AR4STE(A)M

Use gamification strategies and augmented reality for innovative STE(A)M learning

O1

Compendium of gamification strategies based on Augmented reality for STE(A)M learning

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(A 1 – A 4)

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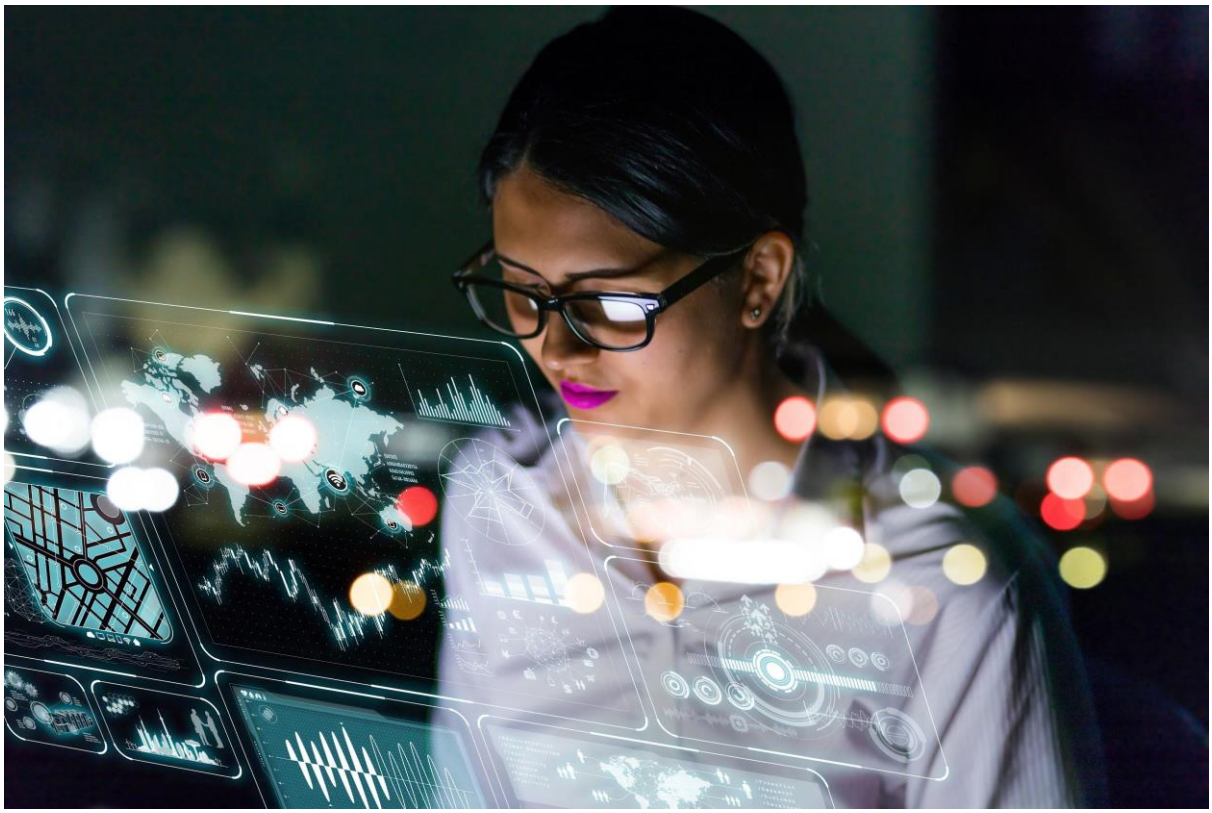
AR4STE(A)M - Use gamification strategies and augmented reality for innovative STE(A)M learning

Table of Contents



Primary Definitions

Augmented reality (**AR**) is an interactive experience where objects that reside in the real world are enhanced by computer-generated perceptual information. These objects can be enriched in one or multiple sensory modalities including visual, auditory, haptic, somatosensory and olfactory (Pope, 2018). AR can be defined as a system that fulfils three basic features: **a combination of real and virtual worlds, real-time interaction, and accurate 3D registration of virtual and real objects**. (Wu et al, 2013) It's computer-mediated but not virtual reality.

An **Augogram** is a computer generated image that is used to create AR.

Augography is the science and practice of making augograms for AR.

Gamification is the process of defining the elements which comprise games that make those games fun and motivate players to continue playing, and using those same elements in a non-game context to influence behaviour. In other words, gamification is the introduction of game elements in a non-game situation.

Gamification Strategy. The **gamification of learning** is an educational approach to motivate students to learn by using video game design and **game elements in learning environments**. The goal is to maximize enjoyment and engagement through capturing the interest of learners and inspiring them to continue learning.

Augmented Reality Game is a game that uses AR technologies. It should not be mistaken with gamification of learning. Since the AR game has its own goals (e.g. such as winning a race), whereas the gamification of learning would be to include a game strategy or element to a learning task for example providing users with “star-levels” after answering a number of math exercises correctly.

Augmented Reality Technology is referred as technologies designed to support the creation of Augmented Reality Applications.

Methodology and key criteria to select examples of AR games and AR technologies to develop games to integrate in upper secondary schools' programmes

Introduction

Developing game-based learning (GBL) activities for innovative STEAM lessons in upper secondary school programs aims to meet the EU requirements to acquire new competences and digital skills for all students, teachers and educational organizations.

AR based gamified approaches in classroom settings raise the level of engagement among the students much more than the traditional curriculum and teaching/learning methodologies. Transferability potential of existing Augmented Reality (AR) games as well as AR technologies enhance the enjoyment during STE(A)M lessons at schools by supporting teacher-student interaction inside classrooms.

The benefits of improving GBL in the field of education helps students achieve better results through visualization and full immersion in the subject matter. GBL is a more effective way to learn because interactive lessons, where all students are involved in the learning process at the same time, help improve teamwork skills. A faster and more effective learning process is achieved with AR based gamified approaches in classroom settings.

AR has the potential to replace traditional education with the use of accessible learning materials – anytime, anywhere. As a result, education becomes more accessible and mobile as meets the EU requirements for education for all.

The result of free access to AR based gamified approaches and AR technologies foster creativity in science and teaching science innovatively. Such a major shift towards more creativity in science education is the result of IO1 achieved by gathering the above-mentioned sources of AR Apps and AR technologies.

This output aims at disseminating examples of existing Augmented Reality (AR) games as well as AR technologies to develop game-based learning (GBL) activities for STE(A)M learning in upper secondary schools' programs including details regarding the methodologies applied and pedagogic results achieved.

It is designed in an attractive, useful and practical manner to allow for easy consultation by different stakeholders: Associated Partners, school staff, teachers, students, professional experts in the field, educational organizations, teacher training organizations, science centers, science associations, science museums, science "entertainers", universities, major broadcasters, the industry sector, research institutes, NGOs, public authorities, policy makers.

Methodological Approach

The methodology for the identification and collection of examples of AR games and AR technologies to develop games to integrate in upper secondary schools programmes according to the quality criteria defined on the basis of the need analysis at the very beginning of the project partners already agreed is to make a research on Gamification based learning. We will compare all the selected AR Apps and AR Technologies once partners will have collected them They are:

Dipf Leibniz-Institut für Bildungsforschung und Bildungsinformation
AR APPS Selection : ARLearn
Technology AR Selection: Cospace Edu

Agora Roermond - Stichting Onderwijs Midden Limburg
AR APPS Selection : WWF Free Rivers
Technology AR Selection**:** Wikitude

Association Européenne Des Enseignants
AR APPS Selection : Energy Roller Coaster
Technology AR Selection: Aria AR

Istituto Tecnico Per Il Turismo Marco Polo
AR APPS Selection : Ars Chimica
Technology AR Selection:MirageMake

Finance & Banking, Associazione Per Lo Sviluppo Organizzativo E Delle Risorse Umane
together with Istituto Tecnico Per Il Turismo Marco Polo
AR APPS Selection : Ars Chimica
Technology AR Selection:MirageMake

Samandira Mesleki Ve Teknik Anadolu Lisesi
AR APPS Selection : Arloon
Technology AR Selection: PlugXR

Hearthands Solutions Limited
AR APPS Selection : SchoolAR
Technology AR Selection: Blippar

To complete the above-mentioned tasks, project Partners will follow the steps described here below: Firstly, academic literature and good practices and EU projects about science and technology have been examined for collecting data which provides additional information on learning on the same topic or similar. Research on Gamification based learning is the starting point for Partners to be aware of the innovative ICT technologies for conducting their STE(A)M lessons in order to overcome and improve the traditional method of teaching and learning in class and increase students' motivation "learning by playing".

Secondly, to develop game-based learning activities in science education has led to select the most suitable good practices aimed at strengthening the link between science education and creativity to support education through the use of augmented reality in secondary school programs. These practices should be available on already existing OERs to develop AR Apps and AR technologies for upper secondary school programs.

Third, it is noted that for the identification and selection of the most appropriate AR Apps and AR technologies to develop games to integrate in upper secondary school programs, it is suggested to make the learning of science like the practice of science which is fully education cantered. This is one of the main project's priorities in order to ensure that the practices collected comply with STE(A)M.

Fourth, small scale pilot applications are made and tested by the Partners to evaluate the results with the project team. Small scale pilot applications are required to produce attractive and useful Apps for the users to record learning progress and learning achievements in AR STE(A)M applications to get suitable indicators for documentation and also will guarantee its transferability to other contexts and countries across Europe to see the permanent effect of gamification and AR.

Finally, the evaluation of suitable indicators for gamification strategies will help teachers and school to continue to develop new pedagogical concepts of their own using GBL in their STE(A)M classes. It will also be the basis of an online teacher training programme on the matter.

Criteria of Selection for AR Games and AR Technologies to Develop Games

The above-mentioned AR games and AR technologies/platforms to develop games will be selected based on the following key criteria defined on the basis of the needs analysis already conducted, on the input received during the preliminary workshops organized with relevant stakeholders for this purpose as well as considering Partners' expertise and interests (*please see excel sheet parallel searching with describing the criteria to select apps for the project*):

The following criteria will be considered for selection:

AR Games and AR Technologies should be suitable for students aged 14-18 years old.

Applications should definitely address STE(A)M (STE(A)M - science, technology, engineering, art and mathematics). teaching and learning.

APPs-applications should not only be used in the regional area, but also can be used by large masses. Thus, dialogue between countries can start, solutions to technical problems can be found more easily, and information can be exchanged.

Applications and platforms - AR APPs and AR Platforms - should produce effective results in education. The impact should be long-term studies and positive comments about it.

Applications should be free if possible or cheap enough to be paid by students.

They should also be compatible with today's education system and should be available even if the education system changes. The phone or tablets used should still be running when the operating system is updated.

The manufacturer is generally accepted by the European Union, if possible, it is multilingual or at least English.

The items described above are summarized below. The AR Game and AR Technology selection criteria, which are also used in the Excel table (*see Annex III*), are accepted by all project partners.

- ✓ **End users:** AR games and AR technologies to develop games 'easy to use' for secondary schools' teachers and students (14-18 years old);
- ✓ **Field of application:** AR games and AR technologies/platforms to develop games to teach/learn STE(A)M (*Fit to* an educational purpose)
- ✓ **Area and context of implementation:** examples identified in Europe and abroad, but addressed to STE(A)M subjects;
- ✓ **Impact/effect:** positive impact for the educational environment
- ✓ **Free to use or at reasonable price**
- ✓ **Up-to-date and still functioning**
- ✓ **Cleared by the company to be used by EU project** (*see Annex III*)

Collection of AR Games

The purpose of this step is to systematically gather and describe a set of existing AR games that might be suited for the project. To conduct this step a template will be designed and distributed among project Partners (*see Annex I*). Moreover, their main characteristics will be extrapolated and included into an excel sheet *google docs/basecamp link* (*see Annex III*). The data to be filled for each AR game are designed to help us to select the AR games that we will use for the AR4STE(A)M project.

Collection of AR Technologies (Apps) to develop Games

The purpose of this activity is to systematically describe and gather a set of existing AR applications and/or technologies to develop games for educational purposes. To conduct this step a template will be designed and distributed among project Partners (*see Annex II*). Moreover, their main characteristics will be extrapolated and included into a google sheet *google docs/basecamp link* (or *see Annex III*).

The data fields to be filled for each AR application are designed to help us to select the AR technologies/platforms to develop games that we will use for the AR4STEAM project.

Partners' Roles and Responsibilities

In order to apply the collaborative approach within the Partnership and establish a good flow of cooperation, during the Kick-off Meeting held in Firenze (IT) on 23-24 of January 2020, Partners confirmed to conduct this activity at Country level. As a result, Partners (except Effebi from Italy) will select, at least, 2 Good Practices each (1 example of AR game and 1 example of AR technology/platform to develop games).

Here below, the main results:

- Methodology and key criteria to select examples of AR games and AR technologies to develop games to integrate in upper secondary schools' programmes (Samandira);
- Collection of AR games (at country level): each Partner (except Effebi) will identify and select at least 1 example (1/country) of AR game applied for teaching and learning STE(A)M;
- Collection of AR technology/platform to develop games (at country level): each Partner (except Effebi) will identify and select at least 1 example (1/country) of AR technology/platform to develop games for teaching and learning STE(A)M;
- Report on suitable indicators for gamification strategies: Partners will be required to describe how activity data from users can be used to record learning progress and grant badges (e.g. Mozilla Open Badges) for learning achievements in AR4STE(A)M applications. The outcome will be an overview of suitable indicators from AR games and how they can be documented and granted with a badge system.
- Compendium of gamification strategies based on augmented reality for STE(A)M learning (at EU level): one Compendium will be designed.

Since Samandira is the leader of output 1 it will be responsible to integrate all the results collected into a **Compendium** and to elaborate the executive summary of the document that will be afterwards translated in each Partners' language for dissemination and evaluation purposes.

Two Partners come from Italy: Istituto Tecnico per il Turismo Marco Polo (ITT Marco Polo) and Effebi, therefore they will share tasks and responsibilities, accordingly.

ITT Marco Polo will look after the selection and collection of good practices for Italy and provide contribution for the completion of the Report on suitable indicators for gamification strategies. Effebi will be responsible for the translation of the executive summary of the final document of IO1.

With regards to roles and responsibilities, based on the collaborative approach, these are distributed as follows:

Partner Organization	Role	Tasks and Responsibilities

DIPF (DE)	● Project Coordinator	● Monitor the activity ○ Assure compliance with the output and project's objectives and deadlines. ● Implement the activity ○ Fill in both templates for collecting AR games and for collecting AR technology/platform to develop games ○ Provide feedback/suggestions for the contents of the Compendium ○ Translate the Executive summary of the Compendium ○ Design the structure of the Report on suitable indicators for gamification strategies ○ Collect Partners' contributions for the above-mentioned report ○ Execute and Complete the Report on suitable indicators for gamification strategies
Samandira (TK)	● Leader of IO1	● Coordinate the activity ○ Design the structure for the final document of IO1 (Compendium) that will be provided in electronic version ○ Develop the methodology, instructions and

	● Partner	templates for the collection of both examples of AR games and AR technology/platform to develop games ○ Collect and integrate feedback/suggestions for the Compendium ○ Elaborate the Compendium ○ Elaborate the Executive Summary of the Compendium ○ Translate the Executive summary of the Compendium ● Implement the activity ○ Fill in both templates for collecting AR games and for collecting AR technology/platform to develop games ○ Provide contribution for the Report on suitable indicators for gamification strategies
Effebi Association (IT)	● Methodological Coordinator ● Partner	● Implement the activity ○ Support Samandira in developing the methodology, instructions and templates for the collection of both examples of AR games and AR technology/platform to develop games

		○ Give support to ITT Marco Polo for the fulfilment of both templates ○ Translate the Executive Summary of the Compendium ● Assure the methodological coherence of the activity ○ Assure the quality of the activity ○ Assure the coherence of the activity
ITT Marco Polo (IT)	● Partner	● Implement the activity ○ Fill in the template for collecting AR games ○ Fill in the template for collecting AR technology/platform to develop games ○ Provide feedback/suggestions for the contents of the Compendium ○ Provide contribution for the Report on suitable indicators for gamification strategies
Agorà Roermond (NL) **HEART SOLUTIONS (EL)** **AEDE (BE)**	● Partners	● Implement the activity ○ Fill in the template for collecting AR games ○ Fill in the template for collecting AR technology/platform to develop games

		○ Provide feedback/suggestions for the contents of the Compendium ○ Translate the Executive summary of the Compendium ○ Provide contribution for the completion of the Report on suitable indicators for gamification strategies

Activity Schedule

The implementation of this activity (Collection of AR games and AR technology/platform to develop games for teaching/learning STE(A)M) will follow the time schedule as follows:

1. **Draft of Methodology and criteria to select AR games and AR technologies to develop games to integrate in upper secondary schools' programmes - by 1 April 2020** Partners' feedback - 2 days
2. **Methodology and criteria to select AR games and AR technologies to develop games to integrate in upper secondary schools' programmes - by 15 April 2020**
3. **Draft version of template for the collection of AR games - by 15 April 2020**

   Partners' feedback - 3 days
4. **Draft version of template for the collection of AR technologies to develop games - by 20 April 2020**
5. Partners' feedback - 3 days
6. **Final version of template for the collection of AR games - by 30 April 2020**
7. **Final version of template for the collection of AR technologies to develop games - by 30 April 2020**
8. **Conduct and fill in of collection of AR games template - between 3 April and 15 May 2020 (with Feedback from IO1 Leaders)**
9. **Conduct and fill in of collection of AR technology/platform to develop games template - between 15 May and 30 May 2020 (with Feedback from IO1 Leaders)**

10. **Draft of graphics and structure for Compendium - by 15 May 2020**

Partners' feedback - 1 week

11. **Draft version of Compendium - 30 May 2020**
12. **Draft of Report on suitable indicators for gamification strategies - by 31 July 2020** Partners' feedback - 1 week
13. **Final version of Report on suitable indicators for gamification strategies - by 5 August 2020**
14. **Final version of Compendium - by end of August/beginning of September 2020**
15. **Executive summary of Compendium - by end of August**
16. **Translations of executive summary of Compendium in Partners' languages (DE,IT,NL,TK,EL,FR) - by 1 week of September**

Annexes

Annex 1 - Collection of AR games

Germany

Partner: **DIPF**

©Shutterstock, license DIPF (Fieldtrip German Class)

1. Title of the AR game:

(possibly used for educational purposes and addressed and/or applicable to STE(A)M)
Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

ARLearn
Stefaan Ternier: stefaan.ternier@ou.nl

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality game has been developed, for what purpose and which has been its period of implementation.

