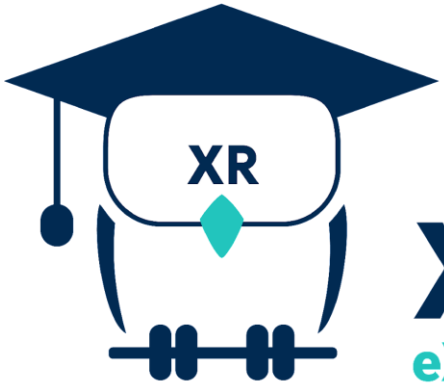
Horizon Innovation Action
HORIZON-CL4-2022-HUMAN-01-19



XR4ED
eXtended Reality for EDucation

D3.4
User/Technology requirement, existing tools and infrastructure - 2

DISCLAIMER
This document is issued within the frame and for the purpose of the XR4ED project. This project has received funding from the European Union's Horizon Europe Framework Programme under Grant Agreement No. 1010931159. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the European Commission. The dissemination of this document reflects only the author's view, and the European Commission is not responsible for any use that may be made of the information it contains. This deliverable is subject to final acceptance by the European Commission. This document and its content are the property of the XR4ED consortium. The content of all or parts of this document can be used and distributed provided that the XR4ED project and the document are properly referenced. Each XR4ED partner may use this document in conformity with the XR4ED Consortium Grant Agreement provisions.

Funded by
the European Union

XR4ED Project Profile

Project title	eXtended Reality for EDucation
Project acronym	XR4ED
Grant agreement No.	101093159
Start date of project	1 January 2023
Duration of project	36 months
Project website	http://www.xr4ed.eu/

Partners

CYENS CENTRE OF EXCELLENCE	CYENS	RESEARCH	CYPRUS
konnektable TECHNOLOGIES	KONNEKTABLE	SME	IRELAND
21 Sci science 27 Co communication	SciCo	SME	GREECE
F6S	F6S	SME	IRELAND
INFINITIVITY DESIGN LABS	Infinity Design Labs	SME	FRANCE
KAINOTOMIA	KAINOTOMIA	SME	GREECE
NUROGAMES	NUROGAMES	SME	GERMANY
CRI	CRI	INDUSTRY	Luxemburg
SIMAVI	Software Imagination & Vision SRL	SME	ROMANIA
UPC	Universitat Politecnica de Catalunya	RESEARCH	SPAIN
CELLOCK	CELLOCK Ltd	SME	CYPRUS

Document information

Related work package	WP3	
Document reference	D3.4 User/Technology requirement, existing tools and infrastructure - 2	
Related deliverables	D3.1 User/Technology requirement, existing tools and infrastructure - 1	
Type		DEM - Demonstrator, Pilot, Prototype
		DMP - Data Management Plan
	✓	R - Document, Report
Status	Final	
Version	8	
Due date	Original: 31/08/2023 Revised: 29/11/2024	
Submission date	Original: 31/08/2023 Revised: 29/11/2024	
Lead partner	KAINOTOMIA	
Contributing partners	CYENS, CELLOCK, SciCo, CRI, KT, IDL	
Reviewers	Athina Papandreou, Katerina Michale, Eleftheria Kouppari, Haris Zacharatos, Fotis Liarokapis, Filip Skola, Alkis Nicolaides, Maria Vicente, Yash Shekhawat, Leonidas Somakos, Christos Angelidis, George Kalmpourtzis	
Keywords	User Requirements, existing tools, XR infrastructure 1	

Dissemination level	
✓	PU: Public
	SEN: Sensitive

List of contributors	
Name	Partner (short name)
Cellock Ltd	CLK
CYENS CoE	CYENS
Science Communication	SciCo
KONNEKTABLE	KT
Infinity Design Labs	IDL
NUROGAMES	NUROGAMES
CRI	CRI

Revision History

Document History			
Version	Date	Change editors	Changes
0.1	29/08/2023	KAINOTOMIA	First Draft
0.2	30/08/2023	CYENS	Second Draft
0.3	31/08/2023	KAINOTOMIA	Third Draft
0.4	31/08/2023	CYENS	Fourth Draft
0.5	31/08/2023	KAINOTOMIA	Fifth Draft
0.6	14/02/2024	KAINOTOMIA	Sixth Draft
0.7	14/02/2024	CYENS	Seventh Draft
0.8	29/11/2024	KAINOTOMIA	Final

Quality control		
Role	Partner (short name)	Approval date
Deliverable leader	KAINOTOMIA	29/11/2024
Quality manager	CLK	29/11/2024
Project coordinator	CYENS	29/11/2024

Table of Contents

XR4ED Project Profile 2
Partners 3
Document information 4
Revision History 5
List of Acronyms 10
Changes 11
Executive Summary 12
1 Introduction 13
2 User Requirements Identification 14
2.1 Interviews 16
2.1.1 Methodology 16
2.1.2 Structure 16
3 XR4ED Architecture, Microservices and Modules 18
3.1 Application tier 19
3.2 Database tier 22
3.3 Front end tier 23
4 Questionnaire and Interview Results 25
4.1 Experts 25
4.1.1 Survey Results Analysis 25
4.1.2 Interview Results Analysis 30
4.1.3 Narrative Analysis 40
4.2 Educators 43
4.2.1 Interview Results Analysis 43
Answers analysis 46
4.2.2 Narrative Analysis 57
4.3 Students 60
4.3.1 Results Analysis 60
4.3.2 Narrative Analysis 62

5 Compiled Conclusion 65
5.1 Discussion 65
ANNEXE I: Questionnaire for Experts 68
ANNEXE II: Questionnaire Students (above 18 years of age) 68
ANNEXE III: Interview for Experts 69
ANNEXE IV: Interview for Educators 71

List of Figures

Figure 3-1: XR4ED Architecture 18
Figure 3-2: Monolithic application architecture (on the left) vs a microservices architecture (on the right). 19
Figure 3-3: APIs communication 21
Figure 4-1: Distribution of years of working experience among experts 25
Figure 4-2: Age distribution of experts responding to the questionnaire 26
Figure 4-3: Experts' experience with XR. 26
Figure 4-4: Responses to "To what extent do you agree with the following statements: XR (AR, VR, MR) are a powerful tool and should be used in teaching within educational environments." 27
Figure 4-5: Responses to "To what extent do you agree with the following statements: XR (AR, VR, MR) technology as a whole is a passing trend." 27
Figure 4-6: Experts' expectations of the possibility of implementing XR in their university 28
Figure 4-7: Importance of 3D design and didactic usefulness 28
Figure 4-8: Importance of realism and immersiveness 29
Figure 4-9: Interviewed Experts' Profile by Country 30
Figure 4-10: Interviewed Experts' Profile by Gender 30
Figure 4-11: Interviewed Experts' Profile by Age 31
Figure 4-12: Interviewed Experts' Profile by Employment Status 31
Figure 4-13: Interviewed Experts' Profile by Years of Working Experience 32
Figure 4-14: Interviewed Experts' Profile by Academic Level 32
Figure 4-15: Interviewed Experts' Profile by their involvement in the XR4ED project 33
Figure 4-16: Interviewed Experts' opinion on how the existing educational and learning frameworks can be integrated or adapted to incorporate XR technologies effectively 34
Figure 4-17: Interviewed Experts' opinion on key user requirements that should be considered when developing an XR platform or application 34
Figure 4-18: Interviewed Experts' opinion on how XR platforms can be designed to ensure ease of use and accessibility for users with varying levels of technical expertise 35
Figure 4-19: Interviewed Experts' opinion on the most important factors to consider when designing user interfaces and interactions for XR experiences5 35
Figure 4-20: Interviewed Experts' opinion on the role customisation and personalisation options should play in an XR platform 36
Figure 4-21: Interviewed Experts' opinion on the critical hardware requirements or considerations for delivering high-quality XR experiences 36
Figure 4-22: Interviewed Experts' opinion on challenges in terms of content distribution and compatibility. 37
Figure 4-23: Interviewed Experts' opinion on what measures can be taken to address concerns related to privacy and data security when using XR platforms 37
Figure 4-24: Interviewed Experts' opinion on the importance of interoperability between different XR systems and platforms 38
Figure 4-25: Interviewed experts' opinion on what kind of support or resources developers and content creators need to effectively utilize an XR platform 38
Figure 4-26: Interviewed Experts' opinion on how an XR platform can facilitate collaboration and knowledge sharing among users 39
Figure 4-27: Educators' Profile by Country 43
Figure 4-28: Educators' Profile by Gender 43
Figure 4-29: Educators' Profile by Age 44

Figure 4-30: Educators' Profile by Employment Status 44
Figure 4-31: Educators' Profile by Years of Working Experience 45
Figure 4-32: Educators' Profile by Academic Level 45
Figure 4-33: Educators' Familiarity with XR Technologies 46
Figure 4-34: Educators' Experience in Utilising XR Technologies in Education 46
Figure 4-35: Educators' opinion on XR Technologies' Impact on Learning Outcomes and Engagement 47
Figure 4-36: Educators' opinion on the most effective XR Experiences for student engagement and understanding 47
Figure 4-37: Educators' opinion on the design considerations for XR platforms in different educational contexts 48
Figure 4-38: Educators' opinion on the importance of ease of use and intuitive navigation in XR Platforms 48
Figure 4-39: Educators' opinion on the most suitable XR technologies for educational purposes 49
Figure 4-40: Educators' opinion on the essential features and functionalities in an XR platform for education 49
Figure 4-41: Educators' opinion on the content creation capabilities in an XR platform 50
Figure 4-42: Educators' opinion on designing XR Platforms for different subjects or disciplines 50
Figure 4-43: Educators' opinion on features or functionalities for educational use 51
Figure 4-44: Educators' opinion on the accommodation of diverse learning styles or varying abilities 51
Figure 4-45: Educators' needs on training or support to effectively integrate XR into the classroom 52
Figure 4-46: Educators' opinion on the incorporation of XR into existing curriculum and teaching methods 53
Figure 4-47: Educators' concerns on the use of XR technologies in the classroom 53
Figure 4-48: Educators' opinion on the affordability and accessibility 54
Figure 4-49: Educators' opinion on potential ethical considerations 54
Figure 4-50: Educators' opinion on the resources or materials to integrate XR into lessons or activities 55
Figure 4-51: Educators' opinion on potential challenges or barriers 55
Figure 4-52: Educators' preference in assessment and evaluation of student learning with XR 56
Figure 4-53: Age distribution of students responding to the questionnaire 60
Figure 4-54: Numbers of student participants having used XR in any of their courses 61
Figure 4-55: Responses to questions regarding preference for XR-mediated teaching material 61
Figure 4-56: Students' expectations of the possibility of implementing XR in their university 62

List of Acronyms

Acronym	Description
AR	Augmented Reality
EdTech	Educational Technology
FEAT	Features
MR	Mixed Reality
PO	Project Coordinator
SMEs	Small and Medium-Sized Enterprises
UC	Use Cases
VR	Virtual Reality
XR4ED	Extended Reality for Education

Changes

In response to the feedback received during the review process, we have implemented substantial changes to this deliverable. Specifically, we have expanded our sample size, increasing the number of surveyed experts from 80 to 301 and the number of surveyed students from 211 to 301. Additionally, we have adjusted our approach to analysing the questionnaires. Our revised methodology now incorporates Descriptive Statistics, Data Visualization, Comparative Analysis, Correlation Analysis, and Qualitative Interpretation techniques.

Executive Summary

The specific deliverable entitled “User/Technology requirement, existing tools and infrastructure - 2” outlines a user-centred design approach employed in the development of initial user requirements for the XR4ED project. The process involves the utilisation of questionnaires to gather valuable insights regarding the user requirements for XR in education. Moreover, the deliverable investigates the adaptability of existing educational and learning frameworks for the Extended Reality (XR) authoring tool and platform. Additionally, this deliverable focuses on the draft formulation of functional and non-functional specifications for XR4ED services and applications. These specifications encompass system functions and component interactions that cater to the needs of the domain and users, and are presented in a comprehensive manner, including descriptions of involved actors and related elements. By applying user-centred design principles and leveraging the consortium's collective expertise, this research aims to ensure the development of an effective XR4ED solution. The first version of the deliverable entitled “User/Technology requirement, existing tools and infrastructure - 1” was submitted for review in May. The revised final version includes the analysis from a larger sample size of responses derived from the same questionnaires used in the first deliverable D3.1 and the identification of the technical requirements of the XR4ED platform as well as of the components to be integrated, identifying their interfaces, data schemas and operational and functional requirements. Therefore, D3.4 has received as input the report of D3.1, towards identifying the technical constraints and specifications of the platform to be designed.

I Introduction

The European EdTech sector is playing an increasingly important role in driving forward digital transformation in Europe covering all education and training sectors. According to estimates, the sector saw a 15% increase in investments in 2021 and global investments are expected to reach over $87 billion in the upcoming decade. Notwithstanding, the sector is heavily fragmented across the European Union with many small players and few companies playing a global role.

The European XR industry has evolved and maintained a leading role globally in software and content production. The use of XR can expand the range of activities through which students can gain hands-on experience, enabling them to go beyond abstract knowledge and supporting skills-based teaching and learning. Currently, developing XR applications for education requires specialised knowledge and strong XR development skills. The process takes a lot of effort, time, and money.

The XR4ED concept is to:

a) **bring together EdTech and XR community and resources**, overcoming fragmentation issues and encouraging the acceleration of innovation for personalised, innovative, efficient, and inclusive learning using XR;

b) **build a one-stop shop and open marketplace for XR applications for learning, training and education** that will act as a European reference platform on learning and teaching with XR4ED will focus on the following sectors which must be further developed to make Europe a leader in cutting-edge technologies for education:

- Boost the deployment of innovative XR applications for learning, training, and education.
- Enable digital start-ups, small and medium-sized enterprises (SMEs), and industry active in the EdTech sector to further advance early prototypes, of digital learning solutions/apps using XR to a market-ready product.
- Provide a single point of access to XR content, tools and solutions based on open standards.
- Provide links to existing relevant initiatives and projects, including existing platforms, catalogues, or repositories.

The first version of the document (D3.1) was submitted for review on the 31st of May 2023. The present document is the final version (D3.4). The purpose of this document is to outline the initial user requirements which are essential to meet the specific project objectives of the XR4ED project. This is included as part of WP3 for the XR4ED project and is specifically the deliverable of Task 3.1.

To understand the user requirements, XR4ED applied principles of user-centred design developed from several validated questionnaires. The objective was to design and distribute questionnaires to the

scientific community (universities, schools, research centres, XR developers and experts in partnership) and gather anonymous information regarding XR and education.

The purpose of this task was also to review existing educational and learning frameworks which can be adopted for our XR authoring tool and platform. Furthermore, the functional and non-functional specifications of the XR4ED services and applications were drafted for D3.1 and are now validated in this updated version of the deliverable, D3.4. The latter includes a set of system functions and component interactions that fulfil the domain and user needs.

D3.1 had the analysis based on the initial questionnaire responses (60 questionnaires from **experts** and 19 from **students**) (above 18 years of age). In this second phase (D3.4), we received an additional 20 valid responses from experts and 192 valid ones from students resulting in a total of 80 valid responses from experts and 211 valid from students. In addition, interviews were conducted with XR experts within the consortium, external experts, and educators. This resulted in a total of 18 interviews – 10 with experts, and 8 with educators. The feedback received has helped us further validate our use cases and has given us information that will allow us to confidently proceed with the development of the XR4ED platform.

In the context of D3.4, a comprehensive analysis was conducted, combining the newly gathered responses with those from the prior phase. This approach was undertaken to reach a holistic comprehension of the user requirements. As such, the assessment encompassed a total of 80 responses from experts, 211 responses from students, alongside the insights garnered from 10 experts and 8 educators who participated in interview sessions. This cumulative effort ensures a robust and inclusive exploration of the subject matter.

2 User Requirements Identification

To effectively provide products and services that meet the users' real needs, it is necessary to identify and involve all types of users as part of the Requirements Modelling process. The potential users of the system are identified, ensuring that the stakeholder community represents them adequately. This section provides a profile of the representative users involved in the project and the key problems that they perceive to be addressed by the proposed solution.

The user requirements document was developed based on literature review and the input of 3 target groups. The target groups were – a) experts from the expert's community (universities, schools, research centres, XR developers and experts in partnership), b) students and young people (over 18 years old), and c) educators of all sectors with experience in using XR in the classroom. Questionnaires were created for the students and the experts. The questionnaires included questions that were validated through empirical studies (see section 3.2). The questionnaires' questions for the experts can be found in ANNEXE I and for the students in ANNEXE II. Interviews were held with experts as complementary to the survey. Interviews were also held with educators for qualitative data. The interview questions included questions that were validated through empirical studies (see section 3.2).

The interview questions for the experts can be found in ANNEXE III and for the educators in ANNEXE IV.

The questionnaires and interviews provided a basis to further detail the use cases and therefore the initial requirements for the XR4ED project. The questionnaires were distributed in Google forms via email and were anonymous. The interviews were held via zoom and the answers were recorded in a word document.

2.1 Interviews

2.1.1 Methodology

The objective of conducting interviews with educators and experts was to gain comprehensive insights into their perspectives, needs, and opinions concerning the XR4ED platform's development. Similar to the approach followed in designing the questionnaires, we first established the scope of the interviews, identified the target participants, and determined the key themes to be explored during the discussions. The integrated questions for the interviews can be found in **ANNEXE III** and **ANNEXE IV**

For the educator interviews, participants were selected based on their experience and roles within educational institutions. An introductory section gathered essential background information, including demographic details, employment status, years of experience, academic level, and affiliations. The subsequent section focused on their expertise in the education sector, enabling us to contextualize their insights.

The expert interviews, on the other hand, were aimed at those with deep expertise in XR technologies and education. As with educators, the introductory section gathered demographic data and professional details. Additionally, we inquired about their specific experience with XR technologies and the education sector, aiming to understand the depth of their insights.

2.1.2 Structure

The interview structure mirrored that of the questionnaires but allowed for more in-depth and open-ended responses. For both educators and experts, the interviews consisted of two main sections:

Background Information

This section aimed to establish a foundational understanding of the interviewee's profile. For educators, details included country, gender, age, employment status, years of experience, academic level, and affiliation. Experts similarly provided demographic data, followed by an exploration of their XR and education-related expertise.

Discussion Questions

Building on the questionnaires, this section delved into the core themes. Educators shared their familiarity with XR technologies, experiences using them in classrooms, perceived benefits, and considerations for designing effective XR experiences. They also discussed challenges, preferences for platform features, integration into different subjects, and ethical considerations.

Experts provided insights on integrating XR into educational frameworks, key user requirements for XR platforms, design considerations for user interfaces, and hardware requirements for optimal XR experiences. They discussed challenges like content distribution and privacy concerns, as well as the

potential benefits and challenges of achieving interoperability. Additionally, they shared thoughts on resources and support needed for XR development and collaboration.

By structuring the interviews in this way, we aimed to systematically gather comprehensive information, ensuring that both educators and experts could provide insights that align with their expertise. The interview format enabled a deeper exploration of their perspectives, contributing to a holistic understanding of the requirements and considerations for the XR4ED platform.

