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ARIES

Augmented and immersive Reality for Improved Education in Schools in Europe

ARIES

Erasmus+ Cooperation partnerships in school education
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The ARIES Survey on Augmented and Immersive Reality in European Schools

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Executive Summary

The ARIES Survey aimed to assess the beliefs, opinions, and educational experiences related to the use of Augmented and Immersive Reality (A&IR) in schools across Europe. Conducted from February to May 2024, the survey involved 156 participants, mainly teachers from secondary public schools, and highlighted the current state of A&IR adoption, its perceived importance, and the barriers to its implementation.

Most participants demonstrated a moderate level of familiarity with A&IR technologies, while acknowledging their potential for enhancing student engagement, motivation, and learning outcomes. Key benefits identified included increased student motivation, critical thinking, and creativity. Despite recognizing the positive impact of A&IR, only 20.5% of participants reported actively using these technologies in their classrooms, indicating limited penetration in educational practices.

The main obstacles to wider adoption of A&IR were identified as lack of access to suitable devices, high costs, limited teacher training, and insufficient content availability. Additionally, a majority of participants expressed a need for easy-to-use, low-cost tools to facilitate integration of A&IR into daily learning activities.

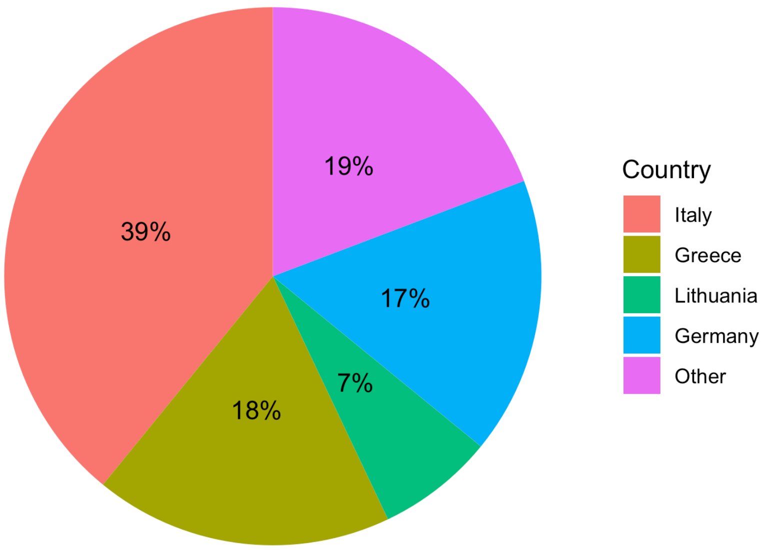
The survey also explored the institutional support for A&IR, finding that only a fraction of schools provide the necessary technologies, and training opportunities for teachers remain scarce. The results underscore the need for greater institutional investment, teacher training, and cost-effective solutions to make A&IR accessible to a broader range of educational contexts.

Introduction

The survey aims to gather beliefs, opinions, and educational experiences regarding the use of Augmented and Immersive Reality (A&IR) in schools from a Europe-wide perspective. The survey has been administered online, leveraging the professional networks of each project partner. The survey has been available in five languages (German, Greek, English, Italian, Lithuanian) from 12/02/2024 to 10/05/2024

Participants

156 persons participated in the survey including 66 females, 82 males, and 8 subjects who preferred to not disclose their sex. The participants' average age of participants was 48.32 (SD = 9.71). A Wilcoxon rank sum test with continuity correction was conducted to compare the ages of males and females (W = 2,828.50, p = 0.64). The test was not statistically significant, indicating no difference in the central tendency of the two distributions. The most of responses came from Italy (39.10%), Greece (17.95%), and a collection of 14 countries other than those in the project (19.23%) as reported in Table 1.



Other countries	**N = 30**[1]
Country	
Albania	3 (10%)
Austria	1 (3.3%)
Bulgaria	1 (3.3%)
Croatia	1 (3.3%)
Danmark	1 (3.3%)
Hungary	1 (3.3%)
Ireland	3 (10%)
Palestina	1 (3.3%)
Poland	2 (6.7%)
Portugal	10 (33%)
Republic of Moldova	1 (3.3%)
Romania	3 (10%)
Rumania	1 (3.3%)
Slovenia	1 (3.3%)
[1]n (%)	

Table 1. Distribution of other countries

Most of the respondents are teachers (88.46%) from public schools (89.10%) and specifically subjects belonging to secondary schools (80.54%), consistently with the target group of the project. Only 11.54% of respondents hold management roles (Figure 1).
The subjects taught by the participants are quite varied, with a predominance of technology subjects (44.08%) as well as those related to language and literature (23.03%), mathematics (13.16%), and science (10.53%) as reported in Table 2

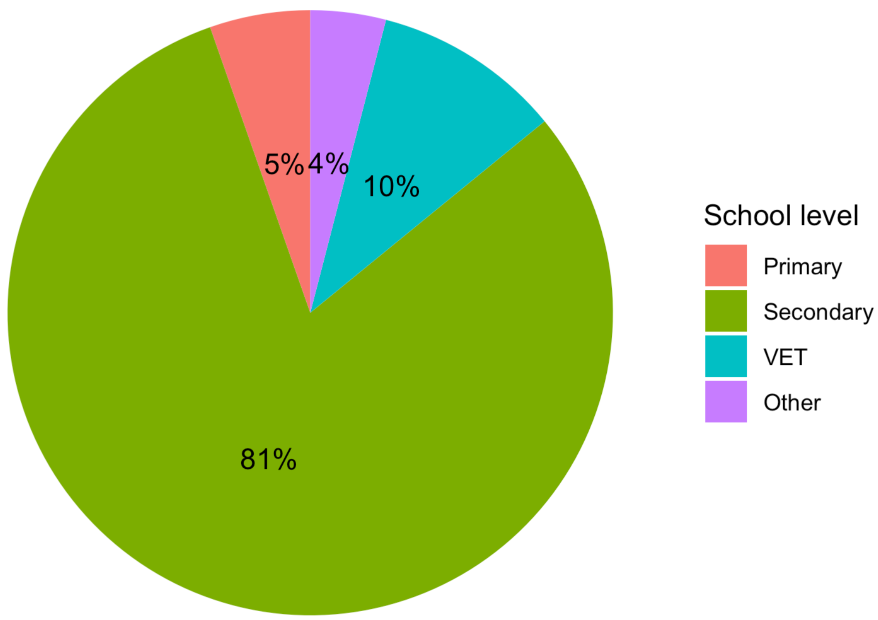


Figure 1. School level

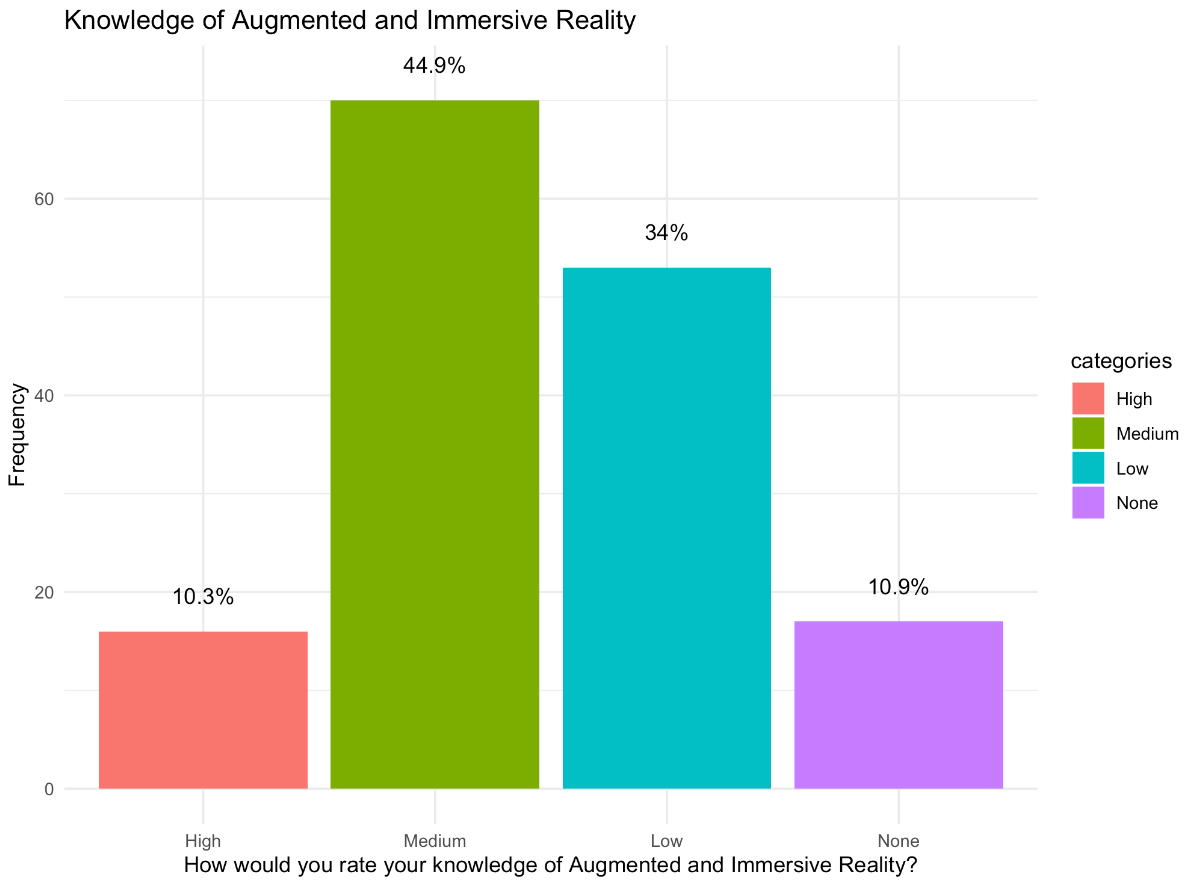
Subjects	**N = 156**[1]
Arts	5 (3.3%)
Business and Economics	2 (1.3%)
Language and Literature	35 (23%)
Mathematics	20 (13%)
Physical Education	2 (1.3%)
Religion	1 (0.7%)
Science	16 (11%)
Social Sciences	2 (1.3%)
Special Education	2 (1.3%)
Technology and Engineering	67 (44%)
Unknown	4
[1]n (%)	

Table 2. Distribution of the subjects taught by the participants

Results

How would you rate your knowledge of Augmented and Immersive Reality?