The application "ARLearn" was developed in 2014 by Welten Institute at the Open University of the Netherlands. ARLearn is an AR Game and mainly useful for any kind of field trip, in which the teacher wants to provide information to the students at different locations. The last update of ARLearn is from May 22nd 2017.

3. Tags

Please choose the tags to easily categorize the augmented reality technology and practice.

Field trips, Inquiry based Learning.

a. Education type

Choose one option (highlighted)

- ❑ Formal secondary school education
- ❑ Informal secondary school education
- ❑ Non formal education

ARlearn can be used in the context of formal and informal secondary school education, as well for non-formal education.

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❑ Teach/Learn using innovative didactical methods
- ❑ Teach/Learn STE(A)M subjects
- ❑ Teach/Learn STE(A)M subjects with innovative didactical methods
- ❑ Support innovative teaching/learning methods
- ❑ Assess new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the source of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify in which country and city the augmented reality game is already implemented and which organisation or educational institute eventually implemented and used it. Specify also from which OER it could be freely downloadable.

ARLearn has been tested in multiple learning scenarios in different countries (Italy, Germany, The Netherlands, etc.), however, to the best of our knowledge there are no institutions that promote/include the formal use of ARLearn in their curricula.

It is open source and can be downloaded from:

https://arlearn-eu.appspot.com/#/
https://www.ou.nl/youplay

Open University
Valkenburgerweg 177
6419 AT Heerlen, the Netherlands
Telephone: +31 (0)45 576 22 22 (reception)
Email: info@ou.nl

5. Target group/End-users

Indicate who are the beneficiaries of the study case. Please, keep in mind that the project is addressing secondary school students (14-18 years old).

Any type of learners that want to apply Inquiry based learning or learn while doing a field trip.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify if it is integrated in upper secondary schools' programmes and how and why it is relevant for educational institutes.
Please, also specify whether it is possible to customize the AR game for the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

ARLearn is a tool which suits educators and learners supporting different phases and activities during a field trip. Learners can use augmented reality clients to explore and annotate real world field trip sites while teachers can monitor their progress in real time.

The ARLearn platform is intended for teachers that organize a didactical field trip, but can support other scenarios as well. For instance, professionals could use the app when inspecting a site to make notes that are synchronized with their current location.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR game is designed for.

Depending on the creativity of the teacher, ARlearn can be used for any type of STE(A)M field.

8. STE(A)M adaptable

In case the AR game was not designed to support a specific STE(A)M field, then state how it can be adapted to be used for one or more of these fields.

Teachers can create games for specific subjects they want to train.

9. Company permission

Please, specify whether the AR game is created for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

Students appreciated the sequential order of the tasks. Although they could click through all assignments in advance, none of the students looked ahead.
In general, students were positive about the game.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR game selected focused on pursuing a defined educational goal? Does it have any impact on the local/national community/students? Please, describe it.

Longitudinal studies about the use of ARLearn have not been conducted, therefore we cannot provide any input for this item.

12. Challenges during implementation

Indicate whether there have been challenges for its implementation. If yes, please describe the difficulties encountered when applying this augmented reality game and how these have been solved.

Teachers have to invest time in creating the games and monitoring the progress of the students. The success of a game created by ARLearn depends on the effort and creativity of the teacher.

13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education, is this game transferable also to formal education, and vice-versa and how.

ARLearn has been tested in formal and informal learning scenarios.

Belgium

Partner: AEDE

1. Title of the AR game:

(possibly used for educational purposes and addressed and/or applicable to STE(A)M) Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

Energy Roller Coaster

Owner: Mirage – réalité augmentée et virtuelle pour l'enseignement http://mirage.ticedu.fr/

2. Timeframe: from the development to implementation

Since 2012, the Mirage project aims to create free mobile applications of augmented reality for education on Android and iOS. Now it can be accessed on Microsoft, Google Play and App Store.

3. Tags

Please choose the tags to easily categorize the augmented reality technology and practice.

a. Education type

Choose one option (highlighted)

- ❑ Formal secondary school education
- ❑ Informal secondary school education
- ❑ Non formal education

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❑ Teach/Learn using innovative didactical methods
- ❑ Teach/Learn STE(A)M subjects
- ❑ Teach/Learn STE(A)M subjects with innovative didactical methods
- ❑ Support innovative teaching/learning methods
- ❑ Assess new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the source of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify in which country and city the augmented reality game is already implemented and which organisation or educational institute eventually implemented and used it. Specify also from which OER it could be freely downloadable.

According to the creator of the applications M.A. Chardine, the use of augmented reality makes it possible to facilitate vision in space, while integrating the mechanics of gamification and collaboration between students.

Country: France
City: Rouen
Organization: Mirage – réalité augmentée et virtuelle pour l'enseignement
Website: http://mirage.ticedu.fr/

5. Target group/End-users

Indicate who are the beneficiaries of the study case. Please, keep in mind that the project is addressing secondary school students (14-18 years old).

Beneficiaries are the teachers, who are provided with attractive and creative tools for integrating scientific content, secondary students who prefer it to the textbook, using integrated data, documents and 3D models in augmented reality.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify if it is integrated in upper secondary schools' programmes and how and why it is relevant for educational institutes.
Please, also specify whether it is possible to customize the AR game for the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

The application is developed by M.A. Chardine, professor of physical sciences, with support of Région Normandie, Microsoft and Mirage . Within this game, students must design a roller coaster with an energy limit. They create safe operation conditions by recording, modifying, if necessary, the potential, kinetic, mechanical energy from data in real time, sharing their decisions with colleagues.
A pedagogical sheet for teachers and interactive evaluation are also provided.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR game is designed for.

Energy Roller Coaster is designed to be used in Physical Sciences disciplines, but is also useful for developing computer skills. Through the information it offers, the game is also useful for students in terms of career guidance.

8. STE(A)M adaptable

In case the AR game was not designed to support a specific STE(A)M field, then state how it can be adapted to be used for one or more of these fields.

This game can be adapted and applied for other disciplines too (chemistry, mathematics technology and others) Three levels are available in the application for high school: Initiation, Confirmed and Expert. The levels display different information, more or less complex to analyse. Students take note of their possibility of continuing this field in specialized schools to acquire skills as engineers in aeronautics, shipbuilding or cars.

9. Company permission

Please, specify whether the AR game is created for (*highlighted)*:

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

The game has been very well received in the education community, bringing out a lot of educational articles and not only, who have praised it and highly recommended the use of this game in class. It is promoted on many websites by teachers and parents.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR game selected focused on pursuing a defined educational goal? Does it have any impact on the local/national community/students? Please, describe it.

The students and teachers found it interesting and they perceived the activities and the tasks to be done attractive and applicable in real life. The teachers also appreciated the educational file. On the internet we can find teachers' opinions that pupils in difficulty have found the interest for the class, due to this game.

12. Challenges during implementation

Indicate whether there have been challenges for its implementation. If yes, please describe the difficulties encountered when applying this augmented reality game and how these have been solved.

The creator of the game had to make efforts for funding and appealed for public donations too. He succeeded with the help of all to bring this project to life and transform, through digital, the way of teaching by developing educational tools that allow students to create exceptional and motivating productions.

13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education, is this game transferable also to formal education, and vice-versa and how.

The game is transferable for non-formal education too. It is easy to access for French speaking countries: France, Belgium, Switzerland, Luxembourg, but it can already be found on quite a large number on English website.

Project number: 2019-1-DE03-KA201-059708

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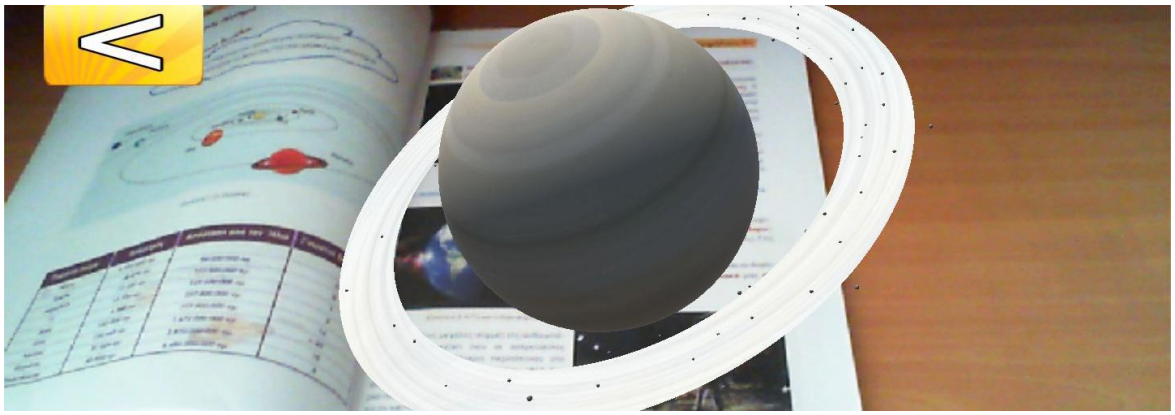
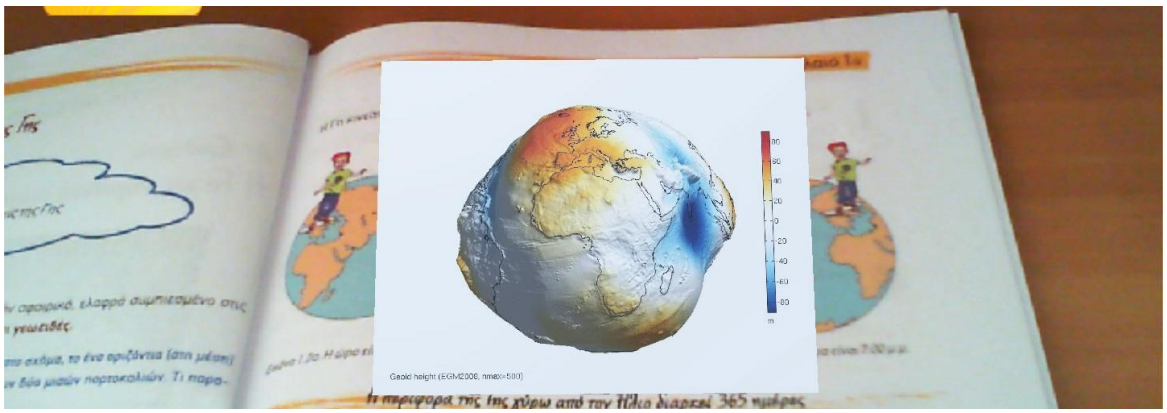
Greece

Partner: HESO





©SchoolAR

1. Title of the AR game:

(possibly used for educational purposes and addressed and/or applicable to STE(A)M) Provide the full title of the augmented reality technology/platform identified. Please, also specify the promoter and/or owner, whether it exists.

SchoolAR

Owner: Sotiris Georgiou

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality game has been developed, for what purpose and which has been its period of implementation.

Developed (year): 2017
General purpose: integration of AR practices in secondary education, familiarization of students and teacher with AR capacities/practices

3. Tags

Please choose the tags to easily categorize the augmented reality technology and practice.

a. Education type

Choose one option (highlighted)

- ❏ Formal secondary school education
- ❏ Informal secondary school education
- ❏ Non formal education

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❏ Teach/Learn using innovative didactical methods
- ❏ Teach/Learn STE(A)M subjects
- ❏ Teach/Learn STE(A)M subjects with innovative didactical methods

- ❏ Support innovative teaching/learning methods
- ❏ Assess new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❏ Free access
- ❏ Instructions/tutorial for use
- ❏ On-line assistance (i.e video tutorial: https://www.youtube.com/watch?v=uuHwX8_hbjQ)

4. Area and context of implementation

Summarize in max. 450 characters (space included) the source of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify in which country and city the augmented reality game is already implemented and which organisation or educational institute eventually implemented and used it. Specify also from which OER it could be freely downloadable.

SchoolAR has been designed based on the concept of bringing into life the educational material of specific modules included in the official curricula. While it is incorporated into the official public school curricula as an official educational element, it is developed upon the formal taught modules. SchoolAR has received the Education Leaders Award (2018) and is currently developing AR scenes for more subjects. Available for download: https://play.google.com/store/apps/details?id=com.Samgeorg.GymAR&hl=en_US

Country/ies: Greece
City/ies: -
Institution/Organization (e.g. museum, school, etc.):-
Website: http://www.schoolar.gr

5. Target group/End-users

Indicate who are the beneficiaries of the study case. Please, keep in mind that the project is addressing secondary school students (14-18 years old).

Secondary school students and Secondary schools' teachers.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify if it is integrated in upper secondary schools' programmes and how and why it is relevant for educational institutes.
Please, also specify whether it is possible to customize the AR game for the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

SchoolAR app has been developed upon the logic of connecting the digital and the physical world via AR technology. Through 'bringing to life' the educational content of any book, students can interact in real-time with what they learn in theory. Thus, they can gain a deeper and more practical understanding of the subjects. This is also the same reason why SchoolAR can be adaptable to several STE(A)M-related fields. SchoolAr is not integrated in the official school curricula but it has been designed upon it - SchoolAR markers bring to life the specific modules taught in schools. It has been used as a complimentary educational method in various training and after-school facilities to help students engage and enjoy ICT and Geology classes.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR game is designed for.

SchoolAR app was originally developed to support ICT official curricula. The app is currently used in Computer Science classes across the country. The team behind the development of SchoolAR app has already been testing the integration of features and media elements to also support the official learning modules for Geology and Maths.

8. STE(A)M adaptable

In case the AR game was not designed to support a specific STE(A)M field, then state how it can be adapted to be used for one or more of these fields.

Theoretically, the AR app could be modified to fit a rather wide variety of subjects given how it is populated and developed to 'react' to different triggers (i.e markers). As far as the SchoolAR app is concerned, while it was originally designed to support exclusively one STE(A)M field, the team behind it saw its full potential and started to research if it could also support additional fields in a timely manner.

9. Company permission

Please, specify whether the AR game is created for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

Amongst the main results noted on behalf of the students, increased in-classroom participation and triggered curiosity seem to come first. On the side, SchoolAR suggests a more effective way of learning as it exceeds theory by creating an interactive experience via gaming elements thus, enhancing the attention-span/focus of students.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR game selected focused on pursuing a defined educational goal? Does it have any impact on the local/national community/students? Please, describe it.

As this app is still in development, its impact cannot yet be properly described. However, increased engagement and interest has been noted on behalf of students.

12. Challenges during implementation

Indicate whether there have been challenges for its implementation. If yes, please describe the difficulties encountered when applying this augmented reality game and how these have been solved.

Challenges regarding the SchoolAR implementation and integration appear to be in line with the reported challenges in employing AR technologies in school curricula. Amongst them, the little familiarization of school teachers with this type of technology, the 'resistance-to-change-mentality' and the more specific bits of integrating traditionally non-formal practices to official, formative grading systems.

