institute	Energy	Methods of virtual reality synthesis	4 ECTS	MSc	Digital Technologies in Energy Industry	4 ECTS
Ukrainian State University of Science and Technology	Technology	Virtual Reality and 3D Modelling	4 ECTS	MSc	Information - management systems and technologies	4 ECTS
Sumy State University	Psychology	Virtual technologies of the psychologist's work in organizations	5 ECTS	MSc	Organisational psychology	5 ECTS
Technical College of Lutsk National Technical University	Technology	Technologies of Virtual Reality	5 ECTS	VET	Computer Engineering	5 ECTS

Table A1.14: Learning Objectives per course in Ukraine

Ukraine			
Education institute	**Course name**	**Level (VET, BSc, MSc, PhD)**	**Learning Objectives**
Zhymoryr Polytechnic State University	Virtual and Augmented Reality	BSc	Get basic knowledge of VR/AR technology. Learn to create virtual and augmented reality applications for various types of computer equipment.
Igor Sikorsky Kyiv Polytechnic Institute	Methods of virtual reality synthesis	MSc	The purpose of the credit module is to provide students with a comprehensive understanding of virtual reality technologies by mastering the theoretical and algorithmic base of augmented reality, augmented virtual reality and virtual reality synthesis methods.
Ukrainian State University of Science and Technology	Virtual Reality and 3D Modelling	MSc	Formation of competences regarding the process of training specialists capable of using innovative technologies in the field of engineering modelling
Sumy State University	Virtual technologies of the psychologist's work in organizations	MSc	The purpose of teaching the discipline is the formation of general cultural, social, communicative, scientific and professional competencies of master's students in the direction of professional self-realization with the use of virtual space technologies
Technical College of Lutsk National Technical University	Technologies of Virtual Reality	VET	The purpose of studying the academic discipline is to provide students with the knowledge, skills and abilities necessary to work with virtual, augmented and m reality technology, the ability to apply the acquired knowledge in working with various CAD programs and the use of these technologies in design. Learn to cre virtual and augmented reality applications for various types of computer equipment.

ANNEX 2. SUMMARY OF RESPONSES FROM THE QUESTIONNAIRE ON CURRENT AND FUTURE PROVISION OF XR-RELATED EDUCATION

In total, the survey collected 28 responses from academia stakeholders. A summary of the responses is provided in Annex 2 of this report. The respondents are teachers and are asked to answer all questions as individuals, not as representative of their education institute.

Potential benefits of using XR in education

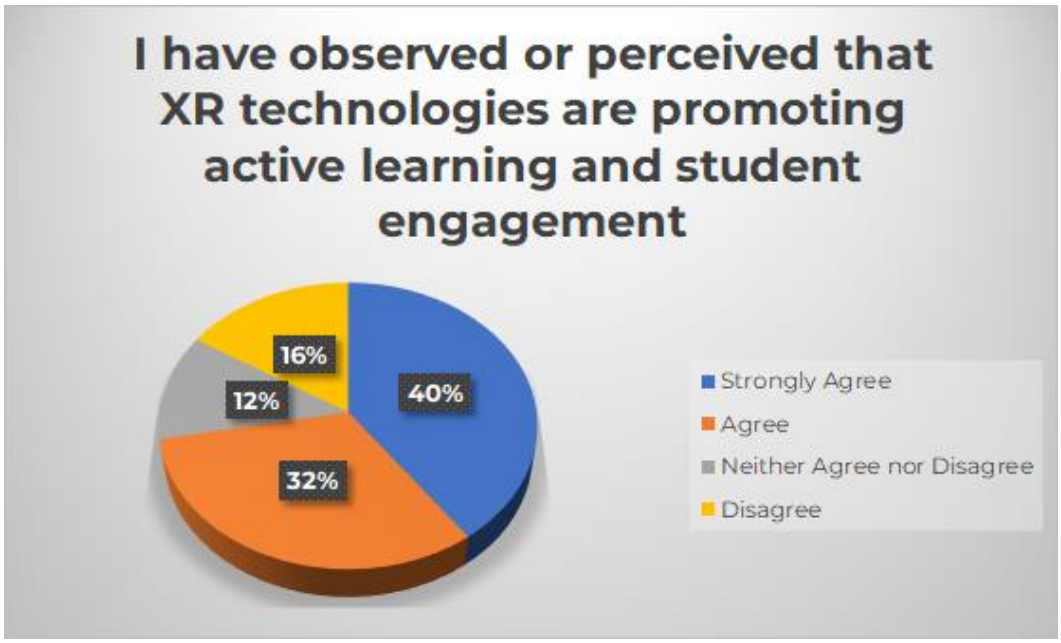


Figure A2.1. I have observed or perceived that XR technologies are promoting active learning and student engagement

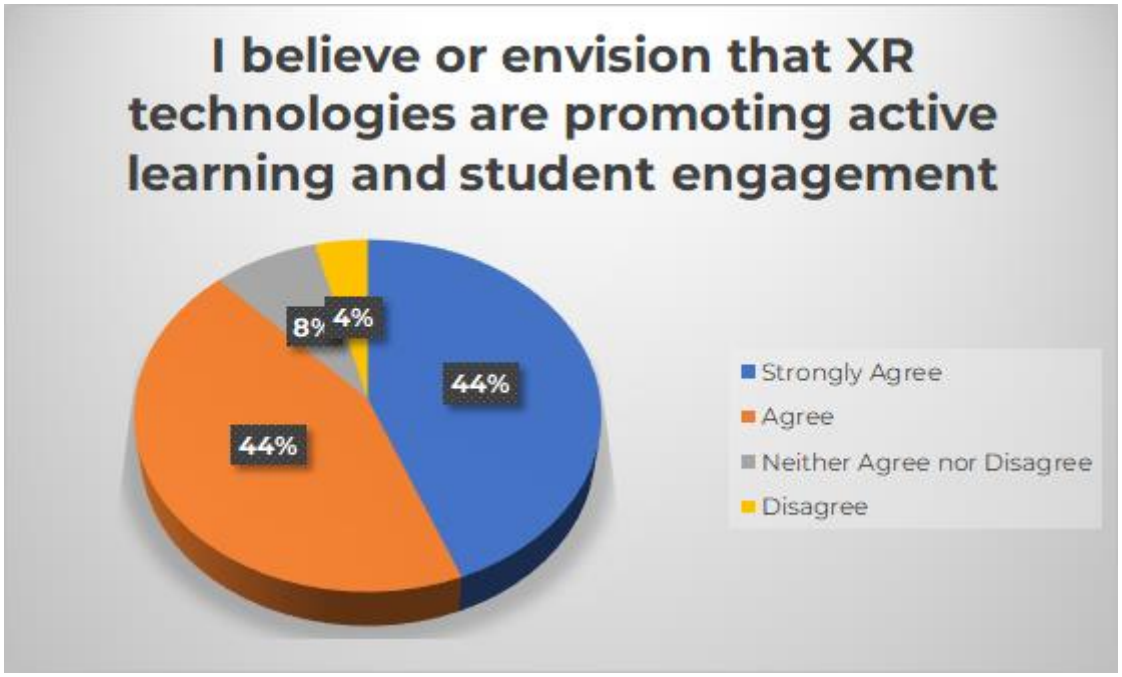


Figure A2.2. I believe or envision that XR technologies are promoting active learning and student engagement

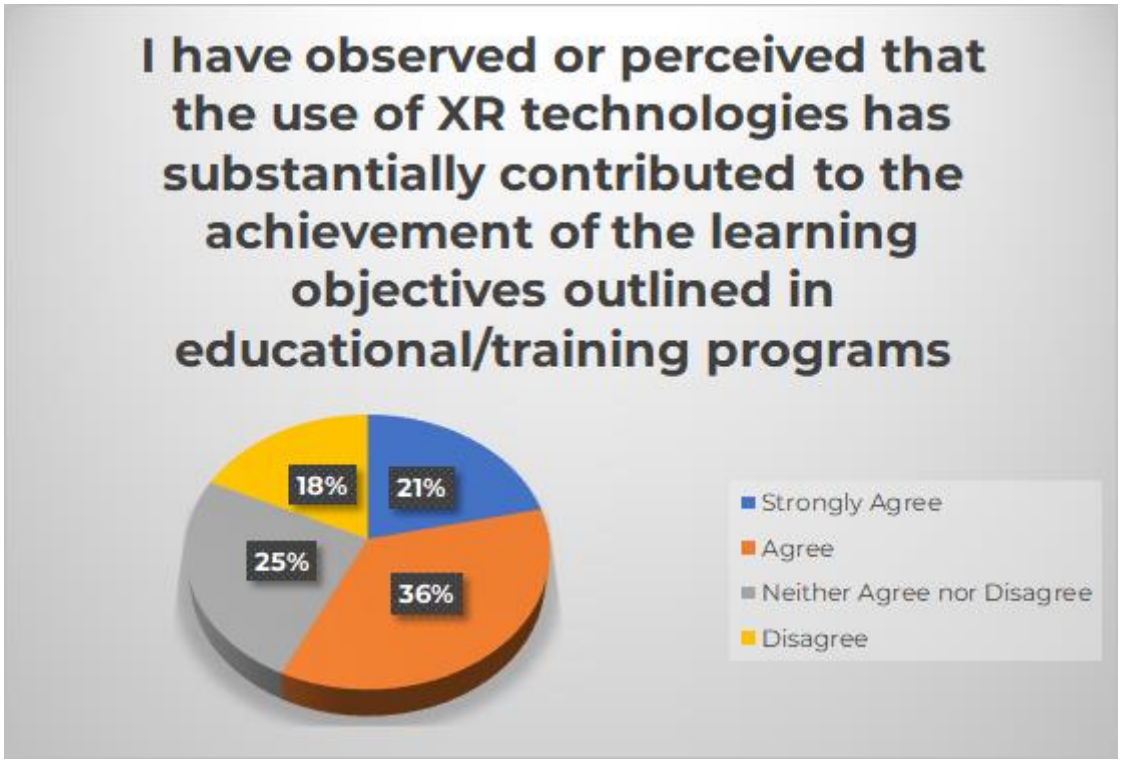


Figure A2.3. I have observed or perceived that the use of XR technologies has substantially contributed to the achievement of the learning objectives outlined in educational/training programs

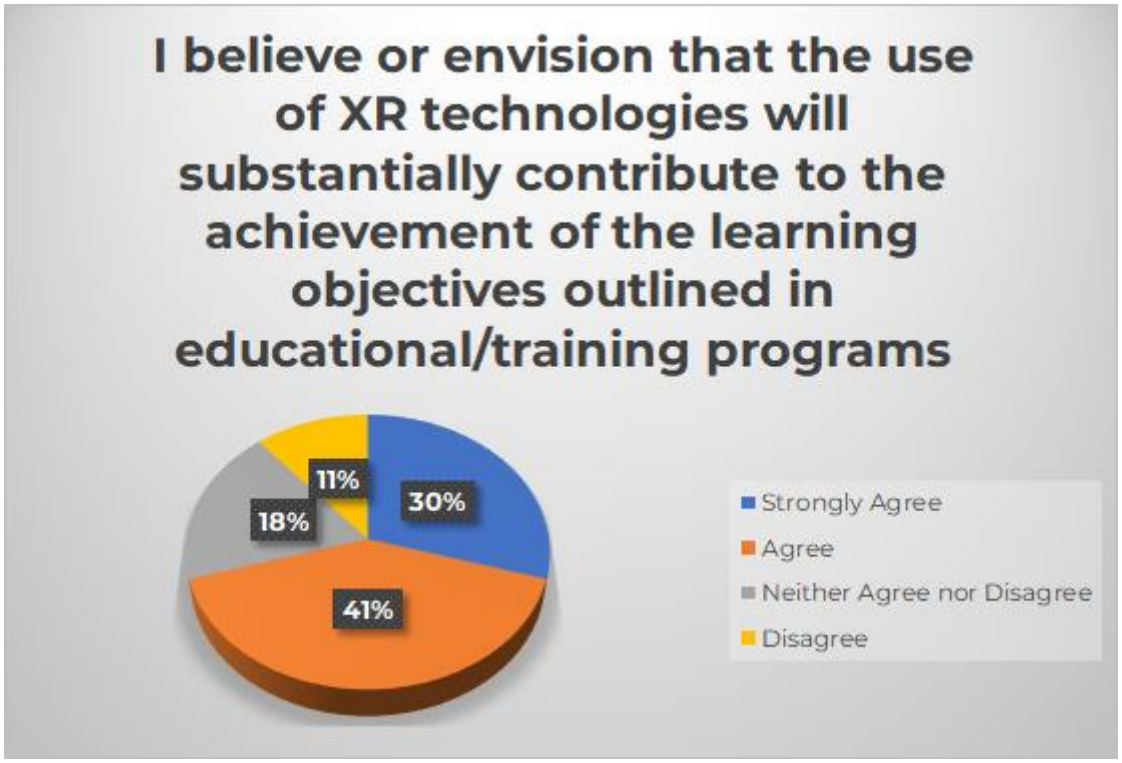


Figure A2.4. I believe or envision that the use of XR technologies will substantially contribute to the achievement of the learning objectives outlined in educational/training programs

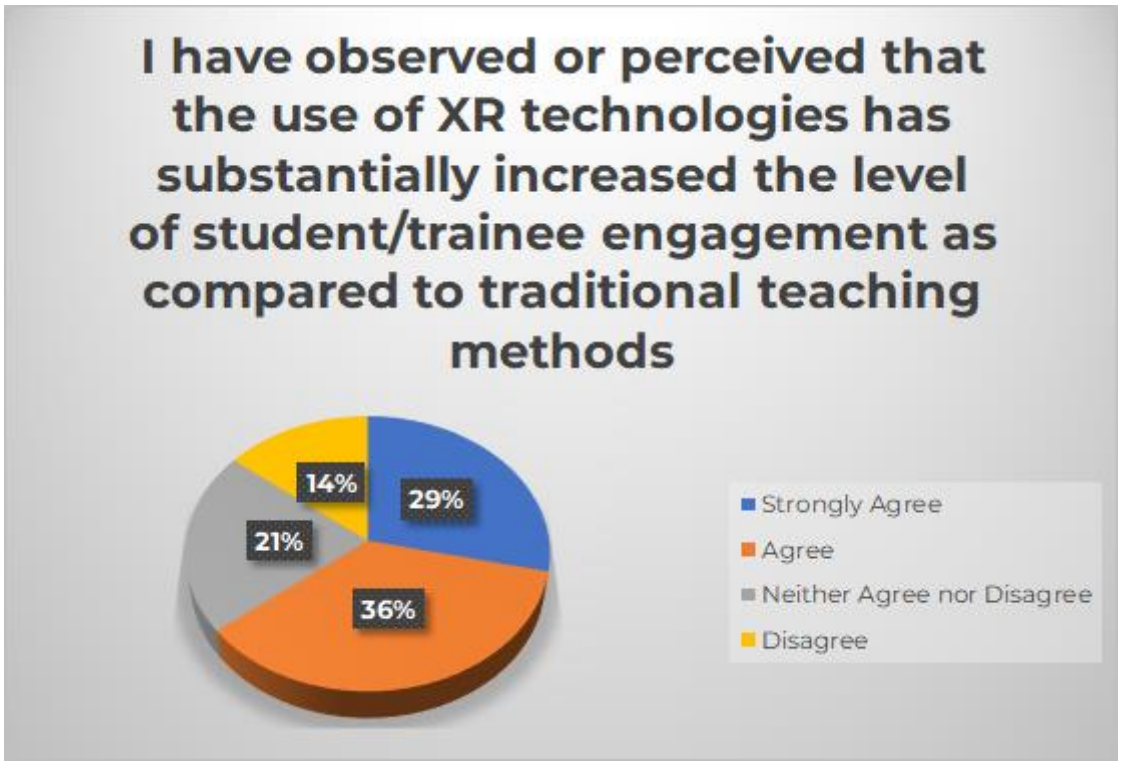


Figure A2.5. I have observed or perceived that the use of XR technologies has substantially increased the level of student/trainee engagement as compared to traditional teaching methods