The distribution of knowledge levels in A&IR among participants is summarized as follows: high (10.30%), low (34%), medium (44.90%), and none (10.90%). These findings indicate a predominant level of medium expertise, with significant representation, also observed at lower levels, suggesting varying degrees of familiarity and proficiency among respondents with A&IR technologies.



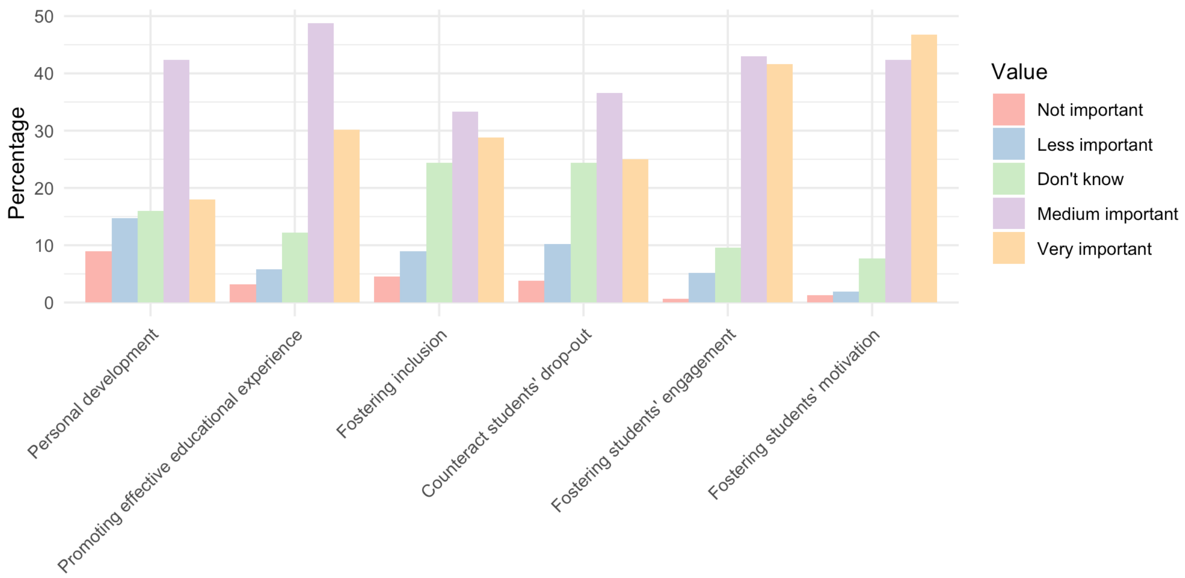
How do you rate the importance of Augmented and Immersive Reality?

"Personal Development" was notably perceived as "Medium important" by 42.3% while 17.9% rated it as "Very important".

In the category of *"Promoting Effective Educational Experience"*, participants demonstrated a broad consensus about the importance that educational A&IR experiences can have for students. In fact, nearly half of the respondents, 48.7%, rated it as "Medium important," and 30.1% as "Very important".

"Fostering Inclusion" revealed a diverse set of opinions, with 33.3% rating it "Medium important" and 28.8% "Very important." However, the fact that 24.4% were unsure ("Don't know") reflects a considerable degree of uncertainty or ambivalence about the importance of inclusion initiatives.

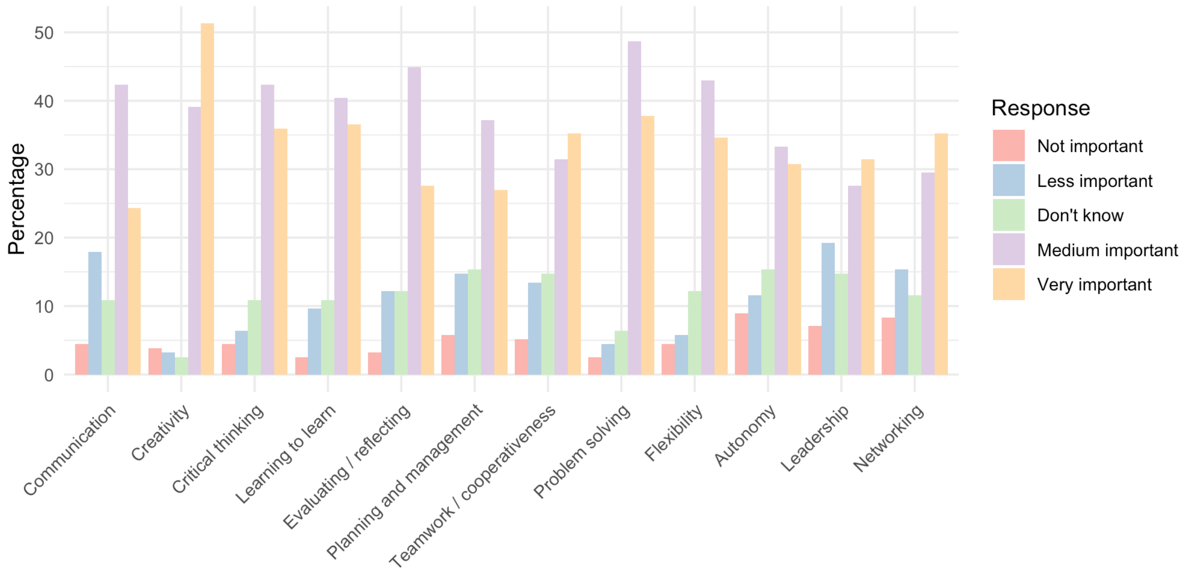
The responses for *"Counteracting Students' Drop-Out"* showed that 36.5% deemed it "Medium important" and 25% "Very important" which underscores the perceived need to address drop-out rates, though the same 24.4% uncertainty suggests that the agreement on this issue is not shared by all.
In terms of *"Fostering Students' Engagement"* there was a strong consensus on its importance, with 42.9% rating it "Medium important" and 41.7% "Very important." The minimal 0.6% who found it "Not important" indicates near-universal acknowledgment of its value.
Lastly, *"Fostering Students' Motivation"* emerged as highly significant, with 46.8% rating it "Very important" and 42.3% "Medium important" indicating a widespread recognition of motivation as a critical factor in student success.



How do you rate the importance of "Augmented and Immersive Reality" about

Which competences developments do you expect to be developed within Augmented and Immersive Reality settings?

The responses to this item revealed that, in general, is possible to find a positive view of the impact of A&IR on the skills that educators expect to be developed. Competences developed with A&IR seen as very important are creativity (51.3%), problem solving (37.8%), learning to learn (36.5%), teamwork (35.3%), networking (35.3%), critical thinking (35.9%), flexibility (34.6%), and leadership (31.4%) which are all above 30 percent.
The impact of A&IR on evaluating / reflecting (27.6%), planning (26.9%) and communication (24.4%) is considered more marginal.
The item allowed additional values to be entered if desired. Some participants mentioned other skills such as: accuracy, public speaking, digital skills, emotional intelligence, mental and emotional health, and holistic thinking.

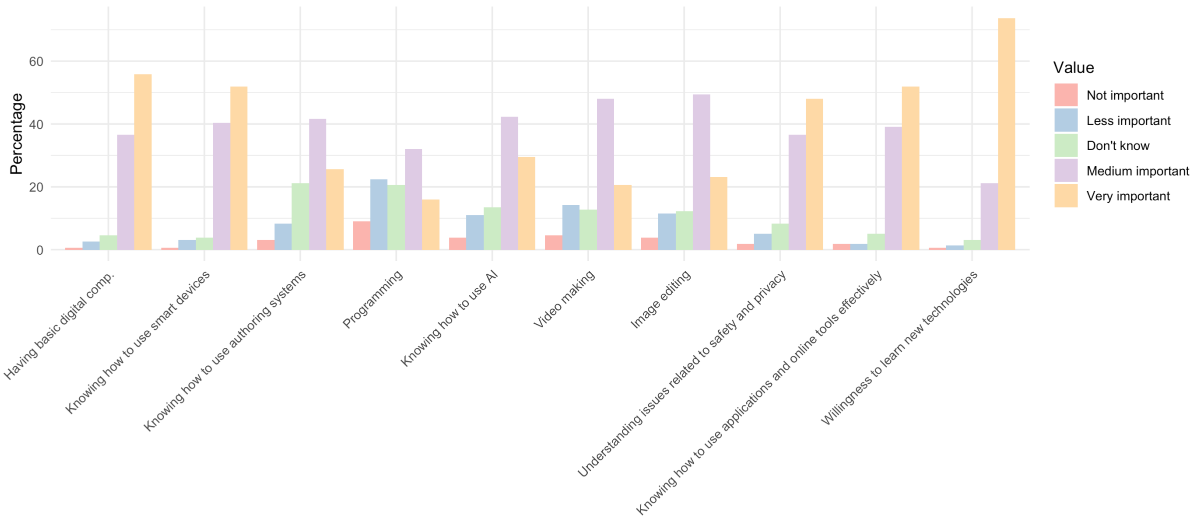


Which competences do you expect to be developed within Augmented and Immersive Reality settings?

What do you think it is important for a teacher implementing Augmented and Immersive Reality activities in school contexts?

