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## **ARSTEAMapp.Fostering Scientific Vocation through Augmented Reality about European Cultural Heritage**

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### **Abstract.**

In recent years, the landscape of education has witnessed substantial changes, primarily propelled by progress in technology and the evolving needs and expectations of students. *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) is an innovative approach to the educational teaching and learning environment for the future. Using prior knowledge and experience, this application allows students to build on their existing skills and apply them to new situations, encouraging integrative learning at an effective level. The *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) adapts seamlessly to Augmented Reality resources, presenting new theoretical foundations for the development of integrative *STEAM* (Science, Technology, Engineering, Arts and Mathematics) education in the context of European Cultural Heritage. *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) aims to provide the teaching community with an easily accessible tool for adopting this approach, making it readily adaptable in European schools and ensuring that students and their teachers are prepared for the challenges and opportunities of the future.

**Keywords:** Augmented Reality, STEAM, Heritage, Future of Teaching, ARSTEAMapp

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## 1. Introduction

In recent years, we have seen remarkable technological advances and remarkable changes in student needs and expectations, reshaping the future of teaching in exciting and promising ways. The key to this future lies in the skill sets of educators and their ability to harness the potential of future education. As e-learning teachers, they must skillfully navigate a diverse range of digital tools and platforms, adapting to the paperless environment as a new norm. Without cluttering the classroom with numerous apps and digital resources, they need to be discerning, ensuring that the tools they use are effective and contribute to valuable learning experiences. These teachers need to continually learn and serve as role models for their students, continually incorporating current teaching scenarios and encouraging a culture of productive feedback. Their goal is to create interactive, enjoyable and challenging learning environments that fully engage their students. By adopting these skills and tools, educators gain the power to create enriching learning environments that empower their students. In addition, they need to take a fresh perspective on learning technologies. A reshaped learning environment incorporates immersive technologies that captivate learners, engaging them deeply in the process of discovery and creation. Virtual Reality (VR) enables learners to experience real-life scenarios within a safe and controlled setting. Artificial Intelligence (AI) facilitates personalized learning experiences, automates administrative tasks, and supports teachers in their educational practices. Hologram interactivity brings complex concepts to life, offering students 3D visualizations of abstract ideas. Among all these fascinating technologies, *Augmented Reality* (AR) stands out as a significant step in the future of learning, generating creative ways of deep adaptive learning. (Iqbal et al., 2022)

Erasmus+ Project No.: 2021-1-ES01-KA220-SCH-000030257, *ARSTEAMapp* - Promoting Scientific Vocations through Augmented Reality about European Cultural Heritage, presents a real educational model, which aims to develop STEAM skills (Science, Technology, Engineering, Arts and Mathematics) using an Augmented Reality application that analyzes 3D models of European cultural heritage. It serves as an educational tool for students between the ages of 12 and 16, combining science, technology, engineering and mathematics with art and elements of European cultural heritage. The project equips teachers with a pedagogical guide that enables them to acquire skills and competencies in STEAM teaching. *ARSTEAMapp* - Promoting Scientific Vocations through Augmented Reality about European Cultural Heritage addresses the challenge of improving the inclusive teaching of STEAM (Science, Technology, Engineering, Arts and Mathematics) subjects to 12-16-year-olds through an innovative approach that makes meaningful and feasible connections between these subjects in an educational context. The project has two main objectives as benchmarks. The first goal focuses on providing resources that facilitate an integrated STEAM approach. In contrast, the second goal aims to achieve outcomes that enable teachers to adopt and implement this approach effectively. The project's priorities and themes align with the current trend of integrative learning and aim to cultivate both interest and excellence

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in Science, Technology, Engineering, and Mathematics (STEM) while promoting the STEAM (Science, Technology, Engineering, Arts and Mathematics) approach. It also targets digital transformation by promoting digital readiness, resilience, and capability. In addition, the project also supports teachers, principals, and other education professionals. With all beneficiaries in mind, the ARSTEAMapp (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) lays the groundwork for new theoretical foundations in the didactic implementation of integrative STEAM (Science, Technology, Engineering, Arts and Mathematics), using the potential of Augmented Reality resources. The goal is to provide easily accessible teaching and learning resources to the educational community, thus facilitating the widespread adoption of this innovative educational approach in all European schools. (Kîrmaci, 2022).

*ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) focuses in particular on the benefits it brings to students aged 12-16 and their teachers, taking a comprehensive approach incorporating *European Cultural Heritage*, through which the project aims to generate increased motivation and engagement among students in the STEAM (Science, Technology, Engineering, Arts and Mathematics) disciplines. For teachers working with this age group, the project provides improved accessibility to new resources for STEAM (Science, Technology, Engineering, Arts and Mathematics) educational actions, empowering them with digital and pedagogical tools and promoting the integrative *STEAM* (Science, Technology, Engineering, Arts and Mathematics) approach. This in turn leads to increased self-efficacy in classroom management, equipping teachers with motivating, engaging and innovative tools, resources and techniques for their students. The impact of the project extends beyond students and teachers; other educational categories also benefit. For policymakers, *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) facilitates improved knowledge transfer and intellectual exploitation of developments, fostering collaboration with both public and private entities within the academic community. Additionally, it enhances the visibility of research in STEAM (Science, Technology, Engineering, Arts and Mathematics) education, active methods, and participative approaches. Associations and families benefit from more interactive resources and motivating learning tools for out-of-school education. As participants, the organizations involved in the project gain new synergies and networks for potential future research projects and education alliances. They also have the opportunity to exchange ideas and share good practices among the project partners, including UBU - Universidad de Burgos, Burgos, Spain (the coordinator), CLF - Colegio Luso Frances, Porto, Portugal, KYAL - Arnavutköy Korkmaz Yiğit Anadolu Lisesi, Istanbul/Beşiktaş, Turkey, SCOALA - Școala Gimnazială "Ion Creangă", Suceava, Romania, Kveloce I+D+i – Senior Europa, S.L., Spain. (Hreciuc, 2022)

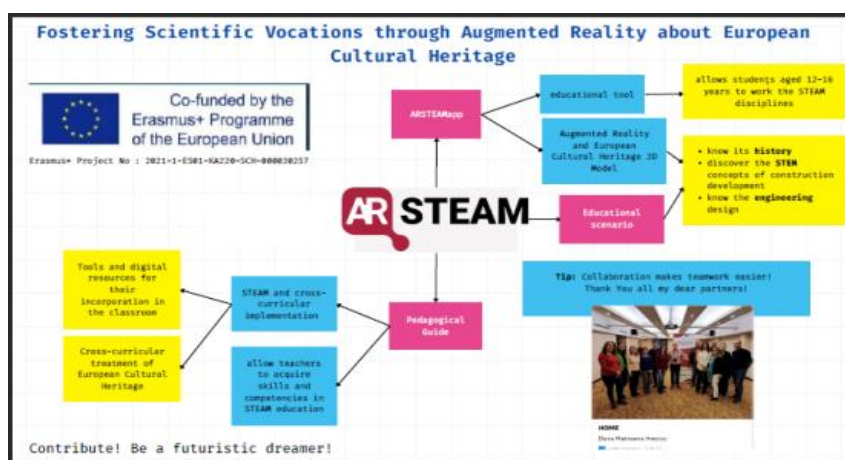
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## 2. AR mobile app and Pedagogical Guidelines

The ARSTEAMapp (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) project is producing several outputs, including a mobile augmented reality application - AR mobile app, a comprehensive handbook for students and pedagogical guidelines designed specifically for teachers. A brief representation of these outputs is depicted in *Figure 1*.

Figure 1: ARSTEAMapp results



Source: ARSTEAMapp project website

### 2.1 AR Mobile app

The AR mobile app (Augmented Reality mobile application) seeks to showcase 10 elements/scenarios of *European Cultural Heritage*, with a specific focus on *UNESCO Heritage Buildings*. Each element will be enriched with information related to the STEAM disciplines - Science (S), Technology (T), Engineering (E), Arts (A), and Mathematics (M). Moreover, the app will emphasize *STEAM* (Science, Technology, Engineering, Arts and Mathematics) role models for both male and female learners. To ensure inclusivity and accessibility, the app will be translated into five languages: English, Spanish, Portuguese, Romanian, and Turkish. Additionally, it will include a student workbook comprising various engaging and challenging activities. Through these activities, students will develop a profound understanding of the significance of each *STEAM* (Science, Technology, Engineering, Arts and Mathematics) discipline concerning the preservation and construction of cultural heritage elements. For example, they will learn to appreciate the role of mathematics in the construction of a cathedral. (Kîrmaci, Hreciuc, 2023)

The *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) mobile app System is built upon the Play&Learn concepts, which organize the application into three main components:

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1. Download the app (mobile application): Users can easily access the app by searching for the QR (Quick Response) code and scanning it with their device.
2. 3D (three dimensional) object emergence: After scanning the QR (Quick Response) code, a captivating 3D (three dimensional) object emerges through the augmented reality feature.
3. Quiz-solving and wallet acquisition: To progress, users engage in a quiz related to the 3D (three dimensional) object, and upon successful completion, they receive the 3D (three dimensional) object, which is stored in their digital wallet.