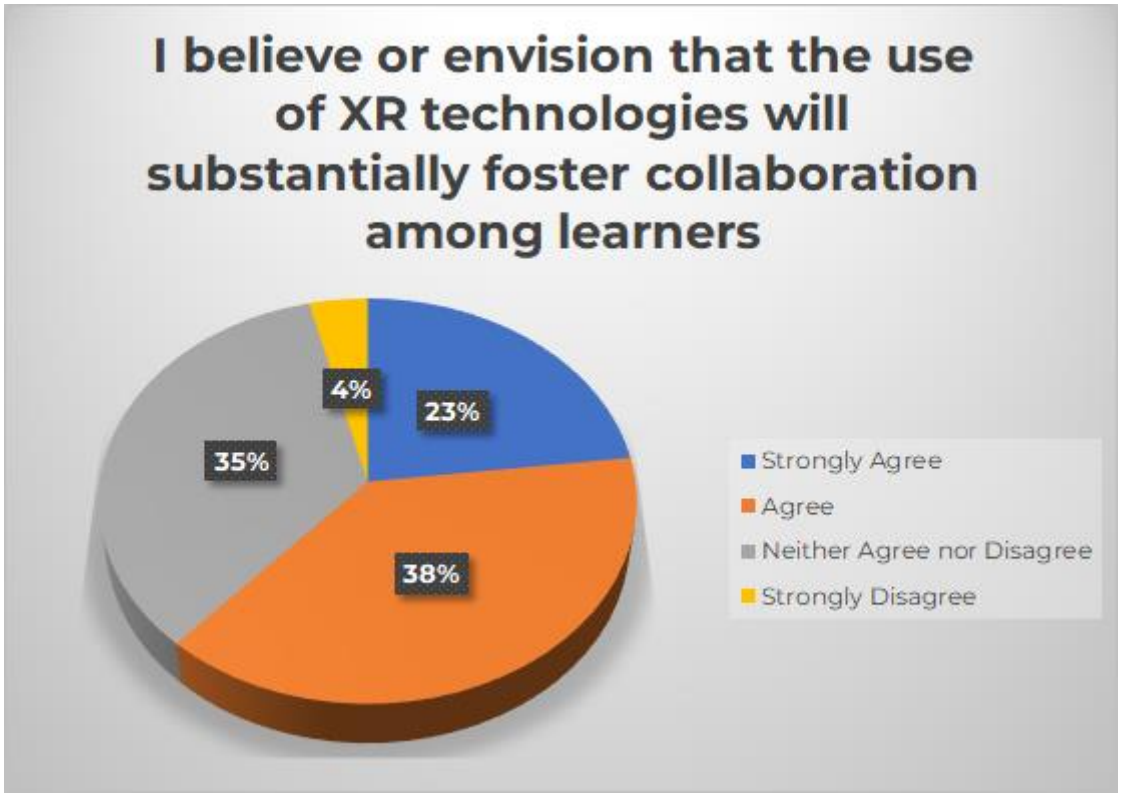


Figure A2.6. I believe or envision that the use of XR technologies will substantially foster collaboration among learners

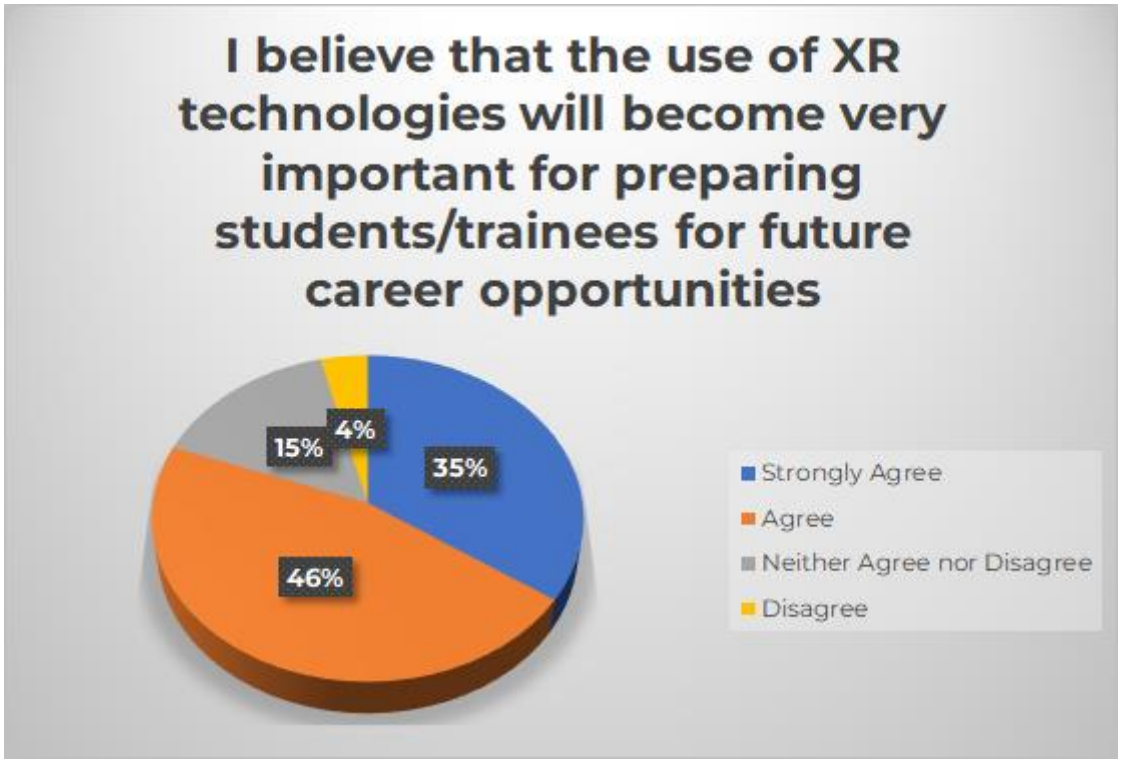


Figure A2.7. I believe that the use of XR technologies will become very important for preparing students/trainees for future career opportunities

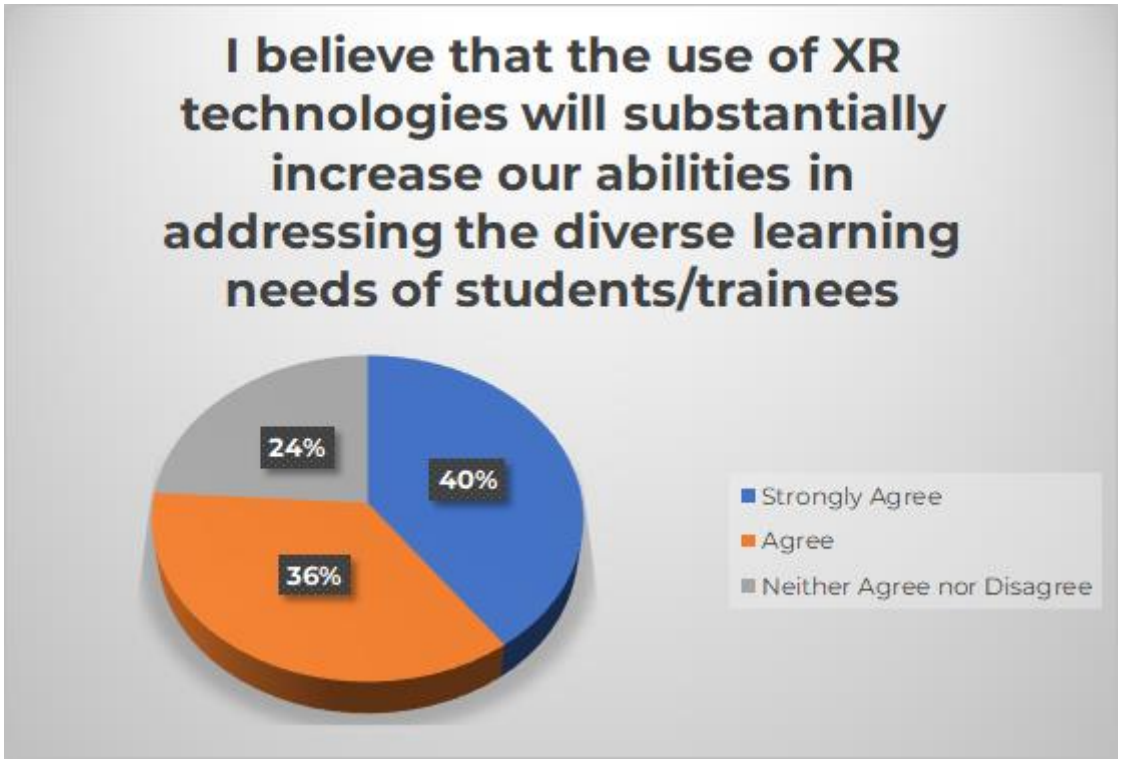


Figure A2.8. I believe that the use of XR technologies will substantially increase our abilities in addressing the diverse learning needs of students/trainees

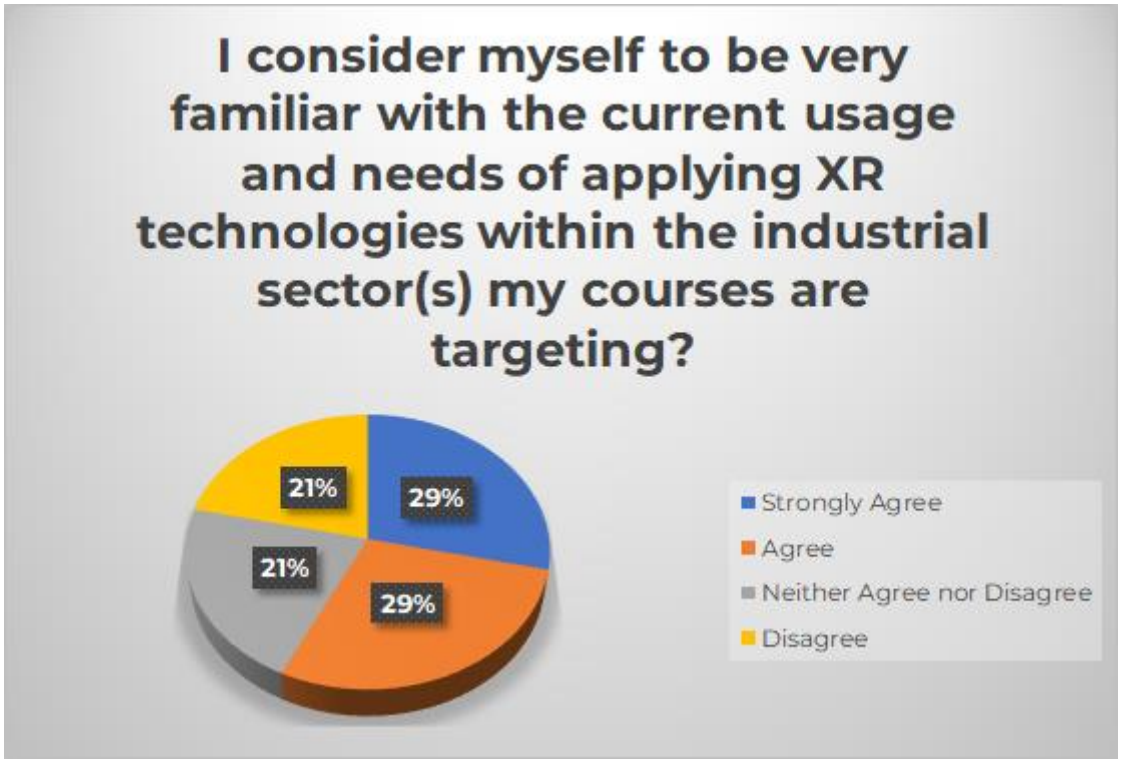


Figure A2.9. I consider myself to be very familiar with the current usage and needs of applying XR technologies within the industrial sector(s) my courses are targeting?

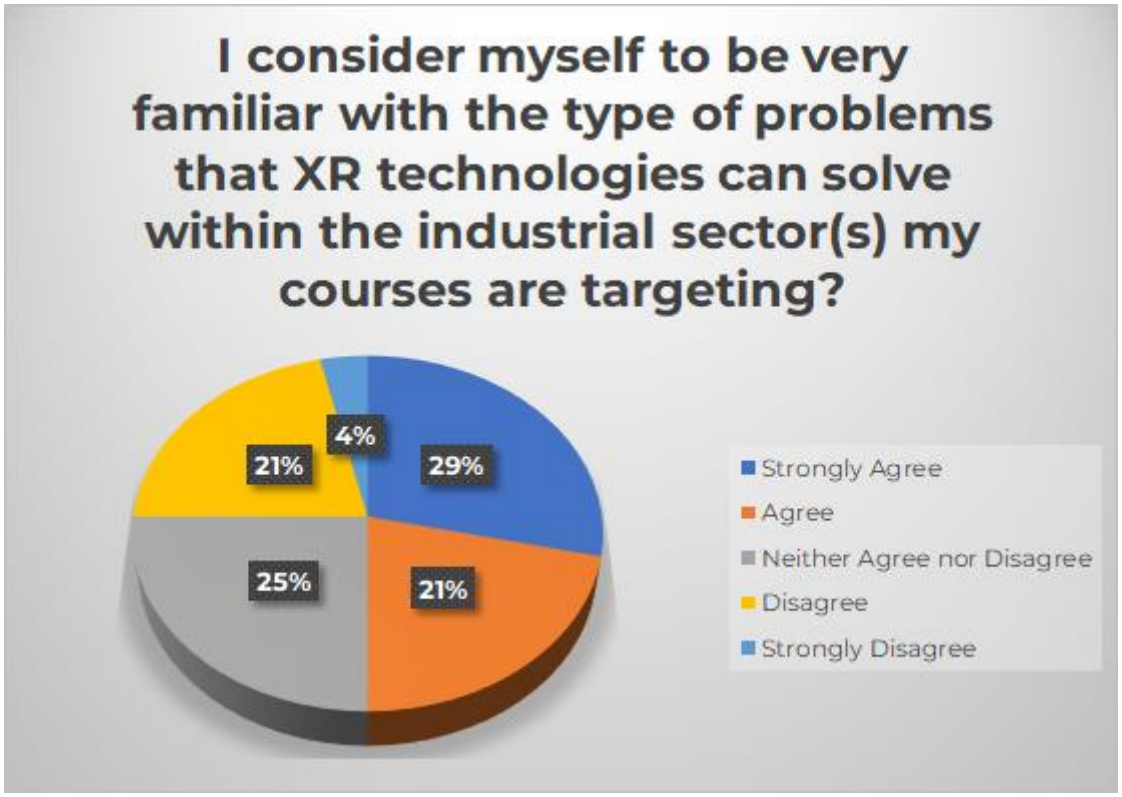


Figure A2.10 I consider myself to be very familiar with the type of problems that XR technologies can solve within the industrial sector(s) my courses are targeting?