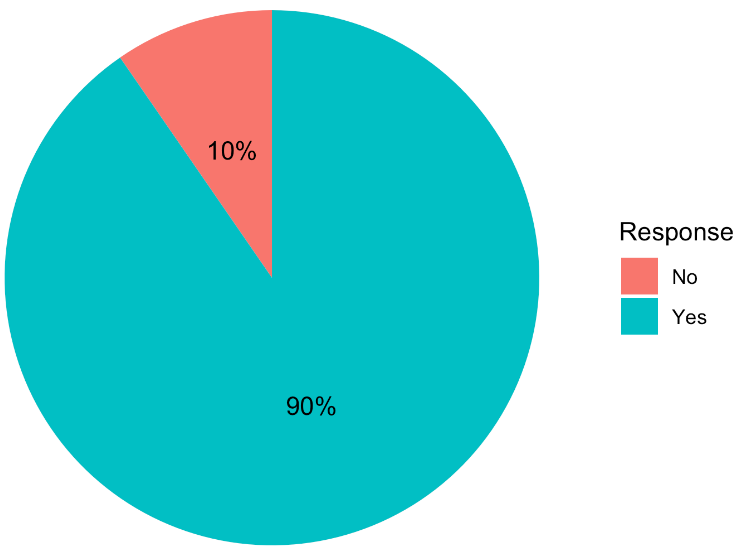
"*Having basic digital competences*" was rated as "Very important" by 55.8% of respondents and "Medium important" by 36.5%.
Similarly, "*Knowing how to use smart devices*" was deemed "Very important" by 51.9% and "Medium important" by 40.4%.
Conversely, some competencies were less uniformly valued. "*Knowing how to use authoring systems*" was marked as "Very important" by only 25.6%, while 21.2% were unsure.
"*Programming*" saw a diverse response: 16% considered it "Very important," and 22.4% rated it as "Less important".
"*Knowing how to use AI*" showed a notable interest, with 29.5% considering it "Very important" and 42.3% rating it "Medium important," though 13.5% were uncertain. This reflects growing but not universal recognition of AI's potential in education.
"*Video making*" and "*Image editing*" were rated as "Very important" by 20.5% and 23.1%, respectively. "Medium important" ratings were higher, at 48.1% for video and 49.4% for image editing. These findings suggest that multimedia skills are considered crucial for using A&IR in educational contexts.
"*Understanding safety and privacy*" issues was considered "Very important" by 48.1% and "Medium important" by 36.5%.
"*Knowing how to use applications and online tools effectively*" was seen as "Very important" by 51.9% and "Medium important" by 39.1%, highlighting its perceived necessity.
Lastly, "*Willingness to learn new technologies*" was rated as "Very important" by a significant 73.7%, reflecting a strong consensus on the importance of adaptability and continuous learning in the evolving educational landscape.
Overall, the survey reveals a high value placed on digital competences and a willingness to learn new technologies among teachers, while views on the importance of specific technical skills like programming and the use of authoring systems are more varied.

Some participants suggested additional useful skills in an open-ended question related to the item, highlighting the need for collaboration, easier digital content creation, the ability to distinguish relevant information, methods to enhance students' motivation, and advanced knowledge and skills in ICT use.



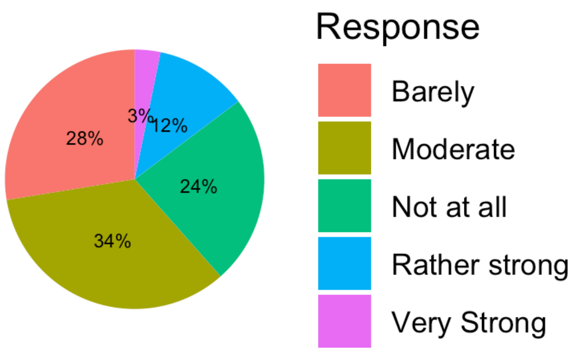
Do you think that easy-to-use, low-threshold, and low-cost tools would facilitate the adoption of A&IR in daily learning activities?

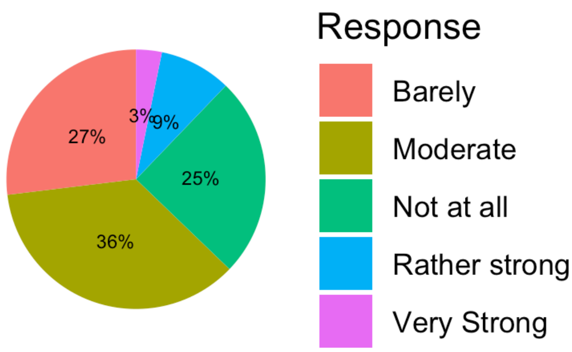
An absolute majority of the participants believe that easy-to-use, low-threshold, and low-cost tools would facilitate the adoption of A&IR in daily learning activities as shown in the following figure:



To what degree would you say that your school promotes the acquisition and development of competencies related to Augmented and Immersive Reality in teachers?

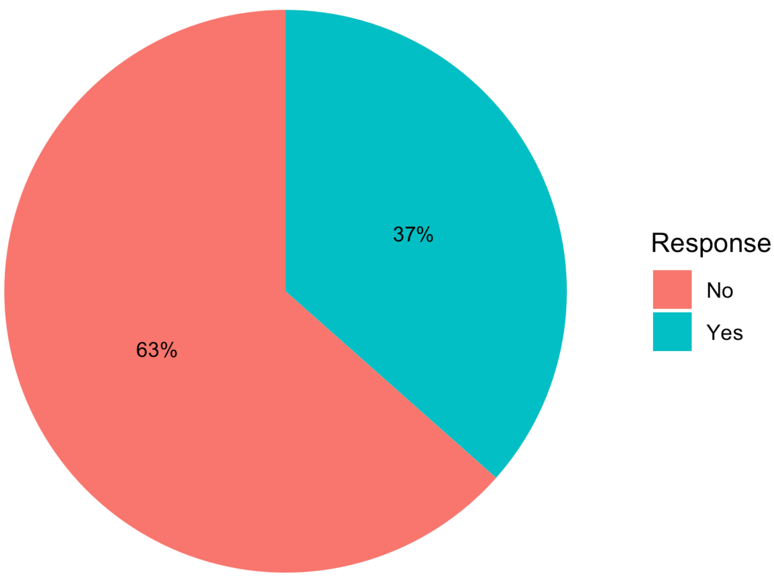
The survey respondents agree that there is a lack of training initiatives by schools to develop skills related to A&IR. According to the responses, 83% indicate little or no training activity for teachers, while 86% indicate the same for students.





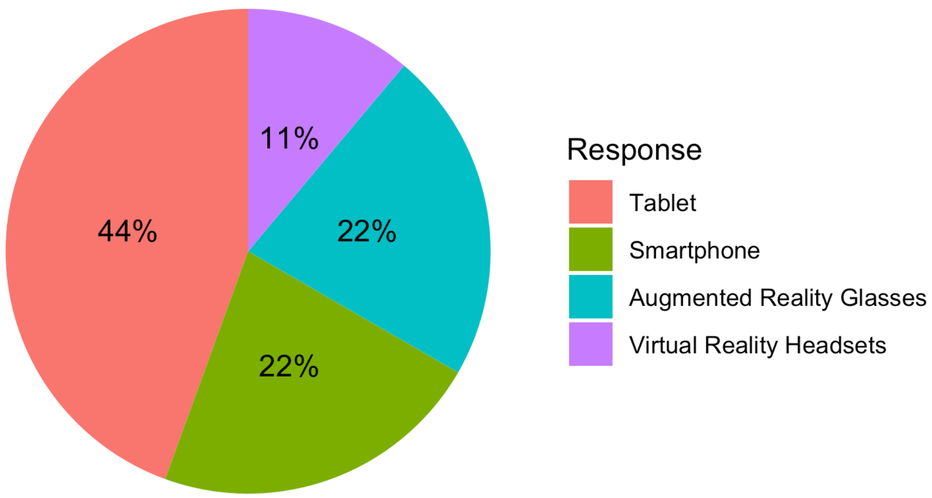
Does your institution provide teachers with technologies to implement Augmented and Immersive Reality experiences?

About 2/3 of participants' schools provide useful technology for A&IR. However, the share of schools that do not provide it is still quite high.



If yes, which technologies do they provide?

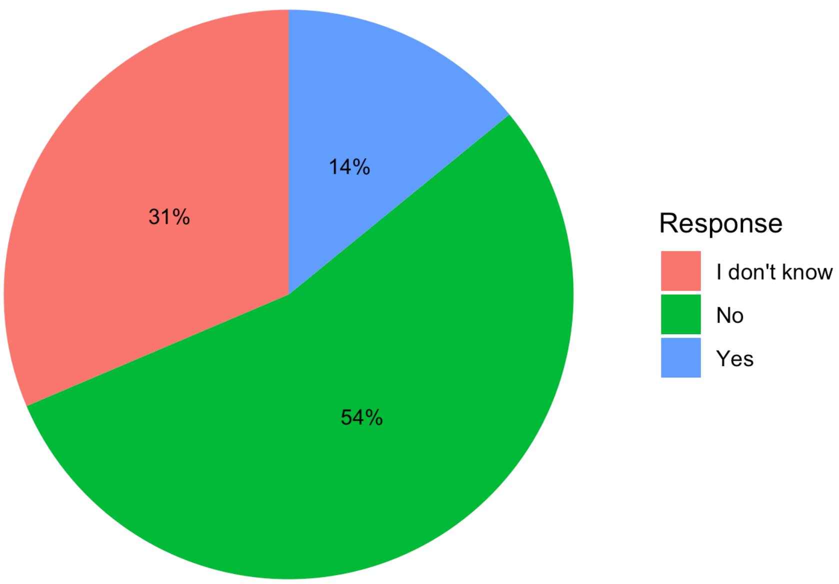
The device most frequently provided by schools are tablets (44.4%), followed by smartphones (22.2%), Augmented Reality Glasses (22.2%), and Virtual Reality Headsets (11.1%).