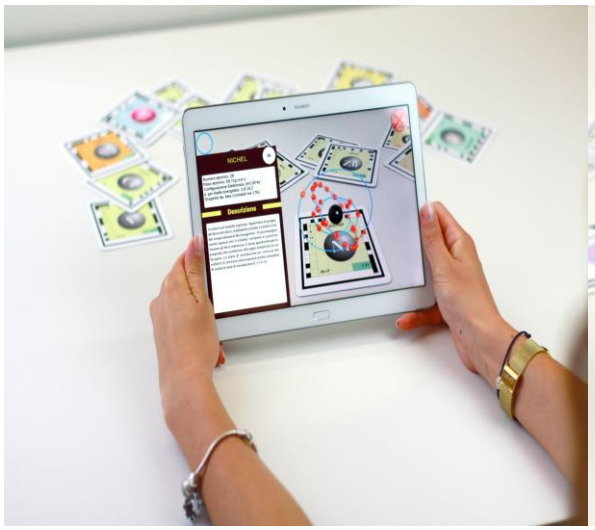
13. Transferability to other formative contexts and countries across Europe

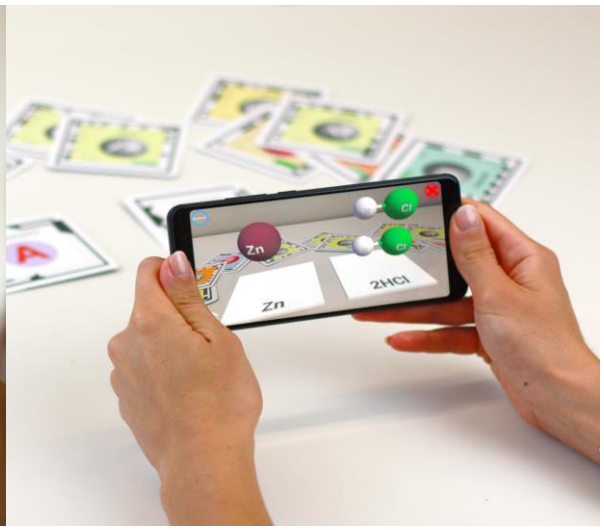
Indicate if the example refers to non-formal education, is this game transferable also to formal education, and vice-versa and how.

At least with regards to a national scale, AR practices have been traditionally considered non formal and have been used as such. However, with apps such SchoolAR, AR technology adoption has made a notable shift especially when it comes to private educational/ training institutions.
Taking into account the transferability potential of AR in 'livening' any teaching experience and the rate of its adoption across the globe, one would figure that it could easily become a formal method of teaching and assessing the class within the following years.

Italy

Partner: ITT Marco Polo





1. Title of the AR game:

(possibly used for educational purposes and addressed and/or applicable to STE(A)M) Provide the full title of the augmented reality technology/platform identified. Please, also specify the promoter and/or owner, whether it exists.

Ars Chimica per Scuole superiori

The App is developed and commercialised by the Italian company Software House Lucana Sistemi s.r.l., based in Matera, Basilicata.

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality game has been developed, for what purpose and which has been its period of implementation.

Ars Chimica has been developed in 2017. It has been conceived from a corporate brainstor ming and from the awareness that new technologies are changing the way in which knowledge will be transmitted.
ARSchooInnovation is a project developed by the Italian company Lucana Sistemi Software House with the aim of using Augmented Reality as a simple technology to support the learning process of young students both at school and at home.
It was created to enable 'digital natives' to use mobile devices for educational purposes, to deepen in class or at home topics already illustrated by teachers or to learn something new autonomously. It is an application that, through the use of 'cards', allows you to enjoy content exclusively through augmented reality and 3D software.
The Ars Chimica project intends to experience the role of Augmented Reality for learning purposes, especially in formal contexts, specifically Secondary Schools. It can be even used by families in order to reach a teaching purpose for children within a gamified context. Therefore, it can be applied even in non-formal or informal situations.

3. Tags

Please choose the tags to easily categorize the augmented reality technology and practice.

a. Education type

Choose one option (highlighted)

- ❏ Formal secondary school education
- ❏ Informal secondary school education
- ❏ Non formal education

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❏ Teach/Learn using innovative didactical methods

- ❏ Teach/Learn STE(A)M subjects
- ❏ Teach/Learn STE(A)M subjects with innovative didactical methods
- ❏ Support innovative teaching/learning methods
- ❏ Assess new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❏ Free access
- ❏ Instructions/tutorial for use
- ❏ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the source of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify in which country and city the augmented reality game is already implemented and which organisation or educational institute eventually implemented and used it. Specify also from which OER it could be freely downloadable.

Ars Chimica has been developed and implemented by the Italian company Lucana Sistemi s.r.l., a Software House based in the southern part of Italy.

Country/ies: Italy
City/ies: the APP can be purchased through the company website and it is potentially available in every Italian city.
Institution/Organization (e.g. museum, school, etc.): Secondary Schools in Italy; private families.
Company WebSite: www.lucanasistemi.com
Project WebSite: www.arsbook.it

5. Target group/End-users

Indicate who are the beneficiaries of the study case. Please, keep in mind that the project is addressing secondary school students (14-18 years old).

ARS Chimica enables learners of secondary schools to gain knowledge in chemistry. Many students consider chemistry as a complicated science, due to the use of notions that are not of easy comprehension. ; As a result, students have to create images, virtual objects in their imagination but not all students are able to create such objects, or to create them in an appropriate correspondence to reality. That's why teaching tools conceived to intensify visualization are always essencial in the process of chemistry teaching. This APP, based on augmented reality and game-based learning, can be useful, for example, to study non-perceptible notions (e.g. atoms, molecules, chemical bonds, etc.). 3D-models and graphic interfaces of tools for chemistry teaching which use augmented reality might have indeed a positive influence on the upper secondary and iVET students' level of interest in the discipline and a corresponding increase of acquiring knowledge and competences

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify if it is integrated in upper secondary schools' programmes and how and why it is relevant for educational institutes.

Please, also specify whether it is possible to customize the AR game for the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

ARS Chimica is an educational AR game that supports the learning process through gamification strategies. For instance, one can simulate a reaction and check its validity through the APP, or use a set of quizzes to verify one's progress.

It consists of an APP to be downloaded on a mobile device and a set of paper cards. The game is structured to be used in a Game-Based-Learning context, since it challenges students with a learning through failure strategy. It helps to strengthen soft skills like problem solving, information use, and self-awareness.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR game is designed for.

ARS CHIMICA is an excellent tool to improve the achievement of a basic knowledge in chemistry. However, the learning by doing approach is a basic strategy, common to all science and technology fields.

At the moment, Lucana Sistemi S.r.l. has developed an augmented reality software aimed to teach not only chemistry but also STE(A)M subjects like maths, science, geography, art to students between 8 and 13 years old.

8. STE(A)M adaptable

In case the AR game was not designed to support a specific STE(A)M field, then state how it can be adapted to be used for one or more of these fields.

The APP is designed to specifically support STE(A)M fields.

9. Company permission

Please, specify whether the AR game is created for (highlighted):

- ❏ Open source
- ❏ Commercial use
- ❏ Free for educational purposes
- ❏ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

ARS CHIMICA was specifically designed to support the learning process through gamification strategies, with the result of a smoother, more entertaining approach to a difficult topic.

It achieves the objective of integrating immersive technologies and game-based learning in educational programs.

It helps upper secondary students to develop creative thinking and supports teachers to raise motivation and scientific curiosity in their students.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR game selected focused on pursuing a defined educational goal? Does it have any impact on the local/national community/students? Please, describe it.

Throughout the use of AR and Game-Based-Learning, ARS CHIMICA provides user friendly access to get the students more involved when approaching difficult topics.

- The expected short term impacts are:
  - a better knowledge in chemistry,
  - a more efficient guidance from teachers.

- The expected long term impacts are:
  - a wider curiosity in scientific topics,
  - enhancement of soft skills, especially problem solving, organization skills, use of information.

12. Challenges during implementation

Indicate whether there have been challenges for its implementation. If yes, please describe the difficulties encountered when applying this augmented reality game and how these have been solved.

One of the most important challenges is to persuade teachers not only to trust in the potentiality of augmented reality but also to use this new innovative teaching method at school. Moreover, it will be useful to have the opportunity to deliver training courses for teachers and conduct pilot projects with students.
In an “AR mode” training course, it is necessary to take into consideration that the delivery of training and information contents must be combined with the playful and

communicative aspects to allow students to learn and reach the set objectives while having fun.
The challenge, in developing a training game or AR materials, is the ability to replicate educational scenarios (contents proposed by the teachers) by stimulating reasoning, creativity and intuitiveness. It is also necessary to offer opportunities for interaction to increase the proactive attitude of the learners and therefore to enhance learning.
The flexibility and versatility of Ars Chimica makes it particularly suitable for a variety of contexts of use:
• Teaching in traditional school contexts, to 'enrich' the static message of the printed book with additional dynamic and multimedia contents;
• Conducting experimental activities, in order to associate them with theoretical concepts, making the learning process more playful and immediate;
• Delivering in-depth courses, to increase the teaching materials available, through the construction of interactive and immersive educational paths and scenarios to facilitate learning in "learning by doing" mode.

Thanks to this technology, the teacher can count on the development of experiential educational systems characterized by a more dynamic and engaging didactic learning thanks to the increased visualization capacity of the pupil, put at the center of a more effective and immersive teaching process, characterized by a strong real-time interaction where it is possible to verify and experiment directly on the field.

13. Transferability to other formative contexts and countries across Europe

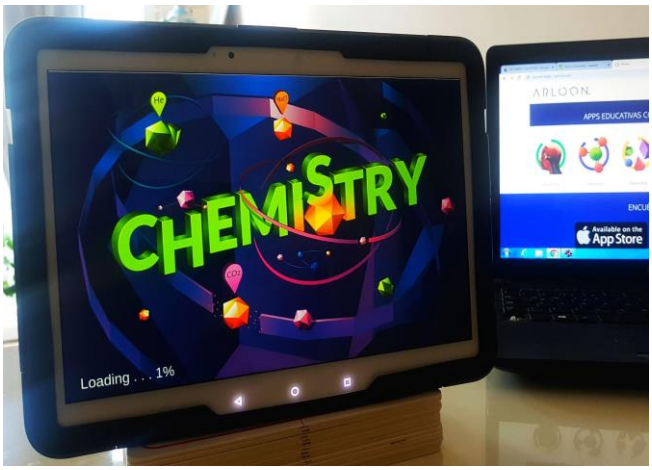
Indicate if the example refers to non-formal education, is this game transferable also to formal education, and vice-versa and how.

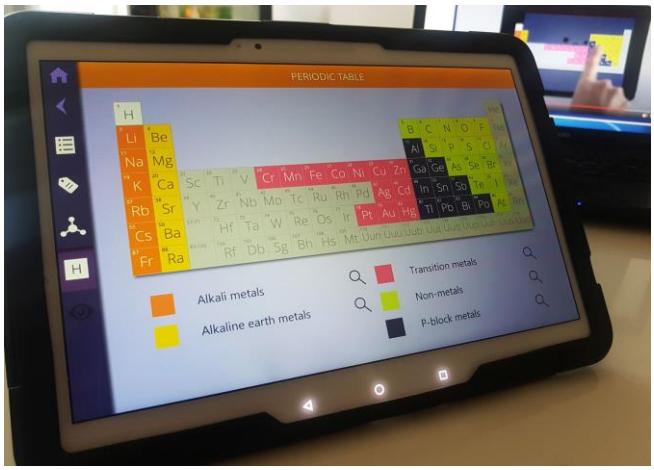
At the moment, Arsbook for Chemistry is mainly thought to be applied in upper secondary and iVET education. There are new pedagogies to which this technology could be very beneficial, for example for the so-called 'DADA': educational learning environments. This methodological approach, founded in the Scandinavian teaching context, is based on a learning landscape that serves as an educational tool and catalyst for learning. Within this model the use of technological devices like tablets, smartphones and game-based learning applications is considered a meaningful contribution to the development of several 'soft skills' such as Self Awareness, Effective Communication, as well as Decision Making and Creative Thinking.
The APP is easily transferable to non-formal context, especially considering that it is already 'equipped' with game-based learning activities. It is not a game, but a type of active learning experience within a game-based framework with specific learning objectives and measurable outcomes. So, the learning process gives a child or a teenager, even in a domestic

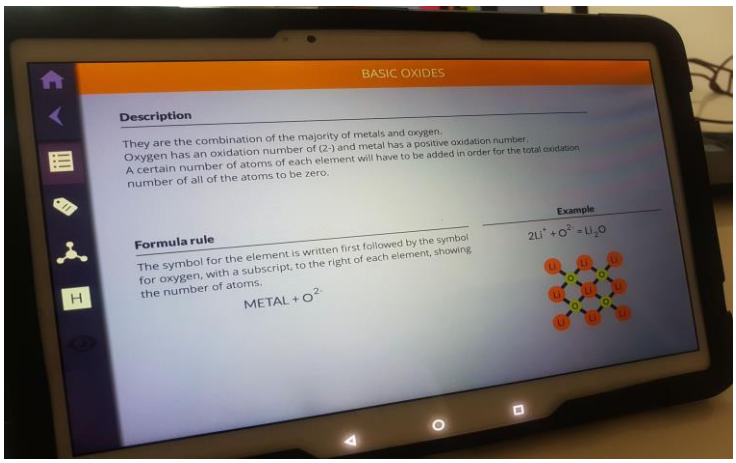
environment, clear and challenging goals within a virtual game architecture, it requires a high-degree of interaction and offers informative feedback on user performance.

Turkey

Partner: Samandira







1. Title of the AR game:

(possibly used for educational purposes and addressed and/or applicable to STE(A)M) Provide the full title of the augmented reality technology/platform identified. Please, also specify the promoter and/or owner, whether it exists.

Arloon Chemistrys

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality game has been developed, for what purpose and which has been its period of implementation.

The company didn't provide this information yet!

3. Tags

Please choose the tags to easily categorize the augmented reality technology and practice.

a. Education type

Choose one option (highlighted)

- ❏ Formal secondary school education
- ❏ Informal secondary school education
- ❏ Non formal education
- ❏ The App is appropriate for all types of education systems and for all who need information about the human body.

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❏ Teach/Learn using innovative didactical methods
- ❏ Teach/Learn STE(A)M subjects
- ❏ Teach/Learn STE(A)M subjects with innovative didactical methods
- ❏ Support innovative teaching/learning methods
- ❏ Assess new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the source of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify in which country and city the augmented reality game is already implemented and which organisation or educational institute eventually implemented and used it. Specify also from which OER it could be freely downloadable.

ARLOON CHEMISTRY, is an augmented reality mobile application that has been implemented in Spain and England to increase the learning motivation of secondary school students. Observing molecules becomes an important topic in the Chemistry subject that must be understood by learners. Understanding the periodic table with the help of an innovative and attractive representation helps students in writing formulae for more than 3,000 compounds.

This application enables students to learn the theory behind the formation of binary and ternary compounds and to learn the basics of writing formulas with the help of tutorials.

The content of this application is essential as a basic knowledge of some relevant fields of science to enhance students' understanding of science, inorganic chemistry, mathematics and linguistics (English and Spanish).

AR has the potential to engage, stimulate and motivate students who have difficulties to understand and deepen the intangible concepts of chemistry. With creating an active learning environment the scientific literacy of students is strengthened to move away from memory based learning.

5. Target group/End-users

Indicate who are the beneficiaries of the study case. Please, keep in mind that the project is addressing secondary school students (14-18 years old).

Beneficiaries of the ARLOON are children at the age of 13 to 18 who are attending secondary education. The content of the application is provided in English and Spanish languages.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify if it is integrated in upper secondary schools' programmes and how and why it is relevant for educational institutes.
Please, also specify whether it is possible to customize the AR game for the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

This app features 3D models with Augmented Reality to observe molecules in 3D and move them to their desktop.

ARLOON makes it possible for students to use Augmented Reality to learn how to write formulae and name chemical compounds.

Learning Outcomes of the App indicates that it can easily be integrated in upper secondary school's programmes because of its curricular content and the exercises to practice the STE(A)M subjects.

The App can be easily integrated in upper secondary school programs because of its curricular content and the appropriate exercises to practice the STE(A)M subjects.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR game is designed for.

STEM is a curriculum based on the idea of educating students in four specific disciplines — science, technology, engineering and mathematics — in an interdisciplinary and practical approach. Science in STEM typically refers to two out of the three major branches of science: natural sciences, including biology, physics, and chemistry, and formal sciences, of which mathematics is an example.

Arloon Chemistry is designed to interpret three-dimensional structures of molecules and crystals to be the leading direction of the use of AR-technologies in the process of chemistry teaching. Composition and structure of substances, the level of spatial awareness concerning

the composition of substances are essential as a basic knowledge of some relevant fields of science such as biochemistry, medicine and pharmacy. That's why learning chemistry becomes an important topic that must be improved.