The three interconnected parts create an engaging and interactive learning experience, encouraging users to explore and gain knowledge about *European Cultural Heritage* through the lens of *STEAM* (Science, Technology, Engineering, Arts and Mathematics) disciplines.

### **2.1.1. Download the app**

By integrating the AR mobile app (Augmented Reality mobile application) into classroom activities, students are presented with engaging and interactive learning opportunities that foster the transfer and combination of knowledge from various STEAM (Science, Technology, Engineering, Arts and Mathematics) disciplines. This approach cultivates critical and creative thinking skills among students, encouraging them to explore and understand European Cultural Heritage in a fun and immersive way. As illustrated in *Figure 2*, students will be excited to go through the stages, much like playing a game, to access the learning content:

- a) Print & Stick the QR (Quick Response) Code: Teachers can provide students with QR (Quick response) codes related to heritage reproductions, such as pictures or objects.
- b) Download AR mobile app (Augmented Reality mobile application): Students are encouraged to download the *ARSTEAMapp* (Augmented Reality mobile application) mobile application and select the corresponding object from the provided QR codes.
- c) Explore and Engage: Students are tasked with searching for the QR codes in the physical environment, checking the *STEAM* (Science, Technology, Engineering, Arts and Mathematics)-related explanations provided within the app, solving the associated quiz, and finally, collecting their well-deserved prizes, which are stored in their digital wallets. (Hreciuc, 2023)

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Figure 2: App System – QR code



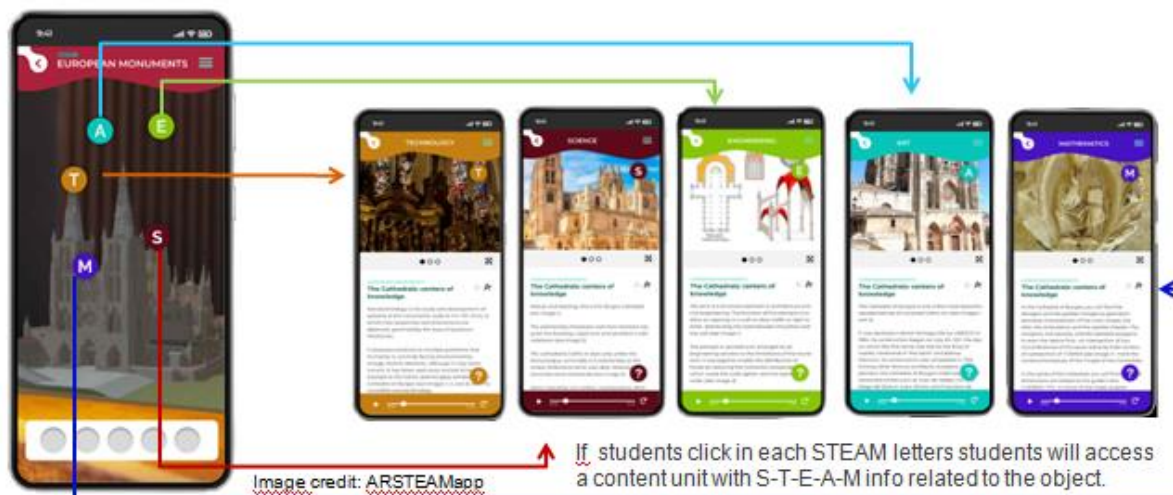
Source: ARSTEAMapp project website

This gamified - learning process keeps students motivated and actively involved in their educational journey, promoting a deeper understanding and appreciation of European cultural heritage while strengthening their STEAM(Science, Technology, Engineering, Arts and Mathematics)-related knowledge and skills. (Kîrmaci & Hreciuc, 2023)

### 2.1.2. 3D (three dimensional) object emergence

The ARSTEAMapp (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) is designed so that students get information about the object by accessing the letters S-T-E-A-M, each letter corresponding to a specific aspect: S for Science, T for Technology, E for Engineering, A for Arts and M for Mathematics. Each of these letters gives students access to relevant content units, providing a comprehensive and well-rounded learning experience. As illustrated in *Figure 3*, students will enjoy using a graphical interface that is friendly and easy to use. This interface improves their interaction with the application, making the learning process pleasant and intuitive. The visually appealing design engages students, encouraging them to explore and delve into STEAM (Science, Technology, Engineering, Arts and Mathematics)-related content, thereby stimulating interest and genuine understanding of European Cultural Heritage from a multidisciplinary perspective.