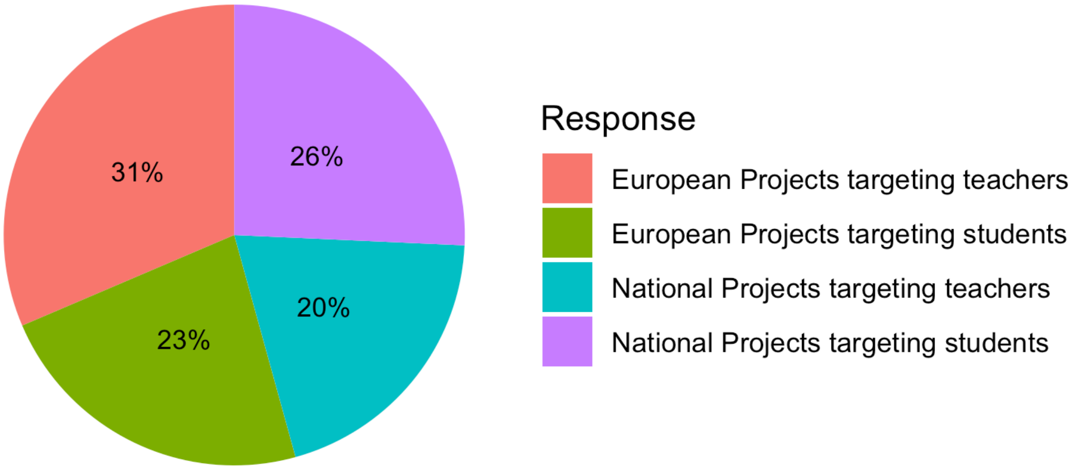
Participants reported that schools provide also computers, merge cubes, Google Cardboards, Interactive Whiteboards, and 360-degree Cameras.

Is your institution involved in Augmented and Immersive Reality projects?

Most of the schools involved in the survey are not participating in European projects related to augmented and immersive reality (54.49%). A significant proportion of respondents are unsure whether their school is involved in such projects (31.41%). Only a small percentage of participants reported that their schools are engaged in these types of projects (14.10%).



Among the respondents who stated that their school is involved in European projects, European Projects targeting teachers are the most common (31.4%). European Projects targeting students (22.9%) and national projects for teachers (20%) and students achieving similar scores (25.7%).



The following tables (Table 3 and Table 4) detail the projects in which the respondent institutions are involved and highlight other notable projects that do not involve their institutions

Projects
Ateities inžinerija
Augmented assessment
Augmented reality Italy
eTwinning 2022-2023 με τίτλο LEARNT
Εθνικό πρόγραμμα Νόησις "Πράσινη ενέργεια και τεχνολογία"
Ευρωπαϊκό πρόγραμμα Erasmus+ 2020-1-EL01-KA201-079206 "Shape the future teacher"
FabLab SchoolNet: STEAM education and learning by Robotics, 3D and Mobile technologies
X-Lab: Schwerpunkt Naturwissenschaften
ΠΟΛΙΤΙΣΤΙΚΟ ΠΡΟΓΡΑΜΜΑ
Πολιτιστικό πρόγραμμα για το Βαρούσι

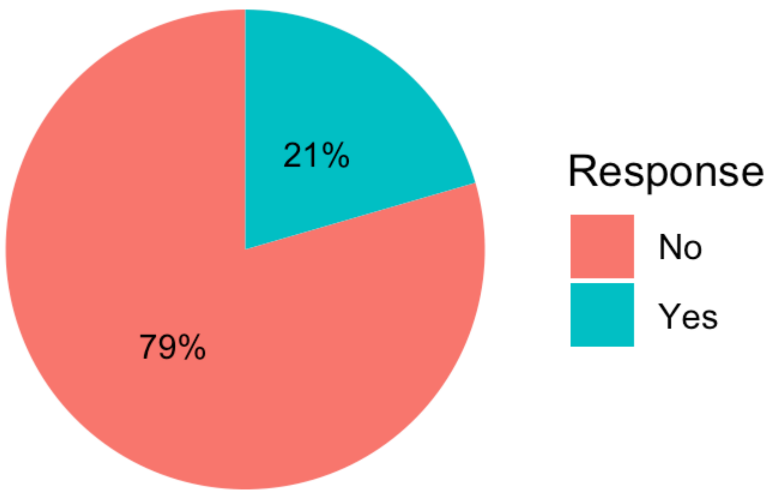
Table 3. List of projects carried out in respondents' institutions

Projects
ARIDLL project (https://aridll.eu)
ARTutor (https://artutor.ihu.gr/category/projects/)
Augmented Assessment - Assessing Newly Arrived Migrants' Knowledge in Science and Math Using Augmented Teaching Material (https://iep.edu.gr/el/europaika-se-ekseliksi/assessing-newly-arrived-migrants-knowledge-in-science-and-math-using-augmented-teaching-material-augmented-assessment)
ClassVR (https://www.classvr.com/it/)
Digital Practicum 3.0: Exploring Augmented Reality, Remote Classrooms, and Virtual Learning To Enrich and Expand Preservice Teacher Education Preparation (http://prac3.fundacionusal.es)

Table 4. List of projects not carried out in respondents' institutions

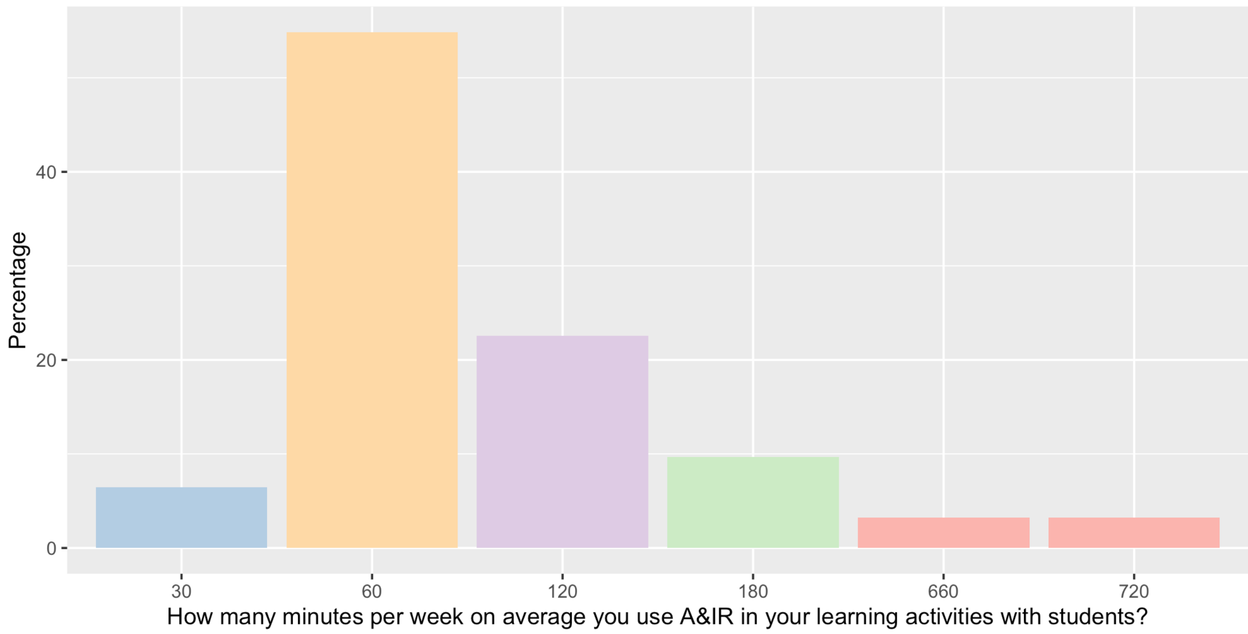
Do you use Augmented and Immersive Reality in your learning activities with students?

79.49% of respondents indicate that they do not use Augmented and Immersive Reality in their learning activities, demonstrating that these practices are still not widely utilized and applied in schools.



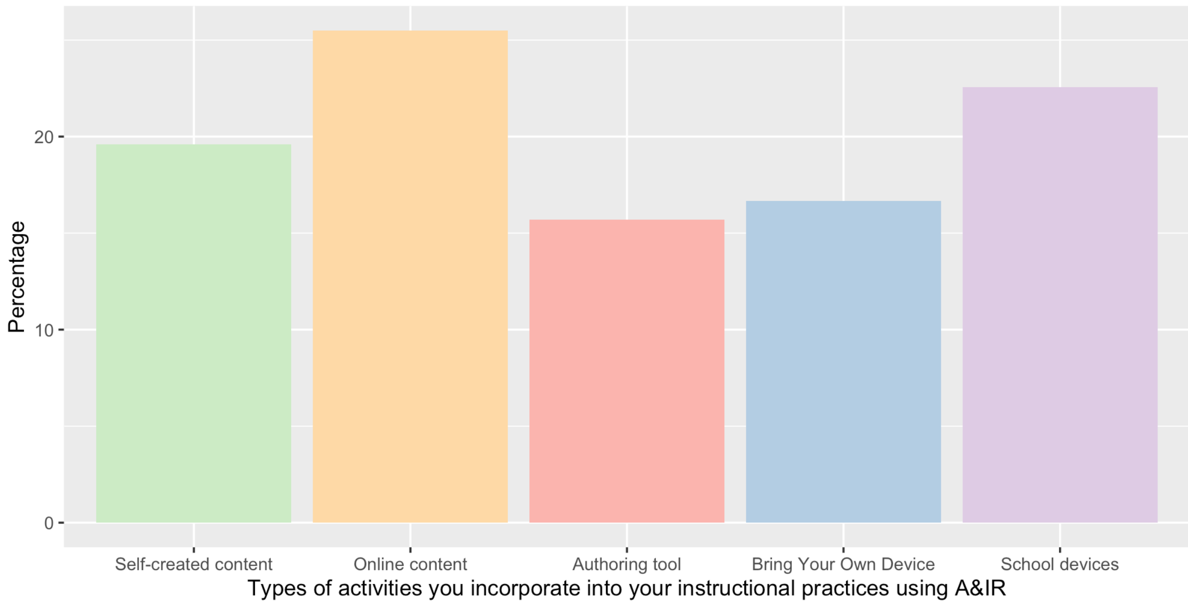
Please specify how many hours per week on average you use Augmented and Immersive Reality in your learning activities with students

Of the 31 subjects using A&IR technologies in teaching, the majority spend only 60 minutes (54.80%) per week on this type of activity.