3 XR4ED Architecture, Microservices and Modules

Our solution will be based on 3-tier architecture. A 3-tier application architecture is a modular client-server architecture that consists of a presentation tier, an application tier and a data tier. The data tier stores information, the application tier handles logic, and the presentation tier is a graphical user interface (GUI) that communicates with the other two tiers. Below is a high-level diagram of our solution:

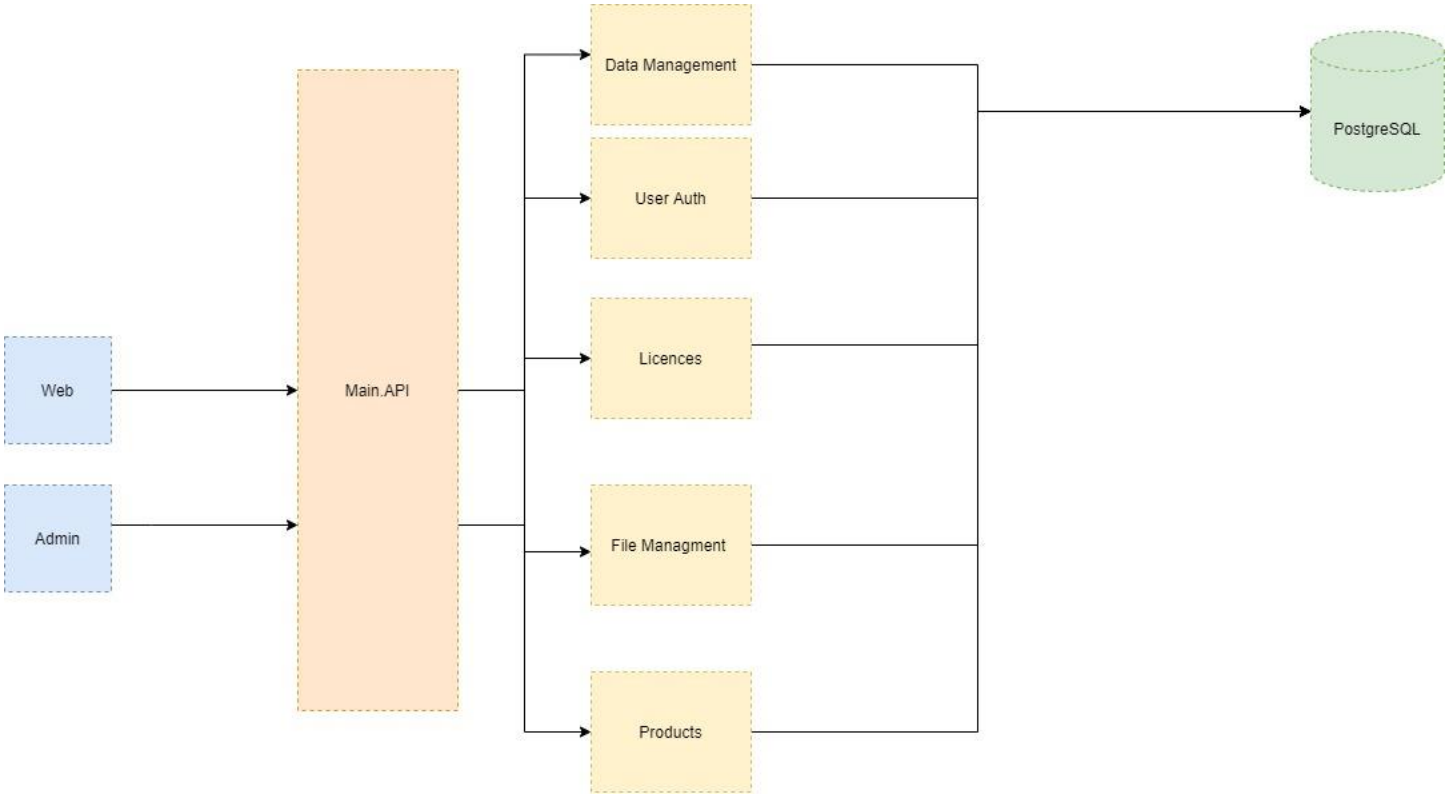


Figure 3-1: XR4ED Architecture

Presentation tier: Will be built with React and React Native for mobile applications. The presentation tier communicates with the other tiers through application program interface (REST API) calls.

Application tier (Backend): The application tier, which may also be referred to as the logic tier, will be written in node js programming language and contains the business logic that supports the application's core functions. The architecture of the application layer will be based on microservices. For the GIS functionalities we will use the GEO Server and the GIS API.

Data tier: The data tier consists of a database and a program for managing read and write access to a database. We will use PostgreSQL database for storing all related data.

3.1 Application tier

We will implement our application tier based on microservices architecture. The microservice architectural style is an approach to developing a single application as a suite of small services, each running in its own process and communicating with lightweight mechanisms, often an HTTP resource API. These services are built around business capabilities and independently deployable by fully automated deployment machinery. There is a bare minimum of centralized management of these services, which may be written in different programming languages and use different data storage technologies.

To start explaining the microservice style it's useful to compare it to the monolithic style: a monolithic application built as a single unit. Enterprise Applications are often built in three main parts: a client-side user interface (consisting of HTML pages and JavaScript running in a browser on the user's machine) a database (consisting of many tables inserted into a common, and usually relational, database management system), and a server-side application. The server-side application will handle HTTP requests, execute domain logic, retrieve, and update data from the database, and select and populate HTML views to be sent to the browser. This server-side application is a monolith - a single logical executable. Any changes to the system involve building and deploying a new version of the server-side application.

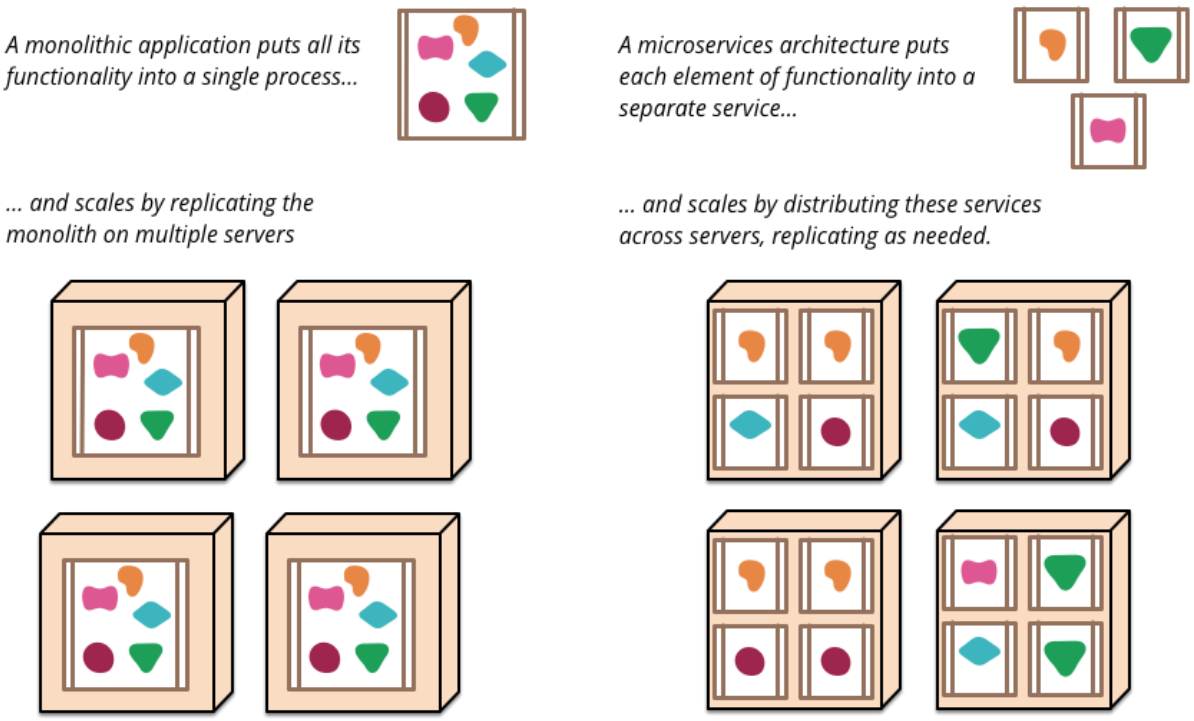


Figure 3-2: Monolithic application architecture (on the left) vs a microservices architecture (on the right)

Such a monolithic server is a natural way to approach building such a system. All your logic for handling a

request runs in a single process, allowing you to use the basic features of your language to divide up the application into classes, functions, and namespaces. With some care, you can run and test the application on a developer's laptop and use a deployment pipeline to ensure that changes are properly tested and deployed into production. You can horizontally scale the monolith by running many instances behind a load-balancer.
Monolithic applications can be successful, but increasingly people are feeling frustrations with them - especially as more applications are being deployed to the cloud. Change cycles are tied together - a change made to a small part of the application, requires the entire monolith to be rebuilt and deployed. Over time it's often hard to keep a good modular structure, making it harder to keep changes that ought to only affect one module within that module. Scaling requires scaling of the entire application rather than parts of it that require greater resource.

These frustrations have led to the microservice architectural style: building applications as suites of services. As well as the fact that services are independently deployable and scalable, each service also provides a firm module boundary, even allowing for different services to be written in different programming languages. They can also be managed by different teams.

The microservice approach to division is to split up into services organized around business capability. Such services take a broad-stack implementation of software for that business area, including user-interface, persistent storage, and any external collaborations. Consequently, the teams are cross-functional, including the full range of skills required for the development: user-experience, database, and project management.

Application tier will consist of several microservices for specific functionalities. Below is a list of the available microservices:

1. **User Authentication:** Will be responsible for login, registration and permission management.
2. **Product Management:** Monitor all the available Products of the platform such as Assets, XR components, third party modules.
3. **License manager:** Assign difference licenses for different kind of products and users. Will decide if a user has the right licence to consume a specific product.
4. Data Management: Responsible to store all the data exchanged between the different microservices.
5. File Management: Upload and store all the XR modules in the cloud infrastructure.
6. Main API: all the requests will be processed from the main API which will act as a proxy and Business rule engine for the rest of the microservices

All the components of the system will communicate via REST API. REpresentational State Transfer (REST) is an architectural style that defines a set of constraints to use to create web services. The REST API is a way to access online services in a simple and flexible way without the need for processing.

REST technology is generally preferred to more robust simple object access protocol (SOAP) technology because REST uses less bandwidth, simple and flexible making it more suitable for use on the internet. It is used to get or give some information from a web service. All communications made through the REST API use HTTP request only.

A request is sent from client to server in the form of a web URL as an HTTP GET or POST or PUT or DELETE request. After that, a response returns from the server in the form of a resource that can be anything like HTML, XML, Image, or JSON. But now JSON is the most popular format used in Web Services.

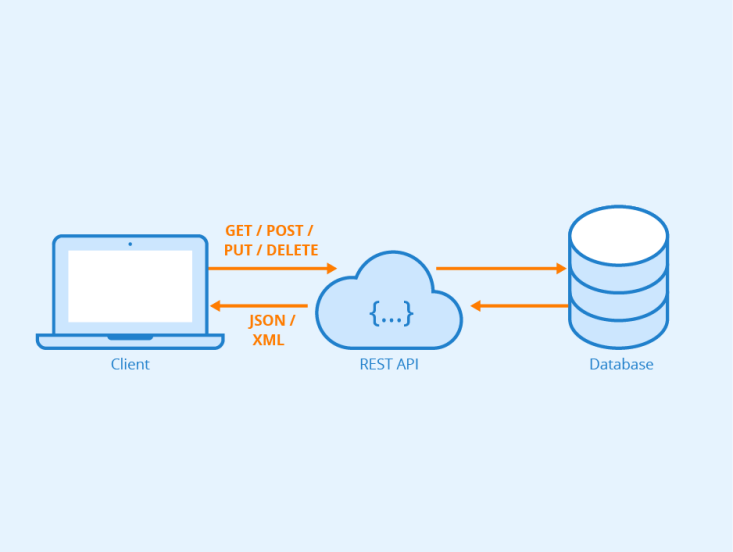


Figure 3-3: APIs communication

Some of the benefits of REST APIs are the following:

- **Lightweight:** One of the main advantages of REST APIs is that they are based on the HTTP standard, which means it's an agonizing format and you can use XML, JSON, HTML, etc. This makes REST APIs fast and lightweight — which is essential for mobile app projects, internet of things devices, and more. Independent: Another advantage of REST APIs is the fact that the client and server are independent. In other words, the REST protocol separates the data store and user interface from the server. This means that developers can work independently on different areas of a project and test multiple developer environments as needed.

- **Scalable and flexible:** One of the benefits of REST APIs, and perhaps one of the most important, is scalability and flexibility. REST APIs can scale quickly mainly due to the separation between client and server. In addition, developers can also easily integrate REST APIs without much additional work.

The system interfaces will be designed based on the following:

- The Interfaces layer will be designed to meet and include Web Content Accessibility Guidelines (WCAG), W3C Standard and Web Accessibility Initiative Guidelines (WAI – AA level) and offer usability and ergonomics.
- The system will allow the use of open application programming interfaces (APIs). Development of a complete interface (Application Programming Interface), compatible with the REST architecture, which will provide end-points from which third party services can gain access to receive or give

information to the System for all objects that will be identified in the relational model of the database.
- The system will be able to support multilanguage, with the possibility to add further languages if needed.
- The system will allow the processing and monitoring of all web requests (http/https protocols), based on defined security rules.

3.2 Database tier

PostgreSQL will be the main database of our system. PostgreSQL is a powerful and open-source relational database management system (RDBMS). Renowned for its robustness, extensibility, and advanced features, PostgreSQL has gained popularity among developers, data architects, and businesses seeking a reliable and scalable solution for managing their data.

PostgreSQL finds its application across a wide range of use cases, making it a versatile choice for various industries. It is commonly used for:

- **Web Applications:** Many web applications utilize PostgreSQL as their backend database, benefiting from its ability to handle high traffic loads and complex data structures.

- **Geospatial Applications**: PostGIS, an extension of PostgreSQL, enables the storage and querying of geospatial data, making it an ideal choice for location-based services and Geographic Information Systems (GIS).

- **Data Warehousing:** PostgreSQL's support for analytical queries, indexing, and optimized storage management allows it to be used in data warehousing environments for efficient data analysis.

- **Large-scale Enterprise Systems:** Its ACID compliance and support for transactions make PostgreSQL suitable for mission-critical enterprise applications, ensuring data integrity and reliability.

- **Time Series Data:** PostgreSQL's capabilities for handling time series data make it popular in industries like finance, IoT (Internet of Things), and monitoring.

Some of the benefits of PostgreSQL

- **Open-Source and Cost-Effective:** Being open-source, PostgreSQL eliminates licensing costs, making it an attractive choice for businesses looking to manage their data without a significant financial burden.

- **Robust and Reliable:** PostgreSQL's focus on data integrity, support for transactions, and crash recovery mechanisms ensure that your data remains consistent and available, even in the face of hardware or software failures.

- **Extensibility and Customization:** With its support for user-defined functions, procedural

languages, and extensions, PostgreSQL can be tailored to specific application requirements and can integrate with various programming languages.

- **Advanced Features:** PostgreSQL offers advanced features such as support for JSON and JSONB data types, full-text search, geospatial querying via PostGIS, and more, making it suitable for modern and complex data needs.

- **Performance Optimization:** Its query optimization capabilities, indexing options, and parallel processing enable developers to fine-tune performance for optimal execution speed.

- **Community and Support:** PostgreSQL has a vibrant and active community that contributes to its development, provides support through forums, mailing lists, and resources, ensuring that users can find help and solutions to their challenges.

In conclusion, PostgreSQL stands out as a versatile and powerful database management system, suitable for a wide array of applications across industries. Its open-source nature, reliability, extensibility, and feature-rich architecture make it a compelling choice for businesses and developers seeking a robust solution for managing their data effectively.

3.3 Front end tier

All the Web User interfaces will be implemented in a modern approach compatible with all browsers in a responsive design. The programming language we will use for mobile applications and web browsers will be the popular framework of Facebook React. React is a JavaScript-based UI development library. Facebook and an open-source developer community run it. Although react is a library rather than a language, it is widely used in web development. The library first appeared in May 2013 and is now one of the most used frontend libraries for web development.

It offers various extensions for entire application architectural support, such as Flux and React Native, beyond mere UI.

React's popularity today has eclipsed that of all other front-end development frameworks. Here is why:

Improved performance: React uses Virtual DOM, thereby creating web applications faster. Virtual DOM compares the components' previous states and updates only the items in the Real DOM that were changed, instead of updating all the components again, as conventional web applications do.

- Reusable components: Components are the building blocks of any React application, and a single app usually consists of multiple components. These components have their logic and controls, and they can be reused throughout the application, which in turn dramatically reduces the application's development time.
- Unidirectional data flow: React follows a unidirectional data flow. This means that when designing a React app, developers often nest child components within parent components. Since the data flows in a single direction, it becomes easier to debug errors and know where a problem occurs in an application now in question.

- It can be used for the development of both web and mobile apps: We already know that React is used for the development of web applications, but that's not all it can do. There is a framework called React Native, derived from React itself, that is hugely popular and is used for creating beautiful mobile applications. So, in reality, React can be used for making both web and mobile applications.

For Mobile app development we will use React Native. With React Native Framework, we can render UI for both iOS and Android platforms. Since React Native components have the counterpart rights, we can reuse these components for building both Android and iOS apps. REACT Native helps you create real and exciting mobile apps with the help of JavaScript only, which is supportable for both android and iOS platforms. Just code once, and the REACT Native apps are available for both iOS and Android. Found a great popularity and backed by Facebook, REACT Native, has a huge community support today. React Native is built on top of ReactJS which has given a huge competition to the long-time favourite, AngularJS.

4 Questionnaire and Interview Results

Results from the questionnaires and interviews are split into 3 sections: experts, educators, and students. An overview of the outcome is provided in the next sub-sections.

4.1 Experts

4.1.1 Survey Results Analysis

Data from 301 experts in education and the XR (VR/AR/MR) related fields were collected, while about half of the participants are teachers who have at least some experience with XR and about a quarter of participants are XR experts (see Figure 4-1). The age of the respondents follows the normal distribution (Figure 4-2), while their years of working experience are equally distributed (Figure 4-3).

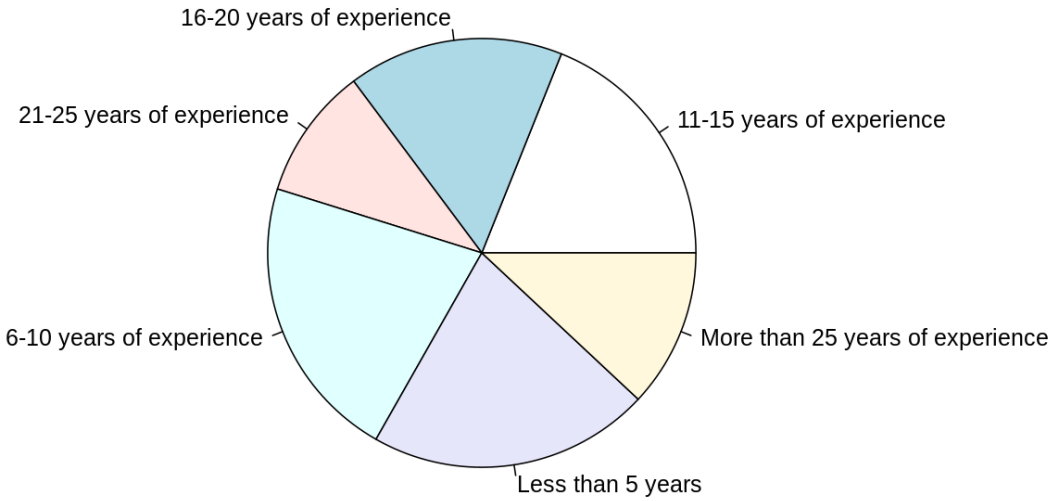


Figure 4-1: Distribution of years of working experience among experts

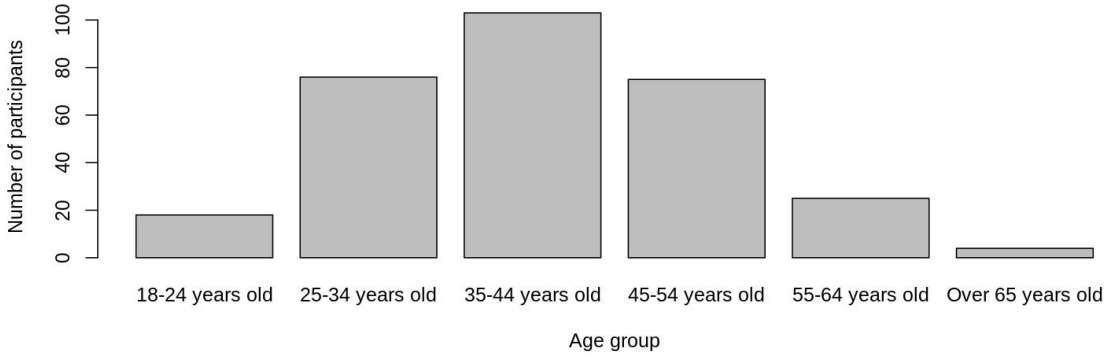


Figure 4-2: Age distribution of experts responding to the questionnaire

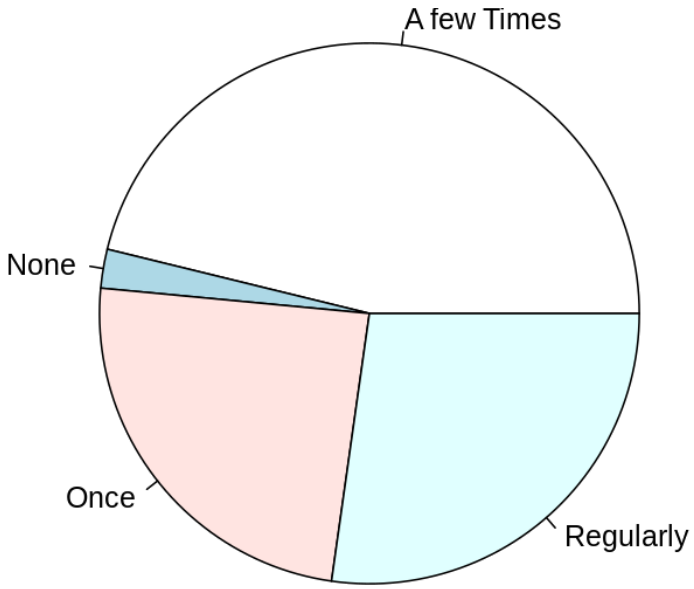


Figure 4-3: Experts' experience with XR.