8. STE(A)M adaptable

In case the AR game was not designed to support a specific STE(A)M field, then state how it can be adapted to be used for one or more of these fields.

The AR game was designed to support Science in the fields of chemistry. It can be adapted to be used for inorganic chemistry, biochemistry and pharmacy as well.

9. Company permission

Please, specify whether the AR game is created for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

Arloon Chemistry makes easier the learning of periodic table, and atomic structure of the elements and molecules with a student-centred Augmented Reality environment

The Application increases the interest of secondary school students to learn more about molecules and the spatial relations between them. For students it is very informative to see actual molecule representations in a 3D environment, inspect molecules from multiple viewpoints and control their interaction.

11. Impact

Indicate whether there have been challenges for its implementation. If yes, please describe the difficulties encountered when applying this augmented reality game and how these have been solved.

In the short term period ARLOON enables the students to understand the spatial structures of the chemical particles. While, in the long-term period it makes students understand element composition and their reactions with other elements.

ARLOON has a positive impact on the local/national community. Moreover, it encourages students to learn, to be curious and to be a true science lover.

For this reason ARLOON has got many prizes and compliments from the media.

Here below some awards:

– Winner of the Academics' Choice Smart Media Award (July 2014)

– Learning Best Practice Award (October 2014)

– 2nd prize winner of the "La CaixaEmprendedores XXI" awards for entrepreneurs (June 2014)

– Winner of the first Lanzadera business incubator program (May 2013)

Learning the notions of chemical bonds, the law of periodicity, a periodic table of chemical elements help students design, learn and interact with chemical structural models and reactions in a better and intuitive way.

When one uses the app is captivated by its effectiveness, compliance for secondary education students and impressed by the joy it provides.

Its organization is appreciable .It is extremely useful, effective and enjoyable.

The App inspires to create other apps along this path to teach physics, biology, language, gym electricity, electronics and other subjects.

The APP is appropriate for STEAM learning.

12. Challenges during implementation

Indicate whether there have been challenges for its implementation. If yes, please describe the difficulties encountered when applying this augmented reality game and how these have been solved.

The main problem is that the App is not available for free. But, on the other hand, it is not so expensive.
The second problem is about the timing of using it by telephone. When exceeding, there happens a fast battery consumption.
The solution could be to use a cooling system for the phone or even to equip it with a battery bank.

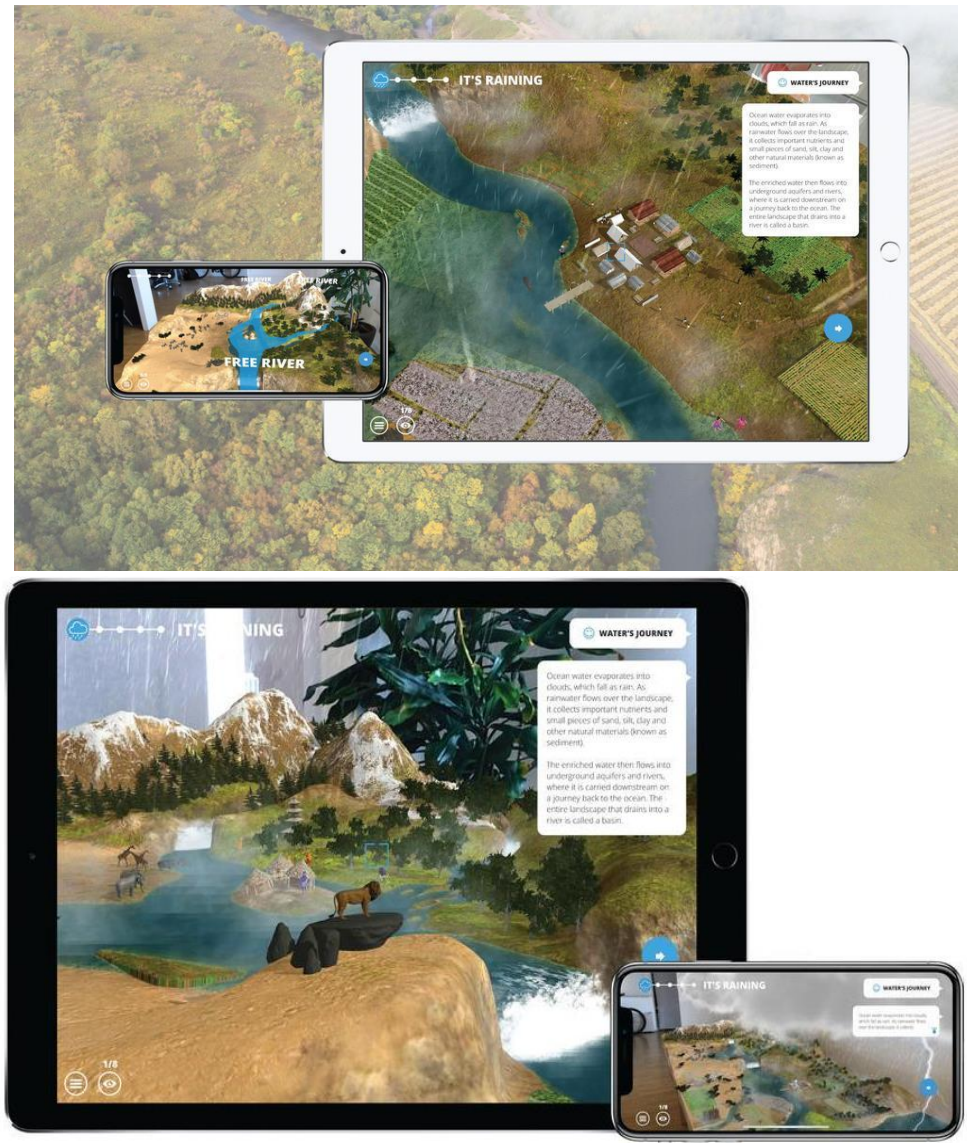
13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education, is this game transferable also to formal education, and vice-versa and how.

The App suits all types of education systems and is of high support for those who need information about chemistry.

Netherlands

Partner: Agorà Roermond



©WWF

Free Rivers

1. Title of the AR game:

(possibly used for educational purposes and addressed and/or applicable to STE(A)M) Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

WWF Free Rivers - Experience the power of rivers

World Wildlife Fund:
https://www.worldwildlife.org/pages/explore-wwf-free-rivers-a-new-augmented-reality-app

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality game has been developed, for what purpose and which has been its period of implementation.

Imagine seeing an entire, living landscape on your table. You can zoom in, look around and learn more about why free flowing rivers are so important. Through helpful little floating tips, you learn more about the journey of water, how it impacts the area through which it flows, the people it affects and how building dams can cause damage to delicate ecological systems. Place a dam and you can see (in accelerated time) how the river changes and how everything else is affected downstream. This app is the WWF's concerted effort to educate about how human development can either be harmful or sustainable.
See please the website: http://www.onebigrobot.com/work/wwf-free-rivers to view the process of development. (From idea till realisation).

3. Tags

Please choose the tags to easily categorize the augmented reality technology and practice.

Unity, AR, Interactive

a. Education type
Choose one option (highlighted)

- ❑ Formal secondary school education
- ❑ Informal secondary school education
- ❑ Non formal education

b. Aim of the selected example
You can choose more than one option (highlighted)

- ❑ Teach/Learn using innovative didactical methods
- ❑ Teach/Learn STE(A)M subjects

- ❑ Teach/Learn STE(A)M subjects with innovative didactical methods
- ❑ Support innovative teaching/learning methods
- ❑ Assess new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the source of the augmented reality game selected used for educational purposes (teaching and learning of STE(A)M subjects in secondary schools. Specify in which country and city the augmented reality game is already implemented and which organisation or educational institute eventually implemented and used it. Specify also from which OER it could be freely downloadable.

Country/ies: World Wide
City/ies: Washington, USA
Institution/Organization (e.g. museum, school, etc.): missing information
Website: https://www.worldwildlife.org/pages/explore-wwf-free-rivers-a-new-augmented-reality-app

5. Target group/End-users

Indicate who are the beneficiaries of the study case. Please, keep in mind that the project is addressing secondary school students (14-18 years old).

Children from 4 years on, students, teachers.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality game selected for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). Specify if it is integrated in upper secondary schools' programmes and how and why it is relevant for educational institutes.
Please, also specify whether it is possible to customize the AR game for the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

WWF Free Rivers puts an entire landscape in your hands. Through this immersive, augmented reality experience, you'll discover a river that flows through the lives of people and wildlife, and how their homes depend on those flows. Dam the river to see what happens, and then try different options for sustainable development that keeps the river healthy and flowing. Collect stories of people and animals along the way.

Features

• In-depth, educational storytelling experience for environmental science
• Stunning, animated, augmented reality model users can interact with and learn from
• Five distinct habitats based on real places: the Himalayan mountains, tropical jungles, African savannah, South American grasslands, and Southeast Asian deltas.
• Opportunity to get involved and help protect rivers, and the people and wildlife that depend on them.
• An augmented reality map of the world's rivers - and some of the biggest threats and opportunities they face.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR game is designed for.

Sustainability development of nature. Different aspects of creativity, planning, Engineering, Mathematics are needed to find solutions.

8. STE(A)M adaptable

In case the AR game was not designed to support a specific STE(A)M field, then state how it can be adapted to be used for one or multiple of these fields.

9. Company permission

Please, specify whether the AR game is created for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

The app is very useful to try and see what happens when humans disturb nature. It demonstrates how we can live together with nature and how to respect each other. Setting up the app is easy to do, intuitive.
The idea behind the App is very good but the storytelling is very short.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR game selected focused on pursuing a defined educational goal? Does it have any impact on the local/national community/students? Please, describe it.

The goal of this app is to create awareness on the impact of human beings on nature. For educational purposes the app is not that high level.

12. Challenges during implementation

Indicate whether there have been challenges for its implementation. If yes, please describe the difficulties encountered when applying this augmented reality game and how these have been solved.

There was no challenge to implement this.

13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education, is this game transferable also to formal education, and vice-versa and how.

This app could be used as a starting point of a problem with rivers and nature that should be solved.

Annex 2 Collection of AR Technologies

Germany

Partner: DIPF

1. Title of the AR technology/platform to develop games

(possibly used for educational purposes and addressed and/or applicable to STE(A)M subjects)
Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

Technology: CoSpaces Edu

Owner: Delightex - Delightex is a tech startup founded in 2012 by Eugene Belyaev, co-founder of JetBrains, and based in the lovely city of Munich, Germany.

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality technology/platform has been created, for what purpose and which has been its period of implementation.

The implementation of CoSpaces Edu started in 2012.

3. Tags

Please choose the tags to easily categorize the augmented reality technology/platform selected.

Virtual world creation

a. Education type

Choose one option (highlighted)

- ❑ Formal education
- ❑ Informal education
- ❑ Non formal education
- ❑ Other (please, specify)

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❑ Develop games for supporting innovative teaching/learning methods through stimulating and attractive didactical methods
- ❑ Develop games for teaching/learning STE(A)M subjects
- ❑ Develop games for also assessing new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Paid access
- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the "functioning" of the augmented reality technology/platform selected for developing games also indicating how many games can be developed. Specify whether an organisation/educational institute has already implemented the game/s for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). In the case of a positive sample, please specify the country/ies and city/ies the institution/organisation comes from and if the game/s is/are freely downloadable (if yes, please, quote the source/s).

The platform is used all around the world. It is made to teach and learn **STE(A)M subjects** using innovative methods while improving **digital skills** . The pupils use the virtual world to create their own learning environments, which can be observed afterwards in a Virtual or Augmented Reality mode. It therefore combines the process of developing codes and observing the results and is classified as an AR Technology.

Country/ies: Turkey, Spain, Portugal, Italy, Germany
City :Munich
Web: https://cospaces.io/edu/
CoSpace Project Link : https://edu.cospaces.io/

5. Target group/End-users

Indicate who are the potential beneficiaries of the study case (e.g. experts of ICT, STE(A)M teachers, secondary schools' students, etc.)

"CoSpaces Edu" is adaptable to any grade, from primary to secondary school education. The AR Technology is adaptable to any subject, including the STE(A)M subjects and especially Coding.
For teachers, especially for those who have never used a technology in their classroom before, the technology provides many different resources to encourage
the teaching and for making any kind of questions . This includes an online support, a community, checklists as well as descriptions to enable the best possible use to be made by teachers and students.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality technology/platform selected. Specify if upper secondary schools can integrate it into their own online environments and how. Also indicate why it is relevant for educational institutes.

Please, also specify whether it is possible to integrate the game/s developed into schools' programmes and if it is possible to customize it/them according to the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

"CoSpaces Edu" is created by the German company Delightex in Munich and hosted in Germany. The platform is used all around the world. It is made to teach and learn **STE(A)M subjects** using innovative methods, while improving **digital skills**. The pupils use the virtual world to create their own environments, which can be observed afterwards in a Virtual or Augmented Reality. It therefore combines the process of developing codes and observing the results and is classified as an AR Technology.
Students and teachers create content with CoSpaces Edu, therefore this content (games) can be integrated into school programs.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR technology/platform allow to include when developing the game/s.

Cospaces Edu is a tool to develop AR content, the fields for using this technology are only constrained by the creativity of the users. Therefore, if users are creative it can be applied to any STEAM field.

8. STE(A)M adaptable

In case the AR game/s could not be developed to support a specific STE(A)M field, then state how it can be adapted to be used for one or multiple of these fields.

While Cospaces was not specially designed for STEAM education, it can be adapted to it.

9. Company permission

Please, specify whether the AR technology/platform has access for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)* Free to try but you need to pay to get more options

10. Results

Describe which are the main results that the case study has achieved.

Cospace Edu, helped to make learning more immersive (Han, 2018)
However, more research is needed on the empirical testing of the phenomenon (Marjanovic et al.)
Informal results suggest that the project sparks students' interest in possible future business applications of VR (Frydenberg, & Andone, 2019)

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR technology/platform for developing games selected focused on pursuing a defined educational goal? Does it have any impact on the local/national educational community (e.g. teachers, students, school as a whole, etc.)? Please, describe it.

To the best of our knowledge no longitudinal studies have been conducted to assess the impact of Cospace Edu.

12. Challenges during implementation

Indicate whether there have been challenges when applying to this augmented reality technology/platform. If yes, please describe the difficulties encountered and how these have been solved (or can be solved).

The impact in learning of Cospace Edu depends on the content created by students and teachers. Creating good content requires time, effort, creativity and some basic programming skills.

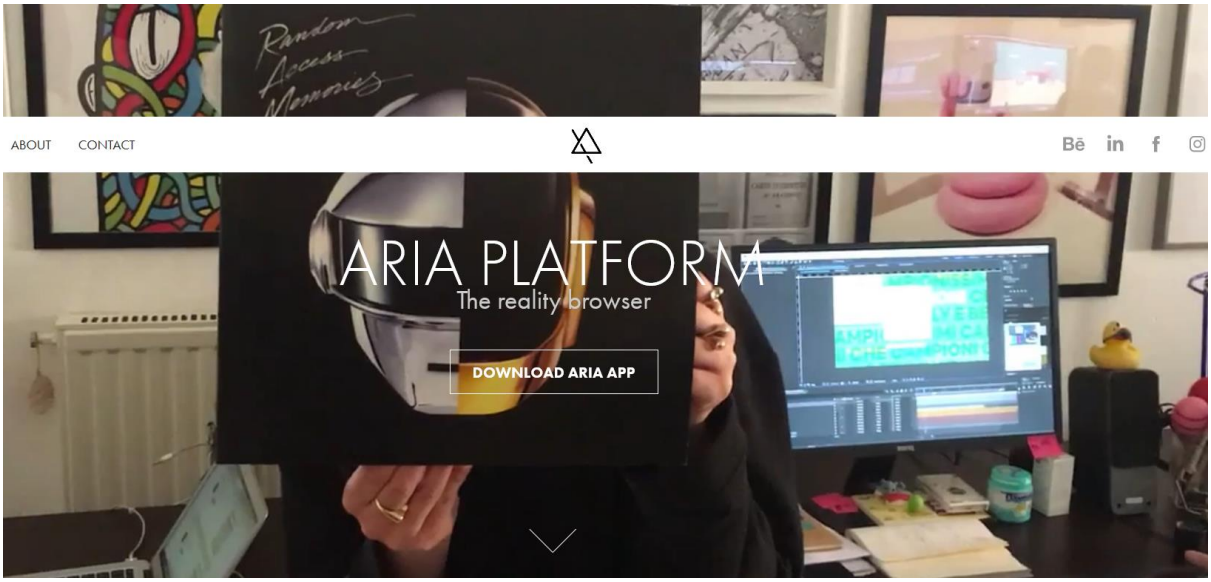
13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education. Is this AR technology/platform transferable also to formal education environments and vice-versa? How?