Please describe the types of activities you incorporate into your instructional practices using Augmented and Immersive Reality

Approximately 19.6% of the respondents reported using self-created content while a quarter of the respondents (25.5%), utilize online content, indicating a preference for available resources that can be easily integrated into various educational contexts. Additionally, 15.7% of the respondents reported using authoring tools, highlighting an interest in mastering software to create interactive and multimedia-rich content.
The Bring Your Own Device (BYOD) approach is utilized by 16.7% of educators. Meanwhile, the use of school-provided devices is reported by 22.5% of the respondents.



In your experiences what is the positive effect of using Augmented and Immersive Reality in a classroom?

The item was an open-ended not mandatory question that could be answered by those who reported using I&AR in the classroom. It received 32 responses of which 29 are valid. Excluded responses are “no”, “I don’t know”, and similar. After having examined all responses, we identified the following 9 recurring categories. Each response can be related to one or more categories.

1. Engagement.

Engagement refers to the increased attention, interest, and active participation of students in the learning process. The use of Augmented Reality (AR) and Immersive Reality (IR) technologies can captivate students’ attention, making learning experiences more interactive and immersive. Example answer: “Students work harder, are more attentive, and learn more easily”.

2. Inclusion.

Inclusion encompasses the ability of AR and IR to create an equitable learning environment where all students, regardless of their learning abilities or backgrounds, can participate fully. These technologies can provide personalized learning experiences and cater to diverse educational needs. Example answer: “There can be many positive outcomes. Some of them include the participation of even weaker students”.

3. Critical Thinking.

Critical thinking involves the enhancement of students’ ability to analyze, evaluate, and synthesize information. AR and IR technologies can stimulate cognitive processes by presenting complex scenarios and problem-solving tasks that require thoughtful engagement. Example answer: “Critical thinking is enhanced as students can analyze, compare, and evaluate virtual experiences”.

4. Motivation.

Motivation refers to the increased drive and enthusiasm of students toward learning. AR and IR create dynamic and visually appealing educational content, which can lead to higher levels of intrinsic motivation and a greater desire to engage with the material. Example answer: “There is usually a strong increase in students’ motivation, a much more curious approach, and a willingness to discover”.

5. Learning.

Learning improvements are reflected in the ability of AR and IR to enhance comprehension, retention, and application of knowledge. These technologies offer experiential learning opportunities that can deepen understanding and foster high-efficiency retention of information. Example answer: “High efficiency in the learning process”.

6. Digital Skills.

Digital skills pertain to the development of students’ abilities to navigate and utilize digital technologies effectively. The integration of AR and IR in the classroom can help students become more proficient with advanced technological tools, preparing them for a digitally driven future. Example answer: “Development of digital skills through modern technologies”.

7. Creativity.

Creativity involves fostering innovative thinking and the ability to generate original ideas. AR and IR can provide students with new ways to explore concepts and express their ideas, encouraging creative problem-solving and experimentation. Example answer: “[…] development of creativity and imagination, application of educational technologies in educational practice.”

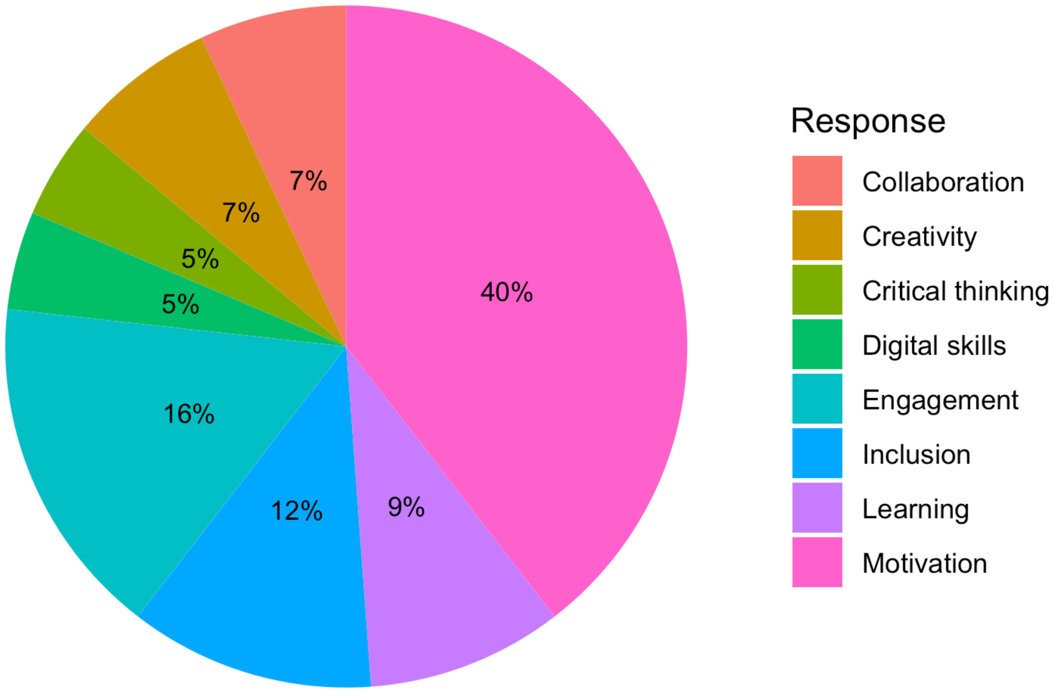
8. Collaboration.

Collaboration refers to the enhancement of students’ abilities to work together effectively. AR and IR can facilitate collaborative learning experiences by enabling interactive group activities and shared virtual environments, promoting teamwork and communication skills. Example answer: “One of the main positive outcomes of using augmented and virtual reality in a classroom is the enhancement of interactivity and student participation”.

9. Awareness and Self-esteem.

Awareness and self-esteem reflect an increase in students’ self-awareness and confidence. The immersive and interactive nature of AR and IR can lead to greater self-assurance and a better understanding of one's own abilities and learning progress. Example answer: "Increase in awareness and self-esteem".

Motivation emerged as the most frequently cited benefit, with 39.5% of respondents highlighting how AR and IR significantly increase students' drive and enthusiasm toward learning. Other advantages of AI&R mentioned by participants are engagement (16.3%), inclusion (11.6%), and learning (9.3%). Collaboration, creativity, critical thinking, and digital skills get fewer than 7 percent of responses.



Would you indicate limitations encountered in the implementation of the Augmented and Immersive Reality experiences

The item was an open-ended question, not a mandatory question that could be answered by those who reported using I&AR in the classroom. 29 responses are valid of the 32 received. Excluded responses are "no", "I don't know", and similar. After having examined all responses, we identified the following 13 recurring categories. Each response can be related to one or more categories.

1. Availability of Devices.

Availability of devices refers to the extent to which students and teachers have access to the necessary AR and IR hardware. Limited availability can impede the effective implementation of these technologies in educational settings. Example answer: "Lack of mobile devices".

2. High Cost of Devices.

The high cost of devices highlights the financial barrier posed by the expensive nature of AR and IR equipment. This can limit the adoption of these technologies, especially in underfunded schools and districts. Example answer: "The development and support of the technological infrastructure for augmented and virtual reality may require investments in equipment and software, which may not always be feasible due to limited budgets”.

3. Compatibility Challenges.

Compatibility challenges refer to the difficulties in ensuring that AR and IR technologies are compatible with existing hardware, software, and network infrastructures. This issue can create barriers to seamless integration and usage, requiring additional resources to address compatibility issues. Example answer: “Compatibility of devices in the BYOD approach”.

4. Lack of Freeware Applications.

The lack of freeware applications points to the scarcity of cost-free AR and IR software. This limitation can restrict access for institutions that cannot afford expensive software licenses. Example answer: “The lack of many free augmented reality freeware applications that are aimed at middle school ages and are simultaneously creative”.

5. Limited Access to Computer or Internet.

Limited access to computers or the Internet encompasses the broader issue of insufficient availability of computers and Internet connectivity for students and teachers, further limiting the use of AR and IR. Example answers: “Lack of necessary infrastructure and equipment in the school”, “Lack of reliable networks”.

6. Limited Content Availability.

Limited content availability refers to the scarcity of suitable educational content for AR and IR platforms. This can restrict the scope and effectiveness of these technologies in enhancing the curriculum. Example answer: “Need for high-quality and educationally valuable content”.

7. Missing Educational Approach.

Missing educational approach highlights the lack of pedagogical frameworks and strategies tailored to effectively integrate AR and IR into the teaching and learning process. Example answer: “Missing educational approach”.

8. Need for Training.

The need for training underscores the necessity for adequate professional development and training for teachers to effectively use AR and IR technologies in their instructional practices. Example answers: “Training students to use the novel technologies for meaningful learning experiences”, “Teachers need adequate training and support to effectively use these technologies in the classroom”.

9. Students’ Resistance.

Students’ resistance refers to the reluctance or opposition from students towards using AR and IR technologies, which can stem from unfamiliarity, discomfort, or perceived irrelevance. Example answer: “There are also less predictable problems, such as some students’ resistance, who show fear towards experiences that are so physically and emotionally engaging”.