Responses to the question "How aware are you of the current use of XR (AR, VR, MR) technology for educational purposes?" indicate that 70.4% of participants were aware or very aware, 20.9% were not so aware/unaware, and 8.7% do not consider themselves nor aware or unaware.

60.8% of expert respondents have not used XR in any form to assist education (39.2% did). This is comparable to the students experiencing courses involving XR (38.9%) and those who have not (55.8%; details in Figure 4-54). However, of participants to whom it applied (272 of 301), 79.4% admitted not receiving sufficient training at their university on the possible applications of XR in education. Still, while setting aside the issues of practical implementation, 82.7% would develop an XR teaching tool within their course, given an opportunity to do so (4.7% no, 12.6% doesn't know). This distribution is remarkably similar to the number of students willing to choose an XR-mediated course (88%, details in

Figure 4-55) over their non-XR counterparts. Related to this, most of the expert participants see XR as a powerful tool suitable for education (Figure 4-4) and do not consider XR to be an overly passing trend (see Figure 4-5).

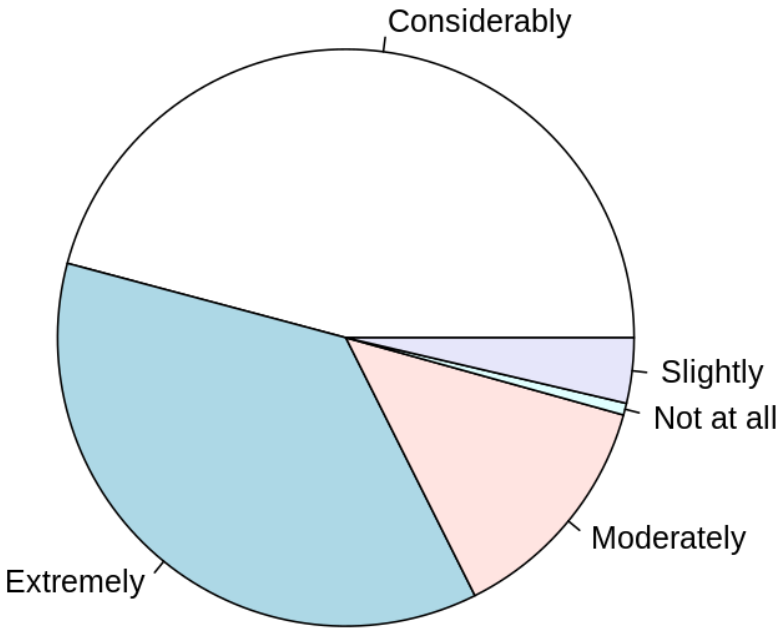


Figure 4-4: Responses to "To what extent do you agree with the following statements: XR (AR, VR, MR) are a powerful tool and should be used in teaching within educational environments."

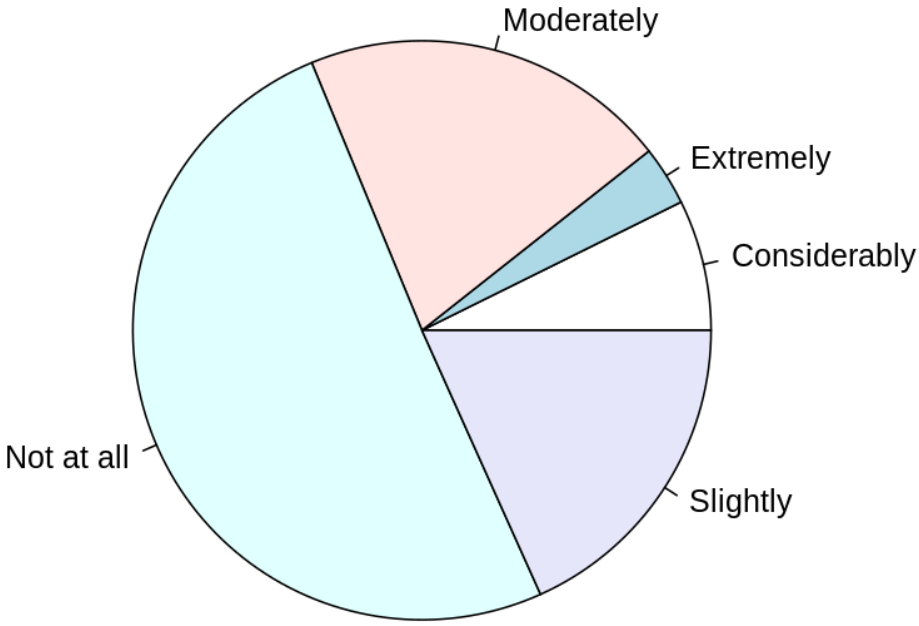


Figure 4-5: Responses to "To what extent do you agree with the following statements: XR (AR, VR, MR) technology as a whole is a passing trend."

Regarding opinions on the possibility of their educational institution implementing XR sustainably in its curriculum, experts were relatively positive (seen as realistic or very realistic by 52.8%, see Figure 4-6). Again, this is aligned with the expectations of the students (same rating given by 59.1%, details in Figure 4-56).

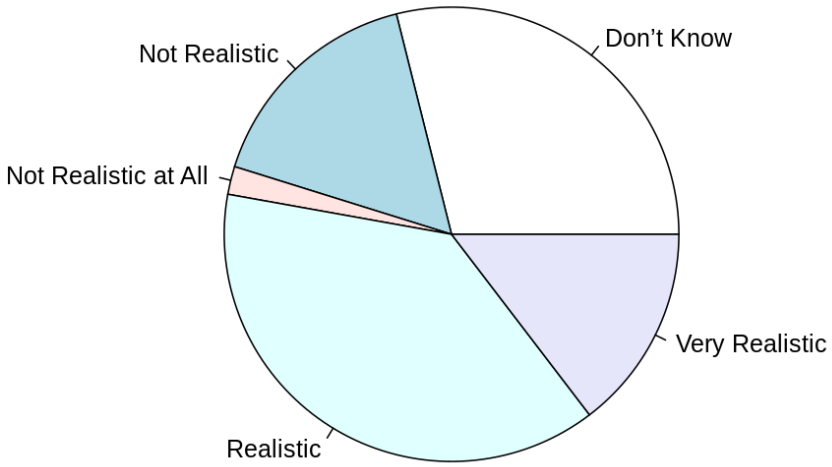


Figure 4-6: Experts' expectations of the possibility of implementing XR in their university

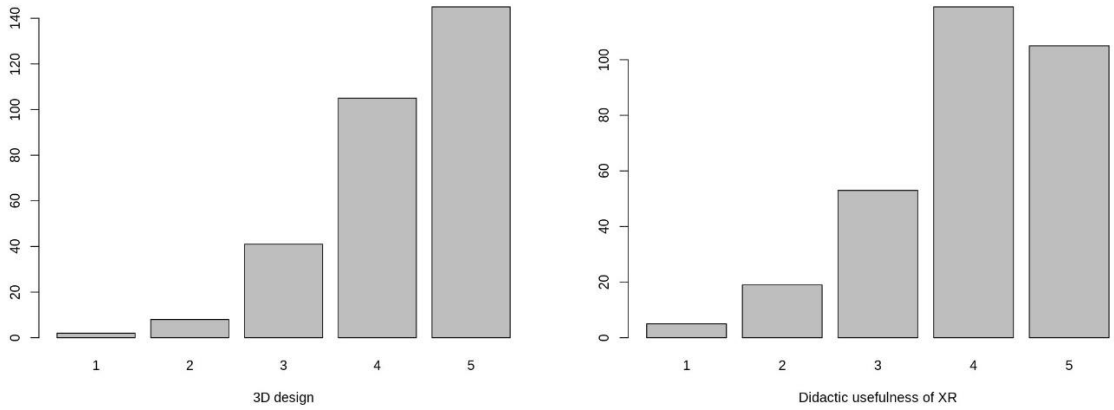


Figure 4-7: Importance of 3D design and didactic usefulness

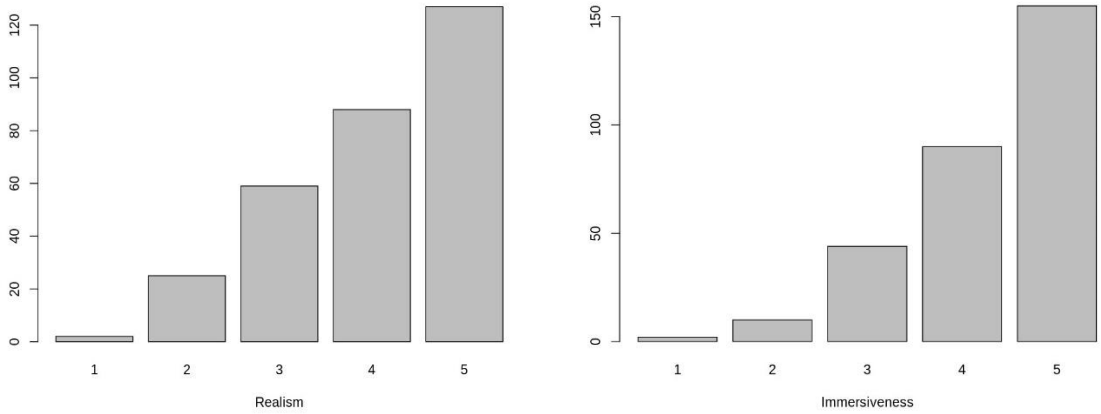


Figure 4-8: Importance of realism and immersiveness

Experts were also asked to rate the importance of various aspects of the XR educational experiences. Figures 4-7 and 4-8 summarize their responses (1 = lowest, 5 = highest importance), suggesting relatively equal importance of the surveyed factors (quality of the 3D design, didactic usefulness of the experience, quality of realism, and the level of immersiveness). Ratings of all these surveyed aspects were correlated to the reported awareness of the individual's current usage of XR in education (Spearman rho = 0.35 for 3D design, rho = 0.34 for immersiveness, rho = 0.18 for realism, rho = 0.34 for didactic usefulness, all p-values < 0.01).

Reported awareness of the usage of XR in education also correlated to the belief that students will accept XR for education (rho = 0.21, $p < 0.01$). This belief does not seem to be influenced by whether the participant has or has not already used XR in education (median answer in both groups 4 out of 5, t-test t = -2.448, df = 270.3, p-value = 0.015).

In terms of general inconveniences of XR, the majority of concerns were about spatial requirements of the XR experiences (30.6% of experts rated as 4 or 5 out of 5). On the other hand, cost was the least concerning factor (16.3% rated it with 4 or 5).

4.1.2 Interview Results Analysis

Demographic data

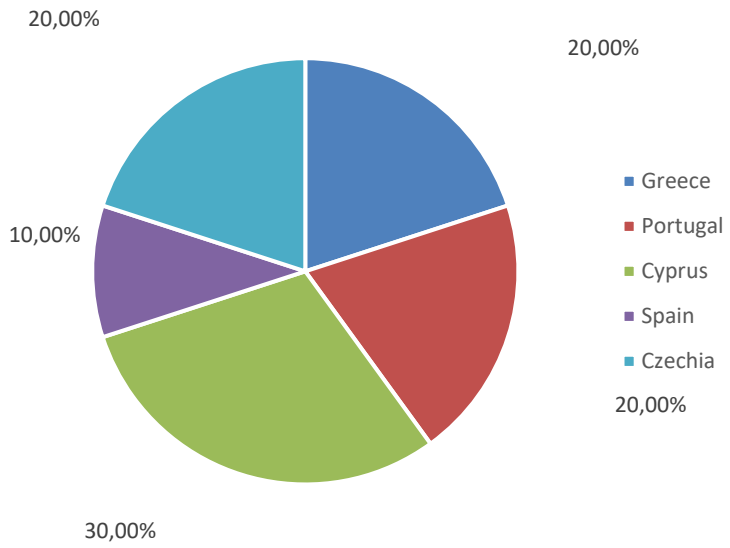


Figure 4-9: Interviewed Experts' Profile by Country

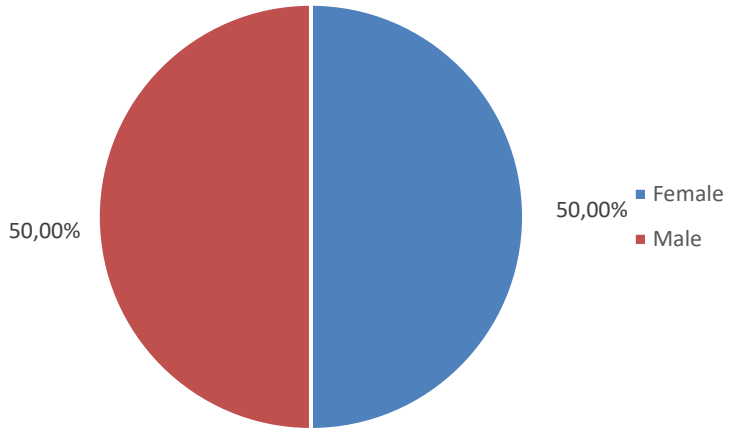


Figure 4-10: Interviewed Experts' Profile by Gender

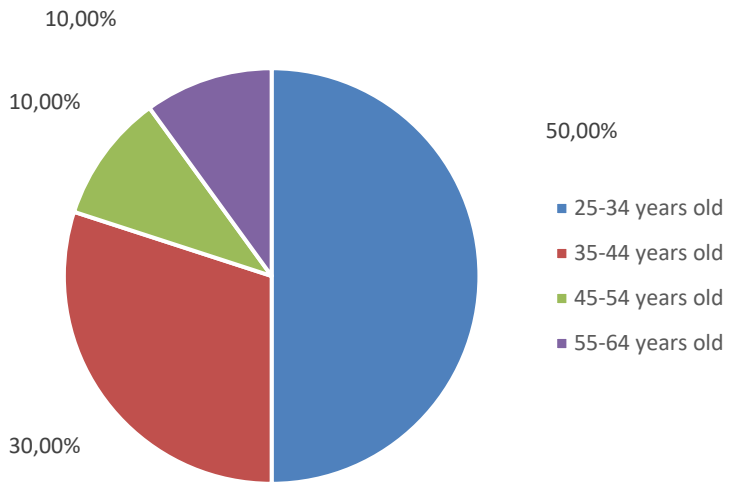


Figure 4-11: Interviewed Experts' Profile by Age

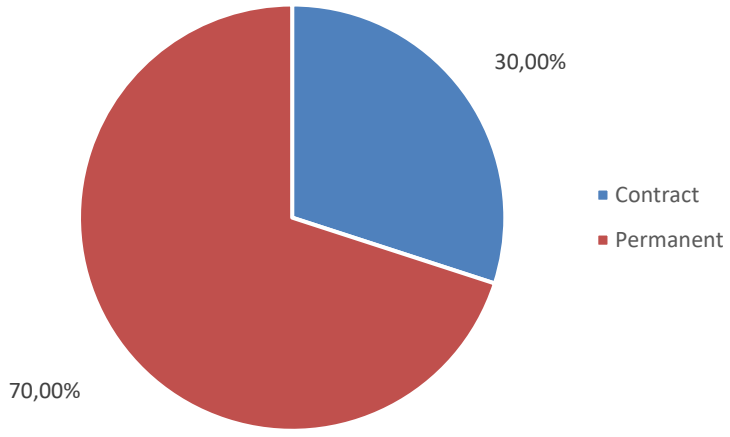


Figure 4-12: Interviewed Experts' Profile by Employment Status

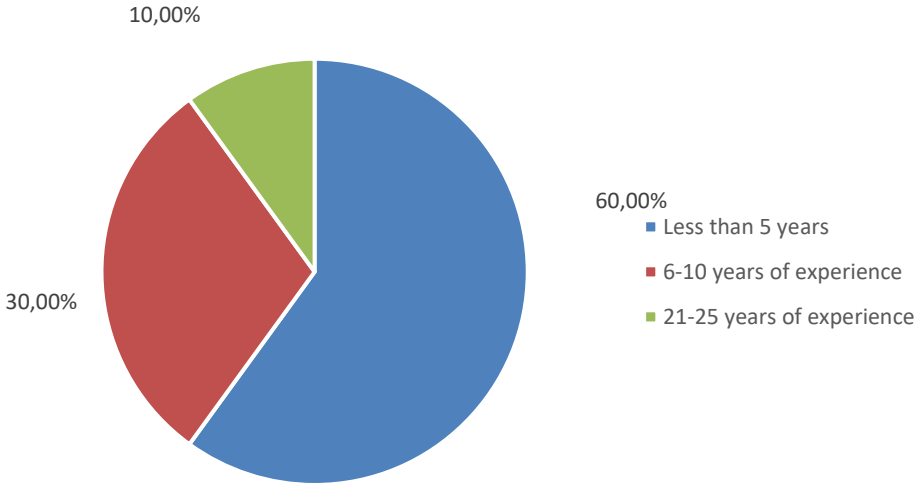


Figure 4-13: Interviewed Experts' Profile by Years of Working Experience

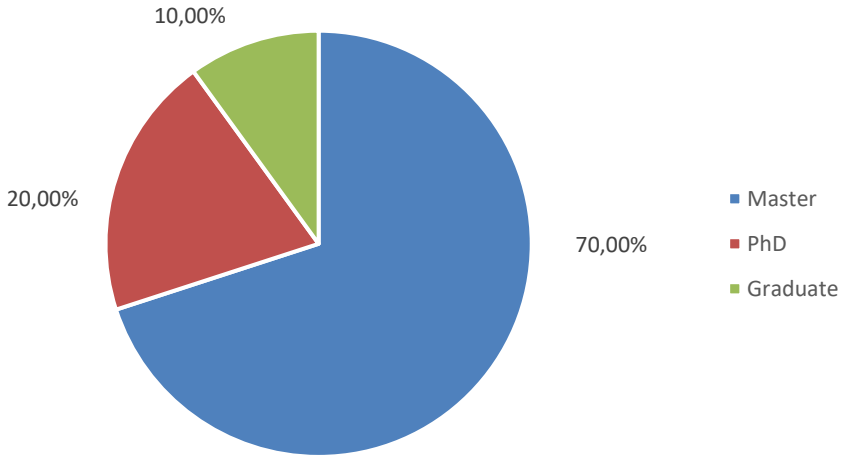


Figure 4-14: Interviewed Experts' Profile by Academic Level

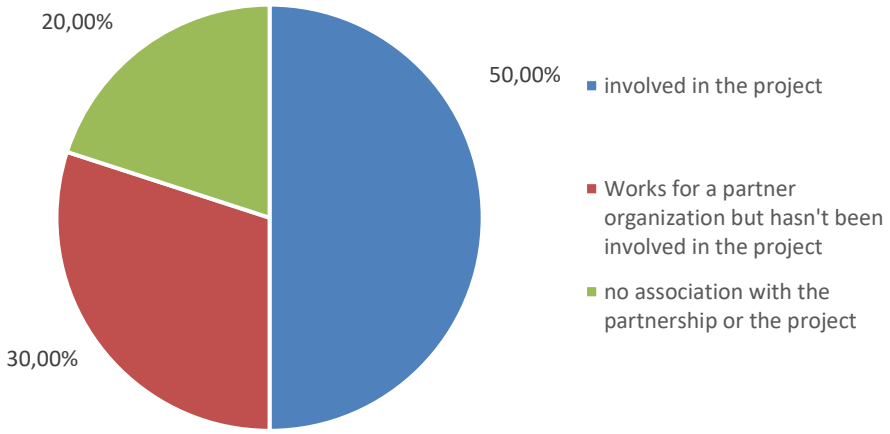


Figure 4-15: Interviewed Experts' Profile by their involvement in the XR4ED project

Answers analysis

Note: not all interviewees provided specific responses to all questions, so the percentages represent the frequency with which each point was mentioned.