XR topics addressed in current and future teaching

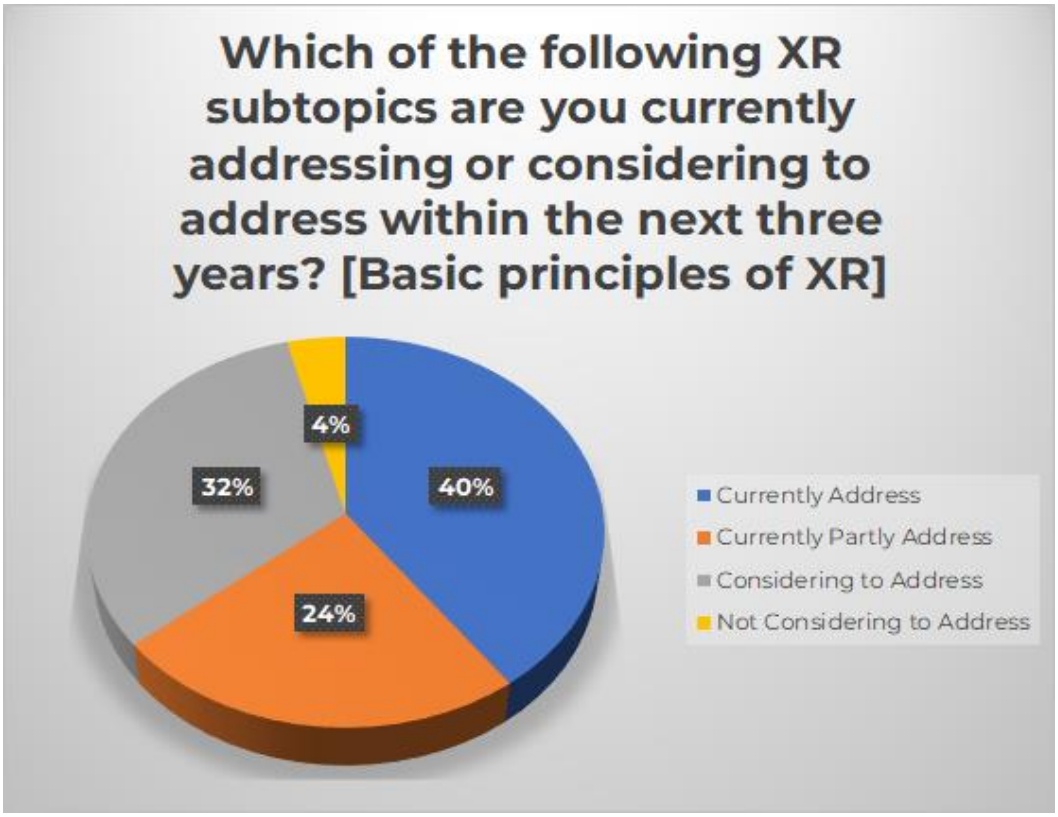


Figure A2.11. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Basic principles of XR]

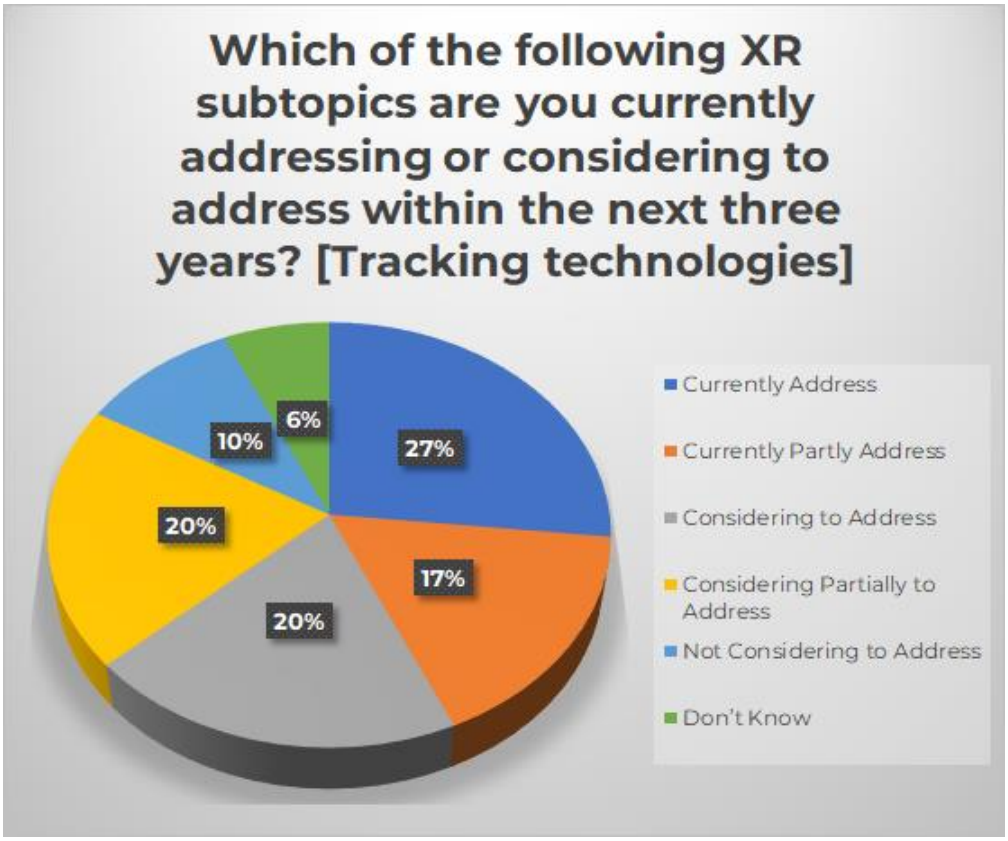


Figure A2.12. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Tracking technologies]

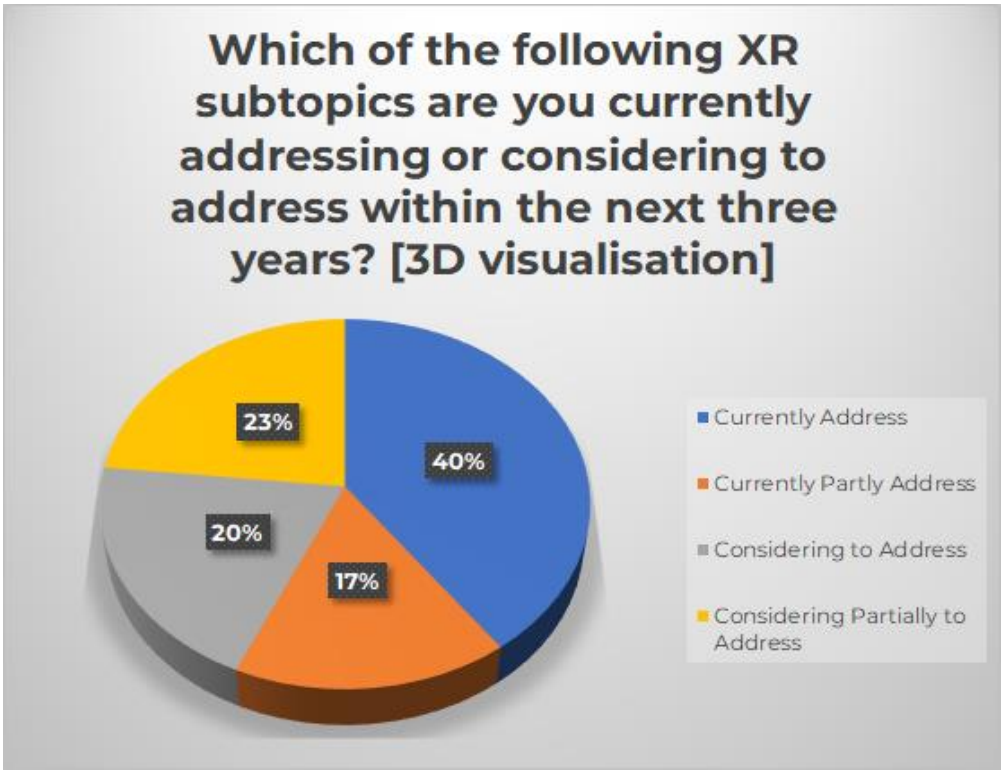


Figure A2.13. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [3D visualisation]

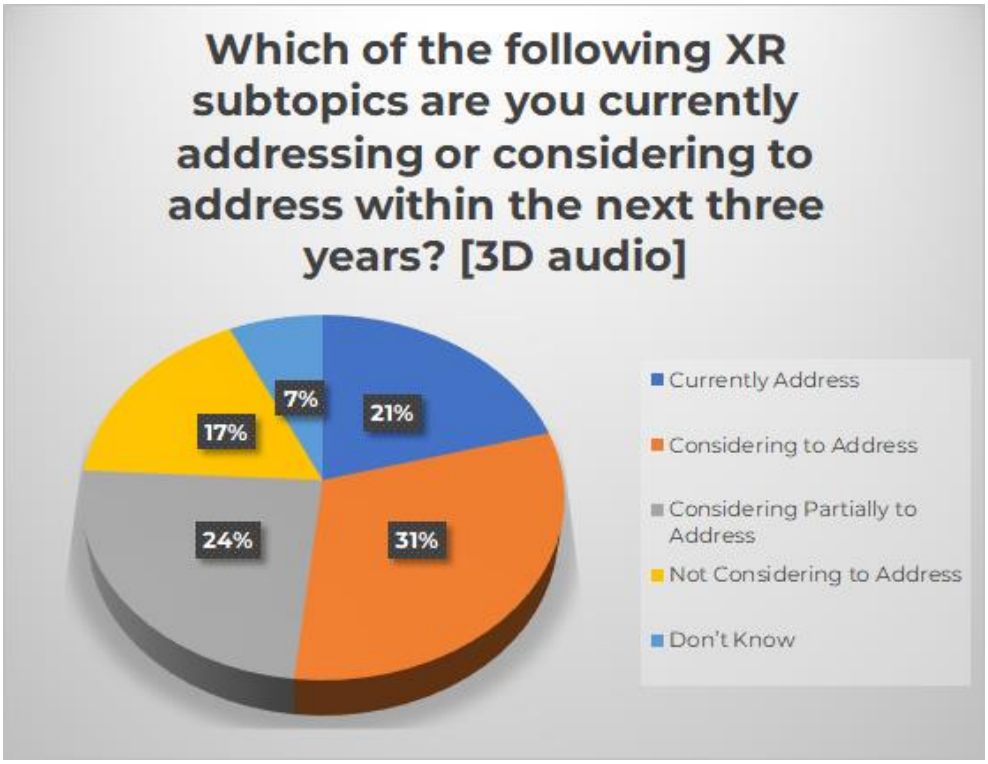


Figure A2.14. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [3D audio]

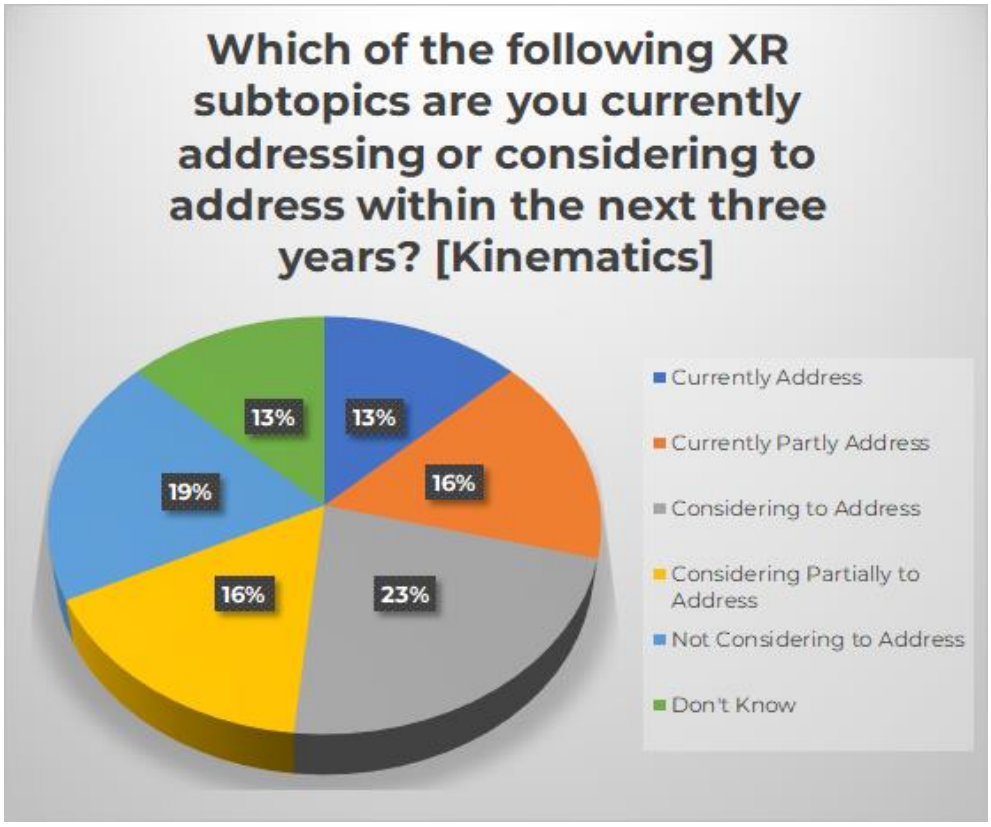


Figure A2.15. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Kinematics]

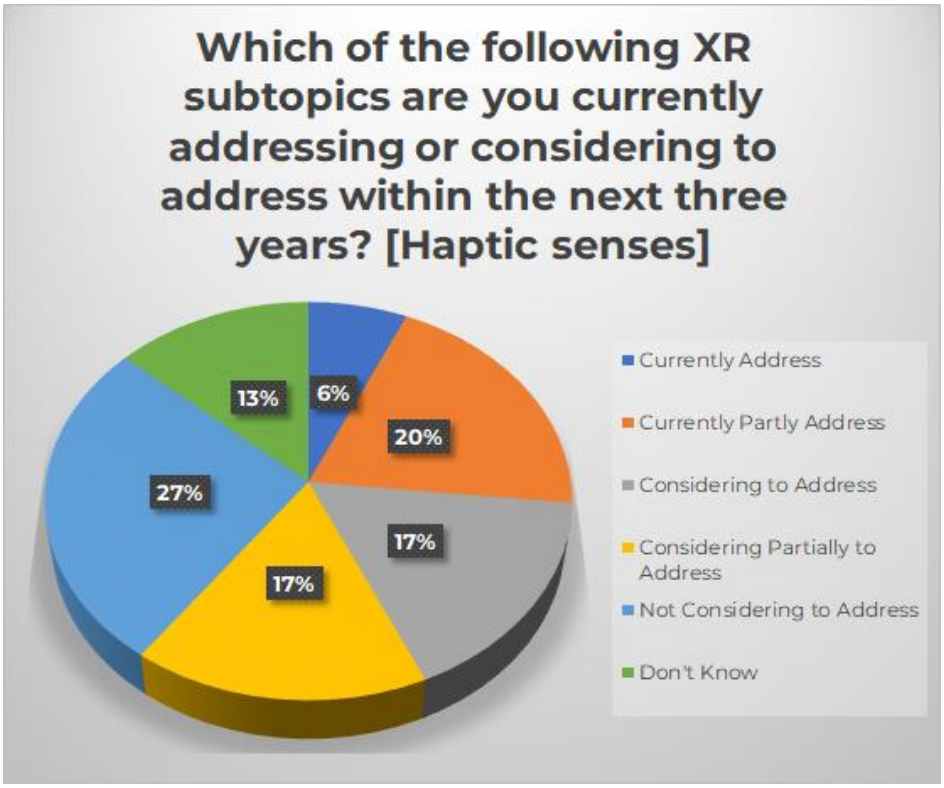


Figure A2.16. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Haptic senses]