10. Teachers’ Resistance.

Teachers’ resistance indicates the reluctance or opposition from educators towards adopting AR and IR technologies, often due to a lack of familiarity, perceived complexity, or skepticism about their educational value. Example answer: “Reluctance on the part of non-computer science teachers”.

11. Technological Limitations.

Technological limitations encompass the various technical issues and constraints inherent in AR and IR technologies, such as hardware malfunctions, software bugs, and limited battery life. Example answer: “Limitations only due to the poor quality of the connection”.

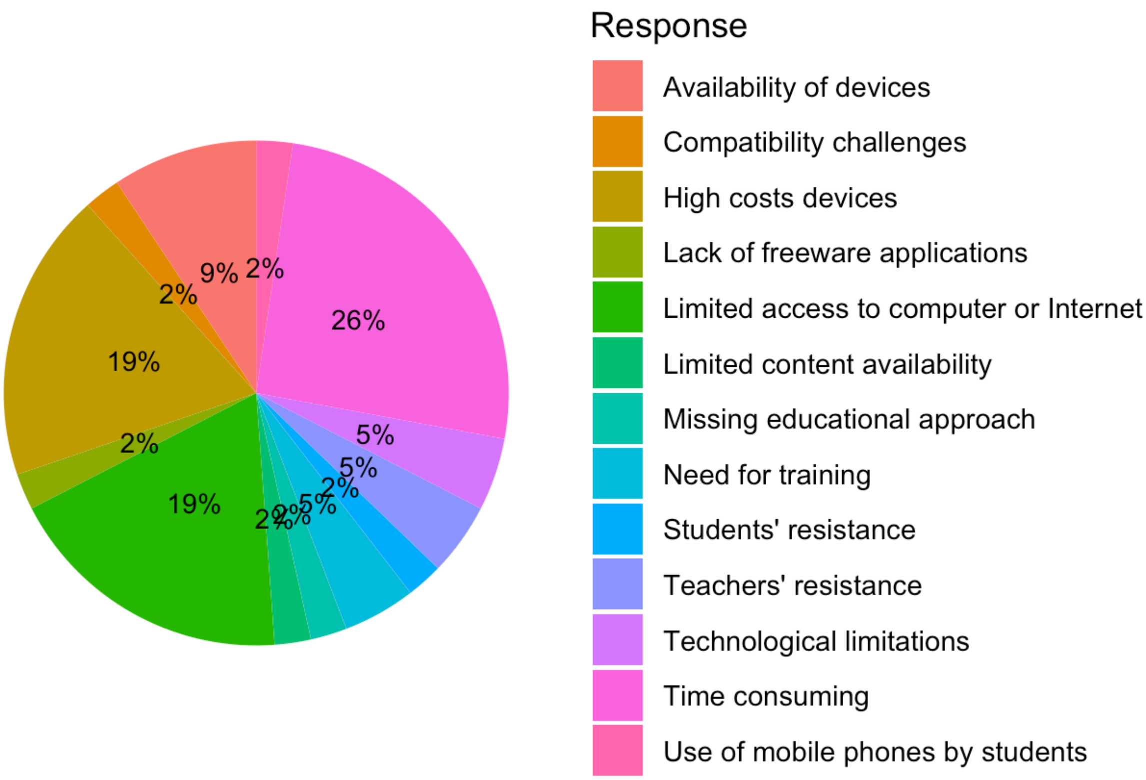
12. Time-Consuming.

Time-consuming refers to the significant amount of time required to set up, learn, and integrate AR and IR technologies into the classroom, which can be a deterrent for teachers and students alike. Example answers: “It takes quite a lot of time, in the beginning, to familiarize students”, and “Creating high-quality and educationally valuable content for augmented and immersive/virtual reality experiences can require time and resources”.

13. Use of Mobile Phones by Students.

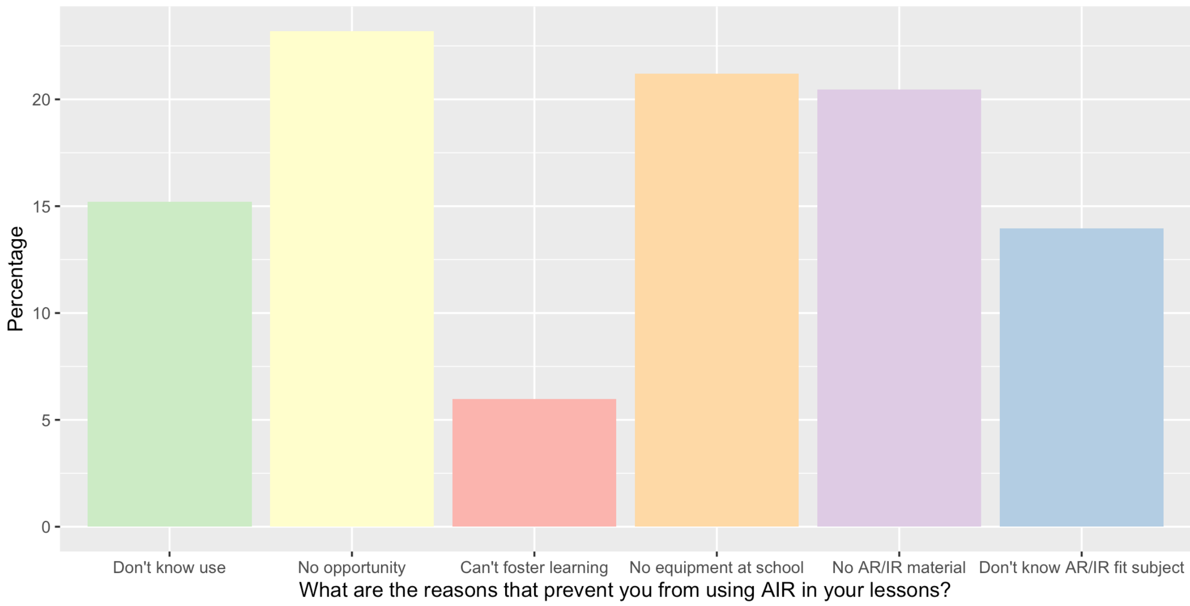
The use of mobile phones by students addresses the challenge of managing the appropriate use of mobile devices in the classroom, which can be a distraction or lead to misuse if not properly controlled. Example answer: “The use of mobile phones by students (Middle School)”.

Issues related to time (25.6%), cost of devices (18.6%), and limited access to computers or the Internet (18.6%), availability of devices (9.3%) are major concerns of educators that could jeopardize the implementation of A&IR practices at school. The other categories above described are perceived as minor concerns, mentioned by less than 5% of respondents.



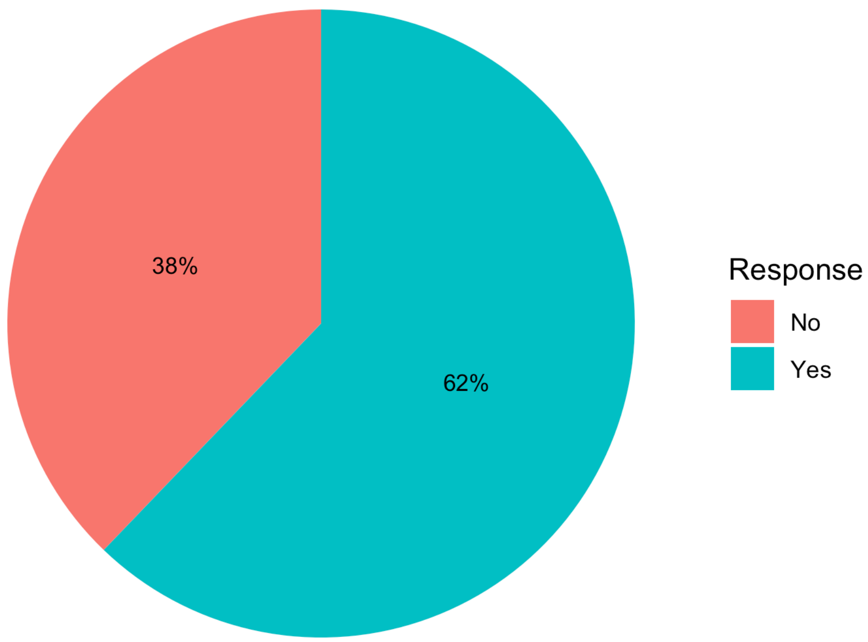
What are the reasons that prevent you from using AIR in your lessons?

In analyzing the reasons for not using A&IR in educational settings, the survey results reveal that the most frequently cited reason is a lack of opportunity, with 23.2% of respondents indicating they have never had the chance to use A&IR. Closely following this, 21.2% reported that the absence of necessary equipment at school is a significant barrier. Similarly, the lack of A&IR material is a concern for 20.4% of the participants.
Additionally, a substantial number of respondents, 15.2%, admitted to not knowing how to use A&IR technology, indicating a potential need for more training and professional development in this area. Meanwhile, 14% are uncertain about how AIR fits into their subject matter, reflecting a need for better integration guidelines and examples of subject-specific applications. Interestingly, only 6% believe that A&IR cannot foster learning, suggesting that most educators recognize the potential educational benefits of this technology despite other barriers.
Some participants suggested additional challenges to implementing A&IR in schools in an open-ended question related to the item. They emphasized the need to consider the best age for students to use these technologies, the requirement for new infrastructures, the extensive preparation needed for effective didactic activities, and the lack of fundamental experience and opportunities to use new technologies in the classroom. They also noted that the existing curriculum in most subjects is very tightly structured, leaving little room for new ideas.