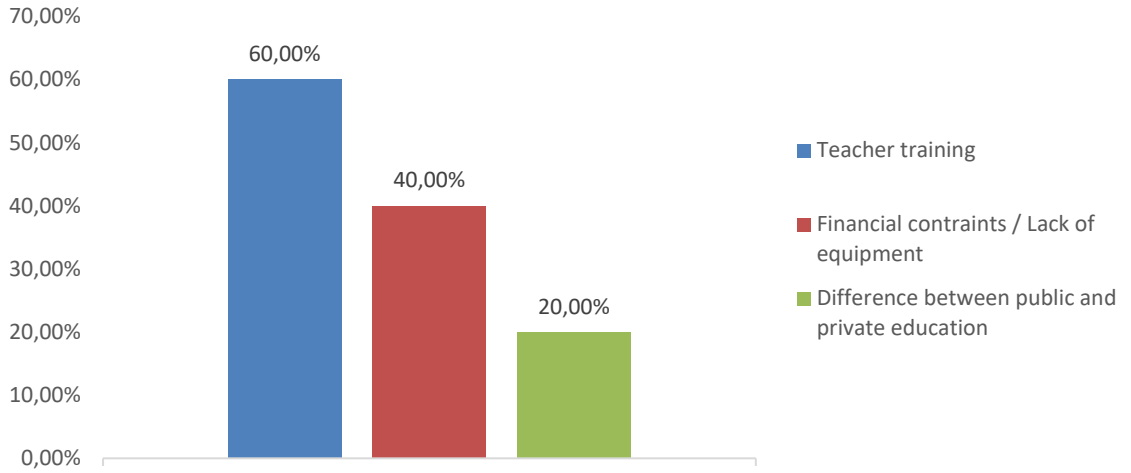


Figure 4-16: Interviewed Experts' opinion on how the existing educational and learning frameworks can be integrated or adapted to incorporate XR technologies effectively

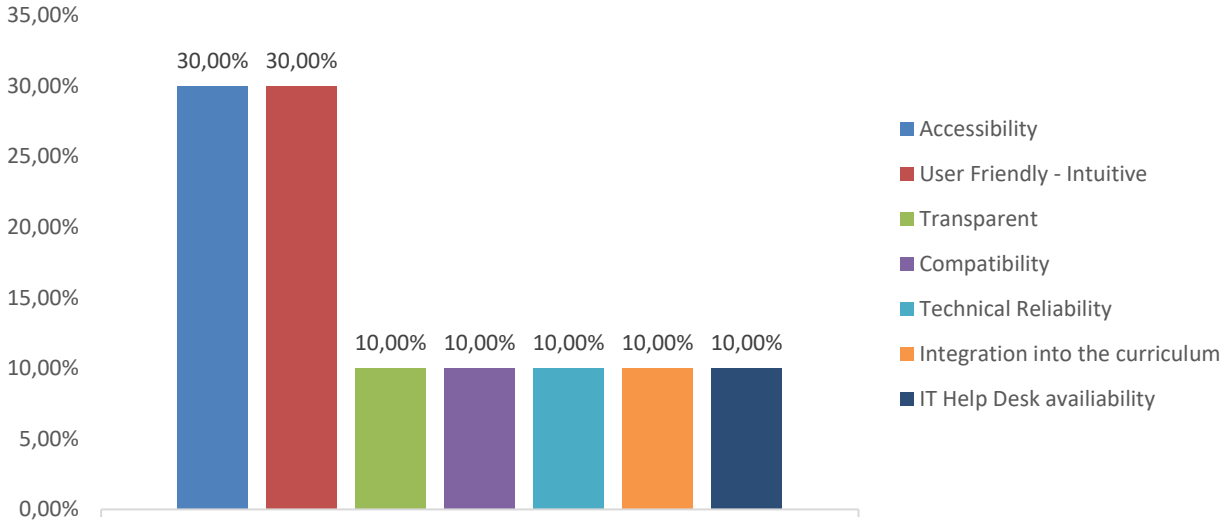


Figure 4-17: Interviewed Experts' opinion on key user requirements that should be considered when developing an XR platform or application

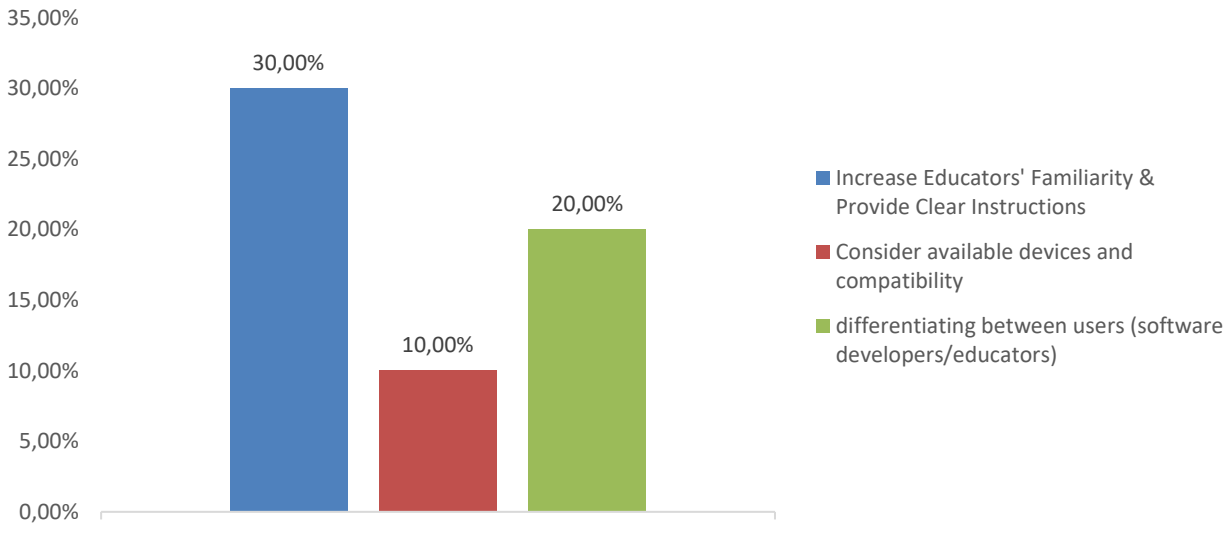


Figure 4-18: Interviewed Experts' opinion on how XR platforms can be designed to ensure ease of use and accessibility for users with varying levels of technical expertise

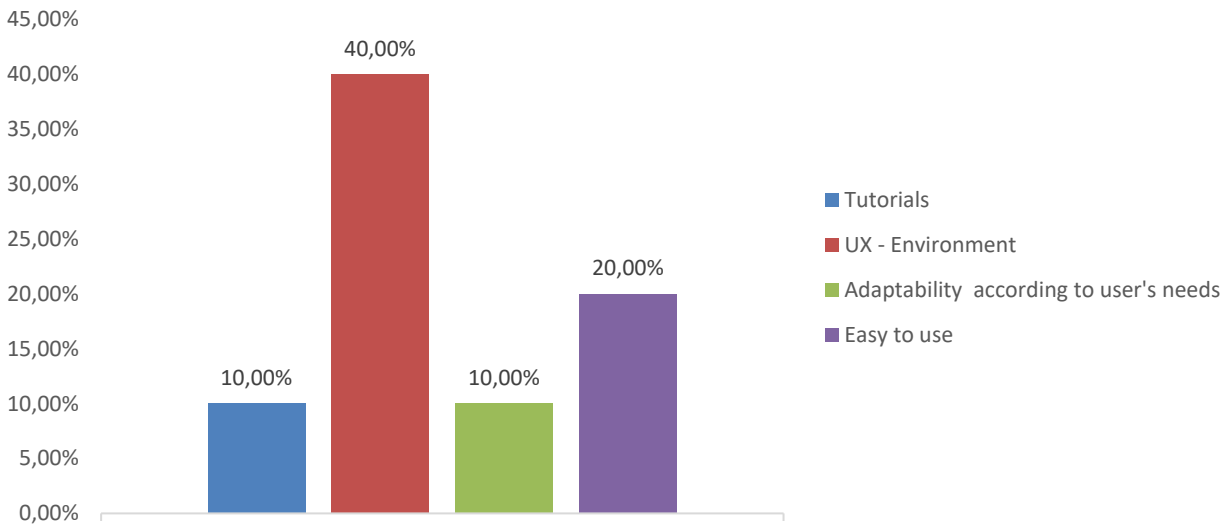


Figure 4-19: Interviewed Experts' opinion on the most important factors to consider when designing user interfaces and interactions for XR experiences5

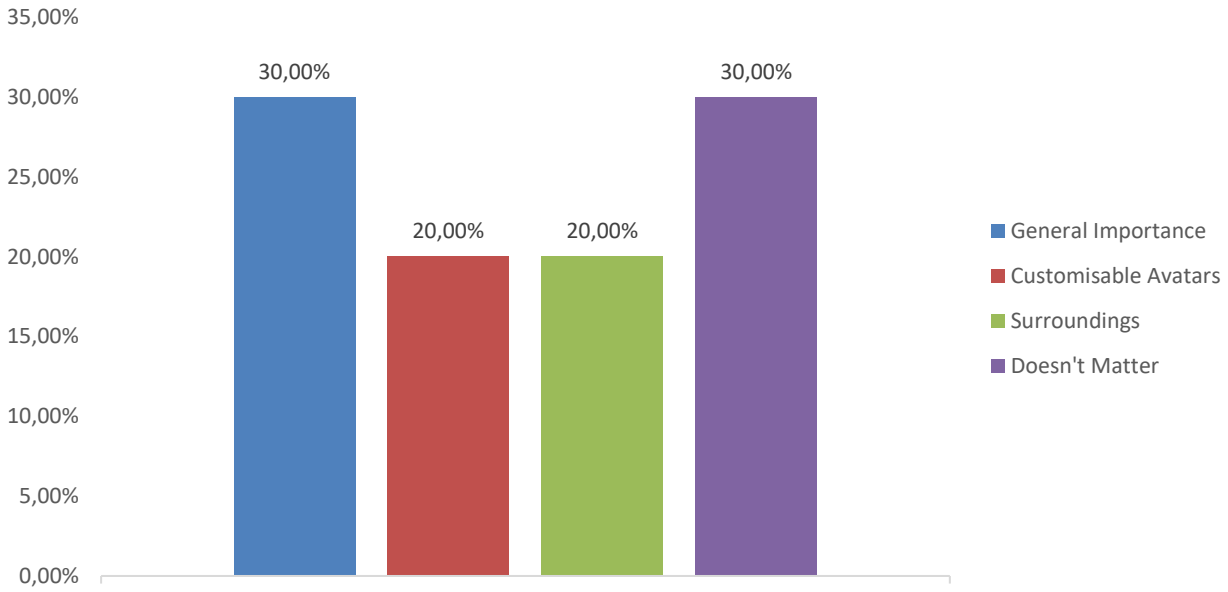


Figure 4-20: Interviewed Experts' opinion on the role customisation and personalisation options should play in an XR platform

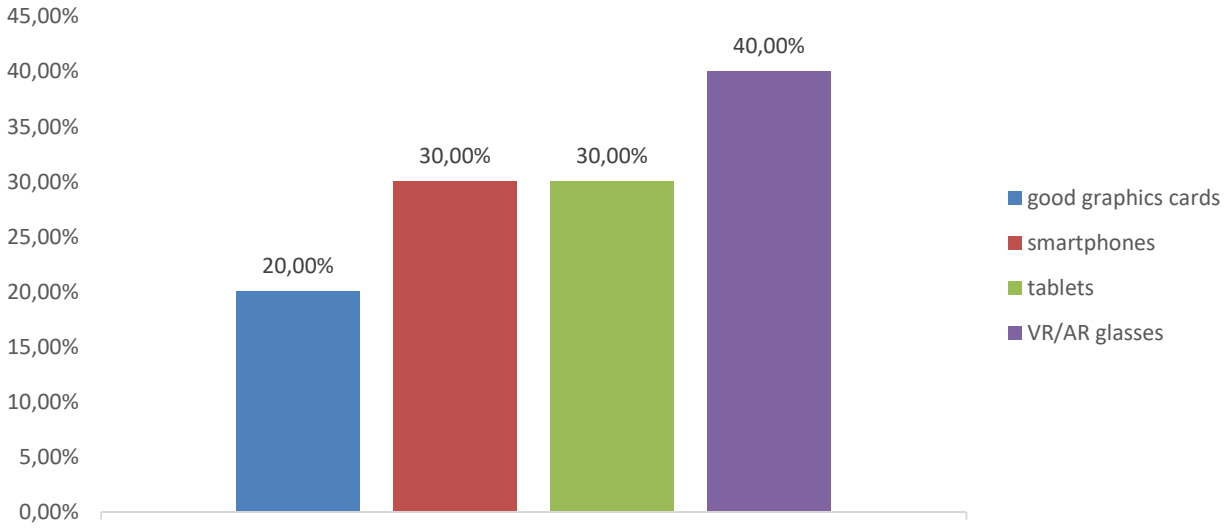


Figure 4-21: Interviewed Experts' opinion on the critical hardware requirements or considerations for delivering high-quality XR experiences

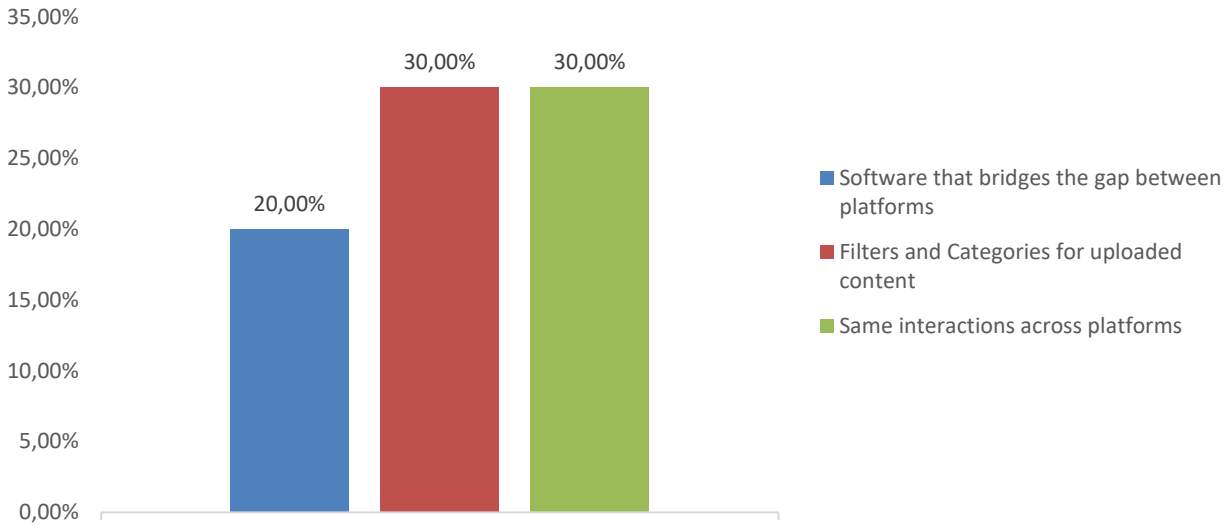


Figure 4-22: Interviewed Experts' opinion on challenges in terms of content distribution and compatibility

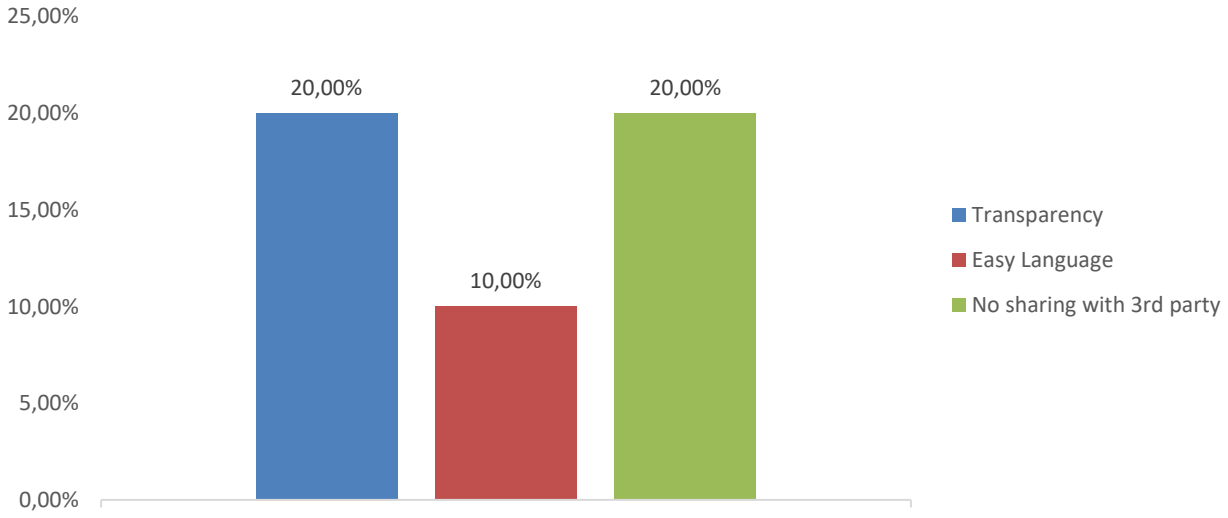


Figure 4-23: Interviewed Experts' opinion on what measures can be taken to address concerns related to privacy and data security when using XR platforms

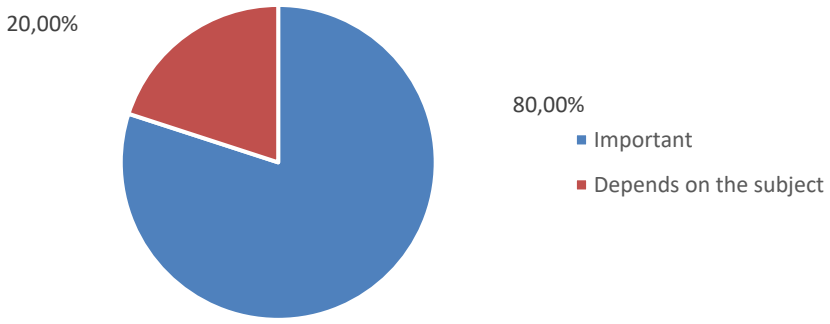


Figure 4-24: Interviewed Experts' opinion on the importance of interoperability between different XR systems and platforms