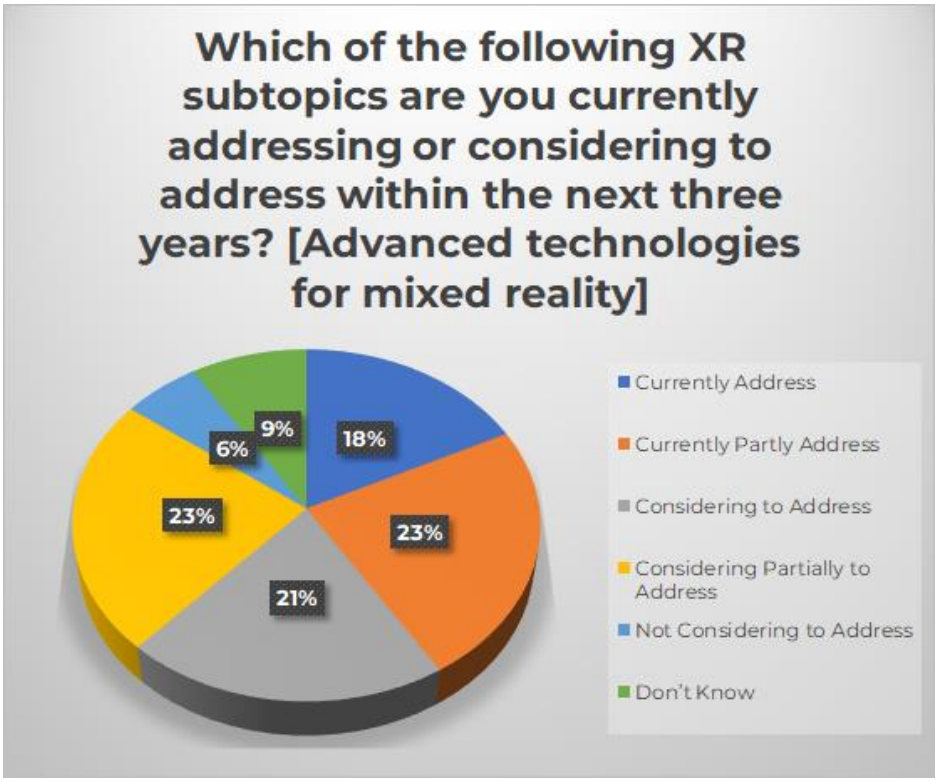


Figure A2.17. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Advanced technologies for mixed reality]

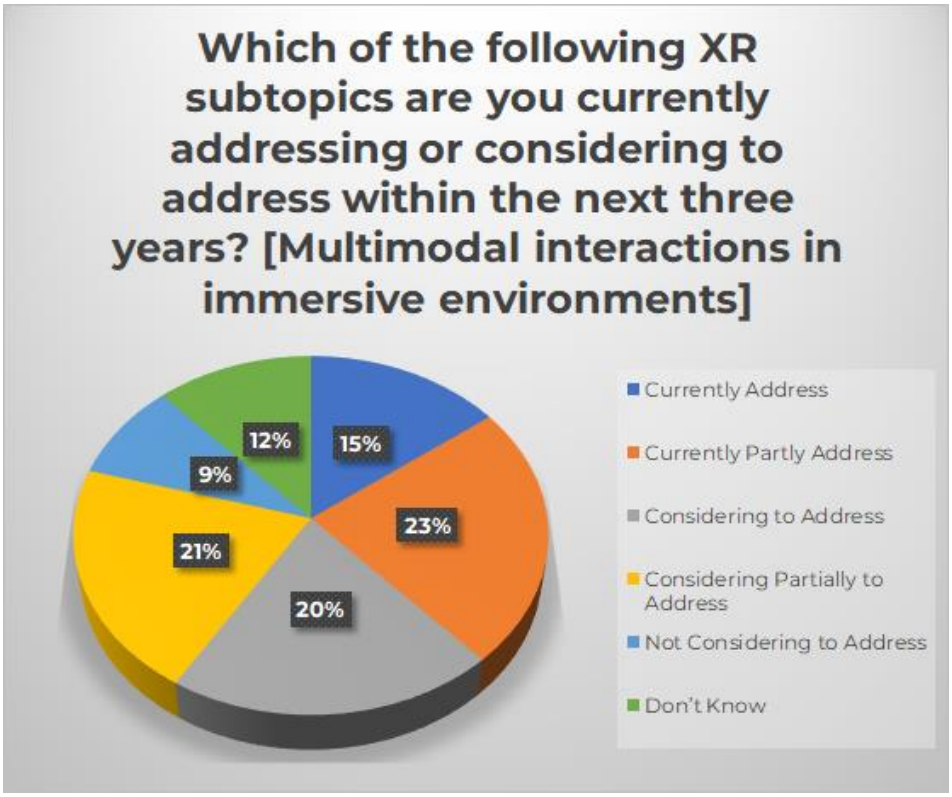


Figure A2.18. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Multimodal interactions in immersive environments]

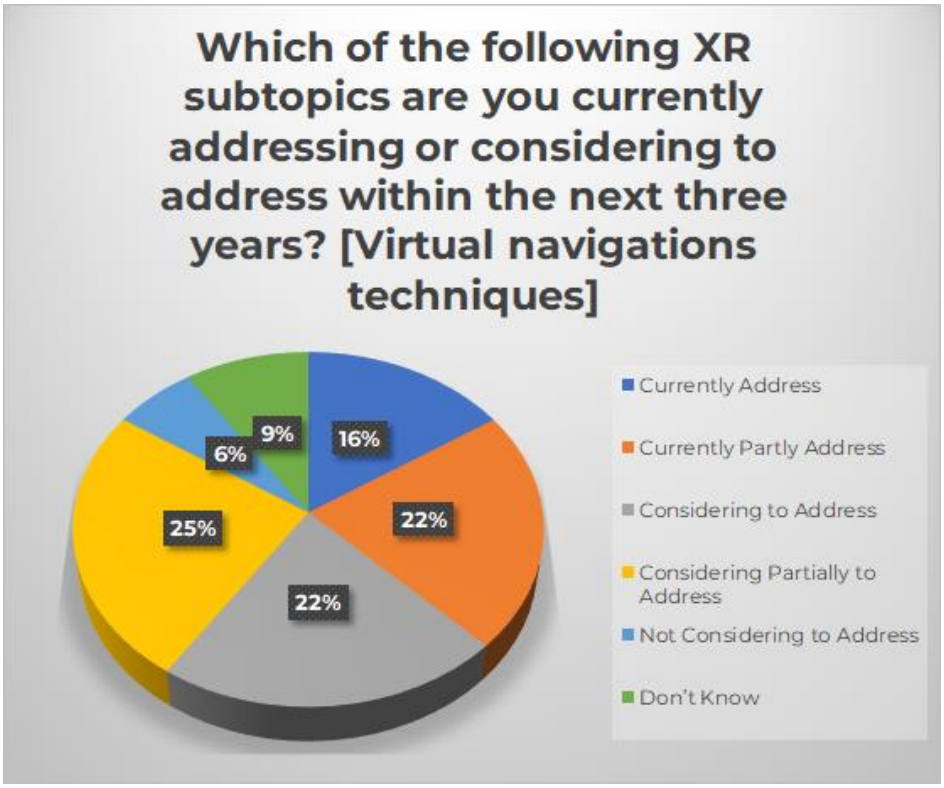


Figure A2.19. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Virtual navigations techniques]

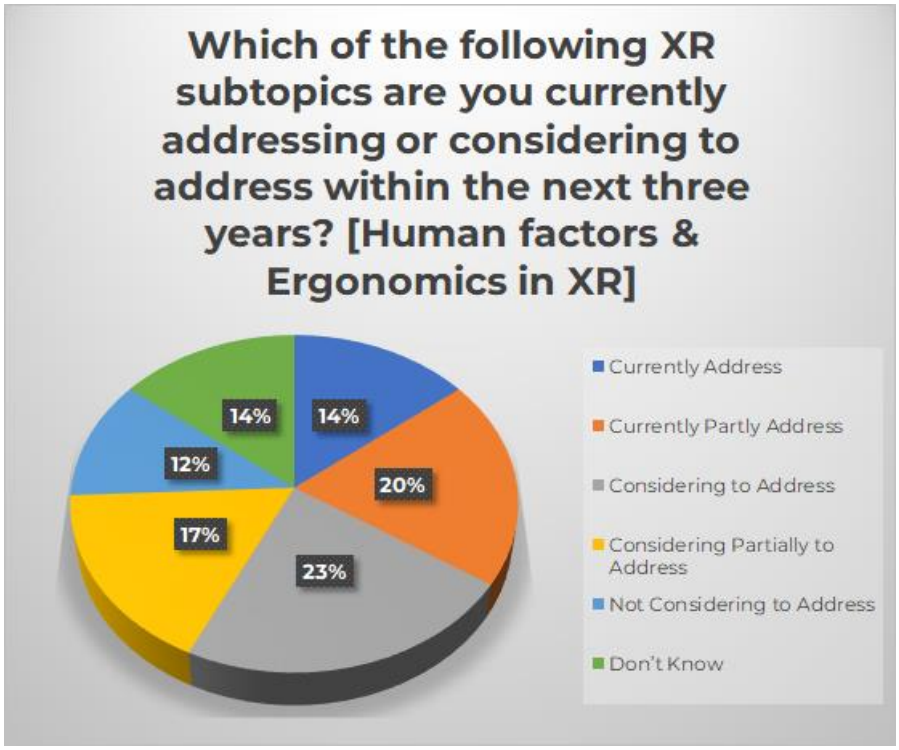


Figure A2.20. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Human factors & Ergonomics in XR]

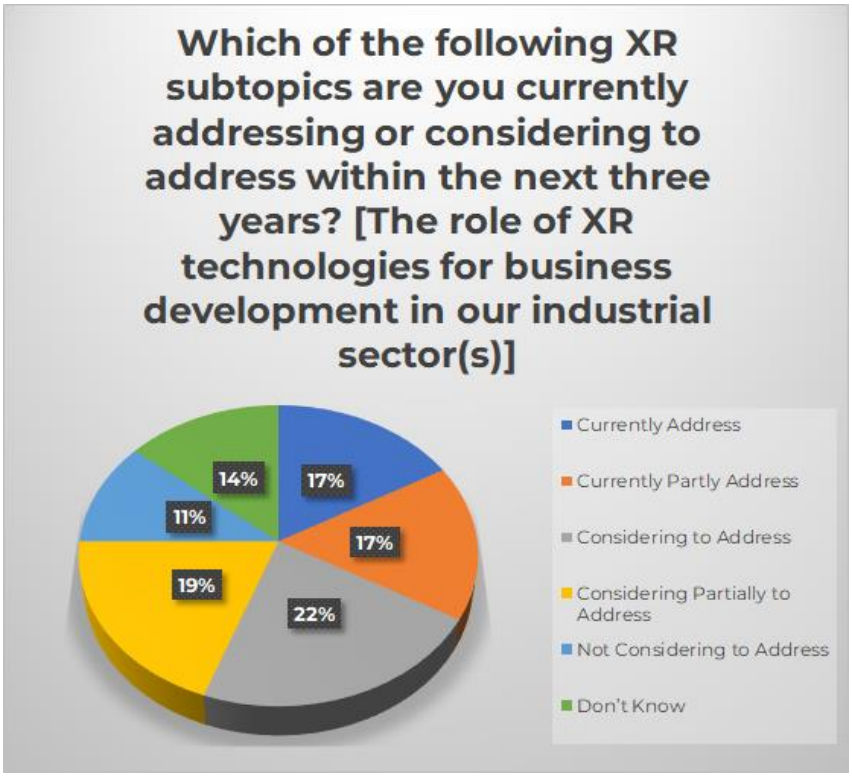


Figure A2.21. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [The role of XR technologies for business development in our industrial sector(s)]

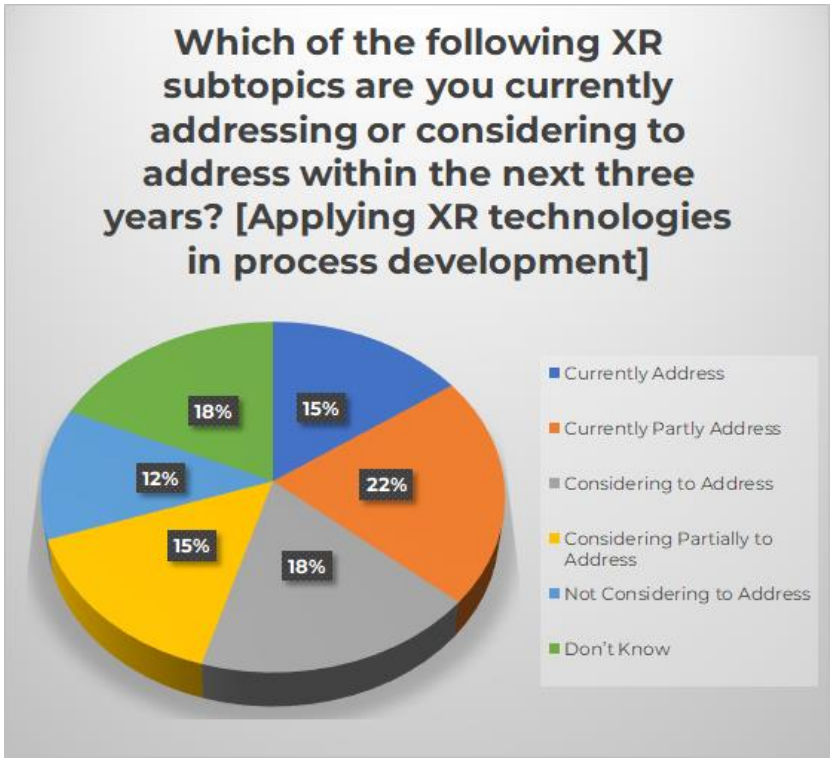


Figure A2.22. Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Applying XR technologies in process development]