Cospace Edu is flexible, it can be used in non-formal or formal educational settings.

Belgium

Partner: AEDE



© AEDE

1. Title of the AR technology/platform to develop games

(possibly used for educational purposes and addressed and/or applicable to STE(A)M subjects)
Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

ARIA the AR platform

Owner: *Alkanoids Snc by Raffaella Roccella is a creative studio based in Milan focused on animation, motion design,direction and brand identity*
Aria the AR platform is design by dilium srl

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality technology/platform has been created, for what purpose and which has been its period of implementation.

The development of Aria started in 2018.

3. Tags

Please choose the tags to easily categorize the augmented reality technology/platform selected.
Virtual world creation, iOS, Android devices.

a. Education type

Choose one option (highlighted)

- ❑ Formal education
- ❑ Informal education
- ❑ Non formal education
- ❑ Other (please, specify)

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❑ Develop games for supporting innovative teaching/learning methods through stimulating and attractive didactical methods
- ❑ Develop games for teaching/learning STE(A)M subjects
- ❑ Develop games for also assessing new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Paid access
- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the "functioning" of the augmented reality technology/platform selected for developing games also indicating how many games can be developed. Specify whether an organisation/educational institute has already implemented the game/s for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). In the case of a positive sample, please specify the country/ies and city/ies the institution/organisation comes from and if the game/s is/are freely downloadable (if yes, please, quote the source/s).

Aria is a platform exclusively designed to let users experience AR with the simple support of smartphones and tablets. Simply downloading the "Aria The AR Platform" application **from the App Store and the Google Play Store**, launching it, one can frame with its own camera the objects and images included at the Alchemica Gallery, on the

Alkanoids website, on posters, stickers and much more. Every time one frames an illustration fantastic animations hidden behind apparently static objects can be discovered.

Country/ies: all
City/ies: Milan
Institution/Organization (e.g. museum, school, etc.):Alkanoids
Source/Website: www.ariaplatform.com,
www.alkanoids.it
www.dilium.com

5. Target group/End-users

Indicate who are the potential beneficiaries of the study case (e.g. experts of ICT, STE(A)M teachers, secondary schools' students, etc.)

Aria is adaptable technology for everyone, starting from age 12.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality technology/platform selected. Specify if upper secondary schools can integrate it into their own online environments and how. Also indicate why it is relevant for educational institutes.
Please, also specify whether it is possible to integrate the game/s developed into schools' programmes and if it is possible to customize it/them according to the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

Aria is designed by the Italian company Dilium srl Milan, it is an AR Platform built to be a reference for the augmented reality world: art, communication, adv, gaming and social. more targets can be traced on instagram @ariaplatform, @thiscover__,@alchemica_gallery and more.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR technology/platform allow to include when developing the game/s.

It is possible to adapt the platform to any STE(A)M field, in terms of visualization of graphic material.
More target info can be traced on instagram @ariaplatform, @thiscover__,@alchemica_gallery.

8. STE(A)M adaptable

In case the AR game/s could not be developed to support a specific STE(A)M field, then state how it can be adapted to be used for one or multiple of these fields.

Aria is not specially designed for STEAM education, but it can be adapted to it.

9. Company permission

Please, specify whether the AR technology/platform has access for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify) free*

10. Results

Describe which are the main results that the case study has achieved.

Students and teachers can bring their instructional graphics to life, posters, pictures and other educational materials and getting an animated layer on top.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR technology/platform for developing games selected focused on pursuing a defined educational goal? Does it have any impact on the local/national educational community (e.g. teachers, students, school as a whole, etc.)? Please, describe it.

Programming can be understood through the use of this visualization software. Fun and engagement is enhanced in any STEM or Arts class.

12. Challenges during implementation

Indicate whether there have been challenges when applying to this augmented reality technology/platform. If yes, please describe the difficulties encountered and how these have been solved (or can be solved).

No technical challenges have been reported.

13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education. Is this AR technology/platform transferable also to formal education environments and vice-versa? How?

Aria is flexible to be adopted by any context or formative environment.

Greece

Partner: HESO-Partner

1. Title of the AR technology/platform to develop games

(possibly used for educational purposes and addressed and/or applicable to STE(A)M subjects)
Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

Blippar.com

Owner: Ambarish Mitra, Omar Tayeb Steve Spencer & Jess Butcher

Country: United Kingdom (London)

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality technology/platform has been created, for what purpose and which has been its period of implementation.

The **Blippar** app is an augmented reality browser. It uses the camera on your smartphone or tablet to recognize images and real-world objects and show digital content right on top. The app was launched in 2011.

Blippar's core vision is to enhance everyday life and 'provide more from the world you see'.

3. Tags

Please choose the tags to easily categorize the augmented reality technology/platform selected.

a. Education type

Choose one option (highlighted)

- ❑ Formal education
- ❑ Informal education
- ❑ Non formal education
- ❑ Other (blippar.com has collaborated with a series of mega-brands (i.e Magnum, Nesquik, Max Factor, etc) to 'liven' their campaigns. However, the brand has extended its scope to transforming the classroom experience by bringing extra interactivity and engagement to any subject.).

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❑ Develop games for supporting innovative teaching/learning methods through stimulating and attractive didactical methods
- ❑ Develop games for teaching/learning STE(A)M subjects
- ❑ Develop games for also assessing new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Paid access** (free for educational purposes due to covid19 outbreak)
- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the "functioning" of the augmented reality technology/platform selected for developing games also indicating how many games can be developed. Specify whether an organisation/educational institute has already implemented the game/s for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). In the case of a positive sample, please specify the country/ies and city/ies the institution/organisation comes from and if the game/s is/are freely downloadable (if yes, please, quote the source/s).

Blippar.com mainly operates upon marker-based technology thus, can add extra layers in any object. Via scanning 'touchpoints', the physical things serving as markers, any potential user can unlock an AR scene. The number of scenes and/games created is up to the user.

1. *Country/ies: UK*

City/ies: London
Institution/Organization (e.g. museum, school, etc.): John Roan School for National Maritime Museum
Source/Website: https://edtechnology.co.uk/latest-news/students-create-interactive-digital-content-with-blippar

2. *Country/ies: UK*

City/ies: London
Institution/Organization (e.g. museum, school, etc.): Anson Primary School
Source/Website:
https://www.youtube.com/watch?v=ZBo6uoCogIA

3. *Country/ies: Cyprus, Greece, Finland, Estonia, Portugal*

City/ies: various
Institution/Organization (e.g. museum, school, etc.): Open University of Cyprus, European University of Cyprus (Cyprus), Doukas School, University of the Aegean (Greece), University of Helsinki (Finland), Tartu Ulikool, Tartu Erakool (Esthonia), Ingeniarius (Portugal).

Source/Website:
http://elstem.eu/

4. *Country/ies: Italy, Greece, Bulgaria, Germany, Poland, Netherlands*

City/ies: various
Institution/Organization (e.g. museum, school, etc.): ***Fachhochschule des Mittelstands FHM*** *(Germany), EFFEBI Association, Marco Polo (Italy), CCS (Greece), NART (Bulgaria), PAIZ (Poland), Niekke School (The Netherlands).*

Source/Website:
http://cultapp.eu/

5. Target group/End-users

Indicate who are the potential beneficiaries of the study case (e.g. experts of ICT, STE(A)M teachers, secondary schools' students, etc.)

Getting to know how to make the best use out of new technologies can only prove useful in terms of outreach and engagement with future generations of industry professionals and entrepreneurs. In a highly digitised world, integrating cutting edge technology into our official practices is of crucial importance to create an open dialogue with students, trainers, educators, developers, researchers, policy-makers and teachers so as to contribute to future educational approaches.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality technology/platform selected. Specify if upper secondary schools can integrate it into their own online environments and how. Also indicate why it is relevant for educational institutes.
Please also specify whether it is possible to integrate the game/s developed into schools' programmes and if it is possible to customize it/them according to the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

As briefly described in the official company website, Blippar aims to three main concepts:

1. Improve recall through:
    - Visualize complex topics
    - Create interactive learning materials
    - Quiz & test students

2. Edutainment through:
    - Learning through play
    - Add gamification

3. Experience in tech through:
    - Letting students create AR, no coding skills needed,
    - Future proof student's skill set,
    - Teaching creativity

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR technology/platform allow to include when developing the game/s.

Blippar mainly operates via marker-based technology thus, can be highly adaptable in creating links between the real and digital world. The selected technology could easily enhance the classroom experience by 'livening' images and providing a more practical understanding of scales and sizes in subjects that include yet and are not limited to; biology, chemistry, science, ecology, geography, physics, history, art classes, etc.

8. STE(A)M adaptable

In case the AR game/s could not be developed to support a specific STE(A)M field, then state how it can be adapted to be used for one or multiple of these fields.

Blippar is adaptable to every field.

9. Company permission

Please, specify whether the AR technology/platform has access for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes** only during covid19
- ❑ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

Based on the desk research implemented to select a fitting AR technology to develop games enriching the classroom experience, it became evident that AR is evolving to a crucial part of a series of sectors, amongst them, education. Several AR technologies were identified and compared to one another to conclude on their suitability for this project.

Given the highly positive feedback available with regards to Blippar employment in a number of formal and non-formal educational environments, it appears as the most suitable technology to employ for AR4STEAM project purposes as well.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR technology/platform for developing games selected focused on pursuing a defined educational goal? Does it have any impact on the local/national educational community (e.g. teachers, students, school as a whole, etc.)? Please, describe it.

Blippar.com became originally known for bringing to life commercial campaigns. AR for education though, started to gain an audience around 2016. In May 2016 Blippar visited Anson Primary School in London, putting our interactive education blipps in the hands of the school's Year 6 students. Shortly after, students at John Roan School in Greenwich created Augmented Reality promotional materials for the National Maritime Museum. Blippar was also used as a selected technology for encouraging STEM-related projects by EL-STEM (www.elstem.eu) project coordinated by the Open University of Cyprus.

Most of the available feedback is highly positive especially with regards to engaging students and triggering their curiosity. As documented by the National Maritime Museum, "using digital technologies to explore pioneering technology of the 18th century and discover how Greenwich became the world's timekeeper, this project is a great example of what Blippar can do for education through connecting students with digital content by exciting and engaging them. This is also a great example of what Blippar can do for cultural institutions (another element of the broader education strategy), turning their assets, content, their objectives and marketing materials into portals for new and more interesting content."

12. Challenges during implementation

Indicate whether there have been challenges when applying to this augmented reality technology/platform. If yes, please describe the difficulties encountered and how these have been solved (or can be solved).

Blippar has been only tested in demo mode - looking forward to working in full version and seeing its full potential.

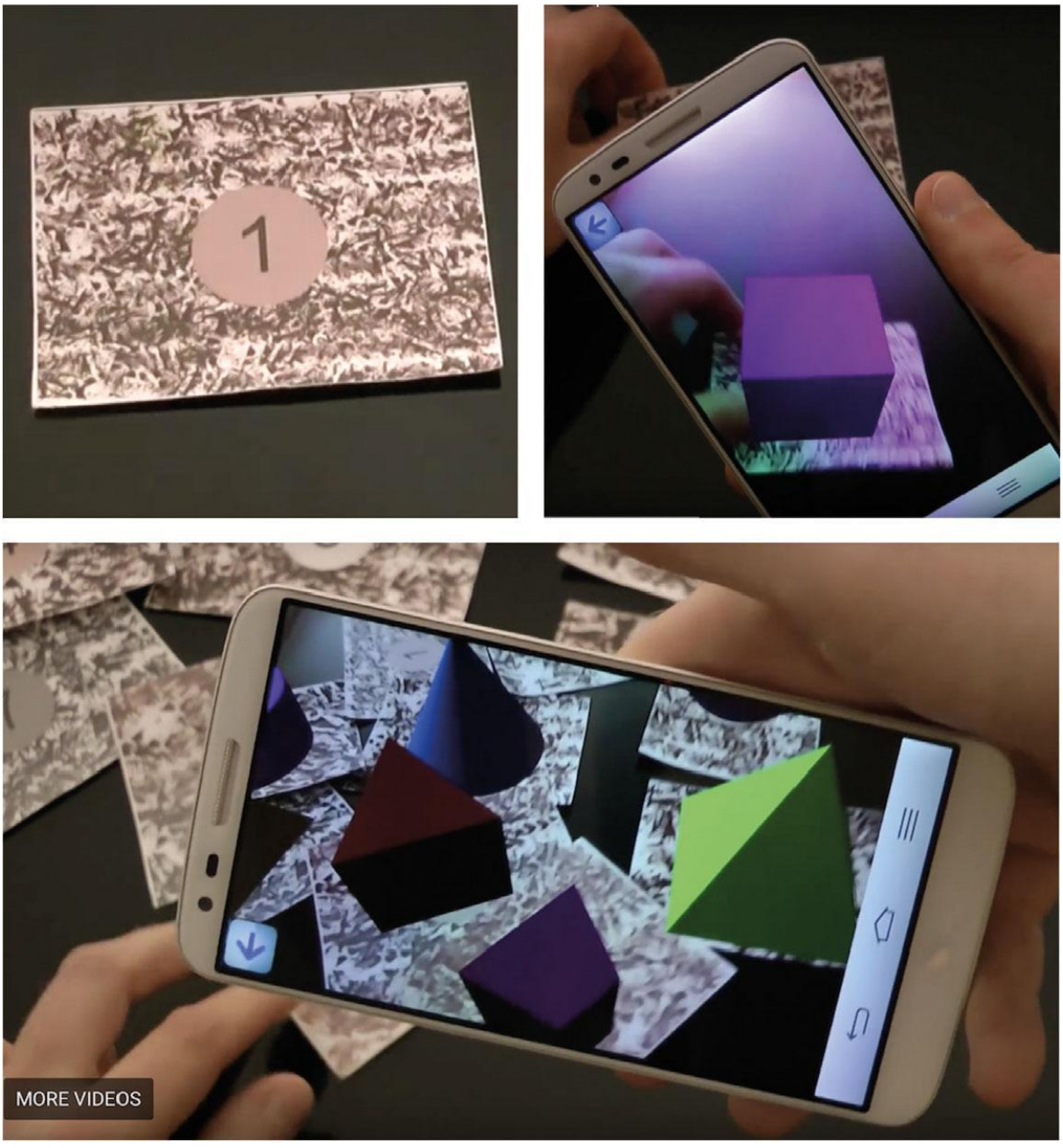
13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education. Is this AR technology/platform transferable also to formal education environments and vice-versa? How?

The selected AR technology example refers to a non-formal educational context. While its typical integration could be challenging due to its corporate origins, it could complimentarily support the official curricula and any projects related to it. Blippar has already been used for official educational purposes from several public and private institutions in selected cases.

Italy

Partner: ITT Marco Polo



1. Title of the AR technology/platform to develop games

(possibly used for educational purposes and addressed and/or applicable to STE(A)M subjects)
Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

MirageMake. The platform is developed and commercialised by the French start-up company MirageMake based in Rouen, France.

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality technology/platform has been created, for what purpose and which has been its period of implementation.

The project Mirage (**M**éthode d'**I**nclusion de la **R**éalité **A**ugmentée dans la **G**estion de l'**E**nseignement) was born in 2013 by the idea of Marc Aurélien Chardine, professor of Physics at the Lyceum Pierre Corneille in Rouen. The Mirage project consisted of creating a kind of "app store" of free augmented reality applications to be easily integrated into educational activities in line with the program of French educational system.
Since 2016, the project has become a real company, MirageMake. The platform is now accessible all over Europe and worldwide (Hong Kong, Chicago, Bangkok), although the applications are delivered only in French. The site has been enriched through the partnership with the Normandie Region, Microsoft and Sqool (a French suite dedicated to educational software). But the philosophy remains the same: everything must be done in three clicks, accessible on all devices and all platforms and at a lower cost for users.

3. Tags

Please choose the tags to easily categorize the augmented reality technology/platform selected.

a. Education type

Choose one option (highlighted)

- ❑ Formal education
- ❑ Informal education
- ❑ Non formal education
- ❑ Other (please, specify)

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❑ Develop games for supporting innovative teaching/learning methods through stimulating and attractive didactical methods

- ❑ Develop games for teaching/learning STE(A)M subjects
- ❑ Develop games for also assessing new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Paid access
- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the "functioning" of the augmented reality technology/platform selected for developing games also indicating how many games can be developed. Specify whether an organisation/educational institute has already implemented the game/s for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). In the case of a positive sample, please specify the country/ies and city/ies the institution/organisation comes from and if the game/s is/are freely downloadable (if yes, please, quote the source/s).