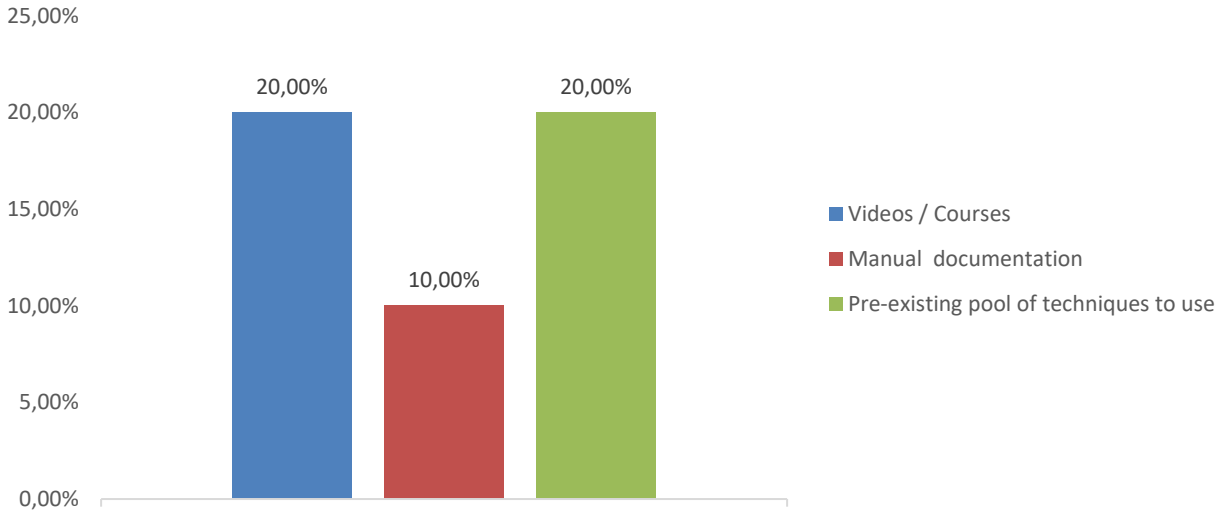


Figure 4-25: Interviewed experts' opinion on what kind of support or resources developers and content creators need to effectively utilize an XR platform

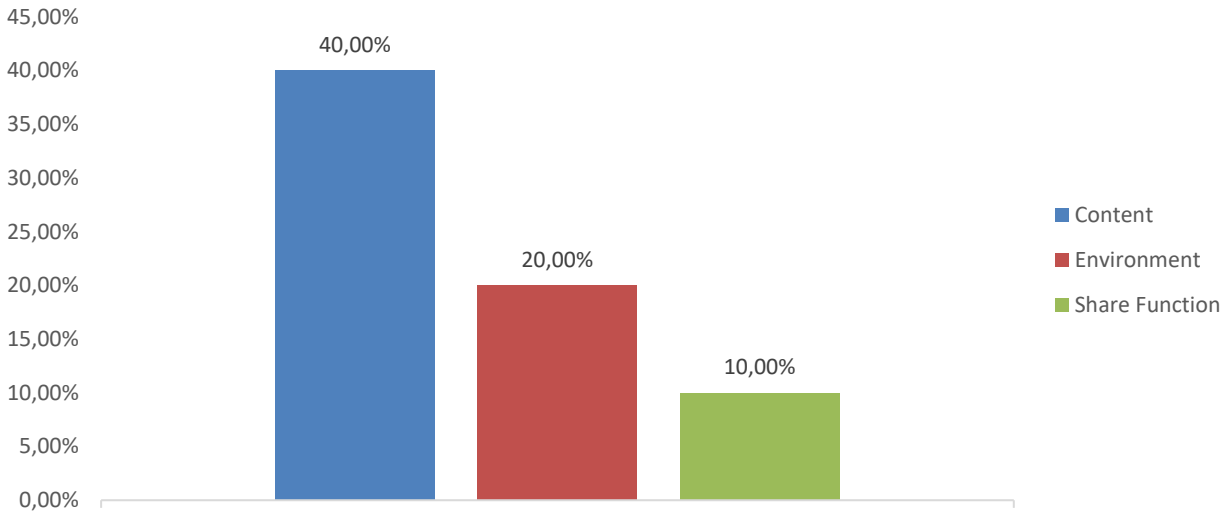


Figure 4-26: Interviewed Experts' opinion on how an XR platform can facilitate collaboration and knowledge sharing among users

4.1.3 Narrative Analysis

The partnership conducted comprehensive interviews and surveys with a diverse group of XR experts from various domains and backgrounds. The experts included game designers, architects, managers, solution architects, computer scientists, researchers, and developers, each bringing valuable perspectives on XR technologies. In total, 10 experts where interviewed and 301 were surveyed.

Among the 10 experts interviewed, the gender representation was equally balanced, with 5 males and 5 females contributing their insights on XR technologies. This gender balance ensured a diverse range of perspectives during the interviews. Both male and female experts demonstrated enthusiasm for the potential of XR, emphasizing technical aspects such as platform functionality and highlighting the importance of inclusivity, usability, and the ethical implications of XR in educational and professional contexts.

The expert sample that participated in the questionnaire-based survey was also balanced, comprising 160 females and 141 males. However, statistical tests identified significant gender-based differences in responses.

Firstly, notable demographic differences emerged. Male respondents reported an average of 5.20 years of work-related XR experience, compared to an average of 1.52 years for females ($W = 5738$, $p < 0.001$). Similarly, males rated their XR experience higher on average (2.30 out of 5) than females (1.78), a statistically significant difference ($W = 7475.5$, $p < 0.001$).

Secondly, responses to several quantitative questions differed between genders, often with high statistical significance. However, the magnitude of these differences was typically small, generally below half a point on a 5-point Likert scale. The most pronounced differences ($p < 0.001$) were observed in the following areas:

- Perceived acceptance of XR as a teaching resource ($W = 14508$; average difference: 0.44 points, with females indicating higher acceptance).
- Confidence in XR enabling effective education ($W = 14252$; average difference: 0.51 points, with females showing higher confidence).
- Importance of realism in educational XR experiences ($W = 14190$; average difference: 0.48 points, with females rating this aspect higher).

Overall, while gender-related differences in responses were consistently observed, their effect sizes were small. These differences are unlikely to affect the broader generalizability of the findings.

Throughout the interviews and the analysis of the survey results, we gained valuable insights into how these XR experts perceive the integration of XR technologies into educational frameworks. The experts emphasised the importance of training educators to effectively incorporate XR into the classroom and bridging the generation gap between learners and teachers, who might have varying levels of familiarity with technology.

Regarding the user requirements for developing an XR platform or application, the experts stressed the need to

ensure ease of use and intuitive navigation. They also highlighted the significance of features like eye-tracking and head-tracking to enhance interaction in XR experiences. Addressing cost, hardware equipment, technical reliability, integration into the curriculum, and learning objectives were seen as crucial considerations to ensure the successful implementation of XR in education.

The experts discussed the challenges and considerations related to privacy and data security when using XR platforms. They emphasized the importance of transparent information, clear guidelines, and informed consent to protect users' privacy and data.

When designing user interfaces and interactions for XR experiences, the experts highlighted the importance of tutorials, user experience (UX) focus, and adaptability according to users' needs. Comfort, clarity, and seamless interactions were emphasized as critical factors in design.

The potential benefits of customisation and personalisation options in an XR platform were recognised by the experts. They stressed the need to accommodate different learning styles and abilities through customisation options, particularly for learners with disabilities.

Regarding hardware requirements, the experts discussed critical aspects necessary for delivering high-quality XR experiences. They mentioned using suitable devices with good graphics capabilities and ensuring compatibility with different XR platforms.

The experts also addressed potential challenges in content distribution and compatibility across various XR devices and platforms. Clear indications of compatibility and proper categorisation were suggested as means to address these challenges.

To support collaboration and knowledge sharing among users, the experts proposed various features and functionalities in an XR platform. Gamified experiences with collaborative rewards and inclusive access to experiences were seen as effective means to foster collaboration.

Regarding assessment methods for XR-based learning, the experts highlighted the potential for simulations, experiments, and self-assessment through interactive experiences. They believed that the platform should offer diverse evaluation tools catering to different learning objectives and age groups.

Overall, the XR experts displayed great enthusiasm for integrating XR technologies into education. They recognised the potential benefits for learners, such as increased engagement and a deeper understanding of complex concepts. However, they also stressed the need for addressing challenges, such as affordability, accessibility, ease of use, and technical training, to ensure that XR becomes an inclusive and transformative educational tool.

By considering the valuable insights shared by these XR experts, the XR4ED project can develop an online platform that effectively caters to the needs of educators and learners, revolutionising the educational landscape and

enriching the learning experiences of students in various educational contexts.

Conclusion on characteristics needed based on experts' opinion.

After conducting interviews with XR experts involved in the field of education, several important user requirements for developing an XR platform for educational purposes have emerged. Here is a summary of the characteristics needed:

Training and Support: Providing comprehensive training and ongoing support is vital for educators to effectively use XR technologies. Workshops, guides, and online courses can empower educators to integrate XR seamlessly into their teaching methods, enhancing the platform's impact.

Ease of Use: User-friendly interfaces and intuitive design simplify XR content creation, benefiting educators with varying technical expertise. A drag-and-drop system and clear instructions streamline the process, encouraging broader adoption of XR in education.

Customisation and Personalisation: Offering extensive customization options caters to diverse learner needs, including those with disabilities. Personalized XR experiences empower learners and boost engagement and motivation.

Compatibility and Interoperability: Ensuring content distribution across various XR devices promotes accessibility. Interoperability allows seamless collaboration and content sharing, fostering an innovative XR ecosystem.

Collaboration and Knowledge Sharing: XR platforms should facilitate collaborative learning, enabling interaction and knowledge exchange among learners. Features like voice commands and shared spaces enhance engagement and communication.

Hardware Requirements: Optimizing XR experiences for a range of devices, from high-end VR headsets to more affordable options, expands accessibility and inclusivity.

Privacy and Data Security: Prioritizing transparent data collection and secure handling ensures trust among educators, learners, and guardians, promoting the ethical use of XR technologies in education.

Integration with Educational Frameworks: Seamlessly aligning XR platforms with existing curricula empowers educators to leverage XR's potential to enhance learning outcomes effectively. Collaborating with educational institutions ensures a natural integration of XR into traditional teaching practices.

4.2 Educators

4.2.1 Interview Results Analysis

Demographic Data

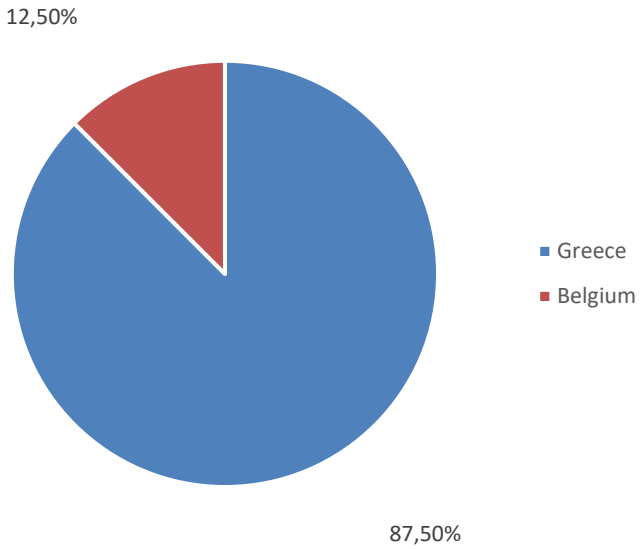


Figure 4-27: Educators' Profile by Country

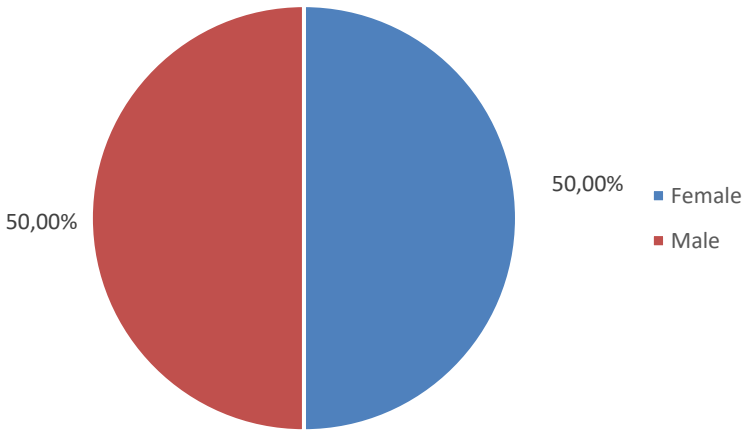


Figure 4-28: Educators' Profile by Gender

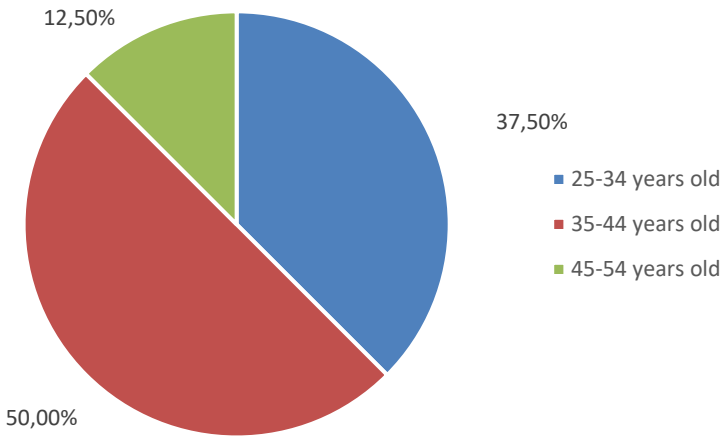


Figure 4-29: Educators' Profile by Age

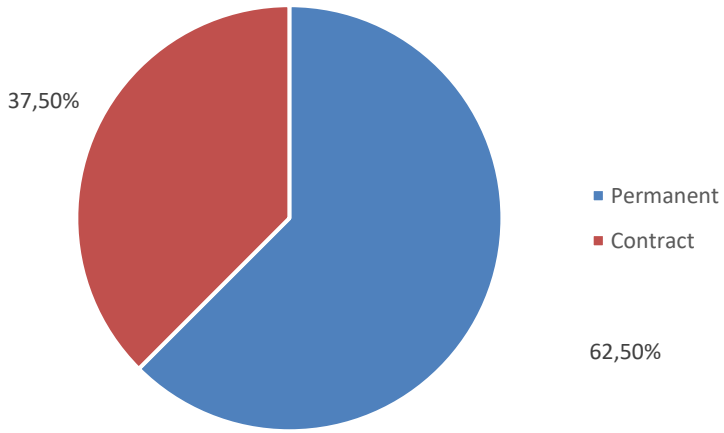


Figure 4-30: Educators' Profile by Employment Status

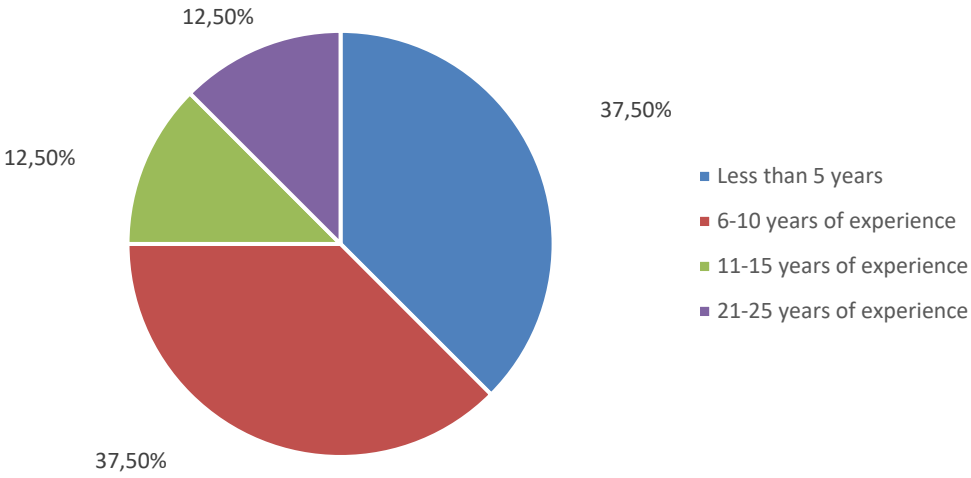


Figure 4-31: Educators' Profile by Years of Working Experience

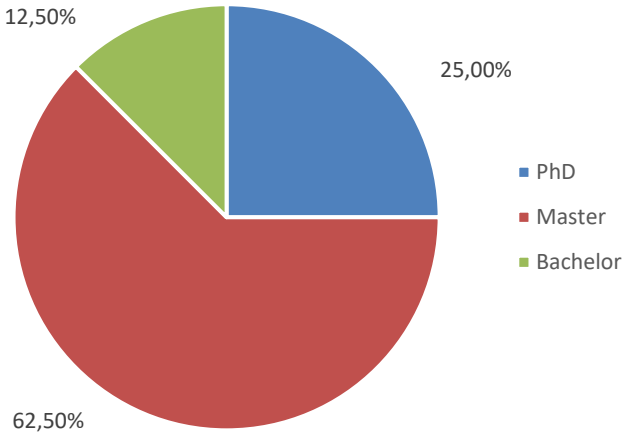


Figure 4-32: Educators' Profile by Academic Level

Answers analysis

Note: not all interviewees provided specific responses to all questions, so the percentages represent the frequency with which each point was mentioned.

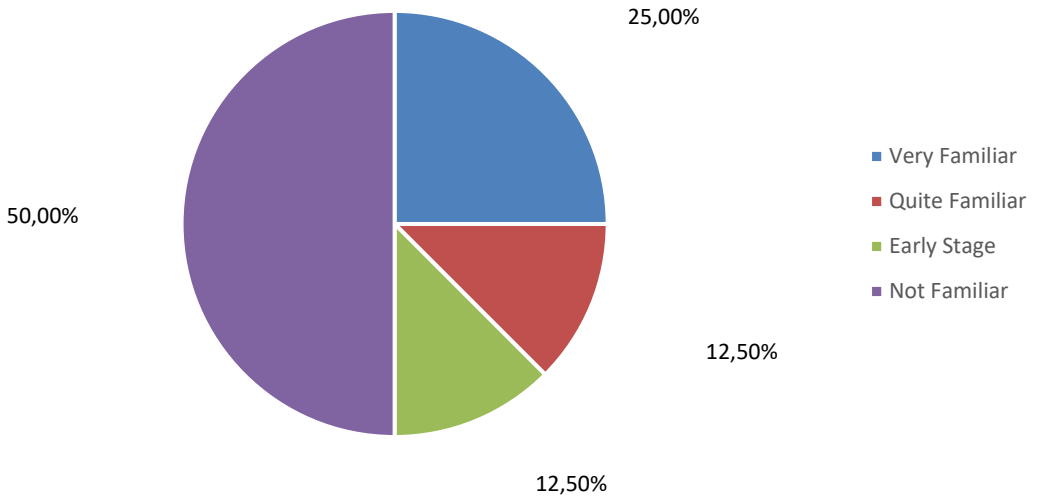


Figure 4-33: Educators' Familiarity with XR Technologies

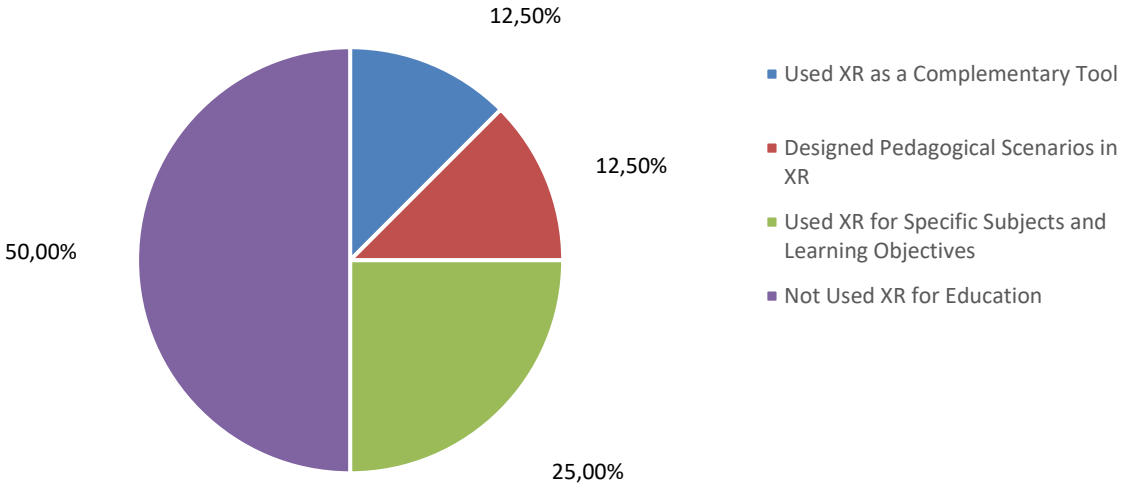


Figure 4-34: Educators' Experience in Utilising XR Technologies in Education

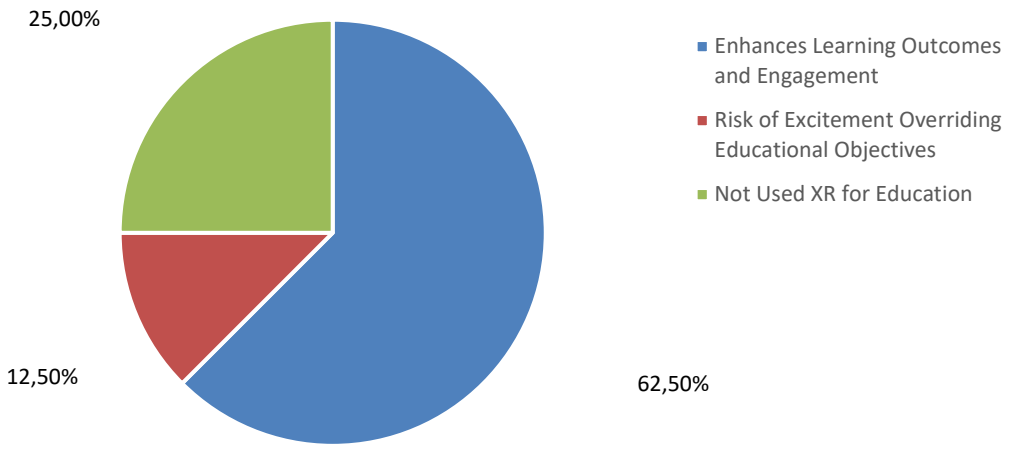


Figure 4-35: Educators' opinion on XR Technologies' Impact on Learning Outcomes and Engagement