Figure 3: App System – S-T-E-A-M



Source: [ARSTEAMapp project website](https://www.arsteamapp.com/)

The *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) offers a wide variety of content formats, catering to personalized learning experiences that suit various learning styles. Whether students prefer visual, auditory, aural, verbal, or logical approaches, the app ensures that they can engage with the content in a way that resonates with their individual preferences.

The diverse content formats available in the app, including:

- **Text:** Written information that provides detailed explanations and descriptions.
- **Images:** Visual representations that enhance understanding and visualization.
- **Illustrations:** Artistic visuals that simplify complex concepts and captivate learners.
- **Videos:** Audio-visual content that brings real-life scenarios and examples to life.
- **Games:** Interactive challenges that make learning enjoyable and interactive.
- **3D Elements:** Immersive 3D (three dimensional) representations that enhance the learning experience.

Incorporating various content formats also promotes inclusivity, accommodating learners with diverse needs and abilities. The interactive and engaging nature of the app fosters a positive learning environment, motivating students to explore and understand European Cultural Heritage through the lens of STEAM (Science, Technology, Engineering, Arts and Mathematics) disciplines. (Hreciuc, 2023)

### 2.1.3. Explore and Engage

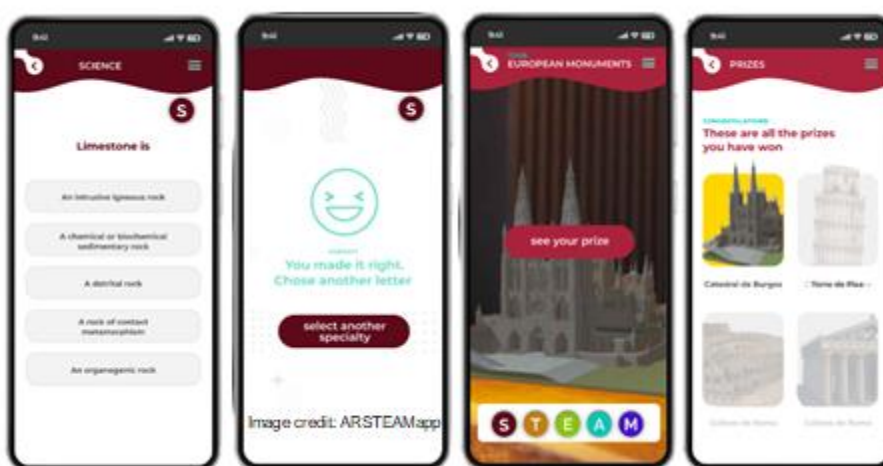
Students will engage in friendly competition with others as they strive to collect all the prizes. To progress, each content module presents a test that must be solved. Upon completing all the content and successfully passing all the tests, the student is notified

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through the STEAM (Science, Technology, Engineering, Arts and Mathematics) letter line in the application interface. This indicates that the student is now eligible to receive their 3D (three dimensions) award. *Figure 4* illustrates how the system effectively monitors and tracks the students' achievement of the set objectives. (Hreciuc, 2023)

*Figure 4: App System – Quiz/3D prize*



Source: ARSTEAMapp project website

The statistics included in the AR (Augmented Reality) system will reveal the performing results.

#### 2.1.4. ARSTEAMapp (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) **pilot version**

The first pilot version of the ARSTEAMapp (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) was presented and validated to all stakeholders in order to get constructive and useful feedback for improvement.