Country: The project is based in France.
Cities: The MirageMake and the MiniApps are available all over Europe and worldwide, potentially can be applied in every city, in Italy as well.
Institution/Organization (e.g. museum, school, etc.): Primary, Middle and Secondary Schools, Museums, private business.
Source/Website: **http://mirage.ticedu.fr/**

5. Target group/End-users

Summarize in max. 450 characters (space included) the "functioning" of the augmented reality technology/platform selected for developing games also indicating how many games can be developed. Specify whether an organisation/educational institute has already implemented the game/s for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). In the case of a positive sample, please specify the country/ies and city/ies the institution/organisation comes from and if the game/s is/are freely downloadable (if yes, please, quote the source/s).

The apps available on the Mirage platform are mostly planned for the field of education. Main users might be primary, middle and secondary schools' teachers and students that can gain benefits by learning via these apps in a gamified learning environment. The apps allow

students to level-up their competences based on their completion of allocated tasks and activities. The integration of game elements into non-game situations and scenarios via mobile apps may empower students to embrace the subject matter that goes from sciences and mathematics to arts and history.

Since at the moment the only available language is French, the applications provided through the platform could even be utilised for Italian upper secondary schools' students with CLIL (Content and Language Integrated Learning) methodology, which refers to teaching subjects such as STE(A)M disciplines through a foreign language as French.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality technology/platform selected. Specify if upper secondary schools can integrate it into their own online environments and how. Also indicate why it is relevant for educational institutes.
Please, also specify whether it is possible to integrate the game/s developed into schools' programmes and if it is possible to customize it/them according to the specific needs of the project (teach/learn STE(A)M subjects into upper secondary schools).

What if a simple sheet of paper would have a third dimension ... virtual? The Mirage Make platform project is aimed at allowing everyone to create their own augmented reality application. Mirage Make is for all those who want to increase a presentation, a working document or a project model, and particularly to the world of education, teachers or students from different school levels, who can create productions enhanced by augmented reality. This creates a motivation dynamic for students who will be able to easily produce captivating documents.
The platform Mirage offers the possibility to download a series of Mini Apps specific for different STE(A)M topics, such as chemistry, physics, maths. Those applications can function in class with no need of Internet connection.
Each application is delivered with an educational sheet intended for the teacher to highlight the points of the program addressed as well as some examples of classroom use. The documents are distributed in an editable format so that each teacher can adapt the activities.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR technology/platform allow to include when developing the game/s.

One section of the platform 'MirageMake' enables the user to download a series of Augmented Reality MiniApps dedicated to a variety of STE(A)M disciplines, specifically

Chemistry, Physics, Mathematics/Geometry, History and Geography. For example the app focusing on maths, uses card papers on which specific AR markers is associated with a geometric shape: cube, parallelepiped, cylinder, sphere, cone, pyramid, tetrahedron, 5 different prisms. These intuitive apps are mainly based on gamification and make homework sessions fun and entertaining.

8. STE(A)M adaptable

In case the AR game/s could not be developed to support a specific STE(A)M field, then state how it can be adapted to be used for one or multiple of these fields.

The APP is designed to specifically support STE(A)M fields.

9. Company permission

Please, specify whether the AR technology/platform has access for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

Mirage Make MiniApps allow you to reach several results. The most important target reached is certainly to enjoy the learning but different aims could be achieved depending on the MiniApp chosen.
For example it is possible to convert evaluation time, often troublesome for students, in a playful manner through an escape room which consists of a treasure chest that could be opened answering correctly to an educational question. Choosing a different app is possible to consult a 10.000 AR molecule library to be employed during the lesson to help students' imagination to visualize the chemistry objects. It is also possible to create your own 3D AR model for different aims (see animals or human skeletons, and so on).

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR technology/platform for developing games selected focused on

pursuing a defined educational goal? Does it have any impact on the local/national educational community (e.g. teachers, students, school as a whole, etc.)? Please, describe it.

The Augmented Reality MiniApps available on the platform in the short term aims at capturing high school students' attention and encouraging their curiosity about STE(A)M subjects through AR learning.

Students that are more motivated to explore scientific themes, that they have known through gamification, is one of the most important long term consequences. In depth knowledge could be achieved thanks to excellent basic activities that could be created through these AR experiences. As an example related to physics, students can get familiar with the law of conservation of energy through the MiniApp "Energy Roller Coaster", which guides the user throughout a simulated trip, with the calculation, in real time, of the different energy forms involved in the motion. When implemented in a wider GBL project, for instance in the simulation of the building of a workable roller coaster, this App is very appealing.
Overall, using these MiniApps can only be appreciated by teachers and students because it is a learning enabler.
Furthermore, Mirage Make is an 'open project', which brings together teachers from different educational communities, by school's level, by country (nation) and by teaching methodologies, to propose new ideas to implement the platform.

12. Challenges during implementation

Indicate whether there have been challenges when applying to this augmented reality technology/platform. If yes, please describe the difficulties encountered and how these have been solved (or can be solved).

The application is easy to use and the same is for the teacher who wants to modify the content within the app for his/her own teaching needs. The construction of GBL experiences is instead more challenging, since the ideas of AR relate to gamification; while the learning strategy must be built by the user.
Moreover, if the application wants to be used in educational systems other than the French one, it would be necessary to rethink some of the models proposed both as regard to the learning evaluation methods, and to the learning process of some scientific disciplines, in order to make them more performing from an interdisciplinary point of view.

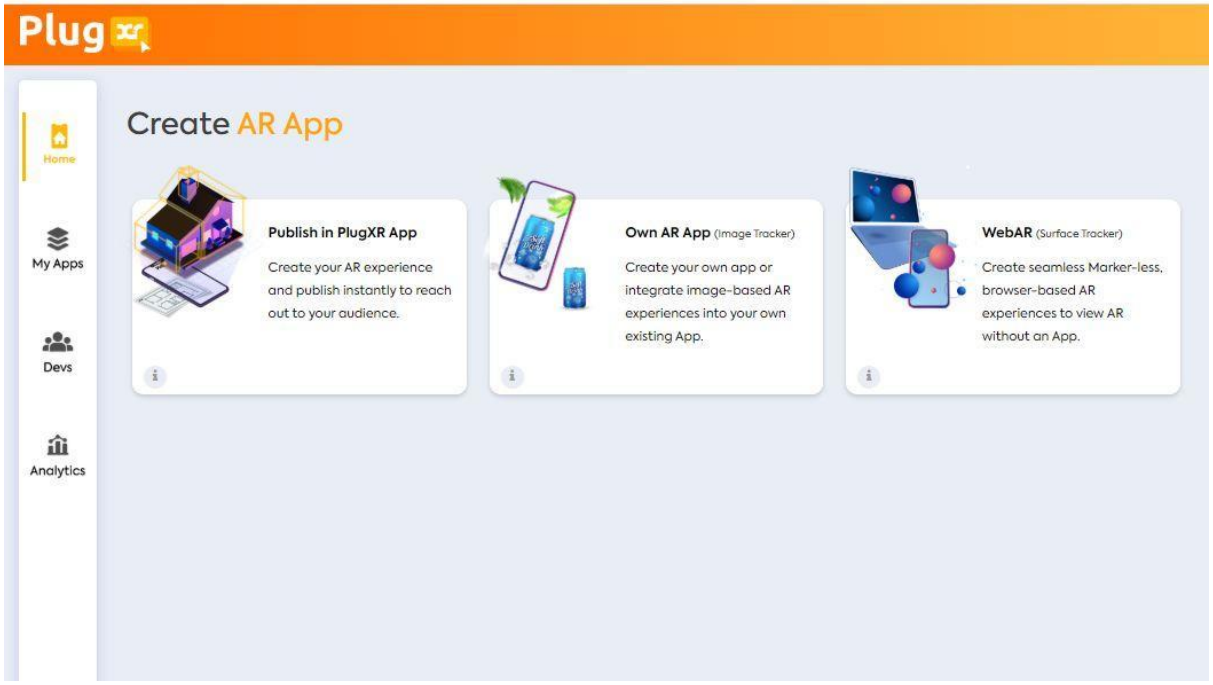
13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education. Is this AR technology/platform transferable also to formal education environments and vice-versa? How?

The applications available from the Mirage platform are designed to enhance the students learning experience both in non-formal and formal context, but generally in an educational context addressing both primary, middle and upper secondary schools' pupils. The use of smartphones is particularly widespread among children and teenagers, in Italy as well. The smartphone has become a kind of 'hands extension' for many youngsters. It could be useful and effective to teach some courses, such as Physics or Chemistry, with the support of devices as mobile phones or tablets that include augmented reality and gamification apps. Moreover, this technological approach is backed up by a pedagogical and educational point of view: indeed the 'social constructivism' philosophy, which pervades our views on learning these days, is particularly supported by the Web 4.0 tools, which help learners to become active players of their cultural growth.

Turkey

Partner: Samandira-Partner



1. Title Of The AR Technology/Platform To Develop Games

(possibly used for educational purposes and addressed and/or applicable to STE(A)M subjects)
Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

PlugXR is an easy-to-use Cloud-based Augmented Reality platform equipped with powerful features to Create & Publish advanced AR Apps and Experiences. Users publish it in WebAR or a white-labelled app on Android & iOS or in the PlugXR app with absolutely NO Coding or Dependency.

Students in K-12 grades develop games applicable to STE(A)M subjects by means of this platform which supports users an end-to-end AR experience by providing a complete solution.

Company Name: PlugXR

Country/ies: Presence in India, USA, UAE, Sweden, Canada

Industries: Augmented Reality (AR)/ Virtual reality (VR)/ Mixed Reality (MR)

Headquarters Regions: Based in Sunnyvale, California (USA)

Sales Department in Sweden

R&D Centre in Hyderabad (India).

Founded Date: 2013

Operating Status: Active

IPO Status: Private

Company Type: For Profit

Website: https://www.PlugXR.com

PlugXR Established in Silicon Valley, CA, USA

PlugXR is the collective name for the group of companies whose parent is PlugXR, Inc. (registered in USA, File number 7199524)

Contact Information

info@plugxr.com

- Facebook: https://www.facebook.com/PlugXRinc/
- Linkedin: https://www.linkedin.com/company/plugxr/
- Twitter: https://twitter.com/PlugXR

2. Timeframe: From The Development To Implementation

Please, briefly provide information on when the augmented reality technology/platform has been created, for what purpose and which has been its period of implementation.

PlugXR has created an environment where students can excel and be their best since 2013.

PlugXR augments revolutionary productive tools for every industry such as automobile, advertising & marketing, education, print & publication, travel & tourism, retail, fashion.

PlugXR aims to accelerate and expand the XR market for everyone with ZERO Coding & Dependency to create & publish XR Apps in minutes while supporting the XR Ecosystem.

PlugXR ensures students can explore their own creations in Augmented Reality (AR)/ Virtual reality (VR)/ Mixed Reality (MR) while learning essential digital skills.

3. Tags

Please choose the tags to easily categorize the augmented reality technology/platform selected.

a. Education type

Choose one option (highlighted)

- ❑ Formal education
- ❑ Informal education
- ❑ Non formal education
- ❑ Other (please, specify) / covers all types of education

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❑ Develop games for supporting innovative teaching/learning methods through stimulating and attractive didactical methods
- ❑ Develop games for teaching/learning STE(A)M subjects
- ❑ Develop games for also assessing new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Paid access
- ❑ Free access
- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area And Context Of Implementation

Summarize in max. 450 characters (space included) the "functioning" of the augmented reality technology/platform selected for developing games also indicating how many games can be developed. Specify whether an organisation/educational institute has already implemented the game/s for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). In the case of a positive sample, please specify the country/ies and city/ies the institution/organisation comes from and if the game/s is/are freely downloadable (if yes, please, quote the source/s).

Hundreds of schools in more than 50 countries around the world use PlugXR to make students future-ready with 21 century skills. Augmented Reality technology brings subjects to 3D life, thus becoming a persuasive storytelling medium set to shape the learning curve experiences helping educators enhance educational engagement amongst continuous learners, whether it is a student's classroom or a billionaire's boardroom.

The following educational institutes have already implemented the game/s for educational purposes to teach STE(A)M subjects in secondary schools.

5. Target Group/End-Users

Indicate who are the potential beneficiaries of the study case (e.g. experts of ICT, STE(A)M teachers, secondary schools' students, etc.)

All features in PlugXR can be adapted to fit different class subjects and learning objectives for students in K-12 grades.

The PlugXR Services are intended to be used by those who are 13 and over; if the user is not 13 then he/she doesn't continue to download or use the Services unless he/she expresses consent of his/her parent or guardian.

6. Description (Abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality technology/platform selected. Specify if upper secondary schools can integrate it into their own online environments and how. Also indicate why it is relevant for educational institutes.

PlugXR is a platform that will help to create detailed and immersive Augmented Reality Apps and Experiences within minutes without coding or dependency.

PlugXR supports all dimensions & verticals of AR tracking with incredibly low time and cost of development to give users an end-to-end AR experience by providing a complete solution.

What are PlugXR's market-leading features?

- No Coding Skills
- Incredibly low cost $$
- Create AR Experience in less than 5 Mins
- Create AR Mobile App in less than 1 Hr
- No Software Dependency
- Access to the project Anytime & Anywhere on Cloud-Platform
- Migrate between SDKs anytime during development

7. STE(A)M Field

Describe which is/are the STEAM field/s that the AR technology/platform allow to include when developing the game/s.

PlugXR AR technology allows students to be creative in designing an interactive world to represent science concepts by exploring scientific phenomena in 3D without coding.

Abstract physics, chemistry, maths, biology concepts and other topics in STEM classes can be so much easier to understand when represented in 3D. For ınstance, students define object properties such as mass, friction and bounciness, as well as more advanced properties like collision precision and they can create physical simulations with many factors such as velocity, acceleration and collision events.

Experiments with physics in PlugXR activate real-world physics by making objects in your scene react as they would in real life. Students can create physical simulations with many factors such as velocity, acceleration and collision events.

Experiment with chemistry in PlugXR has potential to engage, stimulate and motivate students who have problems to learn and understand the intangible concepts of chemistry. With creating active learning environment the scientific literacy of students is strengthened to move away from memory based learning

PlugXR offers many materials and tools thanks to its capability of giving ideas a shape.

One can see all shared Stem applications in the library by other members.

PlugXR inspires to create dedicated apps to teach physics, chemistry, language, gym electricity, electronics and other subjects.

8. STE(A)M Adaptable

In case the AR game/s could not be developed to support a specific STE(A)M field, then state how it can be adapted to be used for one or multiple of these fields.

PlugXR supports all STE(A)M fields and it facilitates the understanding of science and the world around us.

9. Company Permission

Please, specify whether the AR technology/platform has access for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)*: *Commercial / Noncommercial*

Commercial License allows you to create and publish the apps in the play store and app store. Non-commercial License apps cannot be published in play store or app store.

Online/Offline

- A cloud app is a Small size application that would give the end-user the flexibility to not update the app when changes are made. In offline mode, if any change is required the users need to download the whole application again. The prime advantage of this

app is that the end-users don't need the internet connection for downloading the application

SDK Details

- Enter the SDK license keys in the respective blanks to proceed with the creation of AR Experience. Guidelines to obtain license keys for SDK are given in a link on the bottom of the pop-up.

10. Results

Describe which are the main results that the case study has achieved.

The main results that the case study has achieved are listed below

First, it's a Cloud-Based Platform that will allow people to access the platform anywhere regardless of internet connection. Moreover one can add other team members to work on a project remotely.

Second, it eliminates the need of installing Android Studio, XCODE and Unity3D to get App Store & Play Store ready files.

Third, one can build an AR app by choosing any of the AR SDKs like ARCore, ARKit, Vuforia and many other SDK's (Multiple AR SDK's Support), this will allow him/her to migrate from one SDK to another SDK without losing the data.

Fourth, the platform supports All Types of Assets.

Finally, it gives the opportunity to create Complex AR Experiences including advanced interactions.

In addition to all these results achieved it provides the users with advanced Analytics & Reports.

Besides the PlugXR Twitter channel features a mix of company news and featured posts showing how educators use PlugXR around the world.

The PlugXR online forum is open to anyone looking to get support or share ideas with other educators.

Plug XR is all about expanding imagination and offering new ways to let kids express themselves and learn in a more fun and engaging manner.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR technology/platform for developing games selected focused on pursuing a defined educational goal? Does it have any impact on the local/national educational community (e.g. teachers, students, school as a whole, etc.)? Please, describe it.

PlugXR AR technology selected for developing games focuses on creativity, collaboration, critical thinking, digital literacy, and communication to prepare students with 21 Century learning skill sets.