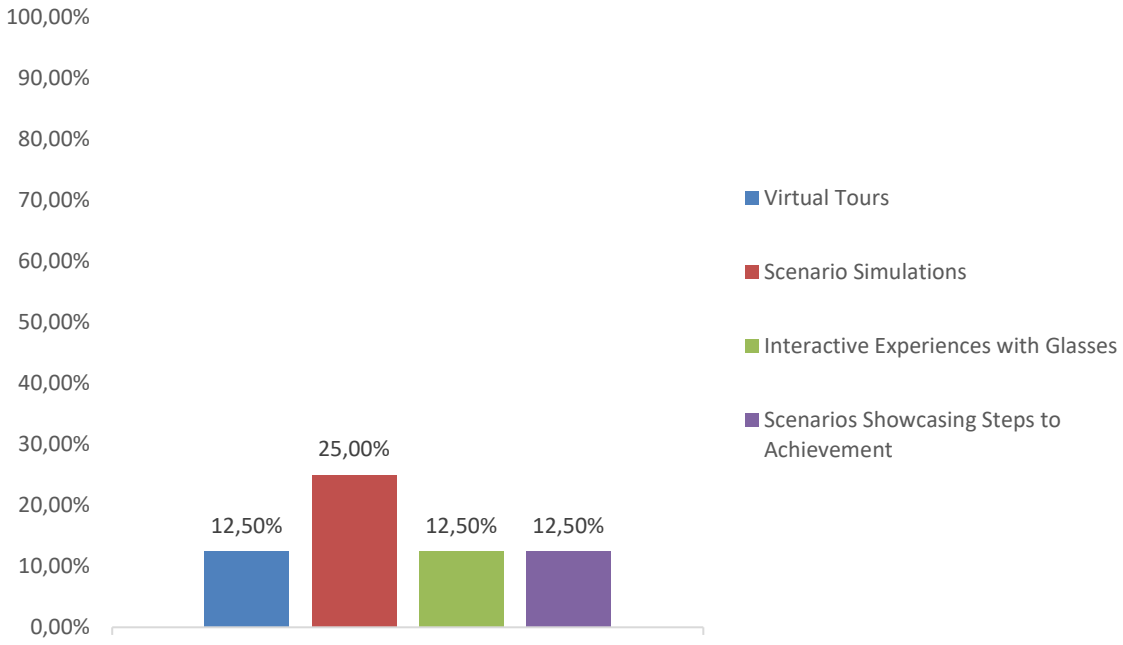


Figure 4-36: Educators' opinion on the most effective XR Experiences for student engagement and understanding

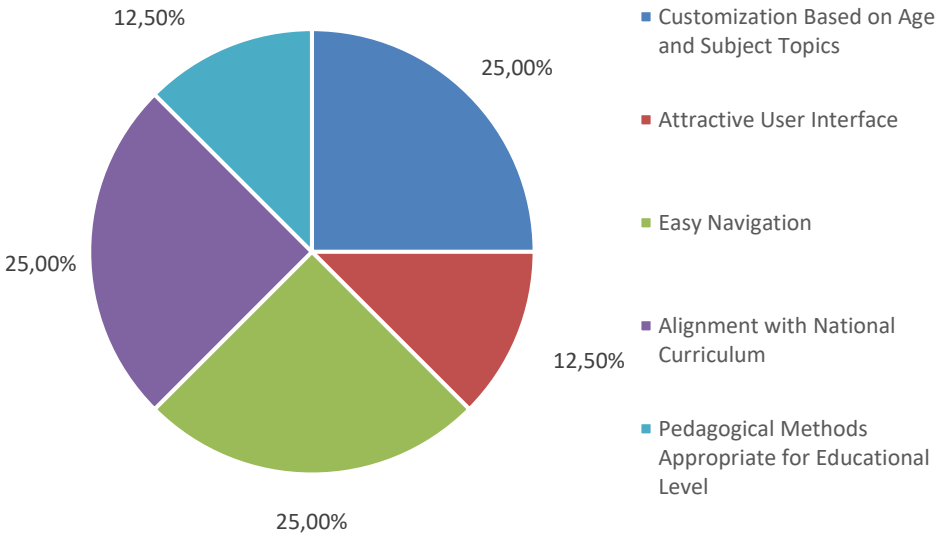


Figure 4-37: Educators' opinion on the design considerations for XR platforms in different educational contexts

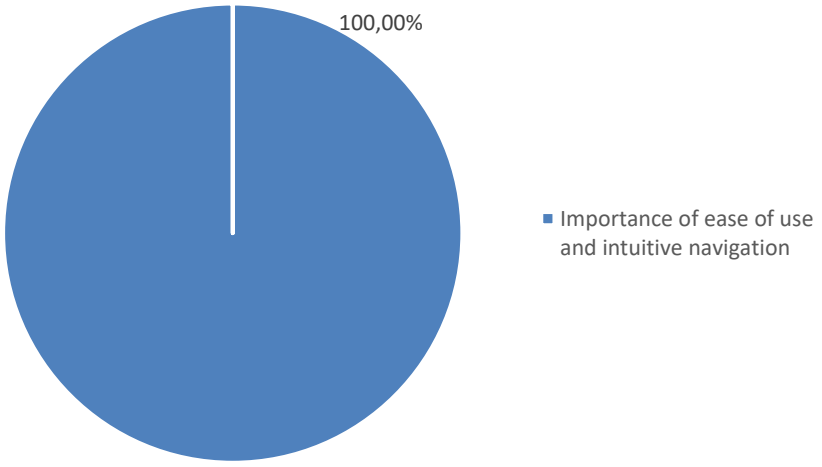


Figure 4-38: Educators' opinion on the importance of ease of use and intuitive navigation in XR Platforms

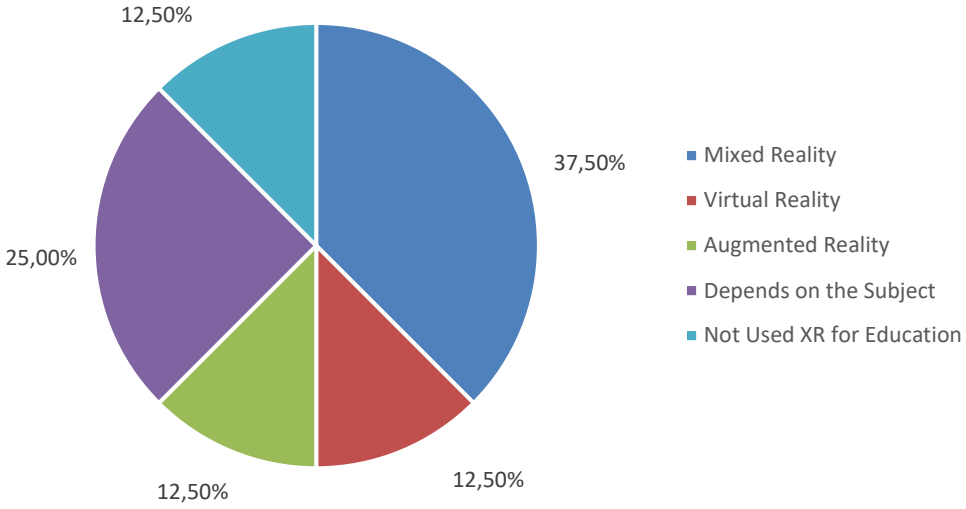


Figure 4-39: Educators' opinion on the most suitable XR technologies for educational purposes

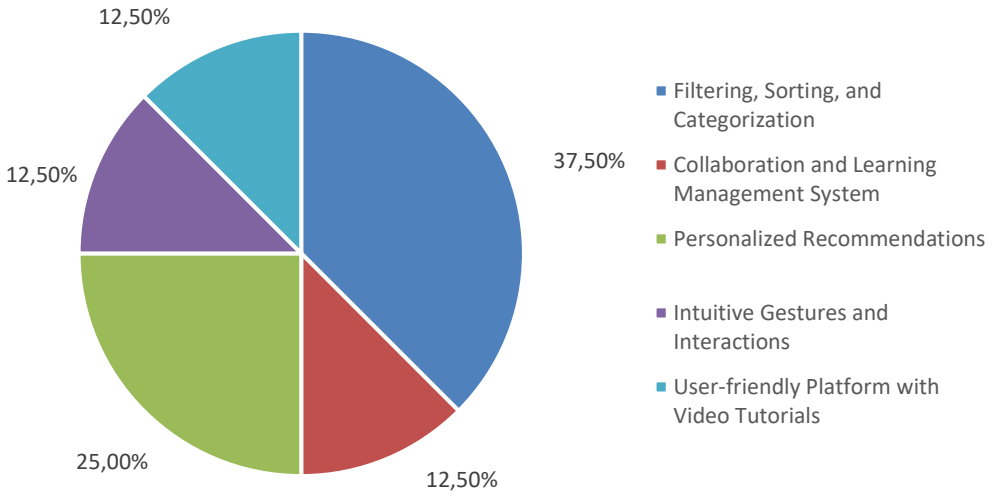


Figure 4-40: Educators' opinion on the essential features and functionalities in an XR platform for education

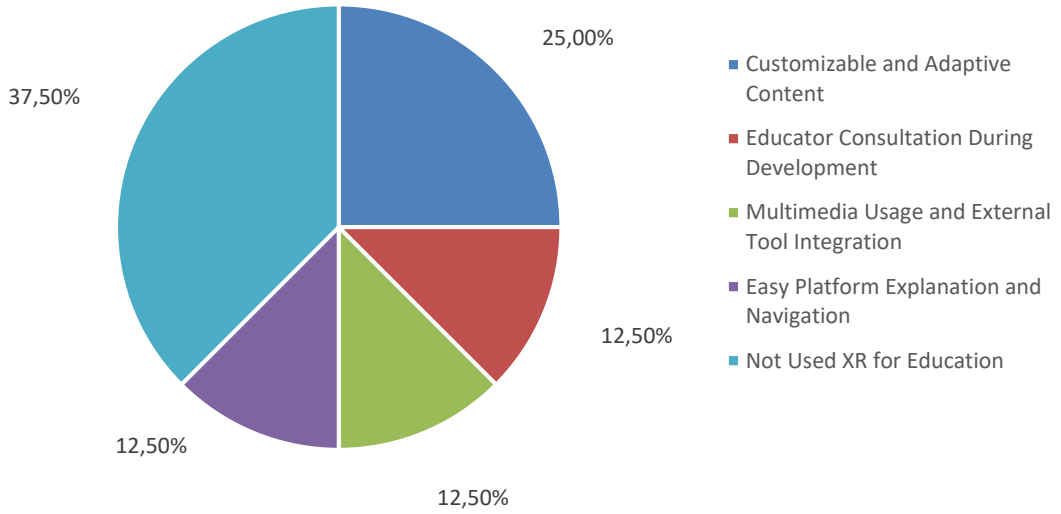


Figure 4-41: Educators' opinion on the content creation capabilities in an XR platform

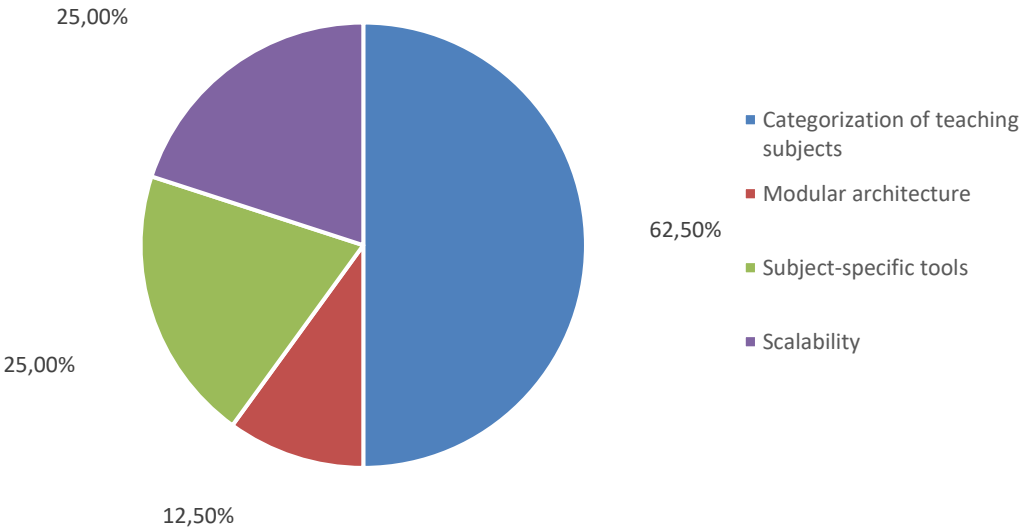


Figure 4-42: Educators' opinion on designing XR Platforms for different subjects or disciplines

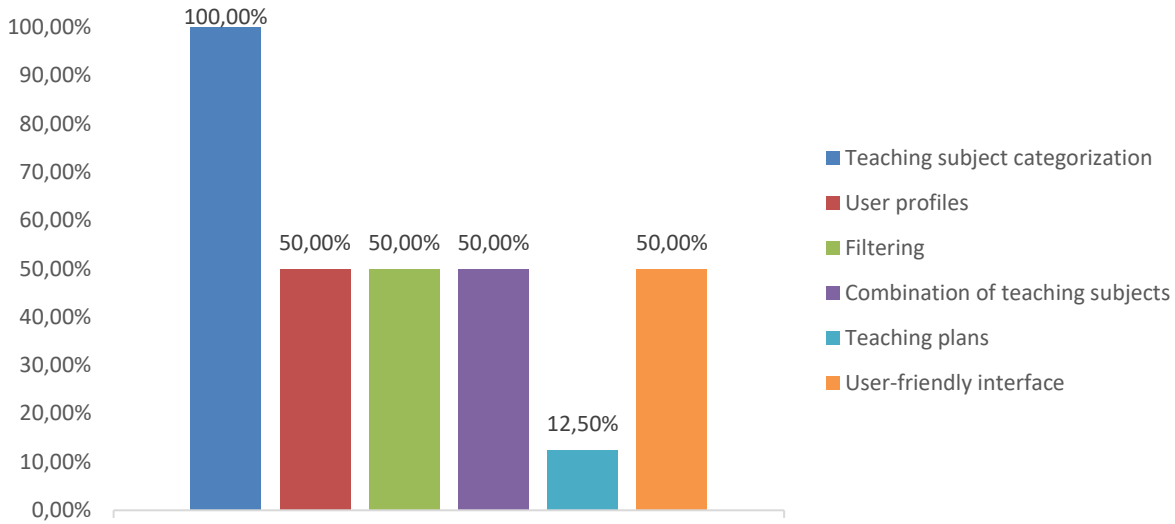


Figure 4-43: Educators' opinion on features or functionalities for educational use

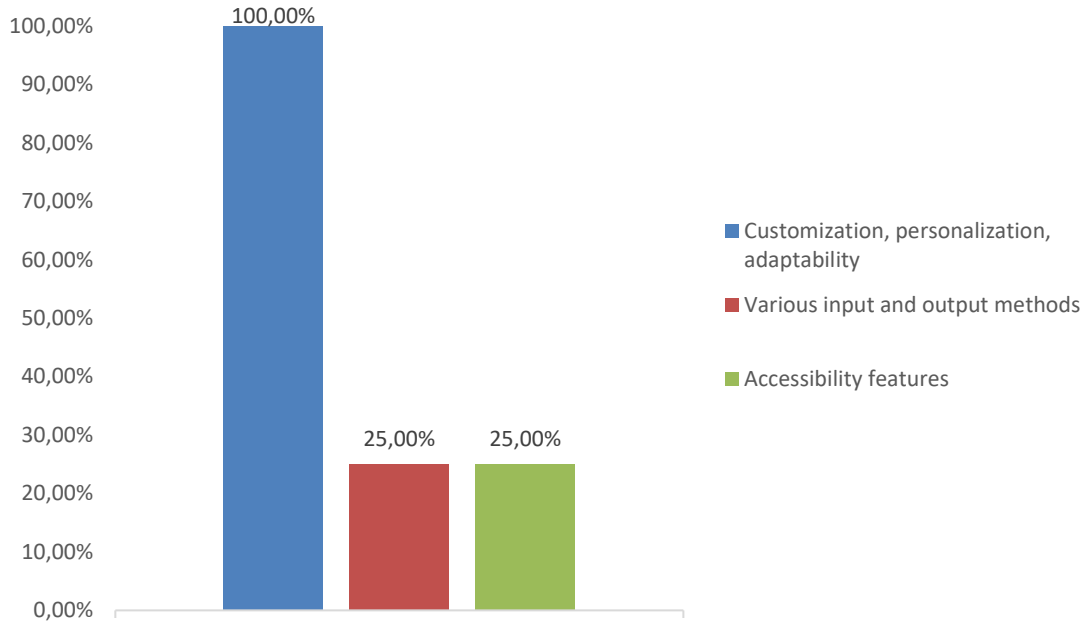


Figure 4-44: Educators' opinion on the accommodation of diverse learning styles or varying abilities