##### Focus Group

A total of 53 people from all the partner countries – Spain, Portugal, Romania, and Turkey - participated in the FG (Focus Group) pilot of the application between November 2022 and January 2023. Of this total, 31 were men and 22 were women as seen in *Figure 5*. The participants were teachers, university professors, researchers, service companies, and business specialists. Of the total number of participants, 25 were teachers, being the most represented group. (Kîrmaci & Hreciuc, 2023)



Figure 5: FG gender statistics



Source: ARSTEAMapp project website

### Valuable educational resource

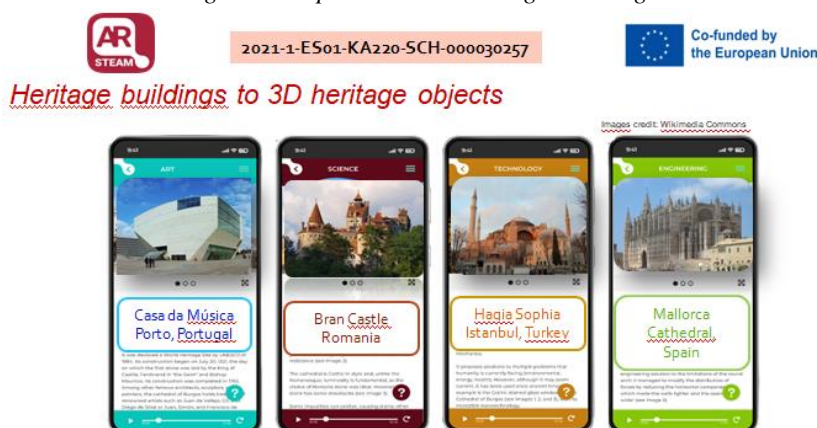
- user-friendly design
- easily accessible and usable
- seamlessly integrated into lessons
- support and incorporate students' cultural backgrounds
- opportunity for technology use
- understand digital product development
- acquiring 21st-century skills activities
- excellent Gamification concept with Quiz and Rewards

The *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) pilot version becomes acceptable to be filled with educational content, for which the team will take into account FG (Focus Group) opinions: incorporation of an audio/video element, a short STEAM (Science, Technology, Engineering, Arts and Mathematics, video tutorial, increased functionality of the module for teachers, and create 2 learning versions - higher and lower difficulty level.

### **2.1.5. Heritage buildings to 3D heritage objects**

The concept of the pilot version of the AR (Augmented Reality) mobile app is clearly outlined, as is the learning content, related to European Heritage Buildings, designed in two levels of difficulty - low and high, each focusing on a STEAM (Science, Technology, Engineering, Arts and Mathematics) disciplines. The continuing concern to achieve the ultimate goal has meant that the buildings proposed to add value to the knowledge of young people aged 12 to 16 falling into two categories. The first category, shown in *Figure 6*, comprises one representative building from each participating country.

Figure 6: Representative Heritage Buildings



Source: ARSTEAMapp website project

The second category, as can be seen in Figure 7, includes UNESCO (United Nations Educational, Scientific and Cultural Organization) Heritage buildings recognised in the partner countries.

Figure 7: Representative UNESCO Heritage Buildings



Source: ARSTEAMapp website project

## 2.2. Pedagogical Guide

The *Pedagogical Guide* will encompass the following areas:

- Pedagogy and curriculum design - fundamental principles applied to personalize learning.
- Practical and cost-effective solutions for integrating active and participatory methods - basic and previously developed validated methodologies.
- STEAM (Science, Technology, Engineering, Arts and Mathematics) and cross-curricular implementation.
- Tools and digital resources for integrating them into the classroom.
- Cross-curricular treatment of *European Cultural Heritage*.

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*ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) aims to equip teachers with skills and competencies in *STEAM* (Science, Technology, Engineering, Arts and Mathematics) education, achieved through the following means:

- Digital competence: Teachers will have access to an educational App, usable on mobiles or tablets, facilitating *STEAM* (Science, Technology, Engineering, Arts and Mathematics) education in the classroom.
- Capacity for integrating *STEAM* (Science, Technology, Engineering, Arts and Mathematics) content into the curriculum: This will be facilitated through various learning scenarios integrated into the app.
- Utilization of *Augmented Reality* (AR) for educational purposes.
- Incorporation of heritage elements for an integrative study of *STEAM* disciplines.
- Creation of custom *STEAM* (Science, Technology, Engineering, Arts and Mathematics) didactic sequences, based on the best practices provided in the pedagogical guide.

*ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) will furnish teachers with a pedagogical guide, empowering them to enhance their skills and competencies in *STEAM* (Science, Technology, Engineering, Arts and Mathematics) education. It represents a futuristic approach to education, fostering the development of digital skills in both students and teachers. It underscores the significance of AR in the learning process and the value of heritage elements in a comprehensive *STEAM* (Science, Technology, Engineering, Arts and Mathematics) approach. (*ARSTEAMapp* website)

### **3. Conclusion**

An educational application idea for *Augmented Reality* (AR), was considered very valuable, from the beginning of the project, for its potential to improve *STEAM* (Science, Technology, Engineering, Arts and Mathematics) teaching and facilitate meaningful interdisciplinary connections in the context of European heritage cultures. The general idea presented was for students to use smartphones and tablets to scan cultural sites such as cathedrals and take virtual tours to explore different *STEAM* (Science, Technology, Engineering, Arts and Maths) topics, but also the importance of heritage and the environment regulations were the basis of subsequent projects.