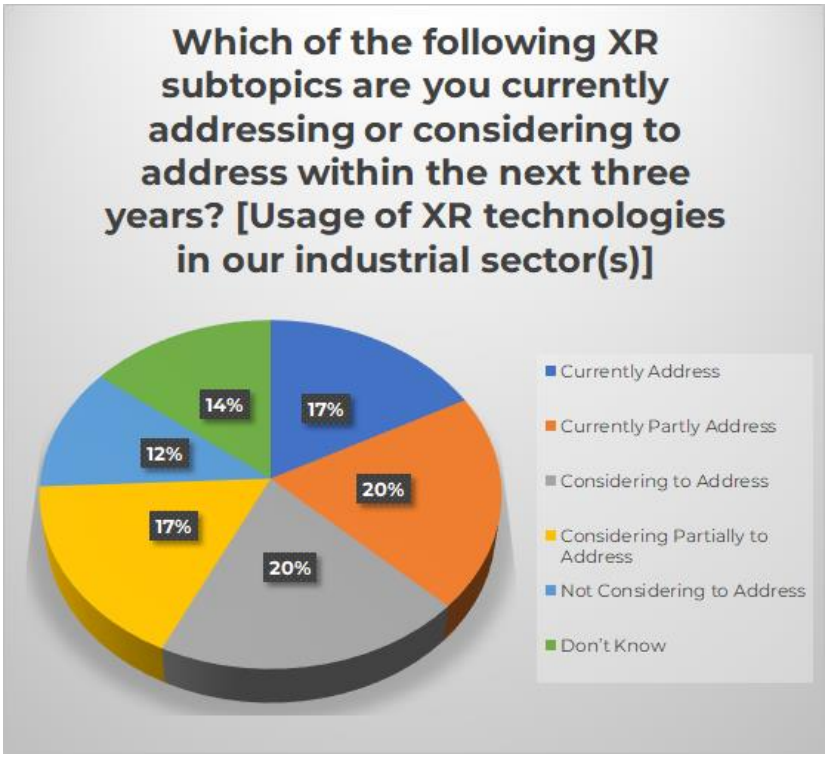


Figure A2.23 Which of the following XR subtopics are you currently addressing or considering to address within the next three years? [Usage of XR technologies in our industrial sector(s)]

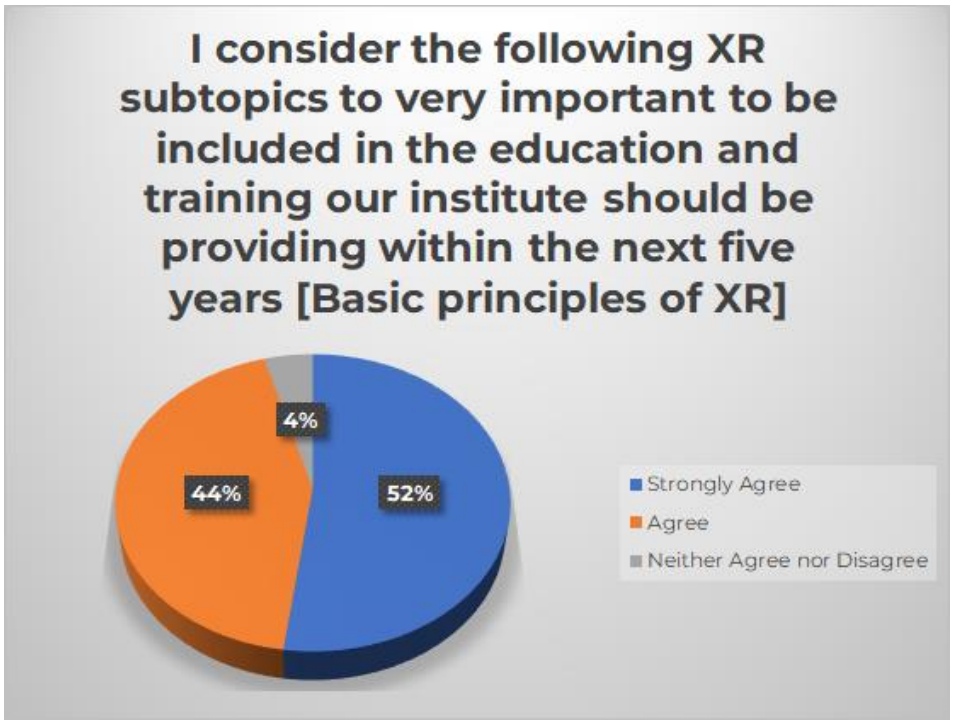


Figure A2.24. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Basic principles of XR]

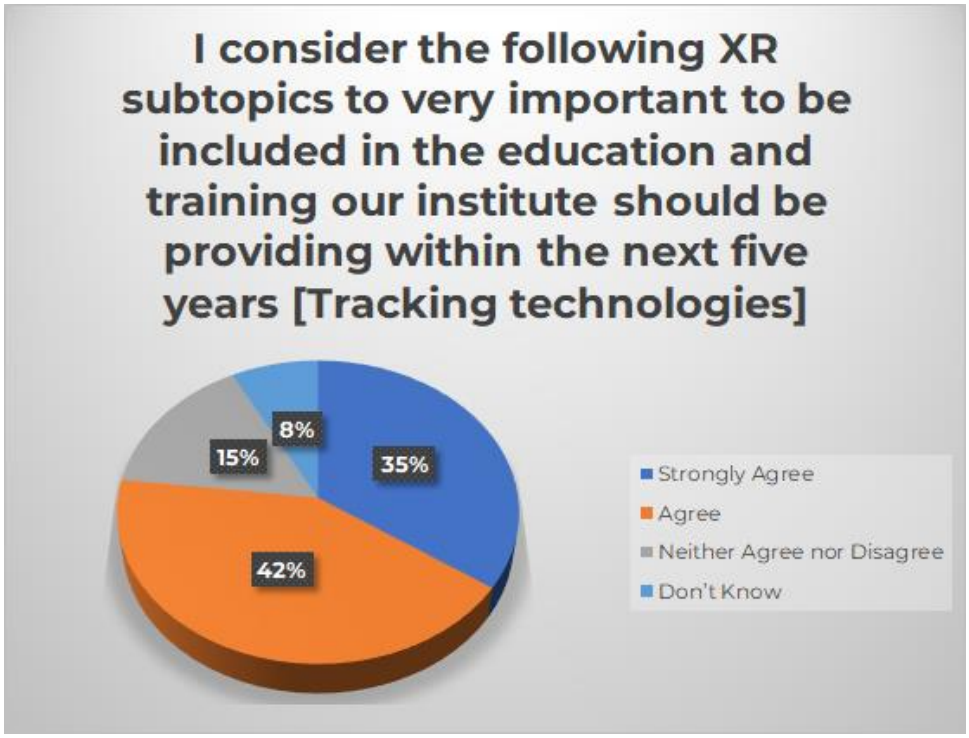


Figure A2.25. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Tracking technologies]

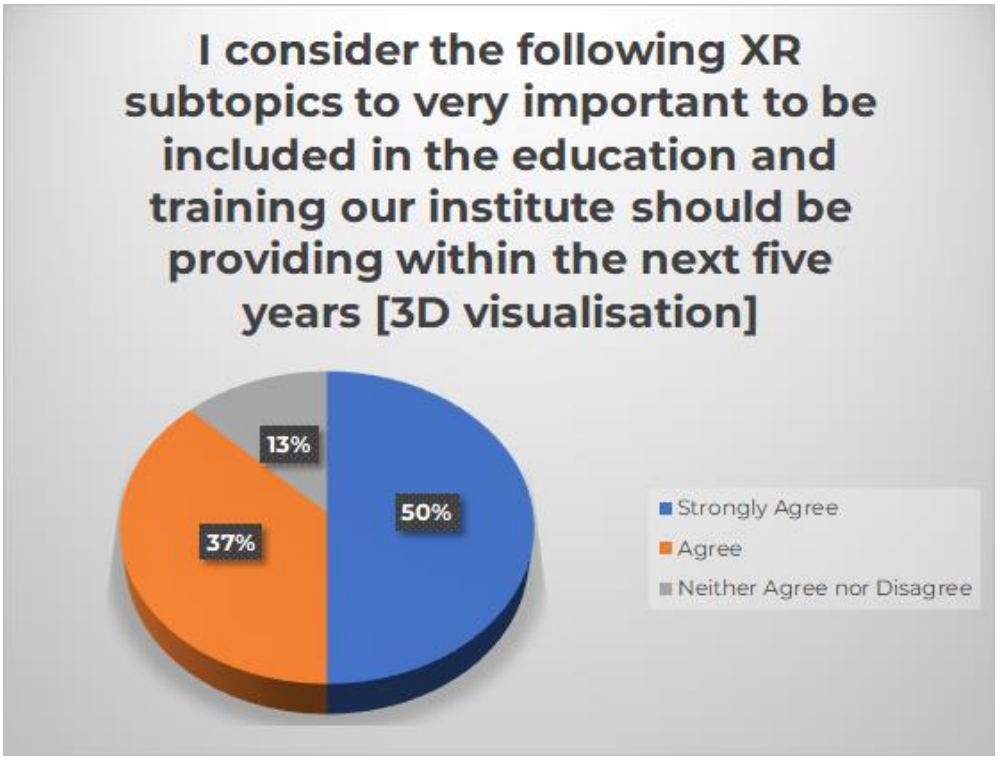


Figure A2.26. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [3D visualisation]

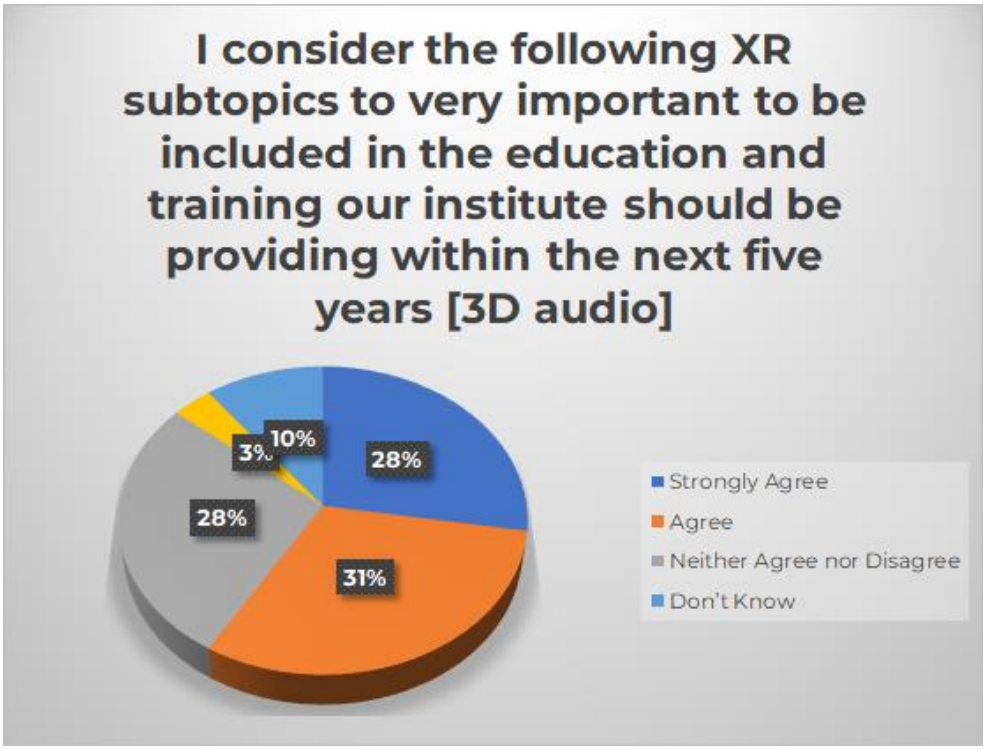


Figure A2.27. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [3D audio]

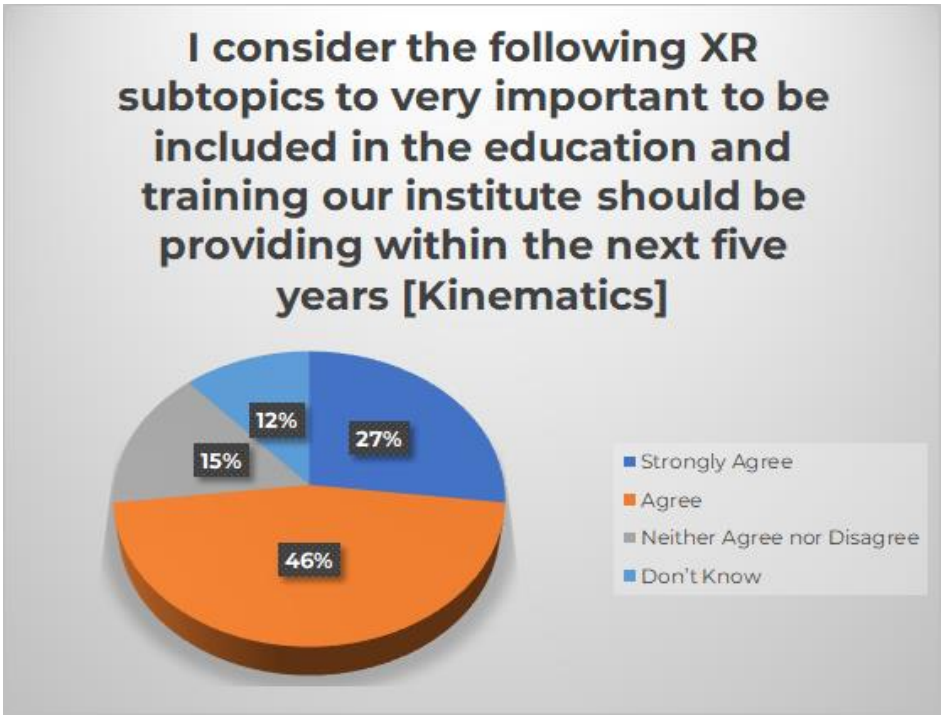


Figure A2.28. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Kinematics]

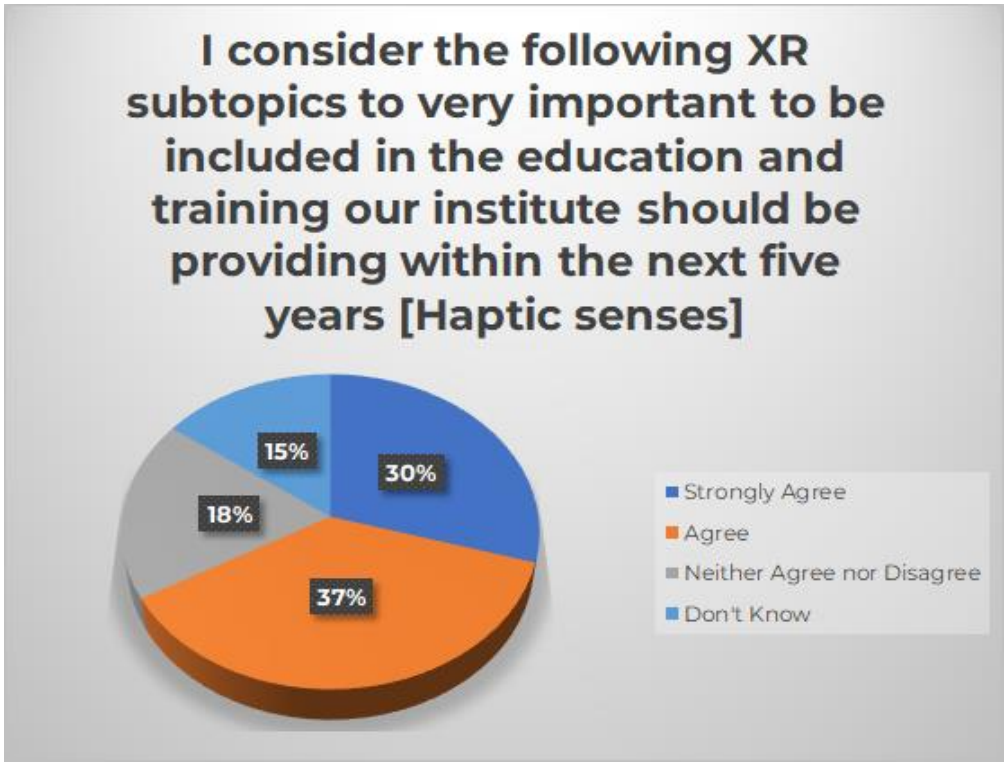


Figure A2.29. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Haptic senses]