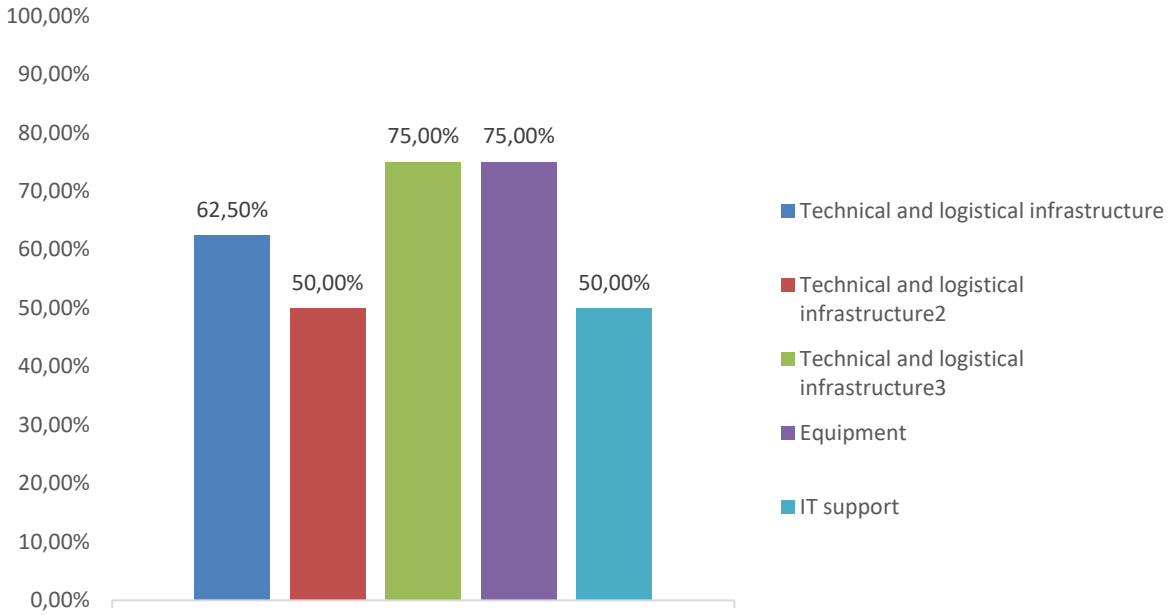


Figure 4-45: Educators' needs on training or support to effectively integrate XR into the classroom

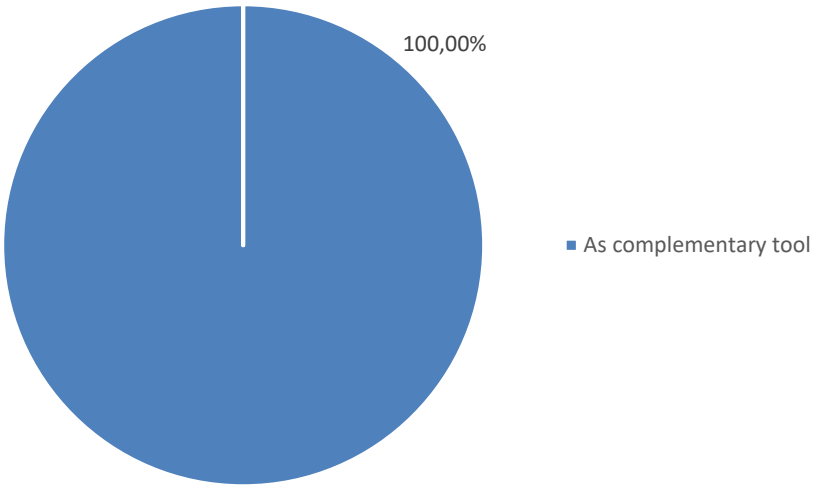


Figure 4-46: Educators' opinion on the incorporation of XR into existing curriculum and teaching methods

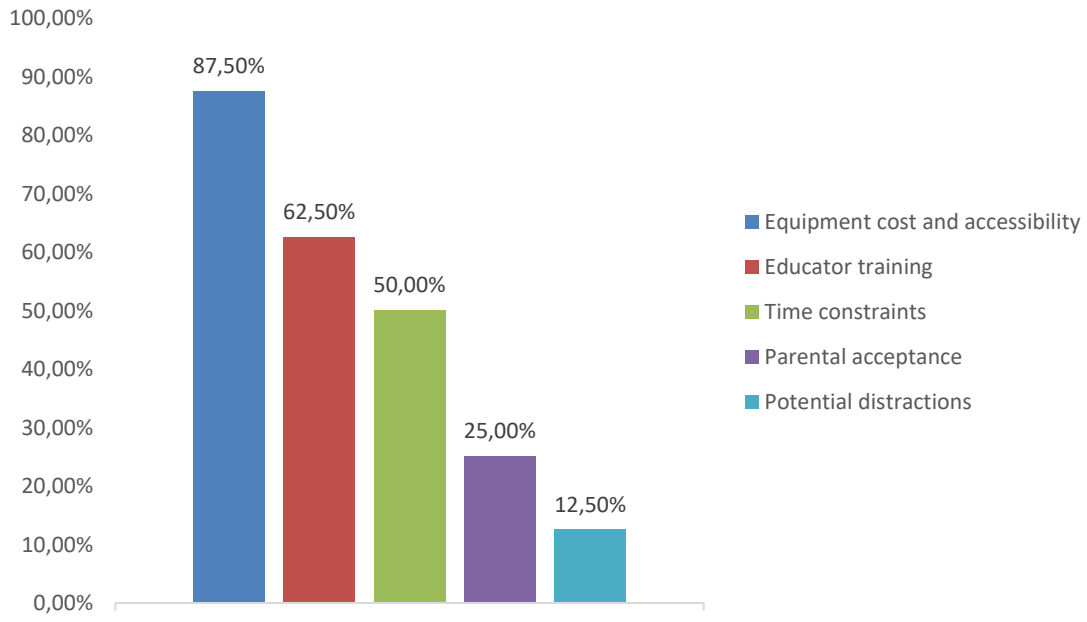


Figure 4-47: Educators' concerns on the use of XR technologies in the classroom

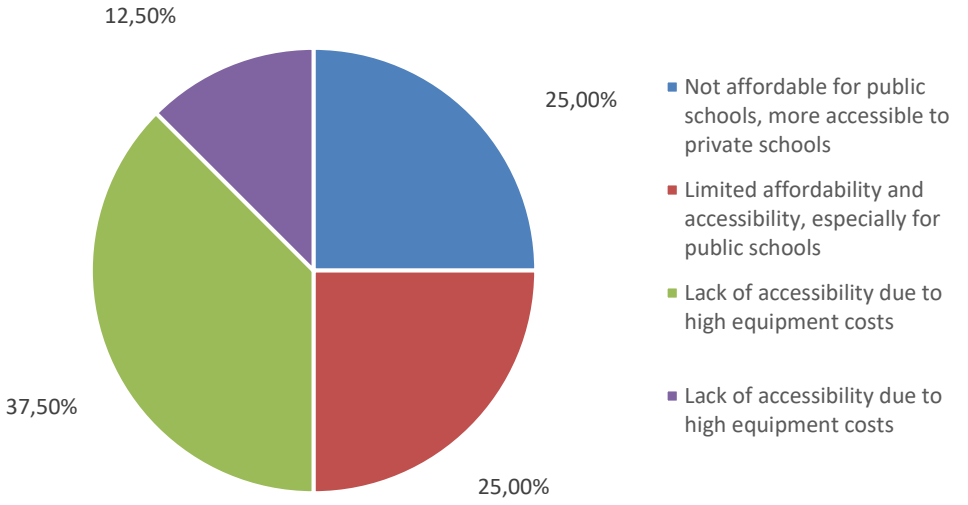


Figure 4-48: Educators' opinion on the affordability and accessibility

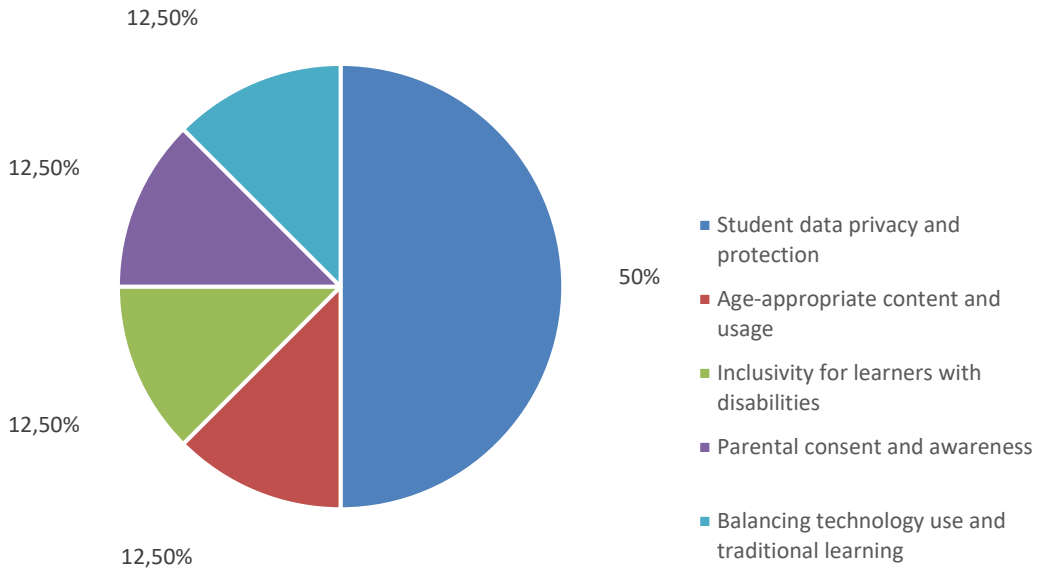


Figure 4-49: Educators' opinion on potential ethical considerations

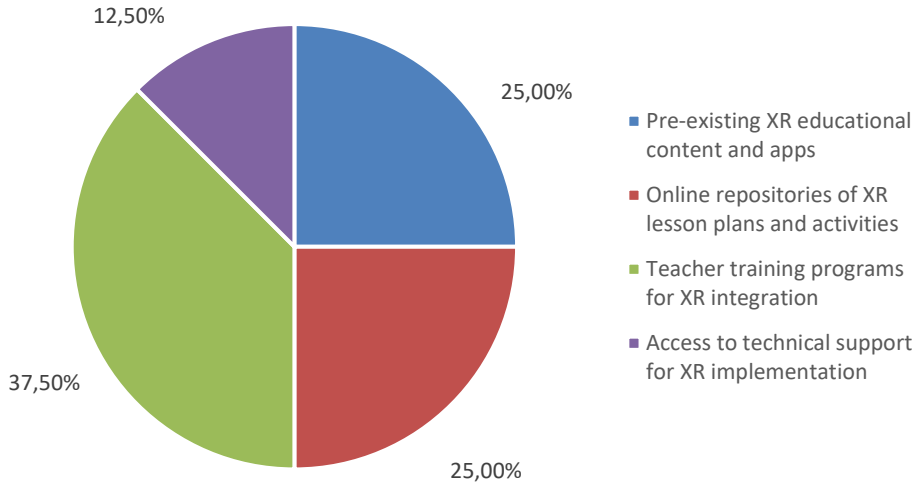


Figure 4-50: Educators' opinion on the resources or materials to integrate XR into lessons or activities

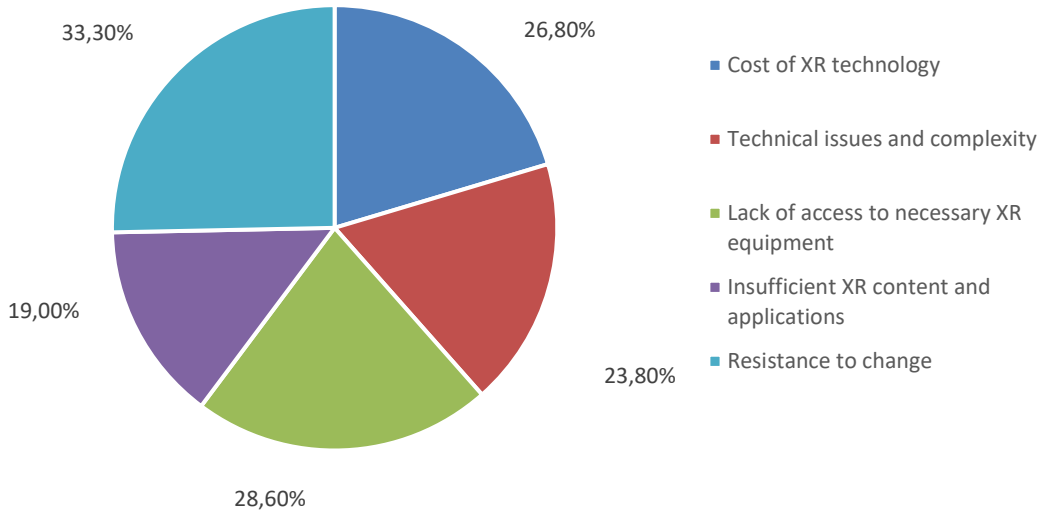


Figure 4-51: Educators' opinion on potential challenges or barriers

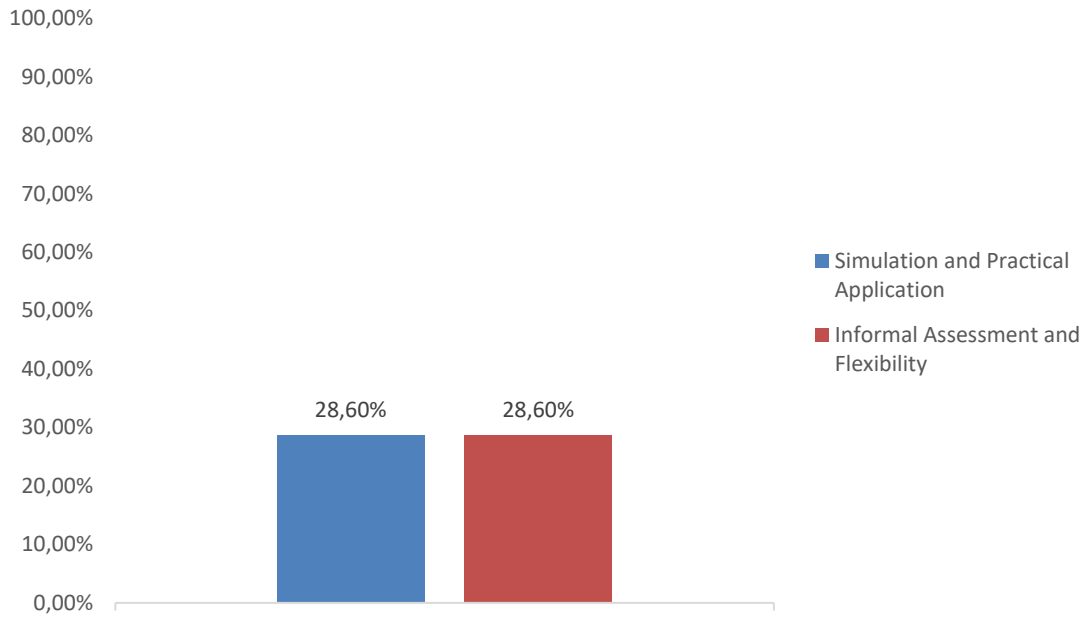


Figure 4-52: Educators' preference in assessment and evaluation of student learning with XR

4.2.2 Narrative Analysis

The interviews were conducted with a diverse group of educators to understand their requirements and perspectives on extended reality technologies in the classroom. These educators hailed from various backgrounds, with expertise ranging from STEM and IT to special needs education. In total, 8 educators were interviewed. Most of them were familiar with XR technologies, particularly VR, and recognized their potential applications in education.

Out of the 8 educators interviewed, the gender representation was evenly balanced, providing diverse perspectives on the integration of XR technology in education. Both male and female educators showed enthusiasm for the potential of XR, albeit with slight variations in focus. Male educators often emphasized the technical capabilities and alignment of XR with subjects like STEM and IT, while female educators highlighted the importance of inclusivity, ethical considerations, and the emotional well-being of students. This balance of perspectives underscores the need for an XR platform that addresses both technical excellence and social-emotional factors, ensuring a comprehensive and inclusive approach to education.

In relation to their experiences with XR in the classroom, most educators used it as a complementary tool to traditional teaching methods. They found that VR and AR experiences could enhance student engagement and understanding, especially in subjects like Medicine, STEM, and VET training for dangerous machinery and chemicals. However, they also highlighted challenges, such as the cost and accessibility of XR equipment, which could create a divide between private and public education.

To effectively integrate XR into their teaching, educators stressed the importance of ease of use and intuitive navigation in the platform. They also expressed the need for personalised experiences to accommodate diverse learning styles and abilities. Customisation and flexibility were key requirements to ensure XR catered to different educational contexts, from primary schools to universities.

Ethical considerations were also a concern, as educators wanted to ensure data protection and avoid potential distractions and misuse of XR tools in the classroom. They emphasised the importance of clear guidelines and informed consent for data usage. Additionally, the potential impact of XR on students' emotional well-being and social interactions need to be carefully monitored.

While educators saw XR as a powerful tool to foster critical thinking, problem-solving, and collaboration, they acknowledged the limitations due to the lack of affordable equipment and proper training. Training and support for educators were seen as essential to effectively integrate XR into the curriculum. Providing accessible resources and technical assistance could help overcome these challenges.

To support diverse subjects, educators envisioned an XR platform with a modular architecture, categorising experiences based on subjects and allowing for seamless navigation. They wanted to see features like collaborative coding spaces, drag-and-drop functionality, and customisable content to suit various learning needs.

Assessment methods for XR-based learning included simulations, experiments, and self-assessment through interactive experiences. They believed that the platform should offer various evaluation tools to cater to different learning objectives and age groups.

Overall, the educators demonstrated great enthusiasm for integrating XR technologies into education. They recognized the potential benefits for learners, including increased engagement and a deeper understanding of complex concepts. However, they also emphasized the need for continuous support, user-friendly interfaces, and affordability to ensure that XR truly becomes an inclusive and transformative educational tool. By addressing these concerns and working collaboratively, this online platform could revolutionize the educational landscape, enriching the learning experiences of students and empowering educators to create dynamic and immersive lessons.

Conclusion on characteristics needed based on educators' needs.

In conclusion, the insights provided by educators regarding the integration of extended reality (XR) technologies in education have shed light on the major characteristics that a platform should possess to cater to their needs effectively.

Accessibility and Affordability: The platform must prioritize accessibility by offering XR solutions that can run on a variety of devices, from high-end headsets to more affordable options like smartphones. It should strive to keep costs reasonable, ensuring that both well-funded institutions and those with limited budgets can harness the benefits of XR.

Modular Architecture and Diverse Content: Educators expressed the importance of a platform that adopts a modular approach, providing a diverse array of XR content across various subjects and grade levels. This flexibility allows teachers to easily integrate XR experiences into their existing curricula.

Alignment with Curriculum Standards: The platform should align its XR content with established curriculum standards, making it easier for educators to justify its integration and demonstrate its relevance to academic goals.

Engaging and Interactive Learning: One of the key benefits of XR is its ability to engage and immerse students in the learning process. The platform must offer interactive XR experiences that promote active participation and a deeper understanding of complex concepts.

Personalisation and Customisation: Educators highlighted the importance of customisation options within the platform. It should allow teachers to adapt XR content to suit the unique learning styles and abilities of their students, ensuring an inclusive educational experience.

Continuous Technical Support and Training: To encourage widespread adoption, the platform should provide comprehensive technical support and training resources for educators. This support will boost their confidence in

using XR and help them overcome any technological challenges.

Ethical Considerations and Data Protection: Educators expressed concerns about data privacy and the ethical use of XR technologies. The platform must prioritize data protection, ensuring that student information is handled securely and responsibly.

Collaborative and Creation-Oriented Features: Apart from consuming XR content, the platform should facilitate collaborative activities and creation-oriented projects. This will foster teamwork, creativity, and critical thinking among students.

Regular Updates and Innovation: To stay relevant and effective, the platform should consistently update its XR content and features based on user feedback and technological advancements.

Integration with Existing Learning Management Systems: To streamline the integration process, the platform should offer compatibility with existing Learning Management Systems (LMS), making it seamless for educators to incorporate XR into their teaching practices.

By incorporating these major characteristics into its design and functionality, an XR-based educational platform can better meet the needs of educators, maximize student engagement and learning outcomes, and contribute to the transformation of education in a rapidly evolving digital age.

4.3 Students

4.3.1 Results Analysis

Responses on the potential of the usage of extended reality (XR), i.e., virtual reality (VR), augmented reality (AR), and mixed reality (MR) in education have been collected from a sample of 301 students (the age distribution of the sample is presented in Figure 4-53).