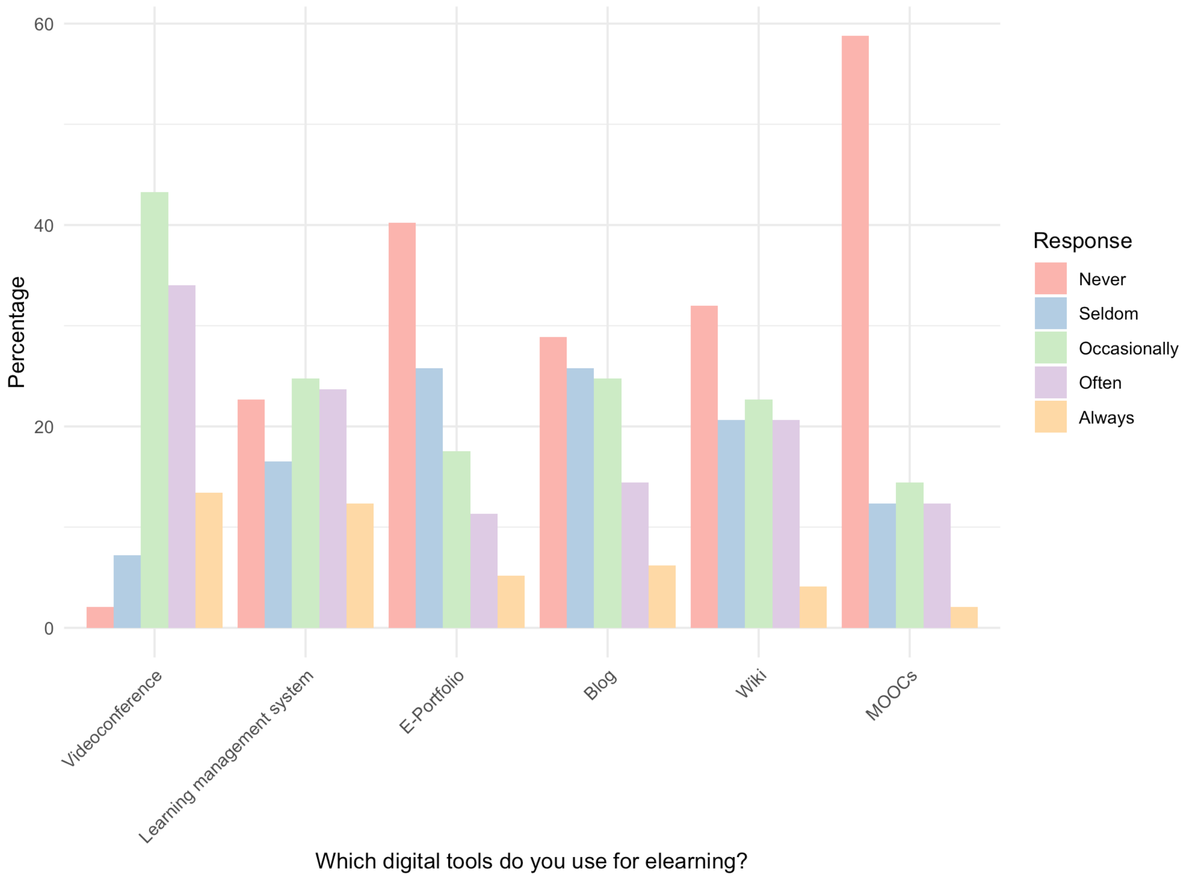


Do you use e-learning or blended learning (a mixture of face-to-face with e-learning) in your institution?

As shown in the following figure, the most of respondents use e-learning or blended learning (a mixture of face-to-face with e-learning) in their institution:

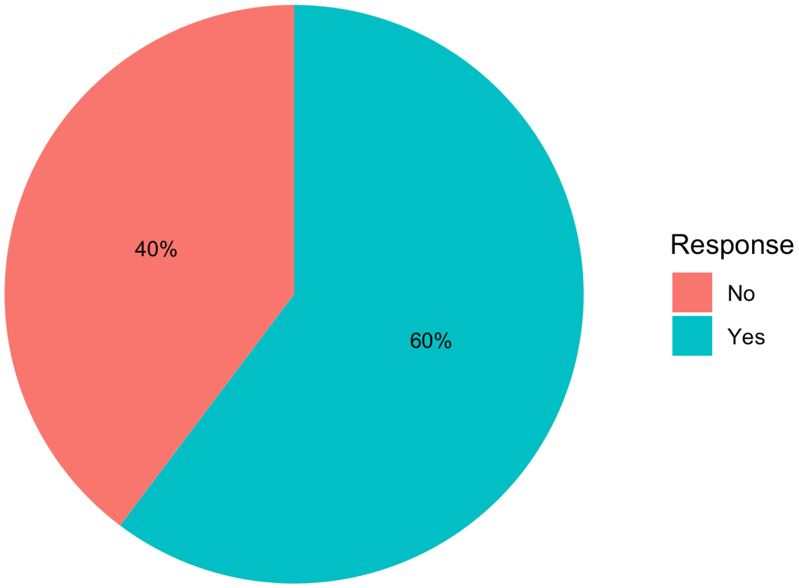


The most used tools for e-learning are videoconferences, blogs, and wikis. The use of tools for e-portfolios or MOOCs is rare. Some participants suggested also open-ended questions: on Google Classroom, iServ, Nextcloud, and Zoom.



Have you ever heard about or used any of the following European competence frameworks?

As shown in the next figure, 60% of participants have heard about or used a European competence framework:

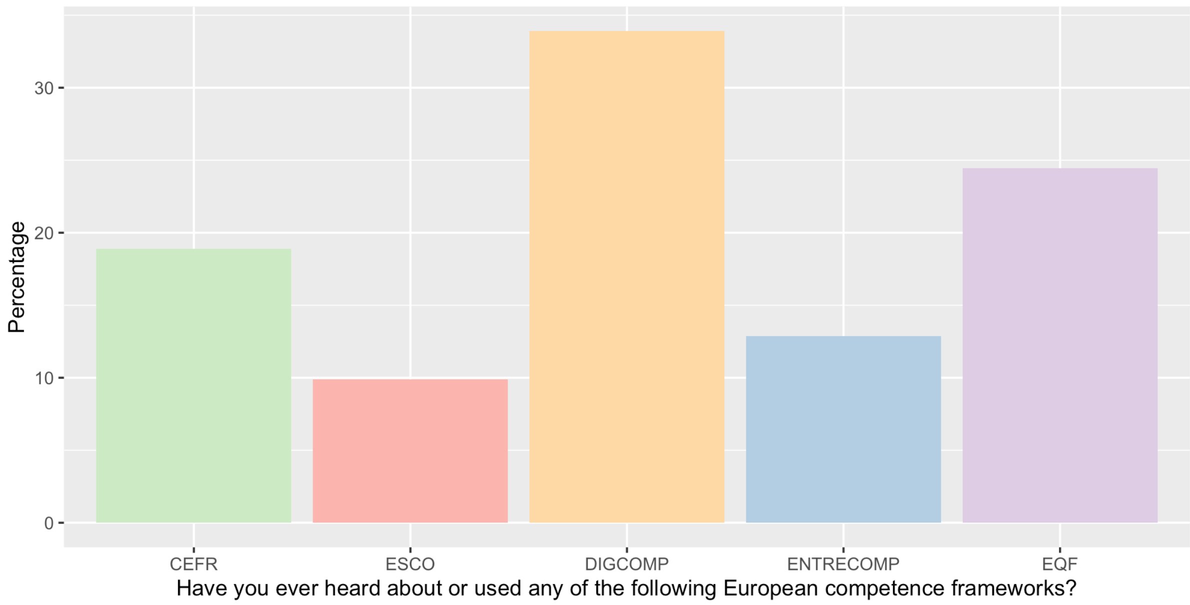


This result confirms that teachers in the European Union are familiar with competence frameworks, though the extent of use can vary between educational contexts. There are several important competence frameworks that guide competence-based learning and development across education in the EU. Amongst these the survey investigates the extent to which participants were familiar with most popular competence framework such as: DIGICOMP, EQF, CEFR, ESCO, and EntreComp. All these frameworks help standardize and align skills, competences, and qualifications across countries and sectors.

The DigComp Framework (European Digital Competence Framework) is widely recognized for its relevance to support digital literacy in the context of integrating digital tools into the classroom and preparing students for the digital era. The EQF is a framework serving as a translation tool between different national qualification systems across Europe. It is very common to promote transparency and mobility across the European Union by describing what a learner knows, understands, and is able to do, from basic knowledge (Level 1) to advanced qualifications like PhDs (Level 8). The Common European Framework of Reference for Languages (CEFR) is widely recognized as the standard for assessing language proficiency across Europe by defining language competences on six levels (A1, A2, B1, B2, C1, C2) ranging from beginner to mastery. The Entrepreneurship Competence Framework (EntreComp) is a framework aimed at fostering entrepreneurial mindsets and skills in which entrepreneurship is not only defined in terms of business dimensions but also as a competence that involves creativity, innovation, and the ability to turn ideas into action. Finally, the European Skills, Competences, Qualifications and Occupations (ESCO), is recognized as the European multilingual classification of skills, competences, qualifications, and occupations.

The following chart shows the results of the survey respondents on the European competence frameworks they have heard about or used. The chart shows that DIGCOMP and EQF are more prevalent compared to ESCO and ENTRECOMP, suggesting that digital competence and qualifications alignment have higher priorities in current education within the EU. Lower recognition of ESCO and ENTRECOMP could indicate a need for more awareness and integration of these frameworks into both educational curricula and training programs. To summarize:

- DIGCOMP is the most recognized or used framework, with over 30% (more precisely 33,9%) of respondents indicating familiarity or usage. This reflects the growing emphasis on digital competence in education and employment.
- EQF (European Qualifications Framework) comes next, with slightly over 20% (specifically 24.5%) of respondents being aware of or using it. This suggests that the EQF is well-known, likely due to its role in standardizing qualifications across the EU.
- CEFR (Common European Framework of Reference for Languages) also has significant recognition, with just above 20% (18.9 %). This is not unexpected, as CEFR is a key tool in language education across Europe.
- ENTRECOMP (Entrepreneurship Competence Framework) has lower recognition, slightly above 10% (12.9%). This might reflect that entrepreneurial competence, while increasingly attracting interest, is not yet as embedded in educational and professional contexts as digital or qualifications frameworks.
- ESCO (European Skills, Competences, Qualifications and Occupations) is the least recognized or used, with under 10% (9.87%). This suggests that despite its support in bridging education and employment, it may not be widely adopted or understood yet by educators or the general public.