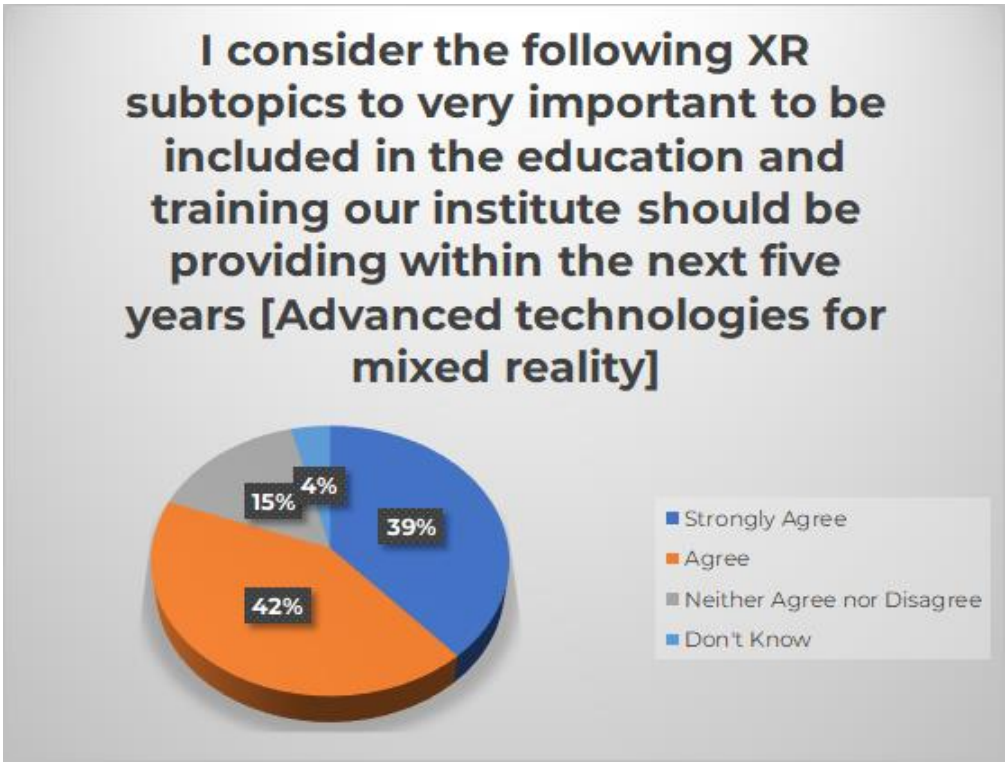


Figure A2.30. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Advanced technologies for mixed reality]

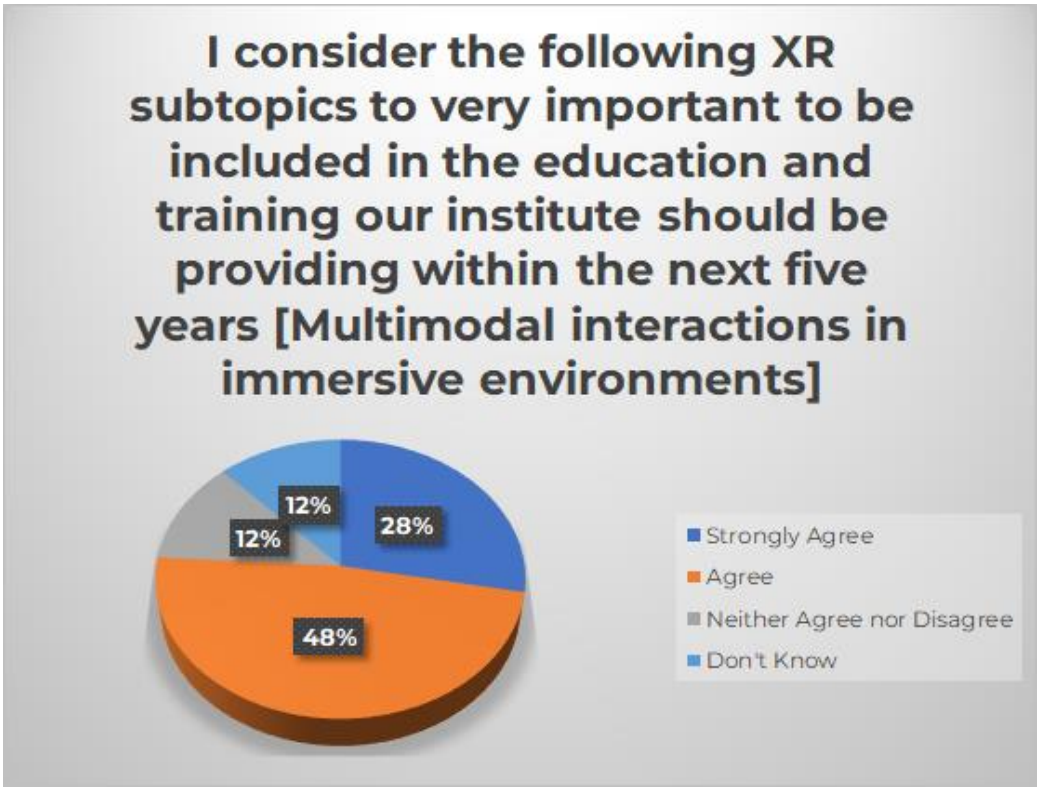


Figure A2.31. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Multimodal interactions in immersive environments]

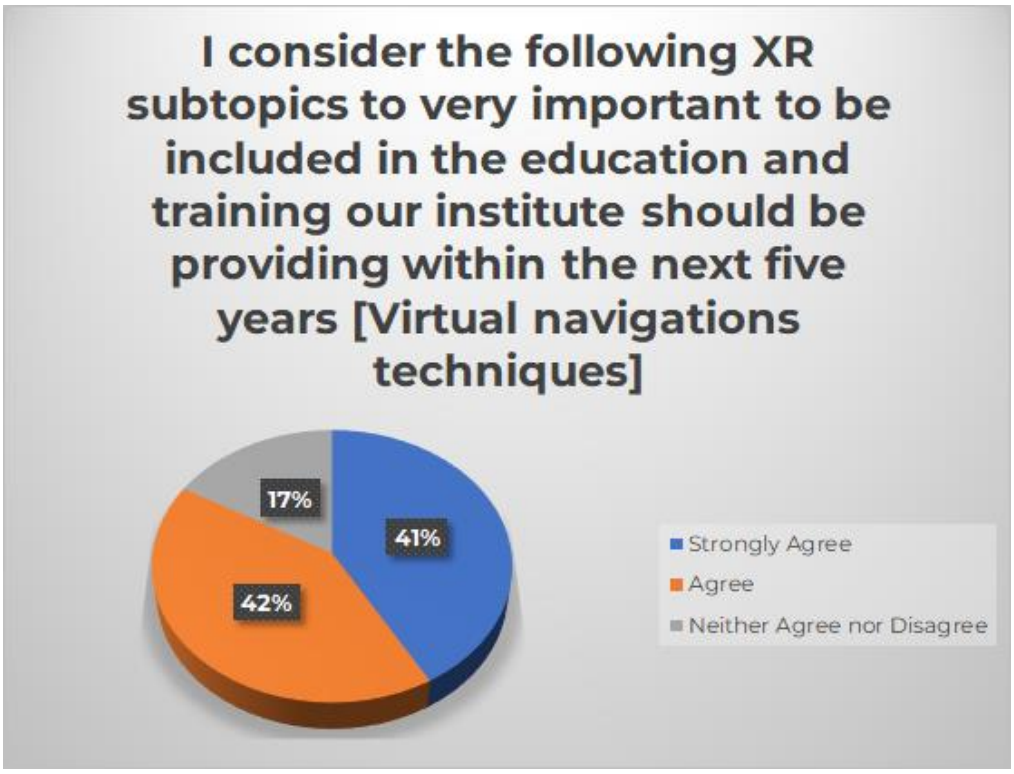


Figure A2.32. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Virtual navigations techniques]

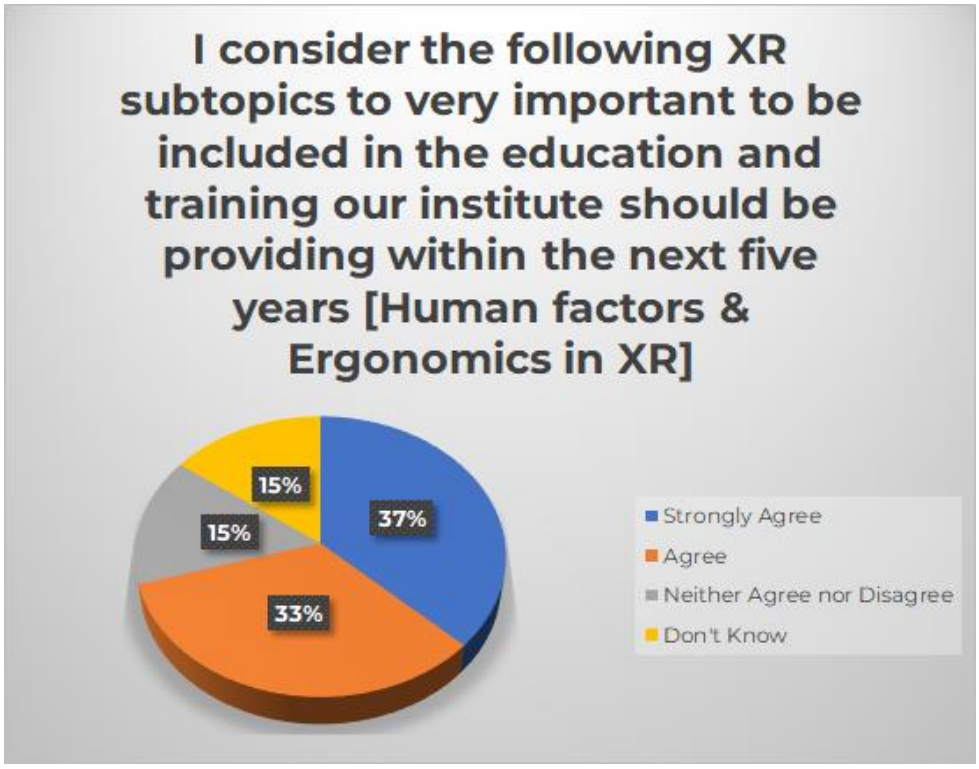


Figure A2.33. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Human factors & Ergonomics in XR]

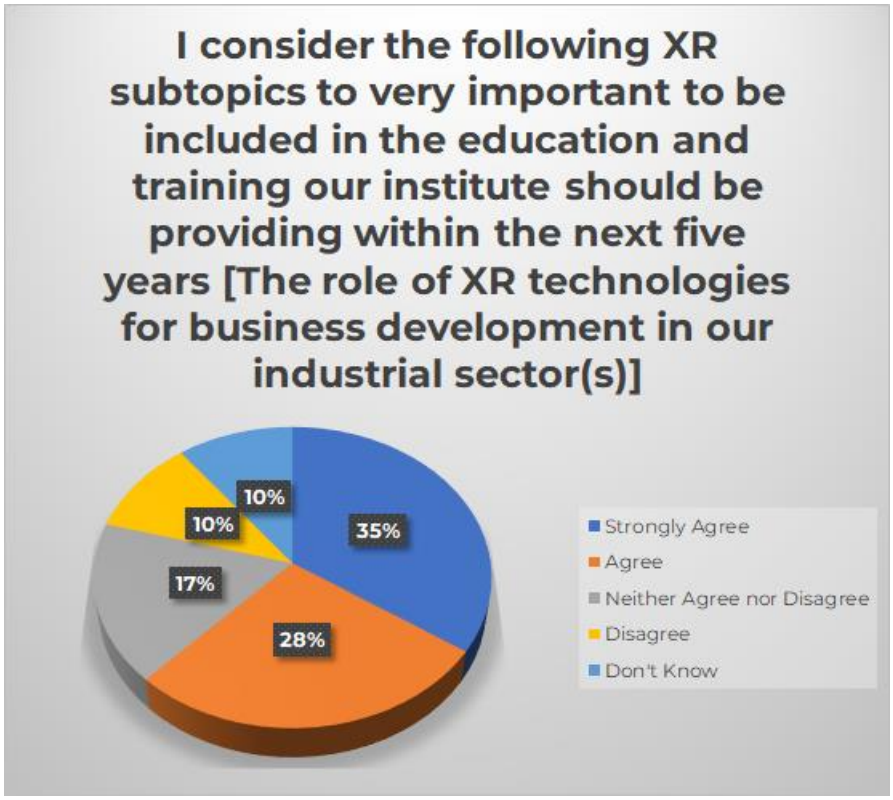


Figure A2.34. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five

years [The role of XR technologies for business development in our industrial sector(s)]

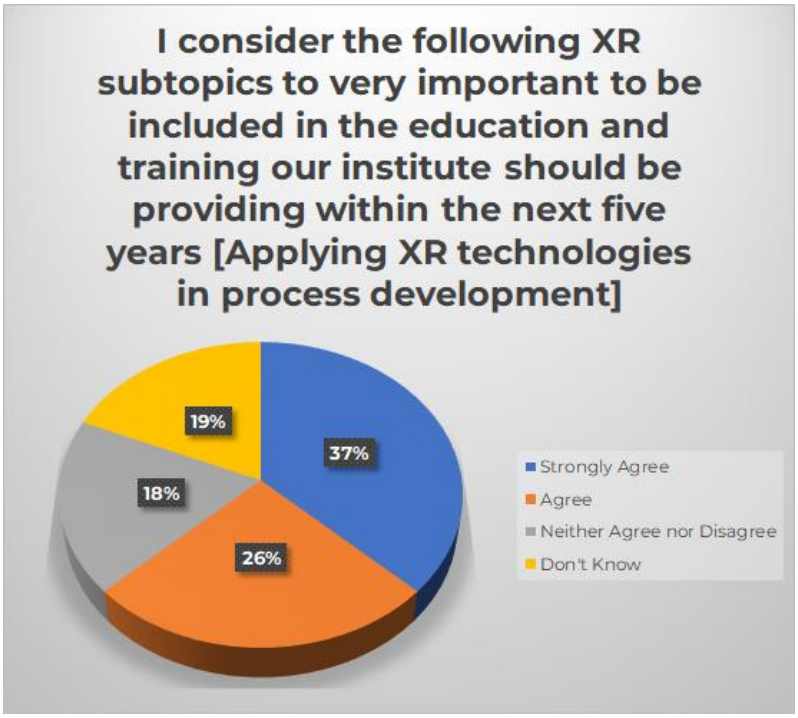


Figure A2.35. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Applying XR technologies in process development]