PlugXR has a positive impact on new generation students who easily get bored and cannot focus on old traditional learning methods. Gamification in education can improve motivation and engagement. Game elements such as immediate feedback and earning badges for completing the challenges successfully are strongly influential on increasing the students' drive in engaging in these games even between the walls of a classroom.

In the long term PlugXR has a positive impact to take students from content consumers to content creators by stimulating them to learn. The brain processes information and can accommodate more new information ıf visual and auditory channels are used together to overload new data into long-term memory. Integrating and organizing new information to existing schemas in our long-term memory makes learning easier.

PlugXR becomes increasingly popular in K-12 education. Its impact on the local/national educational community about teachers, students and school as a whole to navigate using technology in the classroom in the best possible way. PlugXR supports educators, students to take the big step to implement technology in the classroom.

12. Challenges During Implementation

Indicate whether there have been challenges when applying to this augmented reality technology/platform. If yes, please describe the difficulties encountered and how these have been solved (or can be solved).

There have been no challenges when applying to this augmented reality technology. PlugXR platform runs seamlessly on devices that have at least 4GB RAM. PlugXR can be best experienced on any device with Good internet connectivity. The PlugXR platform is readily compatible with leading Operating Systems like Windows, Mac, and Ubuntu and the latest version of the above-mentioned browsers.

With the Free online converter ''PlugXR Converter'' one can convert his/her Assets (3D Models, Videos, Audio) to PlugXR Supported Format.

13. Transferability To Other Formative Contexts And Countries Across Europe

Indicate if the example refers to non-formal education. Is this AR technology/platform transferable also to formal education environments and vice-versa? How?

Learning Outcomes of the platform indicates that ıt can be easily integrated in upper secondary school's programmes and non-formal education because of ıts curricular content and the exercises to practice the STE(A)M subjects.

Netherlands

Partner: Agorà Roermond

©Wikitude

1. Title of the AR technology/platform to develop games

(possibly used for educational purposes and addressed and/or applicable to STE(A)M subjects)
Provide the full title of the augmented reality technology/platform identified.
Please, also specify the promoter and/or owner, whether it exists.

Wikitude, www.wikitude.com

2. Timeframe: from the development to implementation

Please, briefly provide information on when the augmented reality technology/platform has been created, for what purpose and which has been its period of implementation.

Wikitude is a mobile augmented reality (AR) technology provider based in Salzburg, Austria. Founded in 2008, Wikitude initially focused on providing location-based augmented reality experiences through the Wikitude World Browser App. In 2012, the company restructured its proposition by launching the Wikitude SDK, a development framework utilizing image recognition and tracking, and geolocation technologies.

The Wikitude SDK is the company's core product. First launched in October 2008, the SDK includes image recognition & tracking, 3D model rendering, video overlay, location based AR. In 2017 Wikitude launched its SLAM technology (Simultaneous Localization And Mapping) which enables object recognition and tracking, as well as markerless instant tracking.
The cross platform SDK is available for Android, iOS and Windows operating systems, being optimized as well for several smart eyewear devices.
The Wikitude app was the first publicly available application that used a location-based approach to augmented reality.

3. Tags

Please choose the tags to easily categorize the augmented reality technology/platform selected.

AR, Gamification, Object recognition, SDK

a. Education type

Choose one option (highlighted)

- ❑ Formal education
- ❑ Informal education
- ❑ Non formal education
- ❑ Mixed. Wikitude can be used in a training module, formal course, but also informal learning.

b. Aim of the selected example

You can choose more than one option (highlighted)

- ❑ Develop games for supporting innovative teaching/learning methods through stimulating and attractive didactical methods
- ❑ Develop games for teaching/learning STE(A)M subjects
- ❑ Develop games for also assessing new competences and digital skills

c. Accessibility and usage

You can choose more than one option (highlighted)

- ❑ Paid access (only when you want to publish the app)
- ❑ Free access

- ❑ Instructions/tutorial for use
- ❑ On-line assistance

4. Area and context of implementation

Summarize in max. 450 characters (space included) the "functioning" of the augmented reality technology/platform selected for developing games also indicating how many games can be developed. Specify whether an organisation/educational institute has already implemented the game/s for educational purposes (teaching and learning of STE(A)M subjects in secondary schools). In the case of a positive sample, please specify the country/ies and city/ies the institution/organisation comes from and if the game/s is/are freely downloadable (if yes, please, quote the source/s).

Wikitude can be implemented in different ways. You can use the SDK package to build your own apps in Unity. The SDK provides the next features:

Object & Scene Tracking - Recognize, track, and augment objects, rooms, and scenes.

Instant Tracking - Detect, track, and augment surfaces, no marker needed. Image Tracking - Recognize, track, and augment 2D images.

Multiple Image Targets - Augment multiple images simultaneously and interactively.

Cloud Recognition - Cloud-based image target storage for large-scale AR projects.

Geo AR - Create geo markers to augment geographical points of interest.

Cylinder Tracking - Recognize, track, and augment cylinder targets.

Multiple Object Tracking - Augment multiple objects simultaneously and interactively.

Multiple Trackers - Combine Image, Object and Positional Tracking simultaneously.

See for a complete overview: https://www.wikitude.com/products/wikitude-sdk/

Wikitude has also a second tool, named Wikitude Studio. This is an online tool to create AR without having programming skills.

Wikitude Studio is your one-stop shop for generating and managing target collections, as well as for creating and publishing AR experiences!

On the one hand, the Studio component (previously the Target Manager) was designed to optimize your projects for the Wikitude SDK and minimize effort when creating image target collections (wtc) and object target collections (wto). On the other, the integration with Studio

Editor makes it possible to quickly add augmentations to your targets, as well as to test and make AR experiences available to clients inside the Wikitude App or inside your own app built with the Wikitude SDK. See also: https://www.wikitude.com/products/studio/

Country/ies: World Wide
City/ies:
Institution/Organization (e.g. museum, school, etc.): Mixed
Source/Website: https://www.wikitude.com/showcase/

5. Target group/End-users

Indicate who are the potential beneficiaries of the study case (e.g. experts of ICT, STE(A)M teachers, secondary schools' students, etc.)

The target group is more a combination of IT experts, computer science teachers, STE(A)M teachers who are interested in AR and want to work in small groups. Students in IT and design related courses could also be included..
Wikitude studio could be as well used by users with no experiences in programming.

6. Description (abstract)

Summarize in max. 450 characters (space included) what is the aim and objectives of the augmented reality technology/platform selected. Specify if upper secondary schools can integrate it into their own online environments and how. Also indicate why it is relevant for educational institutes.

The fully in-house developed AR technology is available through its SDK, Cloud Recognition and Studio products enabling brands, agencies and developers to achieve their AR goals. With about 100,000 registered developer accounts, Wikitude has grown to be the world's leading independent AR platform. The Wikitude SDK is an integral part of more than 20,000 apps run by both small enterprises as well as many Fortune 100 companies across multiple industries. After adding 3D Tracking, allowing apps to see in rooms, spaces and environments, Wikitude's latest version launch took the technology to the next level with Object Recognition and Tracking. Wikitude® is a registered trademark of Wikitude GmbH.

7. STE(A)M field

Describe which is/are the STEAM field/s that the AR technology/platform allow to include when developing the game/s.

Wikitude can be used in all fields, because it's an SDK that would be used by example Unity (www.unity.com).
Small teams of students and teachers can work on AR projects from different disciplines. Object recognition in particular is very powerful and useful for the development of AR games. An extra feature is the possibility to use GPS coordinates for outdoor games.

8. STE(A)M adaptable

In case the AR game/s could not be developed to support a specific STE(A)M field, then state how it can be adapted to be used for one or multiple of these fields.

9. Company permission

Please, specify whether the AR technology/platform has access for (highlighted):

- ❑ Open source
- ❑ Commercial use
- ❑ Free for educational purposes
- ❑ Other *(please, specify)*

10. Results

Describe which are the main results that the case study has achieved.

Wikitude has a big community and very good online support. The SDK is easy to implement in Unity. Tutorials guide the user during its implementation.
Of course using Wikitude SDK needs some programming skills, but for most teachers in the field of computer science this is not a necessary requirement. There are almost no limits
The wikitude studio is easy to use and no programming skills are needed. Of course this also has its limitations in certain scenarios.

11. Impact

Indicate the impact that the selected example has on short and long-term (indicating also the beneficiaries). Is the AR technology/platform for developing games selected focused on pursuing a defined educational goal? Does it have any impact on the local/national educational community (e.g. teachers, students, school as a whole, etc.)? Please, describe it.

This is maybe one of the top tools in AR. Of course some skills are needed to work with this platform. Teachers who are familiar with innovative activities where IT is involved like to use these kinds of tools.

12. Challenges during implementation

Indicate whether there have been challenges when applying to this augmented reality technology/platform. If yes, please describe the difficulties encountered and how these have been solved (or can be solved).

The challenge is the time needed to learn the platform. After the level of understanding is reached, the options are unlimited. The development of the apps can be best done in small teams with members of different backgrounds in IT and design skills.

13. Transferability to other formative contexts and countries across Europe

Indicate if the example refers to non-formal education. Is this AR technology/platform transferable also to formal education environments and vice-versa? How?

A lot of tutorials are available by informal learning platforms like Youtube or Udemy. In more formal education environments lessons can be designed.

Project number: 2019-1-DE03-KA201-059708

AR4STE(A)M - Use gamification strategies and augmented reality for innovative STE(A)M learning

Annex 3

Summative Table 1: AR Games

Name of the App	ARLearn	socrative (NOT AR!)	Energy Roller Coaster	La Technosphère	SchoolAR	ARS CHIMICA Scuole Superiori	ARLOON ANATOMY	ARLOON CHEMISTRY	ARLOON GEOMETRY
Link	https://streetlearn.appspot.com/#/documentation	https://socrative.com/k-12/	http://mirage.ticedu.fr/?p=3275	http://www.technosphere.be	http://users.sch.gr/samgeorg/scholar/wordpress/	https://www.arsbook.it/v3/prodotti/view/8/ars_chimica_scuole_superiori	https://www.youtube.com/watch?v=GBoLOjSTcNE	https://www.youtube.com/watch?v=FVxFrsVe3GE	https://www.youtube.com/watch?v=5M38opfPJfs
Education type	any type	from kindergarten to K-12	secondary school students	secondary and high school	from 12+	Upper Secondary School		secondary and high school (age 13-18)	
Aim of practice	support innovative teaching methods (most: during a field trip)	asses new competences; teach/learn new innovative methods	- to raise awareness of various forms of energy , using a recording and analyzing of physical data indicated throughout the journey, to study potential energy, kinetic and mechanical, in order to produce energy transfers. - to encourage students to follow engineering professions .	to give students a better understanding of the jobs of tomorrow, arouse their interest in scientific and technological training, raising their ambition to build innovative professional projects for themselves and promising future for society	liven' the bookpage through AR technology	ARS Chimica is an educational game that supports the learning process through gamification strategies.		engage, stimulate and motivate students who have problems to learn and understand the intangible concepts of chemistry, with creating an active learning environment.	
Price free/instructions or tutorial for use / Online assistance	open and free	socrative basic for free; Socrative Pro $59.99 USD/year	free	free		€ 89,00	3,99 $	3,99 $	3,99 $

Description	Learners can use the ARLearn app to organize a field trip, exploring and annotating the real world; teacher can monitor their progress in real time; intended for organizing a field trip, but can support other serious game scenarios; Games need to be created at first, then open for a "run"	to create a more interactive classroom, the students can get assessed by e.g. Space Race quiz, classroom polls or mini competitions; see the individual answers in real time and therefor guide students specifically	The game was designed to fit into the school curriculum, respectively the physical science lessons for high school. Students are put in the position of playing mechanical engineers, who follow the evolution of kinetic, potential and mechanical energies of the roller coaster. They must make a graph according to the recorded values. Finally they decide if the roller coaster meets the safety standards and propose modifications; if these standards are not respected. clues are available to unlock them, but also a lot of useless information to force them to make the correct choice.	Through augmented reality, students travel in an interactive and cooperative game in which they perform various tests: manipulations, reflections, challenges to be met. They can find new kinds of tools to increase persistence in studies and promote success. Students become players in the game by building four wind farms as a team. The activities take place in several major stages: choice of site, assembly of a wind turbine, connection to the electricity network and maintenance. The whole activity is supervised by 2 animators who oversee the management of the group and help groups in difficulty by giving them suitable advice	The first free AR educational material to support the official curricula in Greece. Provides the opportunity to the student to interact with the book and the subjects referred to in real-time enhancing his/hers capacity to grasp a more spherical understanding of the matter.	The APP Ars Chimica, downloadable on a mobile device, must be used in connection with real 'cards' and it allows students to enjoy the content related to Chemistry exclusively through augmented reality and 3D software.	This app features 3D models with Augmented Reality for most ANATOMIC shapes.it teaches human body and make exams and give points	This app features 3D models with Augmented Reality for most CHEMISTRY shapes.it teaches elements and make exams and give points	This app features 3D models with Augmented Reality for most GEOMETRIC shapes.it teaches geometry and make exams and give points
Is it a Game?	yes	yes + assessment	yes	yes	gamified learning	Game-based learning APP	No	No	No
Gamification strategies	script simple game logic on a mobile device	quizzes	very appropriated on a mobile device or computer	A Mirage Make safe allows to diversify gamification strategies: AR with image, sound, video, 3D object and multiple choice. Available on iOS / Android mobile and PC / Mac computer	pop up features (videos, texts, visuals, etc.) act as 'triggers' through markers to 'liven' the book		Yes	Yes	Yes

Stem field	depends on the creation	adaptable	physical sciences	geology, meteorology, electrical engineering, component manufacturing, assembly, maintenance	ICT/Geology/Math	Chemistry	Science	Science	Science
Stem adaptable	yes	yes	yes	yes	yes	Yes, the company is developing the same APP for other topics like Maths, Sciences, Geometry.	Yes	Yes	Yes
Area of implementation (country, city, organization)	not clear	not clear	The game is used either individually or by classroom teachers and even school subscriptions.	this interactive game is made available to all schools for free and deployed in their own classrooms		Italy		Spain and England	
Company Permission	not clear	not clear	Created for educational activity, the game cannot be used for commercial purposes.	full permission granted to schools	downloadable	Yes; Lucana Sistemi Software House	No idea	No idea	No idea
Modifiable	yes	yes	adaptable	yes	yes	No	There is a possibility if we contact the company	There is a possibility if we contact the company	There is a possibility if we contact the company
EU Partner	DIPF	DIPF	AEDE	AEDE	HESO	ITT Marco Polo	Samandira	Samandira	Samandira
Contact	stefaan.ternier@ou.nl	https://socrative.com/contact-us/	twitter @mchardine	technosphere@provincedeliege.be	http://users.sch.gr/samgeorg/scholar/wordpress/%ce%b5%cf%80%ce%b9%ce%ba%ce%bf%ce%b9%ce%bd%cf%89%ce%bd%ce%af%ce%b1/	antonella.dercole@lucanasistemi.it	info@arloon.com	info@arloon.com	info@arloon.com

Summative Table 2: AR Technologies

Name of the Technology	Blippar Blipbuilder	Sphero Education	Wekit (Wearable Experience for Knowledge Intensive Training)	Mirage	CoSpaces Edu	Blippar	PlugXR
owner/promoter			funding by European Union's Horizon, coordinator: GFT Italia S.r.l.		creator: Delightex	blippar	PlugXR
Link	www.blippar.com		http://wekit.eu/	http://mirage.ticedu.fr/	https://cospaces.io/edu/	https://www.blippar.com/	www.PlugXR.com
education type			formal secondary school education	Primary, Middle and Upper Secondary School	adaptable to any	adaptable to any	adaptable to any
aim of practice				The Mirage Make platform project is aimed at allowing everyone to create their own augmented reality. Mirage Make is for all those who want to increase a presentation, a working document or a project model, and particularly to the world of education, teachers or students from different school levels, who can create productions enhanced by augmented reality. This creates a motivation dynamic for students who will be able to easily produce captivating documents.	teach/learn innovative methods and STE(A)M subjects	liven campaigns | educational use	Teaching
Price	free for testing but not commercial (500$ per year for education)	expensive - need to buy a robot (minimum 50€) + a course (except for one free course trial)		Free to download/Tutorial to use	Basic for free; Edu Pro for 1 month with 100 seats with Ambassadors' codes from Twitter	educators: $500 per year* [free for 3 months during covid*]	Trial Version :Free Standard Version :30$ Mon. Pro Version:79$ Month
Description	AR web based Tool			The platform Mirage offers the possibility to download a series of Mini Apps specific for different STE(A)M topics, such as chemistry, physics, maths. For example the app	building via coding an own AR environment; creating 360° pictures, games, simulations and exhibitions		PlugXR AR technology allows students to be creative in designing an interactive world to represent science concepts by exploring scientific phenomena in 3D

				focusing on maths, uses card papers on which specific AR markers are associated with a geometric shape: cube, parallelepiped, cylinder, sphere, ecc. These intuitive apps are mainly based on gamification and make homework sessions fun and entertaining.			without coding.
Platforms/programming languages	Drag and Drop or Javascript				Drag and Drop; CoBlocks (usable until grade 12, visual block-based and intuitive, similar to Scratch); for more advanced: JavaScript & TypeScript	drag and drop / marker-based	Drag and Drop Bloks
Libraries to import	Yes				works on the browser, no need to download anything or with an app	works on browser but needs the app to read the marker	Yes
Ease of use (how easy to install? Use? Run basics?)	Easy. Online				easy, online with youtube tutorials, Checklists and Descriptions	online tutorials	Easy..Only,you have to wait some hours to make APK file and download it
Learning curve (tutorials available?)	Yes, Text and Video tutorials				Yes		Yes
Area of implementation (country, city, organization)				The platform is based in France, available in French language. But it might be used all over Europe	"all around the world"	various	Many Countries (in Europe, Asia, America)
Supporting community: existing?	Online support by Blippar				Online Support by CoSpace	tutorials and tools (https://support.blippar.com/hc/en-us)	Yes: Video conference and blog pages
Company Permission				Not yet	Yes	yes via selected plan	Yes. if you are Pro User
EU Partner	HESO			ITT Marco Polo	DIPF	HESO (UK based))	Based in Sunnyvale, California (USA) Sales Department in Sweden R&D Centre in India

Project number: 2019-1-DE03-KA201-059708

AR4STE(A)M - Use gamification strategies and augmented reality for innovative STE(A)M learning

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AR4STE(A)M - Use gamification strategies and augmented reality for innovative STE(A)M learning

Annex 4:

Study on Suitable Indicators for Gamification Strategies

Table of content

Introduction to Gamification Strategies' Indicators

This paper informs on how Learning Analytics (LA) can be used to monitor the progress of students while interacting with Augmented Reality (AR) applications. First we will present some basic theories behind LA and how they fit learning design. Next, we present some indicators that we find suitable to be used for AR and gamification strategies . Then, we give a concrete example on how LA can be applied in light of AR and gamification strategies within the learning environment (i.e. secondary school education). Finally, orientation steps and solid conclusions are made.