Reliability of results

Reliability refers to the consistency or repeatability of measurements, and one of the most commonly used statistics to evaluate this is Cronbach's alpha. This coefficient measures internal consistency, indicating how well a set of items measures a single unidimensional latent construct.

In this study, the reliability analysis was performed on a dataset consisting of 29 items related to A&IR across 156 sample units. The resulting Cronbach's alpha was exceptionally high at 0.935. Cronbach's alpha values range from 0 to 1, with higher values indicating greater internal consistency among the items. A value above 0.7 is generally considered acceptable, while values above 0.9 are deemed excellent. The obtained alpha of 0.935 suggests that the items used in this study are highly reliable, providing consistent measurements across the sample units.

Comparisons

To assess whether there are differences in the way teachers approach A&IR based on their specific training, the sample was divided according to teaching subject. One group included all disciplines pertaining to STEM (science, technology, engineering, and mathematics), while the other group comprised all other disciplines, primarily humanities subjects. The STEM group consists of 103 subjects, while the other group, primarily humanities subjects, consists of 49 subjects. The comparison of two samples with differing sizes is plausible for several reasons, though it also necessitates careful consideration of certain critical aspects. Modern statistical methods are designed to handle samples of unequal sizes. These techniques can adjust for sample size differences, ensuring that the comparison remains valid. Different sample sizes can still adequately represent their respective populations. The key is ensuring that each sample is randomly selected and representative, which allows for meaningful comparisons despite size discrepancies. Smaller samples generally have lower statistical power, increasing the risk of Type II errors (failing to detect a true effect).

Before conducting the comparison of means described below, the prerequisites of normality and the distribution of variances were assessed. This involved performing tests for normality, such as the Shapiro-Wilk test, and evaluating the homogeneity of variances using Levene's test. These preliminary evaluations ensured the validity and reliability of the subsequent statistical analyses. Based on the results of these assessments, the choice of the statistical test was influenced to ensure the most appropriate and robust method was applied, taking into account any deviations from normality or unequal variances.

How would you rate your knowledge of Augmented and Immersive Reality?

As might be expected, STEM teachers report having more in-depth knowledge of A&IR ($M = 1.67$, $SD = 0.73$) than other teachers ($M = 1.27$, $SD = 0.93$), and this difference is statistically significant ($W = 3189$, $p = 0.00$, $r = 0.23$).

How do you rate the importance of Augmented and Immersive Reality?

In general, STEM teachers do not differ from others in their evaluation of the importance of A&IR for promoting effective educational experiences, counteracting student drop-out, and fostering inclusion and motivation ($p > 0.05$). However, STEM teachers have a more positive view ($M = 3.41$, $SD = 1.48$) than others ($M = 2.84$, $SD = 1.69$) regarding the importance of A&IR in supporting personal development ($W = 3{,}064.50$, $p = 0.03$, $r = 0.18$). Additionally, STEM faculty ($M = 4.28$, $SD = 0.96$) outperform those in other subjects ($M = 3.88$, $SD = 1.05$) in their assessment of the potential for these technologies to foster student engagement ($W = 3212$, $p = 0.00$, $r = 0.24$).

Do you use Augmented and Immersive Reality in your learning activities with students?

No statistically significant differences were found between STEM teachers and those in other disciplines regarding the use of A&IR in learning activities ($p > 0.05$).

How many hours per week on average do you use Augmented and Immersive Reality in your learning activities with students?

No statistically significant differences were found between STEM teachers and those in other disciplines regarding the use of A&IR in the number of hours per week spent on this type of activity ($p > 0.05$).

What do you think it is important for a teacher implementing Augmented and Immersive Reality activities in school contexts?

No significant differences were found in most items investigating the skills a teacher should have to implement A&IR-based teaching activities (for example having basic digital competences, knowing how to use smart devices, knowing how to use authoring systems, knowing how to use AI, etc.). The only significant difference was in the value placed on programming, which is predictably higher among STEM teachers ($M = 3.06$, $SD = 1.65$) compared to teachers in other disciplines ($M = 2.61$, $SD = 1.55$, $W = 3021$, $p = 0.04$, $r = 0.16$).

What are the reasons that prevent you from using AIR in your lessons?

Teachers who do not teach STEM-related subjects believe that not knowing whether and how A&IR technologies fit into their teaching subject prevents their use of them. The difference between the STEM group ($M = 0.36$, $SD = 0.48$) and the group related to other subjects ($M = 0.61$, $SD = 0.49$) is stark and statistically significant ($W = 1153$, $p = 0.01$, $r = 0.23$). Comparisons for the other items (for example, lack of time, no opportunity, no equiment at school, etc.) are not statistically significant ($p > 0.05$).

Annexes

Details of the projects carried out in respondents' institutions

Project: Ateities inžinerija
Reference: https://ateitin.vilniustech.lt
https://ateitin.vilniustech.lt/pluginfile.php/23694/mod_resource/content/1/APIE%20AI%20202310021450pff.pdf
Teachers participating in the Future Engineering platform activities have the opportunity to receive a certificate of professional development.

Project: Augmented assessment
Reference: https://augmented-assessment.eu
The Augmented Assessment Project aims to address the gap that exists in assessing newly arrived migrant students' prior knowledge in the fields of Science and Mathematics, by utilising augmented reality for assessment.

Project: Augmented reality Italy
Reference: NA

Project: eTwinning 2022-2023 με τίτλο LEARNT
Reference: NA

Project: Εθνικό πρόγραμμα Νόησις "Πράσινη ενέργεια και τεχνολογία"
Reference: NA

Project: Ευρωπαϊκό πρόγραμμα Erasmus+ 2020-1-EL01-KA201-079206 "Shape the future teacher"
Reference:
https://www.eedive.gr/ka2shape/?fbclid=IwY2xjawEURoVleHRuA2FlbQIxMAABHadnIVvxeJPHcNJFcdBGuHOv6Ma8Z4mtXe9AksQWEI5mRHge-8X3XP8u3Q_aem_HwvYMCkEB98-bQz9NCAqWQ
https://twinspace.etwinning.net/134451/home
With the "SHAPE the Future teacher" project our intention is to comply with these priorities. It is a partnership between five secondary education schools from five European countries (Greece, Italy, France, Portugal and Spain) supported by a scientific association. The core idea is to develop and apply a set of learning scenarios using I.C.T. tools in a wide and diverse range of subjects . The main target group of the project is primarily Teachers of secondary education both general and vocational schools/Institutions who will implement these scenarios with their students (15-19 years old),thus making them directly beneficiaries. We estimate that the total number of the participants involved directly and indirectly will reach approximately 4000 people

Project: FabLab SchoolNet: STEAM education and learning by Robotics, 3D and Mobile technologies
Reference: https://www.fablabschoolnet.eu/en/
The FabSchoolNet general objective is to create a new model of educational network and a new way of thinking about the goods fabrication, by applying "learning-by-doing" & "hands-on" activities in student classes, encouraging them to participate more intensively, in a corporate workflow, from concept, design, prototyping, fabrication and marketing, with the support and participation of the Small-Medium Enterprises. Furthermore, the project aims to develop and implement a training

program with three modules, based on the latest modern technologies and tools used in STEAM education (Science, Technology, Engineering, Arts and Mathematics), such us educational robotics, 3D printing and mobile technologies using augmented reality (AR) applications. The modules approach will be enriched with elements and themes in the field of Entrepreneurship Education, encouraging participants (teachers, students, etc.) to develop this new way of thinking and to act dynamically in a global market economy. The training programs will be finalized with various competitions / challenges, which aim to encourage participants to consult the real business environment so that they can acquire the ability to think and develop models and ideas closely related to the real market, using their own knowledge, skills and abilities. The activities developed within the project aim to involve the participants at all levels, from conception, design to product realization.

Project: X-Lab: Schwerpunkt Naturwissenschaften
Reference: https://xlab-goettingen.de/en/
XLAB is one of Germany's largest student laboratories for the STEM subjects physics, chemistry, biology and computer science, and has received several awards for its educational concept. Exciting hands-on experimental courses are offered not only for student groups but also for individual students who are interested in advanced and more sophisticated approaches of experimental setups. The offer is aimed at all interested people throughout Germany, Europe and worldwide.

Project:ΠΟΛΙΤΙΣΤΙΚΟ ΠΡΟΓΡΑΜΜΑ
Reference: https://www.arsakeio.gr/en/
Arsakeio (Αρσάκειο) is the general name of the Arsakeia – Tositseia Schools, a group of co-ed private schools in Greece, administered by the Philekpedeftiki Etería (Φιλεκπαιδευτική Εταιρεία, Society for Promoting Education and Learning [SPEL]), which is a non-profit educational organization. The Arsakeio comprises six schools, with campuses in Psychiko [Attica], Ekali (Tosítseio campus) [Attica], Thessaloniki, Patras, Ioannina, and also Tirana, Albania. The school has more than 6.500 students and 700 educators.

Project: Πολιτιστικό πρόγραμμα για το Βαρούσι
Reference:
https://varousi.blogspot.com/?fbclid=IwY2xjawEUSHBleHRuA2FlbQIxMAABHSS_fhghMFoml8Gl0q4Gdy_LNMP1VUSDC9VkoS93N_MP-C1pDT1s0JnaVA_aem_N-RHSJYFeZnnBAuGPh59wA