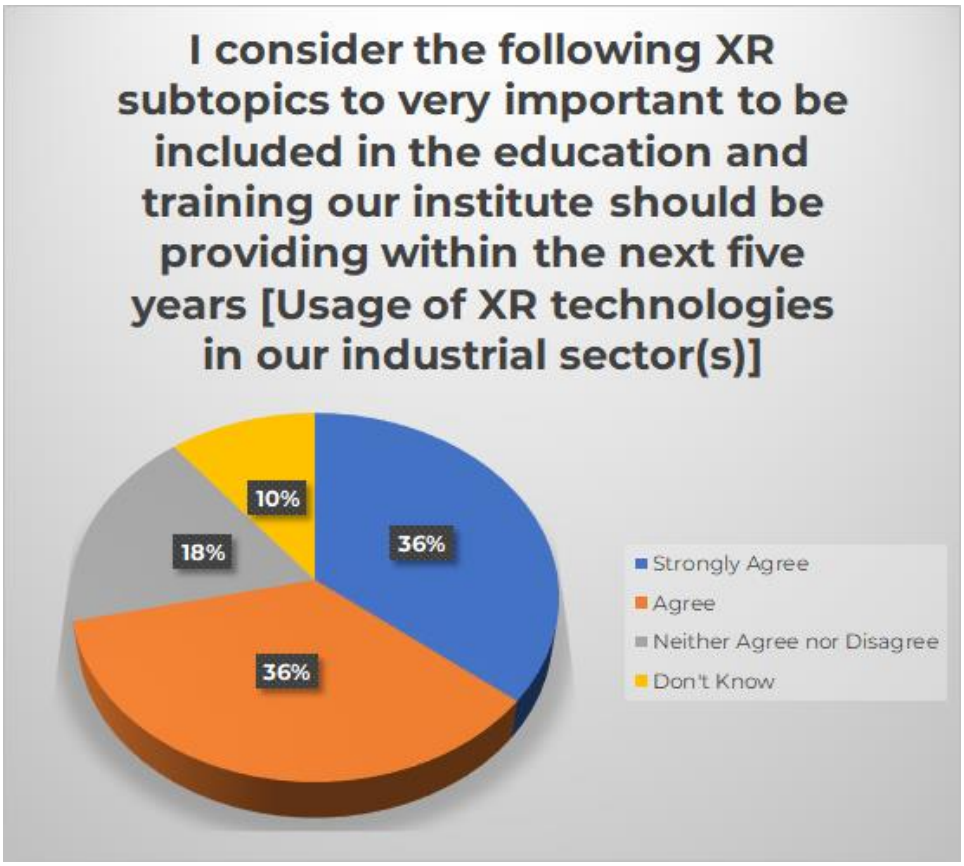


Figure A2.36. I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years [Usage of XR technologies in our industrial sector(s)]

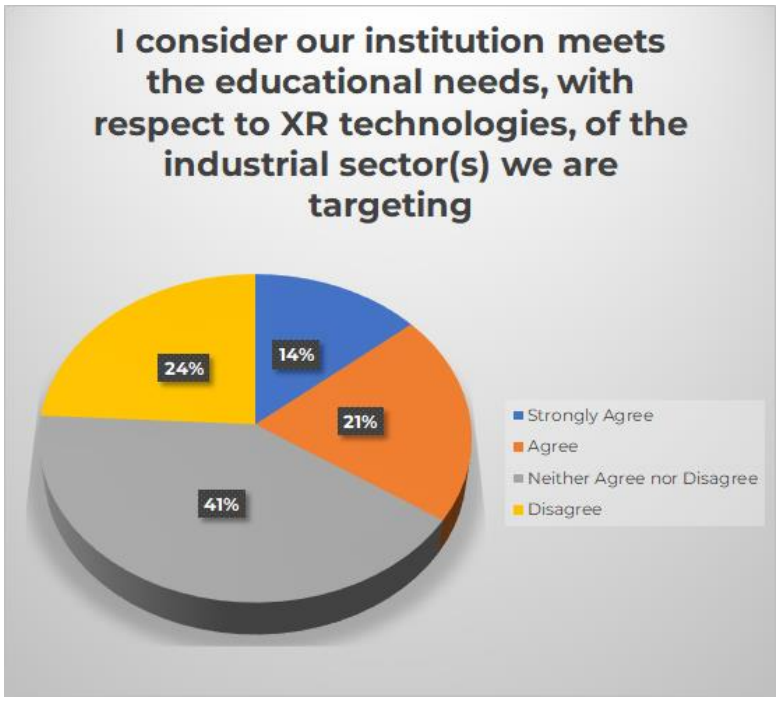


Figure A2.37. I consider our institution meets the educational needs, with respect to XR technologies, of the industrial sector(s) we are targeting

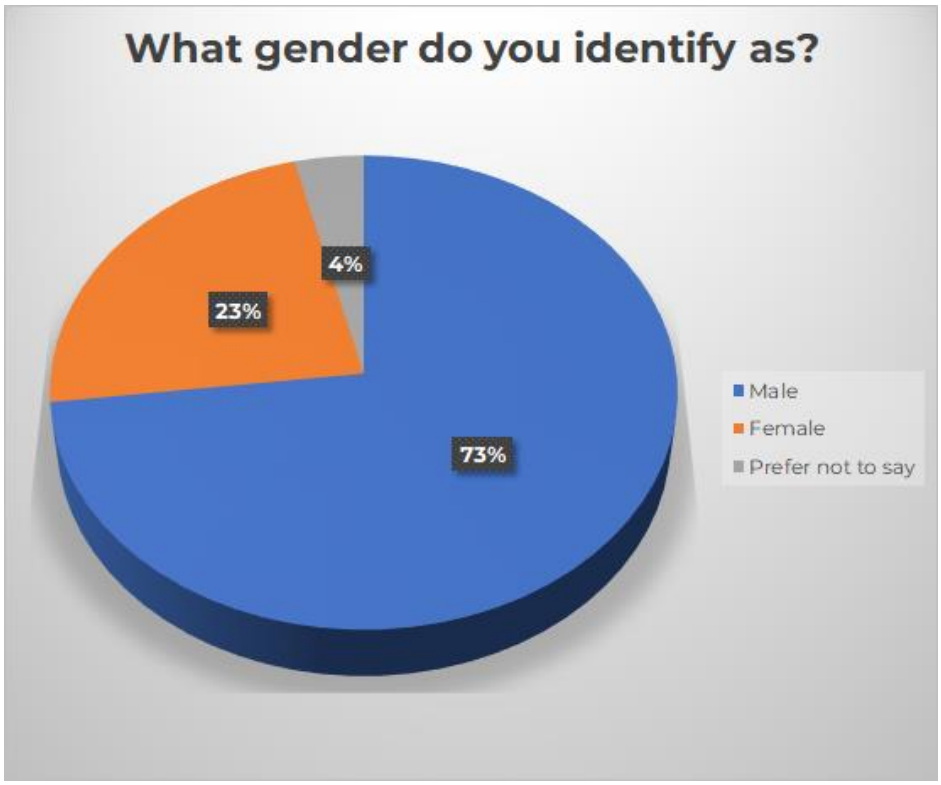


Figure A2.38. What gender do you identify as?

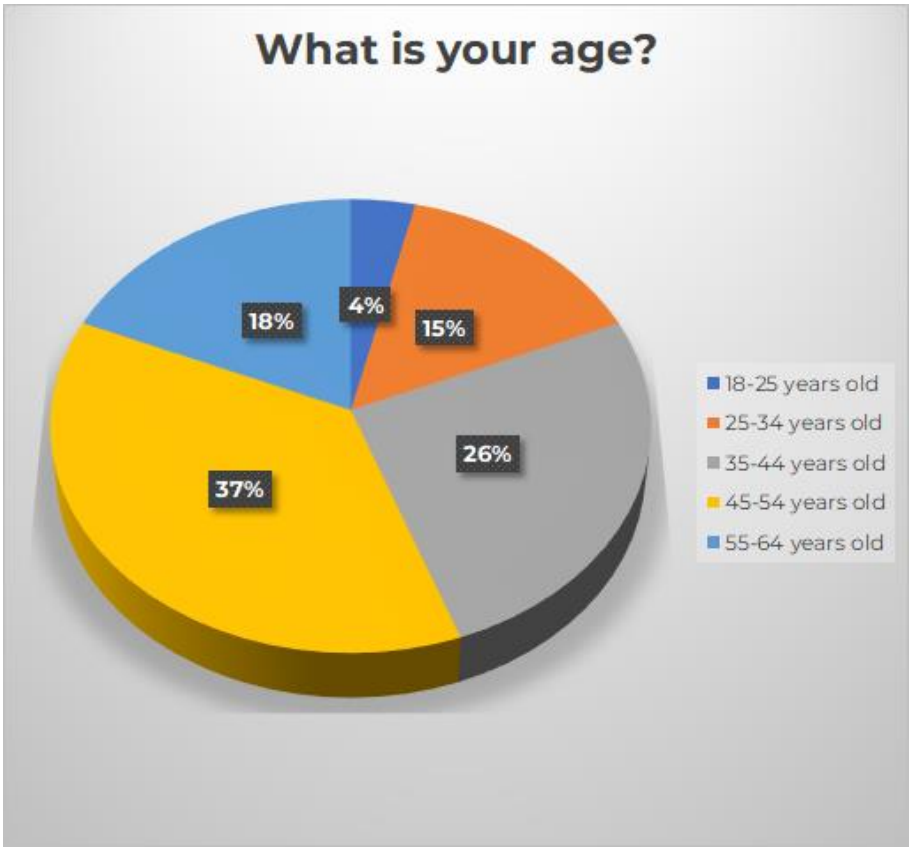


Figure A2.39. What is your age?

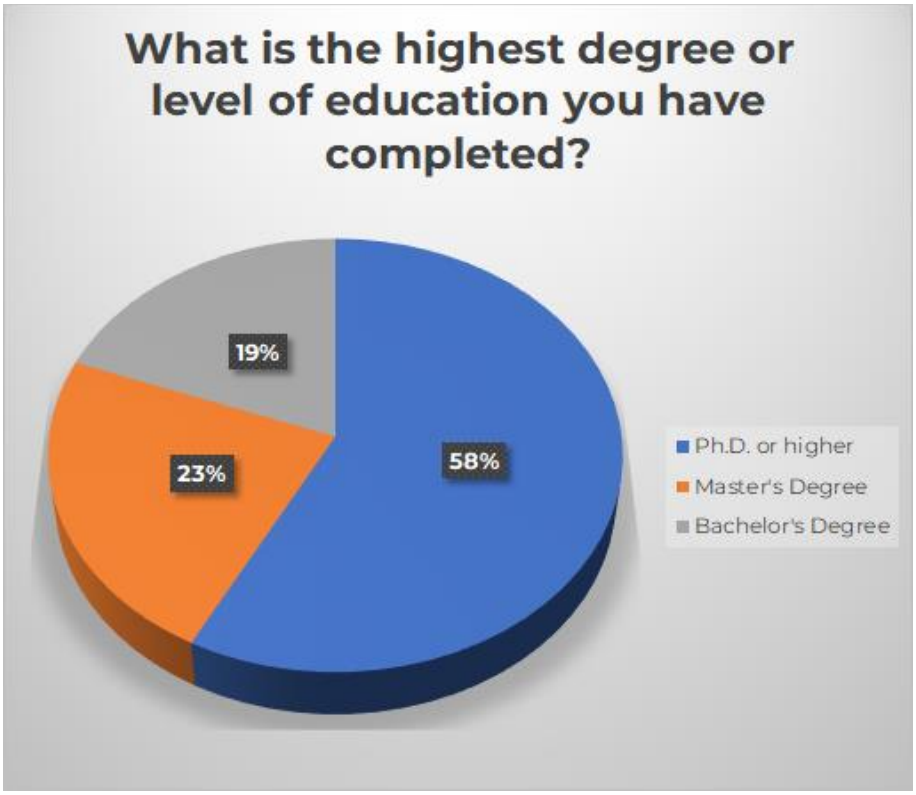


Figure A2.40. What is the highest degree or level of education you have completed?

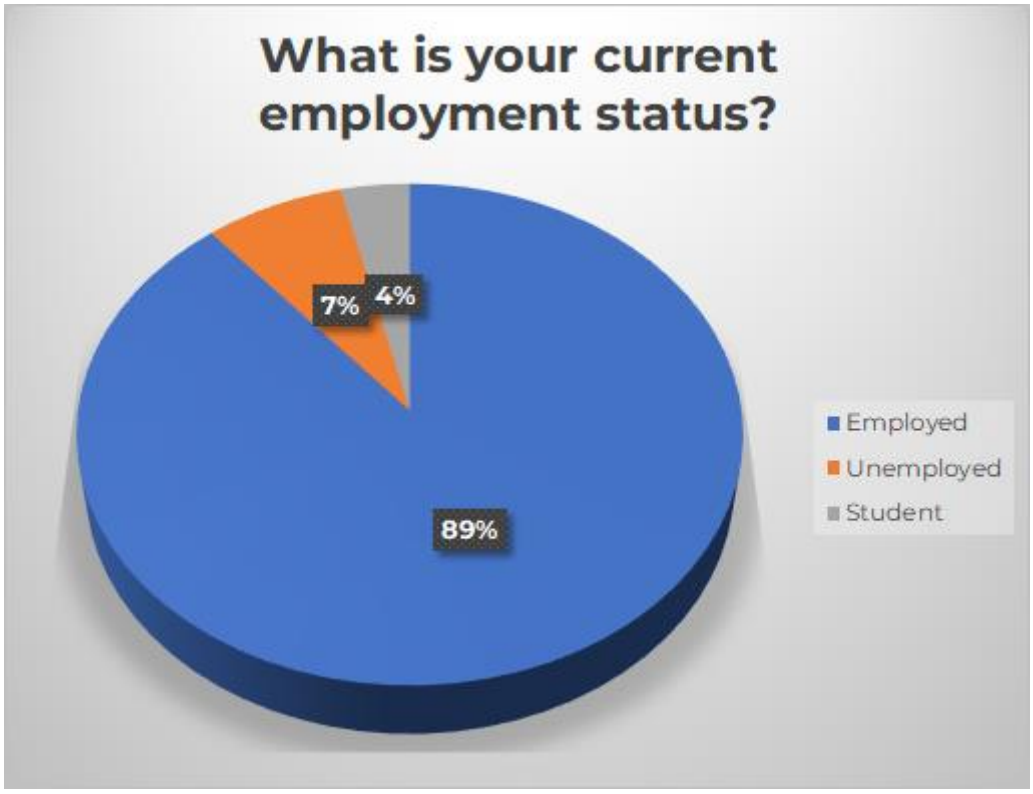


Figure A2.41. What is your current employment status?