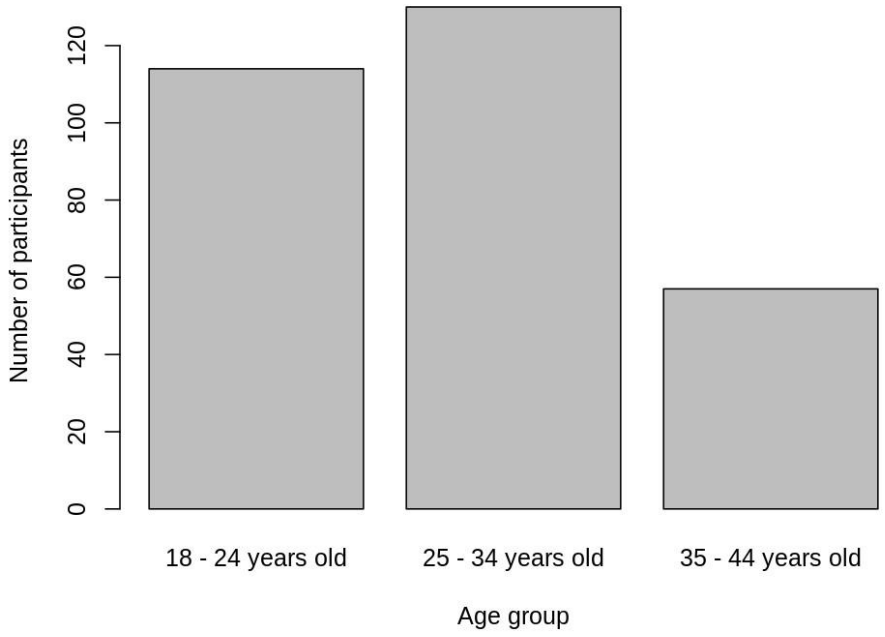


Figure 4-53: Age distribution of students responding to the questionnaire

In total, 38.9% of students reported having used XR technology in any of their courses (Figure 4-54). However, when asked whether they would select a course that offers XR technology as a teaching tool (over a similar course without), 88% responded affirmative (likely or very likely, details in Figure 4-55). Furthermore, the responses to the question "How likely are you to select a course that offers XR (AR, VR, MR) technology as a teaching tool even though you might not be overly interested in the course content as a whole?" indicated most of the students (even though not the majority) would use XR-mediated course even for subject they are not overly interested in (46.8% answered likely or very likely, 31.9% not likely or not likely at all, the rest doesn't know).

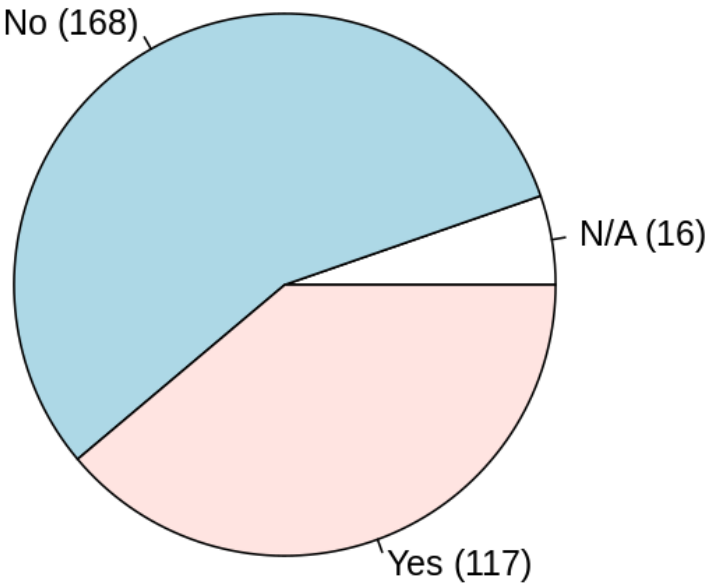


Figure 4-54: Numbers of student participants having used XR in any of their courses

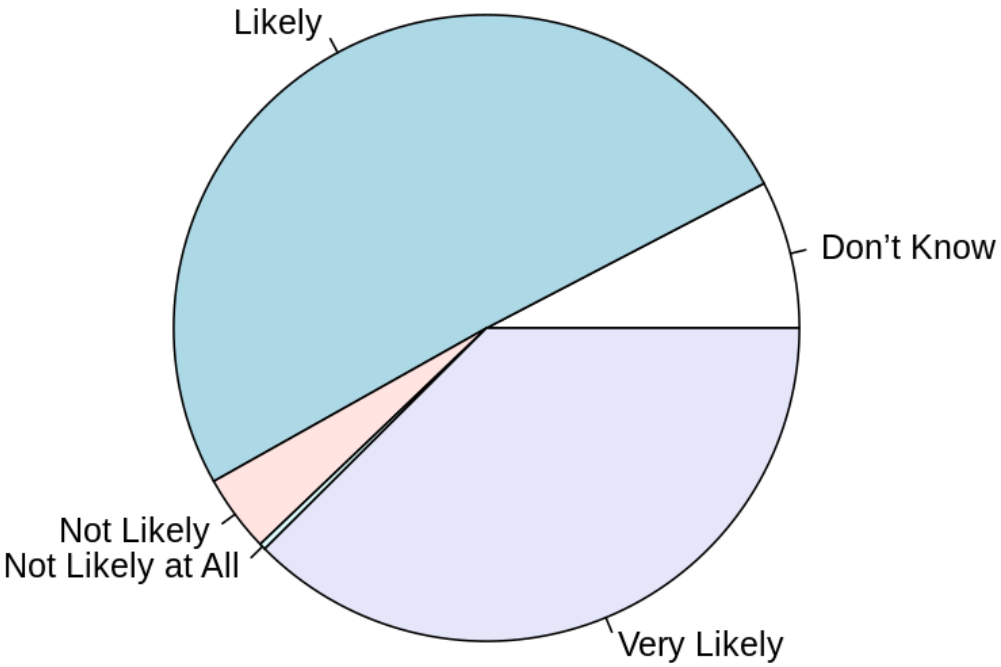


Figure 4-55: Responses to questions regarding preference for XR-mediated teaching material

92% of the students would take advantage of the opportunity to rent or borrow XR-related technology or hardware home (5% answered no, for 3% this question was not applicable).

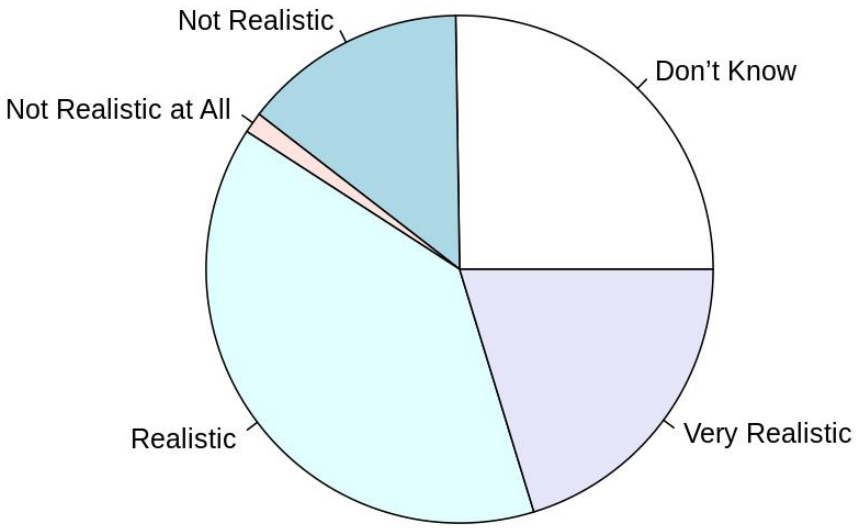


Figure 4-56: Students' expectations of the possibility of implementing XR in their university

Notably, students were generally optimistic (see Figure 4-56) that their university will implement XR sustainably within their curriculum in the next 5 years (59.1% believe it is realistic or very realistic).

4.3.2 Narrative Analysis

The findings from the Students' Questionnaire provide valuable insights into the potential success and challenges of creating an online platform for XR educational material. The survey revealed a diverse and enthusiastic user base, hailing from various European countries and spanning different age groups and educational backgrounds.

The student sample consisted of 159 females, 138 males, and 4 participants who identified as "other". The gender distribution is relatively balanced, and statistical analysis revealed no significant differences in responses across genders.

Most participants hailed from Greece and Belgium, with a significant presence of young adults aged between 18 to 34 years. The educational qualifications varied, with many holding bachelor's or master's degrees. This diversity ensures that the platform can cater to a wide range of learners and educators, fostering cross-cultural collaboration and knowledge exchange.

One significant aspect highlighted by the survey is the prior experience with XR technology among a substantial portion of the participants. This prior exposure to XR platforms, particularly VR, indicates a growing familiarity with immersive technologies, which can serve as a strong foundation for the

success of the XR educational platform. It also suggests that there is an existing community of users eager to explore XR-based learning experiences, creating a ready audience for the platform's content creators.

The respondents' preferred movements in XR, including options like Head Mounted Display/Lean In and Joystick-based interactions, underline the importance of providing diverse interaction methods within the platform. By accommodating various preferences, the platform can enhance user engagement and ensure a seamless experience for both educators and learners.

Moreover, the positive outlook regarding the availability of XR classes in the future demonstrates the potential market demand for XR-based educational content. With more than two-thirds of respondents expressing optimism, there is a clear indication that XR technology has a promising role to play in shaping the future of education.

However, the survey also highlighted several concerns, including technical challenges, cost implications, and health and safety considerations. These concerns underscore the need for the platform to prioritise accessibility, affordability, and user safety. By proactively addressing these challenges, the platform can build trust and confidence among users, ensuring a sustainable and inclusive environment for XR-based learning.

The desire for easy accessibility to XR technology, as expressed by most respondents, further emphasizes the importance of partnerships with educational institutions. Collaborating with universities and schools to provide access to XR hardware through rentals or borrowing will enable learners to explore XR experiences beyond the classroom, fostering a continuous learning journey.

Lastly, the significant interest in owning XR hardware in the next five years and the willingness to select courses offering XR technology as a teaching tool indicate a growing appetite for XR-based learning experiences. This potential demand for XR content further reinforces the platform's viability and presents an exciting opportunity to showcase innovative educational material created by software developers.

Conclusion:

In conclusion, the survey results highlight a promising future for the proposed XR educational platform. The diverse and enthusiastic user base, coupled with prior experience and a positive outlook for XR-based learning, sets the stage for a successful venture.

As the platform envisions the integration of XR technology into educational curricula, it must address concerns regarding technical implementation, content quality, and the balance between XR and traditional learning methods. By providing robust support, training, and resources to educators, the

platform can facilitate a seamless adoption of XR technology, ensuring that the learning experience remains engaging, enriching, and impactful.

To fully harness the potential of XR technology in education, the platform must navigate the challenges raised by the respondents. By doing so, the platform can pave the way for a transformative educational experience that empowers both educators and learners to explore new dimensions of knowledge and understanding through the immersive world of XR.

5 Compiled Conclusion

5.1 Discussion

The exploration of Extended Reality (XR) technologies within the educational landscape involved the perspectives of experts, educators, and students. This diverse range of viewpoints has contributed to a comprehensive understanding of the user requirements and experiences necessary for a successful XR educational platform.

User Requirements and Experiences:

Accessibility and Affordability: The demand for accessibility and affordability echoed across all groups. Educators stressed the importance of affordability to bridge the gap between well-funded and budget-constrained institutions. Students, representing the end-users, underscored their desire for easy access to XR technology both in terms of equipment and software.

Engaging and Interactive Learning: Both educators and students supported the notion of interactive learning. Educators sought XR experiences that actively engage students, enhancing their comprehension of complex subjects. Students expressed enthusiasm for engaging XR content that captures their attention and fosters active participation.

Customisation and Personalisation: The experts and educators alike emphasised the need for customization to accommodate diverse learning styles and abilities. The recognition of personalisation options to cater to disabilities garnered support from experts. Educators highlighted the potential for tailored experiences to boost engagement and motivation among students.

Technical Support and Training: Educators and experts voiced their shared concern about the importance of comprehensive technical support and training. Educators highlighted the necessity of workshops and guides to empower them to integrate XR into their teaching methods effectively.

Collaboration and Knowledge Sharing: Collaboration emerged as a prominent theme supported by educators and experts. Both groups saw the value in fostering collaborative learning through shared XR experiences. Experts suggested gamified experiences with collaborative rewards, while educators envisioned collaborative coding spaces as features of the platform.

Ethical Considerations and Data Protection: Experts and educators demonstrated a shared commitment to ethics and data protection. The experts highlighted the significance of transparent data collection, while educators stressed the importance of guidelines and informed consent. This alignment underlines the need for an ethically responsible approach to XR in education.

Integration with Curriculum and Learning Management Systems: Both educators and experts emphasised seamless integration with existing curricula. Experts highlighted the importance of integrating XR into educational frameworks, and educators requested alignment with curriculum standards. Additionally, educators saw compatibility with Learning Management Systems as a crucial factor for the platform's success.

Innovation and Continuous Improvement: The need for regular updates and innovation resonated with

educators and students. Educators recognised the importance of keeping content relevant, while students' anticipation of XR classes in the future showcased their enthusiasm for innovative educational experiences.

Conclusion:

The synthesis of insights from experts, educators, and students paints a cohesive picture of the user requirements and experiences essential for a successful XR educational platform. These requirements span accessibility, engagement, customisation, technical support, collaboration, ethics, integration, and innovation. The collective support from all three groups solidifies the platform's potential to revolutionise education by leveraging the immersive capabilities of XR technologies. As this platform envisions a dynamic fusion of technology and learning, it strives to address challenges while maximizing the educational benefits of XR experiences.

References

1. Meccawy, M. (2022). Creating an Immersive XR Learning Experience: A Roadmap for Educators. Electronics, 11(21), 3547
2. Vergara, D., Antón-Sancho, Á., Dávila, L. P., & Fernández-Arias, P. (2022). Virtual reality as a didactic resource from the perspective of engineering teachers. Computer Applications in Engineering Education, 30(4), 1086-1101
3. Dalager, S., & Majgaard, G. (2022, May). Development of an Educational AR Tool for Visualization of Spatial Figures and Volume Calculation for Vocational Education. In Virtual, Augmented and Mixed Reality: Applications in Education, Aviation and Industry: 14th International Conference, VAMR 2022, Held as Part of the 24th HCI International Conference, HCII 2022, Virtual Event, June 26–July 1, 2022, Proceedings, Part II (pp. 14-30). Cham: Springer International Publishing
4. Yang, K., Zhou, X., & Radu, I. (2020). XR-ed framework: Designing instruction-driven and Learner-centred extended reality systems for education. arXiv preprint arXiv:2010.13779
5. Kluge, M. G., Maltby, S., Keynes, A., Nalivaiko, E., Evans, D. J., & Walker, F. R. (2022). Current state and general perceptions of the use of extended reality (XR) technology at the University of Newcastle: Interviews and surveys from staff and students. SAGE Open, 12(2), 21582440221093348

ANNEXE I: Questionnaire for Experts

- You Can find the questionnaire in D3.1

ANNEXE II: Questionnaire Students (above 18 years of age)

- You Can find the questionnaire in D3.1

ANNEXE III: Interview for Experts

Section I (Information on the participant) - Background:

1. Ask the partners to provide a brief introduction about themselves.

2. Country:

3. Sex:
   - Male
   - Female
   - Other

4. Age:
   - 18-24 years old
   - 25-34 years old
   - 35-44 years old
   - 45-54 years old
   - 55-64 years old
   - Over 65 years old

5. Employment status:
   - Permanent
   - Contract
   - Temporary
   - Unemployed
   - Internship

6. Years of working experience:
   - Less than 5 years
   - 6-10 years of experience
   - 11-15 years of experience
   - 16-20 years of experience
   - 21-25 years of experience
   - More than 25 years of experience

7. Academic Level:
   - Graduate
   - Master
   - Ph.D.
   - Other (Please specify)

8. Gather information about their experience and expertise in XR technologies and/or the education sector.
   - Can you describe your experience and expertise in the field of XR technologies and their application in education?
   - Which XR (AR, VR, MR) technology platforms are you most familiar with?

Section 2 (Questions)

9. In your opinion, how can the existing educational and learning frameworks be integrated or adapted to incorporate XR technologies effectively?
10. From your perspective, what are the key user requirements that should be considered when developing an XR platform or application?
11. How can XR platforms be designed to ensure ease of use and accessibility for users with varying levels of technical expertise? How can an XR platform support different types of content creation and authoring, considering the diverse needs and skill levels of users?
12. In your opinion, what are the most important factors to consider when designing user interfaces and interactions for XR experiences?
13. What role do you think customization and personalization options should play in an XR platform? How can users tailor their experiences to meet their specific needs?
14. What are the critical hardware requirements or considerations for delivering high-quality XR experiences? How can these requirements be addressed to ensure optimal performance?
15. What challenges do you anticipate in terms of content distribution and compatibility across various XR devices and platforms? How can these challenges be overcome?
16. What measures can be taken to address concerns related to privacy and data security when using XR platforms?
17. How important is interoperability between different XR systems and platforms? What are the potential benefits and challenges of achieving interoperability?
18. What kind of support or resources do developers and content creators need to effectively utilize an XR platform? How can these resources be provided?
19. How can an XR platform facilitate collaboration and knowledge sharing among users? Are there any specific features or functionalities that can enhance collaboration in XR?

ANNEXE IV: Interview for Educators

Section I (Information on the participant) - Background:

1. Ask the partners to provide a brief introduction about themselves.

2. Country:

3. Sex:
   - Male
   - Female
   - Other

4. Age:
   - 18-24 years old
   - 25-34 years old
   - 35-44 years old
   - 45-54 years old
   - 55-64 years old
   - Over 65 years old

5. Employment status:
   - Permanent
   - Contract
   - Temporary
   - Unemployed
   - Internship

6. Years of working experience:
   - Less than 5 years
   - 6-10 years of experience
   - 11-15 years of experience
   - 16-20 years of experience
   - 21-25 years of experience
   - More than 25 years of experience

7. Academic Level:
   - Graduate
   - Master
   - Ph.D.
   - Other (Please specify)

8. Are you currently a staff member of:
   - Elementary School

- High School
- College
- Higher Education Institution
- Vocational Institution
- Other organization

9. Gather information about their expertise in the education sector.

Section 2 – Questions

10. How familiar are you with extended reality (XR) technologies and their potential applications in education?
11. Can you describe your experience and background as an educator in utilizing extended reality (XR) technologies in the classroom/ if any?
12. How can XR technologies enhance the learning outcomes and engagement levels of students? Are there any specific learning objectives or skills that XR can effectively address?
13. What types of XR experiences or applications do you think would be most effective in enhancing student engagement and understanding?
14. From your perspective, what are the most important considerations when designing XR experiences for different educational contexts (e.g., primary schools, universities, vocational training)?
15. How important are the ease of use and intuitive navigation in an XR platform designed for educational purposes? How do think this can be achieved?
16. What types of XR technologies (e.g., virtual reality, augmented reality, mixed reality) do you think are most suitable for educational purposes? Why?
17. What features or functionalities would you like to see in an XR platform to support teaching and learning in your subject area?
18. Do you have any specific requirements or preferences regarding the content creation capabilities of an XR platform?
19. From your perspective, how should an XR platform be designed to support different subjects or disciplines effectively?
20. What features or functionalities do you consider essential in an XR platform designed for educational use?
21. How do you think XR platforms can accommodate students with diverse learning styles or varying abilities?
22. How would you envision incorporating XR technology into your existing curriculum or teaching methods?
23. What kind of training or support would you need to effectively integrate XR into your classroom?
24. Are there any concerns or challenges you foresee in using XR in the classroom, and how do you think they can be addressed?
25. What are the potential ethical considerations or concerns that need to be addressed when using XR in the classroom? How can these concerns be managed?
26. What are your thoughts on the affordability and accessibility of XR technologies for schools and students?
27. What resources or materials would help integrate XR into your lessons or activities?
28. What specific challenges or barriers do you anticipate when integrating XR into the classroom? How can these challenges be addressed?
29. How would you like to assess and evaluate student learning when XR is used as a learning tool? Are there

any specific criteria or methods you would suggest?

30. Based on your experience, can you provide any examples or success stories of using XR in education that have had a positive impact on student outcomes?