Additional investigation uncovered that *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) - Promoting Scientific Vocations through Augmented Reality on European Cultural Heritage is a real educational model, which aims to develop *STEAM* skills (Science, Technology, Engineering, Arts and Mathematics) using an augmented reality application that analyzes 3D (three-dimensional) models of European cultural heritage. It can also serve as an educational tool for students

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between the ages of 12 and 16, combining science, technology, engineering and mathematics with art and elements of European cultural heritage. The project also improves the provision of teachers with a pedagogical guide to enable them to acquire skills and competencies in *STEAM* (Science, Technology, Engineering, Arts and Mathematics) education.

The next stage of research of the *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) clearly highlighted that the adapted *STEAM* (Science, Technology, Engineering, Arts and Mathematics) pedagogical guide is not only accepted as necessary but also an important resource that will empower teachers to improve their skills and competencies in *STEAM* (Science, Technology, Engineering, Arts and Mathematics) education. It represents a futuristic approach to education, favouring the development of digital skills in both students and teachers. It emphasizes the importance of *AR* in the learning process and the value of heritage elements in a comprehensive *STEAM* (Science, Technology, Engineering, Arts and Mathematics) approach.

The actual *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) - Promoting Scientific Vocations through Augmented Reality about European Cultural Heritage *pilot version* that has been validated by a number of 53 specialists and was considered by them a valuable educational resource for students and teachers due to its features: user-friendly design, easily accessible and usable, seamlessly integrated into lessons, support and incorporate students' cultural backgrounds, opportunity for technology use, understand digital product development, acquiring 21st-century skills activities, excellent Gamification concept with Quiz and Rewards. The concept of the pilot version of the *AR* mobile app is clearly outlined, as is the learning content, related to European Heritage Buildings, designed in two levels of difficulty - low and high, each focusing on a *STEAM* discipline

In the next stage of the research, after adding the 3D elements, their related materials, images, animations and quizzes, as well as the rewards for those who achieve the learning objectives, the behaviour of the application will be studied when it is implemented in the focus group of students aged between 12-16 years and that of interested high school teachers, considering the improvement of the continuous review of its characteristics and effectiveness. The teaching guide remains to be completed as the last valuable finality to complete *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application).

In conclusion, *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) represents a real opportunity for *STEAM* (Science, Technology, Engineering, Arts and Mathematics) education, fostering the development of digital skills in both students and teachers. It underscores the significance of *AR* in the learning process and the value of heritage elements in a comprehensive *STEAM* (Science, Technology, Engineering, Arts and Mathematics) approach. The *ARSTEAMapp*

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(Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) team remains committed to achieving the project's objectives and maximising its impact. Through active collaboration, open communication and the exchange of ideas, they ensure progress and continuous improvement of the product. The concept of the pilot version of the mobile app is clearly outlined, as is the learning content, related to European heritage buildings, designed in two levels of difficulty - low and high, each focusing on a *STEAM* (Science, Technology, Engineering, Arts and Mathematics) discipline.

In addition, all the partners promote the project through various online platforms such as Scientix (The Community for Science in Europe), E-PALE (Electronic Platform for Adult Learning in Europe), E-Twinning (European School Education Platform), Twitter (social media platform that allows users to send and read short messages called "tweets"), Facebook and Instagram. In addition, they actively participate in events such as *STEAM* (Science, Technology, Engineering, Arts and Mathematics) symposia and conferences, including the 4th Scientix Conference, and organise specific events, such as World Science Day, to foster new connections with both interested and general audiences. As a partner of the Scientix (The Community for Science in Europe) Discovery 2023 campaign, *ARSTEAMapp* (Augmented Reality, Science, Technology, Engineering, Arts and Mathematics, mobile application) serves as a pathway to the future, aspiring to become a role model in education. It strives to unite theoretical and practical disciplines, incorporate the arts, cultivate creativity and innovation, and encourage collaborative and teamwork skills. The ultimate goal is to create an educational model that embodies a comprehensive and dynamic approach to learning.

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