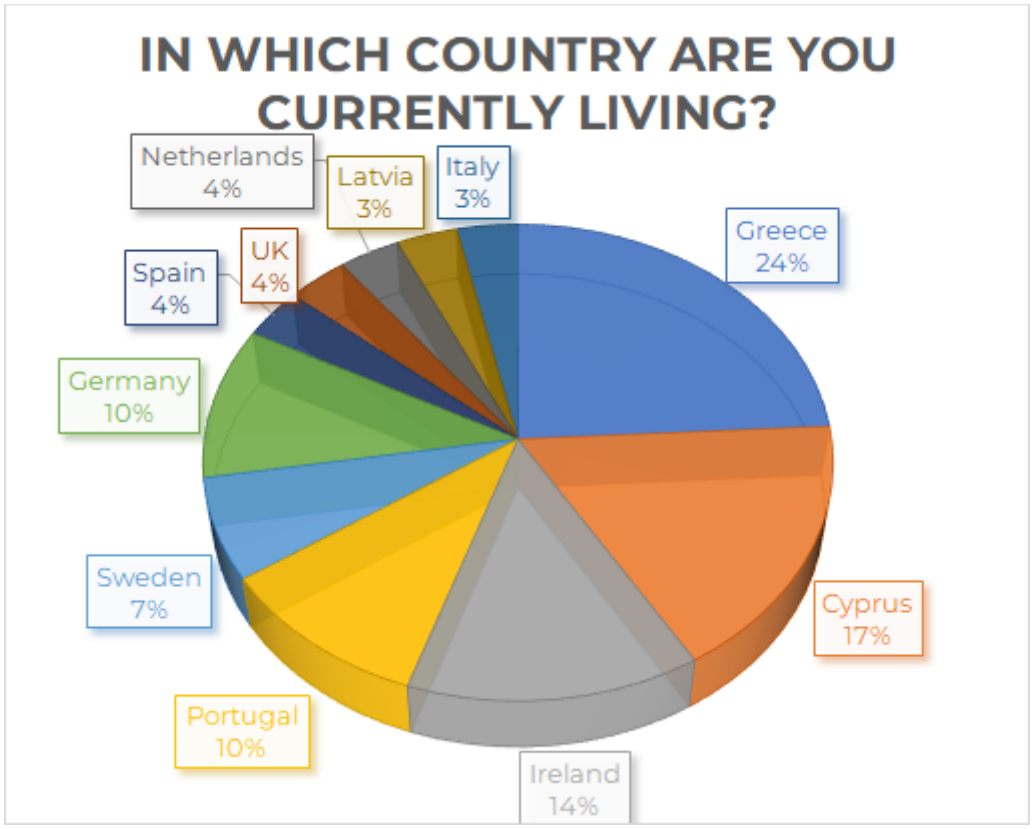


Figure A2.42. In which country are you currently living?

ANNEX 3: DESIGN OF QUESTIONNAIRE AND PRIVACY POLICY

Questionnaire design

eXtended Reality state and needs for Education

Alliance4XR is set on co-creating and testing a well-tailored teaching and training methodology and material for empowering universities, vocational and training centers to successfully address the challenge of XR digital skills mismatch with a focus in engineering.

Project Coordinator:
Mr. **Konstantinos Smagas**, Project Manager, GEOIMAGING LIMITED
Email: kostas@geoimaging.com.cy

Principal Investigator:
Mr. **Anders Östman**, NOVOGIT AB
Email: Anders.Ostman@novogit.se

Survey location and procedure:
You have been invited to participate in a survey called "**eXtended Reality state and needs for Education**", and before starting, to fill and sign electronically a consentment agreement by ticking the boxes in the last part of this page. Answers collected during the survey will stay fully anonymous.
What we are expecting from you:

The full duration to answer the questions of this survey is about 10 minutes. Some answers will be checkboxes, some will be to scale a rating, and some others will expect synthetic descriptions of examples (about 2-3 sentences, maximum).

If you face any issues or if you need additional information you can contact info@alliance4xr.eu

There are 13 questions in this survey.

Which sector is your course(s) / program(s) targeting (What is your current sector/occupation or what industrial sector do you target?) *

Select all that apply
Please choose **all** that apply:

- ☐ Vocational Education and Training (VET)
- ☐ Higher Education Institution (HEI)
- ☐ Structural engineering
- ☐ Energy
- ☐ Maritime
- ☐ Other: _____

In case you are currently using XR technologies as a tool when teaching your course(s), please state your level of agreement or disagreement with the following statements:
*

Please fill in at most 8 answers

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
I have observed or perceived that XR technologies are promoting active learning and student engagement.	☐	☐	☐	☐	☐
I believe or envision that XR technologies are promoting active learning and student engagement	☐	☐	☐	☐	☐
I have observed or perceived that the use of XR technologies has substantially contributed to the achievement of the learning objectives outlined in educational/training programs	☐	☐	☐	☐	☐
I believe or envision that the use of XR technologies will substantially contribute to the achievement of the learning objectives outlined in educational/training programs	☐	☐	☐	☐	☐
I have observed or perceived that the use of XR technologies has substantially increased the level of student/trainee engagement as compared to traditional teaching methods	☐	☐	☐	☐	☐
I believe or envision that the use of XR technologies will substantially foster collaboration among learners	☐	☐	☐	☐	☐
I believe that the use of XR technologies will become very important for preparing students/trainees for future career opportunities	☐	☐	☐	☐	☐
I believe that the use of XR technologies will substantially increase our abilities in addressing the diverse learning needs of students/trainees	☐	☐	☐	☐	☐

1 = Completely disagree, 5 = Fully agree

How do you think XR technologies can or can not address the diverse learning needs of students/trainees within your sector? *

Please write your answer here:

I consider myself to be very familiar with the current usage and needs of applying XR technologies within the industrial sector(s) my courses are targeting? *

Please choose **only one** of the following:

◯ 1
◯ 2
◯ 3
◯ 4
◯ 5

1 = Completely disagree, 5 = Fully agree

I consider myself to be very familiar with the type of problems that XR technologies can solve within the industrial sector(s) my courses are targeting? *

Please choose **only one** of the following:

◯ 1
◯ 2
◯ 3
◯ 4
◯ 5

1 = Completely disagree, 5 = Fully agree

Which of the following XR subtopics are you currently addressing or considering to address within the next three years? *

Please fill in at most 13 answers

	Currently address	Currently partly address	Considering to address	Considering partially to address	Not considering to address	Don't know
Basic principles of XR	☐	☐	☐	☐	☐	☐
Tracking technologies	☐	☐	☐	☐	☐	☐
3D visualisation	☐	☐	☐	☐	☐	☐
3D audio	☐	☐	☐	☐	☐	☐
Kinematics	☐	☐	☐	☐	☐	☐
Haptic senses	☐	☐	☐	☐	☐	☐
Advanced technologies for mixed reality	☐	☐	☐	☐	☐	☐
Multimodal interactions in immersive environments	☐	☐	☐	☐	☐	☐
Virtual navigations techniques	☐	☐	☐	☐	☐	☐
Human factors & Ergonomics in XR	☐	☐	☐	☐	☐	☐
The role of XR technologies for business development in our industrial sector(s)	☐	☐	☐	☐	☐	☐
Applying XR technologies in process development	☐	☐	☐	☐	☐	☐
Usage of XR technologies in our industrial sector(s)	☐	☐	☐	☐	☐	☐

I consider the following XR subtopics to very important to be included in the education and training our institute should be providing within the next five years *

Please fill in at most 13 answers

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree	Don't know
Basic principles of XR	☐	☐	☐	☐	☐	☐
Tracking technologies	☐	☐	☐	☐	☐	☐
3D visualisation	☐	☐	☐	☐	☐	☐
3D audio	☐	☐	☐	☐	☐	☐
Kinematics	☐	☐	☐	☐	☐	☐
Haptic senses	☐	☐	☐	☐	☐	☐
Advanced technologies for mixed reality	☐	☐	☐	☐	☐	☐
Multimodal interactions in immersive environments	☐	☐	☐	☐	☐	☐
Virtual navigations techniques	☐	☐	☐	☐	☐	☐
Human factors & Ergonomics in XR	☐	☐	☐	☐	☐	☐
The role of XR technologies for business development in our industrial sector(s)	☐	☐	☐	☐	☐	☐
Applying XR technologies in process development	☐	☐	☐	☐	☐	☐
Usage of XR technologies in our industrial sector(s)	☐	☐	☐	☐	☐	☐

I consider our institution meets the educational needs, with respect to XR technologies, of the industrial sector(s) we are targeting *

Please choose **only one** of the following:

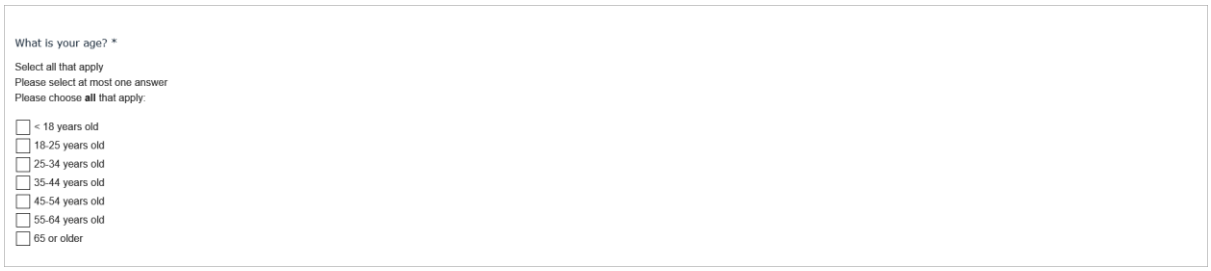
◯ 1
◯ 2
◯ 3
◯ 4
◯ 5

1 = Completely disagree, 5 = Fully agree


What gender do you identify as? *

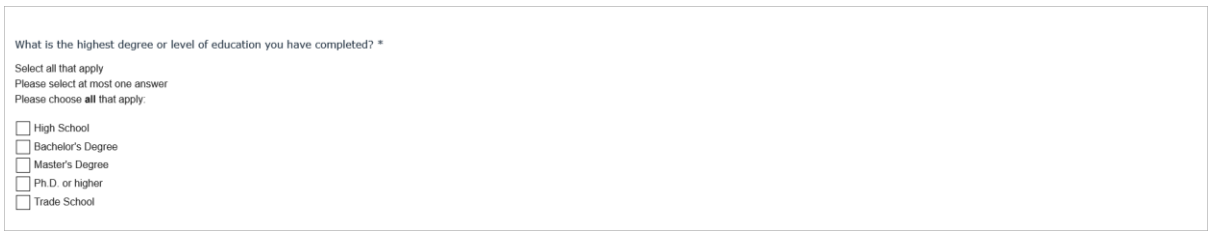
Select all that apply
Please select at most one answer
Please choose **all** that apply:

- ☐ Male
- ☐ Female
- ☐ Non-binary
- ☐ Prefer not to say


What is your age? *

Select all that apply
Please select at most one answer
Please choose **all** that apply:

- ☐ < 18 years old
- ☐ 18-25 years old
- ☐ 25-34 years old
- ☐ 35-44 years old
- ☐ 45-54 years old
- ☐ 55-64 years old
- ☐ 65 or older


What is the highest degree or level of education you have completed? *

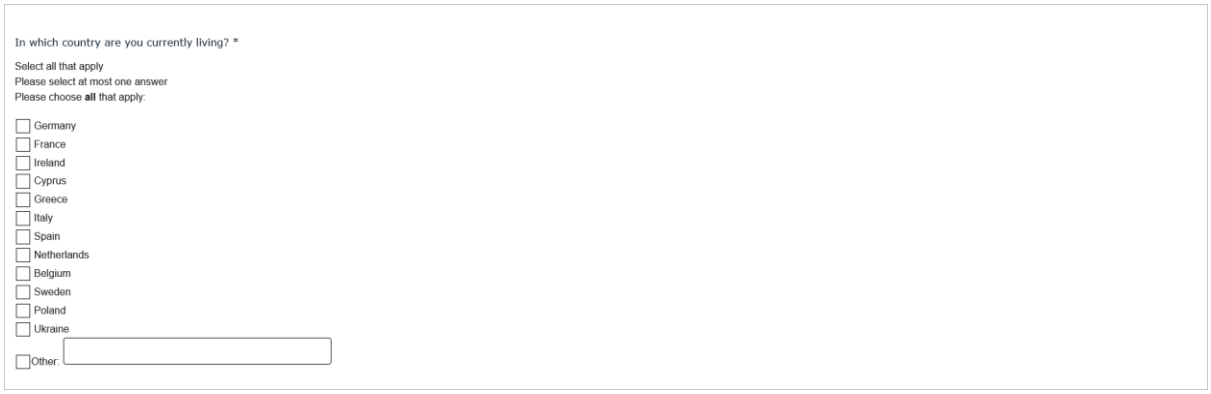
Select all that apply
Please select at most one answer
Please choose **all** that apply:

- ☐ High School
- ☐ Bachelor's Degree
- ☐ Master's Degree
- ☐ Ph.D. or higher
- ☐ Trade School


What is your current employment status? *

Select all that apply
Please select at most one answer
Please choose **all** that apply:

- ☐ Employed
- ☐ Unemployed
- ☐ Student
- ☐ Retired


In which country are you currently living? *

Select all that apply
Please select at most one answer
Please choose **all** that apply:

- ☐ Germany
- ☐ France
- ☐ Ireland
- ☐ Cyprus
- ☐ Greece
- ☐ Italy
- ☐ Spain
- ☐ Netherlands
- ☐ Belgium
- ☐ Sweden
- ☐ Poland
- ☐ Ukraine
- ☐ Other:

Privacy Policy

Participation cost: There is no cost for the participant for the involvement in this study.

How will your data be used?

Your data will be used solely for research purposes to assess how XR is currently being used, what its potential applications are, and what specific needs or challenges exist in integrating XR into educational and training settings. The data

obtained will be confidential. Each participant will be assigned a unique identifier preserving their anonymity. The data automatically captured during the experiment will be linked to this unique identifier and cannot be linked directly to your identity.

How will your confidentiality and privacy be protected?
The personal data specified in this document will be kept in a secure location in order to guarantee your rights of withdrawal and rectification. Only the Principal Investigator will have access to it. Although statistics on all participants may use the specified age and gender information in the aggregate, your identity will not be used or communicated in any way. In accordance with the provisions of the Data Protection Act, you may exercise your rights of access, rectification or deletion of data concerning you by simple request to the scientific manager of the project.

Benefits of the study: Discovery of XR technologies state, needs and use cases scenario for Learning and Training

Possible risks of the study: no risk

Diffusion/Dissemination:
The results of this study will be presented in some reports as official deliverables of the Alliance4XR project to the ERASMUS+ program and at the European Commission. Moreover, it may be presented in academic conferences or symposia, and published in academic journal articles and conference proceedings.

Rights to ask questions:
You can ask questions about the research before and after your participation by contacting by email the Principal Investigator and/or the Scientific supervisors of this survey.

Right to refuse or withdraw:
Your participation is not forced. You can stop the research at any time if you wish. Consent is provided for 6 months until it is revoked by sending an e-mail to the Principal Investigator or the Scientific Supervisors or by sending the application form enclosed at the end of this document to the address of the coordinator of the research/scientific. The right to withdraw consent at any time does not affect

the lawfulness of the processing based on the consent given before its withdrawal.

Data managing:

The data collected within the survey will be stored for six (6) months after the completion of the study and followed by their permanent deletion. The processing of your personal data is based on consent to this processing for a specific purpose. Your personal data will be codified and saved at computers in accordance with appropriate technical and organizational measures. You have the right to access to or rectification or erasure of your personal data or restriction of processing concerning your data or to object to processing as well as the right to data portability. For such request or any enquiry or guidance regarding your rights, you could send an email to the Principal Investigator. Any change in your personal data will take place within 30 days of your communication with the Principal Investigator.

Consent to Participation:

By signing the consent form, you certify that you have read and understood the information above, that the Principal Investigator has answered your questions satisfactorily and that she has informed you that you are free to withdraw your consent or withdraw from this survey at any time, without prejudice.