In the context of education, AR overlays the real world with virtual content to create an immersive platform that places the trainee in a real-world context, engaging all his/her senses [1] having the potential to facilitate complex learning. In learning scenarios, AR is commonly associated with serious games and game-based learning (GBL), and also gamification strategies [2]. GBL is an effective way to learn through its immersive and engaging nature which can lead to better performance than the traditional curriculum and conventional educational methodologies.

Based on Learning Design theory, the design of learning starts with learning objectives and based on these learning objectives more specific learning events, activities and tasks can be outlined. Ultimately, the performance results of these learning activities coincide with the learning outcomes which ideally should align with the learning objectives as well.

With Learning Analytics (LA) it is possible to monitor the learning activities and make timely predictions about the learning outcomes to see if the learner is on track to achieve the learning objectives' set. Such predictions could be incidental, displaying estimations of expected dropout rates or estimations of a particular exam grade, while, on the other hand, the prediction power of LA could also be generalisable on the larger scale of estimating the overall academic achievement [3]. For example, the risk of dropping out

amongst high school students in the USA is a persistent threat each year, as around hundreds of thousands of students fail to graduate high school [3]. In turn, these dropout rates continue to have large-scale ramifications on the economy where students who fail to graduate are met with a high susceptibility to endure poverty and incarceration. In this example LA opens windows for possible early stage interventions through analyzing students' learning activities (e.g., attendance, coursework, number of detentions, etc.) and through the application of *early warning systems (indicator systems capable of identifying students who are off-track and are most likely to benefit from interventions)* [3]. Furthermore, with the help of social network analysis of students in an e-learning environment, LA is also capable of predicting learning performance by examining the on-topic dialogues that students engage in within their social groups, which as a result, promotes performance [4]. Such valuable insights on the nature of the relationship between social networks and performance mediated by *social learning (learning through observation of different perceived situations in social contexts, which eventually influence behaviour)* could be immediately considered while designing and creating a fit e-learning environment that's actually inclusive of aspects that actually work, in this case, by providing features that encourage social networking and social learning to occur in order to foster learning performance [4]. Moreover, LA in Learning Management Systems (LMS) such as Moodle (these are e-learning platforms that manage, document, and deliver courses while providing interactive features, typically used in university courses such as Moodle) shows that not only social interactive learning can foresee academic performance and achievement, but also interactive actions with the LMS does as well, for instance determining the total studying or browsing time (from login to logout) in LMS, the number of downloaded course material, as well as the regularity of a learning interval in LMS, holds a significant predictive power of academic achievement [5]. These patterns of usage deducted from LA possess valuable contributions to current and future designing of more efficient and engaging learning interfaces, that above all deliver improved performance, but are also readily tailorable to teachers' and specific events' unique learning objectives.

In the initial steps of the compendium, a preliminary needs analysis evaluating the scientifically proven advantages and benefits that these innovative pedagogical practices (i.e. AR and GBL) bring to education

has been conducted. Thereafter, the consortium developed a methodology to give an in-depth overview of the most relevant learning practices, selecting and identifying already existing examples of best practices in AR Games and technologies that have the aim to support learning STE(A)M subjects while raising the level of engagement among the students. In this last part of the compendium, Partners report on suitable indicators that allow them to monitor the students' learning process while interacting with AR and game technologies.

This is a report from a learning analytics perspective, encouraging teachers who want to design a learning activity with AR technologies on STE(A)M subjects to reflect on their pedagogical goals and on the opportunities the technology itself grants them to monitor and examine the learning process. Thus, enabling them to reflect on their teaching outcomes thereby, as well as quality assuring components of technology's usage in class.

Therefore, we add to the compendium pedagogical advice on how to utilize the technology reflecting on the aspired learning outcome and the ways to monitor it. Through a systematic review process on Learning Analytics, we identified three suitable indicators for the use of AR and game technologies for STE(A)M Learning. Next we will firstly give some thorough definitions derived from scientific literature, explaining them in further detail and later contextualize them with examples to show their application range.

Definitions of Indicators

In the context of LA indicators are the results of the analysis of one or multiple measurements of student's performance. An indicator covers a particular aspect of an abstract variable (e.g., student attention) by using relevant (measurable) items. It is taken as a way of establishing plausibility on how much a variable is met when direct measurements are not available. LA indicators can show learners' states, progress, and also provide links to relevant information about the activity outcomes from the LD.

For the specific case of AR and game elements in an educational context we consider the following indicators suitable: Game Analytics, Engagement and Affective State.

1) Game Analytics

Game Analytics is a relatively new research term, it's basic definition is - *to understand how users interact with the game systems or game elements while performing a learning task* [6].

Video games are very popular all over the world. Reports describe that over 70% of children and teenagers across the European Union, and over 90% in the United States, play video games. These games are engaging, motivational and beyond that, they push their users to always exceed their current level of performance. That prompted interest in games can also be a means of serving an educational purpose. The bottom line is to understand how games engage, motivate, push users to their performance limits, educational game analytics play an important role [7].

Game analytics is somewhat a broader term for what we intend to display in this paper. To be more specific, the term *Game analytics* entails prospects of examining digital games that have entertainment as their primary goal, but also to a certain extent, mainly in the educational realm, it is used interchangeably to describe analytics of serious games that are also digital games but are created with an intention of serious use, as in: training, education, and health care. *Serious game analytics'* main purpose is to understand how game users interact with the game systems in order to improve skills and performance in learning contexts, they obtain valuable insights on how to improve the game and the learning design and to ultimately reduce human errors [6]. For the latter to be achieved sufficient knowledge about *learning analytics ("insights and responses to real-time learning processes based on educational information from digital learning environments, administrative systems, and social platforms.")*, *game-based learning*, and *gamification (gamification borrows from the concept of game mechanics to motivate people to continue certain behaviours)* is vital [6]. For instance, gamification encourages certain behaviours through point systems, badges, or even monetary rewards, which in turn could be utilized in conjunction with digital games that

serve a predefined educational objective [6]. Hence, the analysis of game analytics for example includes the look at badges earned through educational activities, the analysis of gamification of educational activities, game-based learning analytics, the evaluation of stated learning strategies (in a game) and the predicted performance (within an educational game). These are the indicators that can be measured and can be taken into account when developing the referring technological application of the educational content.

2) Engagement

The concept of engagement deriving from psychological studies is understood as "*... a form of investment that entails time and energy devoted to a certain activity"* [8]. *It is also considered to be a multifaceted concept that involves 3 independent dimensions: behavioural,emotional, and cognitive engagement* [9]. "Behavioural engagement" manifests itself in acts of participation in academic, social or extracurricular activities. "Emotional engagement" involves positive and negative attitudes towards teachers, classmates, academics, and towards the entire school as an educational institute, which in turn could reflect on the behavioural outcomes of students. Finally, "cognitive engagement" represents a mental level of investment, or willingness to exert the effort required in understanding a complex concept and to master a difficult task. These are some of the important aspects of engagement that need to be examined when seeking to maximise students' performance and as well as minimizing their possible alienation.

Engagement of users while they interacted with digital systems like games (or serious games) and e-learning platforms became a popular research subject in recent years. And many online platforms like Massive Open Online Courses (MOOCs) are finding that beyond personal motivations students' engagement does depend to a degree on these systems' behaviour. Also many studies show that students with higher performance do engage more with such systems [10]. For example, making such systems interactive and more socially promoting to student-teacher relationships will result in more stimulated students and thus enhancing performance [11]. For that reason, engagement is a suitable indicator for successful gamification strategies.

3) Affective State

Affective state refers to a person's emotions in a certain situation, however, including also the person's mood and the general attitude in the situative environment. Therefore, the reviewed literature differentiates between 2 types of affective states of students within learning contexts - *the incidental and the integral affect. Incidental affect refers to emotions that are induced from a source indirectly related to the task at hand (e.g., class atmosphere, mood), while Integral affect refers to emotions generated by the actual task at hand (e.g., a reasoning task, educational game)* [12].

Nonetheless, a particular affective state is capable of altering students' emotional engagement which in turn affects their performance. The literature further indicates that an affect-adaptive e-learning system is a significant indicator of better academic performance [13, 14], in other words interactive learning systems that take the affective state of its users into consideration yields better learning results than non-personalized systems. For instance, while *keystrokes (the amount and time of typing keyboard characters while working on PCs)*, among other variables, was a reliable predictor of affective state during 'writing' tasks [13]. Personalized feedback systems that adapt to the affective states of students made them less bored and they were less off-task. These affect-adaptive feedback systems are shown to be most helpful for students that experience on-task confusion or frustration [14]. Analysis of the affective state of students is therefore an effective tool to measure the success factors for a gamified learning activity, as well.

Furthermore, in order to get a more in-depth understanding of the three conceptual indicators, the Indicator Matrix assembled along with this report (see Annex 5 below) will support brainstorming (see Checklist below) and selection of activities for teachers, while still considering all relevant sub-indications in the sketch of a gamified teaching and a learning activity in STE(A)M classes.

Areas of Application & Educational Relevance

Application Examples of Game Analytics Indicators

Examples of Game Analytics Indicators can be found in studies where the authors use game elements like badges earned within a specific learning task [15] or game-based quizzes [16] to motivate and increase the learner's engagement. Hence, the monitoring of the activity is done by tracking quiz points, the number of attempts to solve questions, the number of incorrect attempts, and the number of total attempts. Others used an interactive computer-based game to collect data and they use the collected data to predict the learning outcomes/strategies and performance [17]. Hence, numeric data collection and the resulting statistics are an output of game analytics and can be used to learn about the success of the learning activities as well as for the prediction of learning outcomes and strategies of performance.

Application Examples of Affective State Indicators

In the literature the authors used different techniques to measure the affective state [13, 14, 18, 19, 20]. In these studies, the writing behaviour of the learners is monitored to give insights into their affective state, which can be complemented with surveys for instance. Therefore, the affective state of a student while performing a task, such as writing an essay is measured with data driven text analysis, where the researchers use text analysis, where they track the total number of keystrokes, number of keystrokes per essay, number of backspaces per essay, the longest time between keystrokes per essay, the smallest time between keystrokes per essay, the mean keystroke latency, the median keystroke latency, initial pauses before writing an essay, and the number of pauses above 0.5 seconds/1 second/1.5 seconds/2 seconds/3 seconds to measure affective state [13].

Application Examples of Engagement Indicators

There are multiple studies for measuring the engagement of the learner using different measurements and metrics [21, 22, 23, 10, 24, 25]. One study for example measures the learning achievements in relation to the time used and the average achievement of the particular learning activity to come to a conclusion about the engagement of the learners. Therefore, that study uses the average grade, the average time spent on assignments relative to the class average, the percent of assignments submitted, the percent of assignments submitted late, the percent of assignments submitted on time, the percent of assignments not submitted, the

days since the last submission, and the submission time relative to the due date to measure engagement and disengagement of students [15].

Hence, we can see that different learning activities have different pedagogical objectives and sub-objectives and hence also different game strategies that need to be adopted to them. The monitoring of the game elements and strategies therefore needs to be set up according to these goals at the same time as designing the learning activity in order to be able to measure specific learning outcomes of AR and game technologies in STE(A)M classes. We cannot provide a general approach or example since the interdependence of these preliminary considerations of the teacher determine the success of the design, implementation and learning outcome of the pedagogical learning activity thereby. It is therefore important to conciliate the general intention to teach and learn something in a playful way with the previously brainstormed idea about the content of the lesson in the context of the curriculum and the chosen strategy of gamification in the activity as well as its monitoring with the suiting indicators, as explained above.

Depending on the content of a class that is supposed to be made more fun and engaging, the game and gamification setting can be chosen according to the goals set by the teacher for this particular learning scenario. To illustrate how AR can be used to achieve such a pedagogical goal, we will describe the following example from the Compendium of AR Games Selection:

The ARLearn App - A field trip in biology class learning how photosynthesis works

ARLearn is a tool which suits educators and learners supporting different phases and activities during a didactical “field trip”. Learners can use augmented reality clients on their mobile phones to explore and annotate real world field trips outside in the school gardens, where educational sites such as plants are selected by the teacher as sites of interactive learning with the mobile devices. These plans are used in the app when scanning the plant with the camera of the mobile phone or synchronized with their current location. The Kids scan the plant to access the AR learning content that pops up on their mobile phones.

Now, they will have to perform tasks on the application which can be a questionnaire, a quiz, a drawing exercise or else in a chronological order and they will hence learn about the different phases of photosynthesis, while their teachers can monitor their classes progress in real time via the app. The gamification strategy for the chronological field trip through the phases of photosynthesis could be a strategy to enhance the engagement and motivation of the learners. Hence, the indicator to be measured could be the engagement and disengagement of the learners thereby. It could look like this: When starting the trip, all students have "3 lives". They all need to solve 5 mandatory tasks which they all have to pass, keeping their lives or losing them, but there are two bonus tasks. When they solve these bonus tasks, they can get batches or an extra life or however the teachers want to reward the 2 extra tasks. Like this, some progress indicators are generated through the monitoring of what the students have done so far during the field trip activity, how they solve the tasks looking at the success and failure of each task, the number of badges earned, the number of lives lost, the time of the completion and hence also the prediction which students will complete the trip and which tasks on average were the most successful or least successful ones, where they had hurdles and disengagements along the trip. So, the app and an installed learning analytics function can help the teacher to improve his or her use of AR and game technology in class. Through monitoring functions, teachers can keep track of their students' progress, maybe also their strengths and weaknesses in case the badges are somehow grouped in content categories and they get an overall view on the potential to engage students or disengage them with the gamified learning activity they designed. It becomes thus clear that teachers have to invest time in creating the gamified content and the monitoring to achieve the aspired pedagogical goals. The success of a game created by the teachers therefore highly depends on the effort and creativity of the teacher.

Conclusion

The combination of AR and Gamification paves a solid way to create and enhance learning environments as well as learning experiences that are adaptable to the current technological era, yet still being inclusive of individual engagement levels and affective states of students. Enhancing learning in STE(A)M courses through the integration of Augmented Reality (AR), gamification strategies are now more than ever

applicable and furthermore customizable to learning objectives set by teachers as well as to each student's level of performance. Setting learning objectives is the first step for teachers to be involved in the designing of these educating engaging games. Furthermore, to achieve better performance outcomes through these games concrete gamification strategies are needed. To do so, borrowing performance predictors from the realm of LA and borrowing gamification features from the realm of Game Analytics, that enable teachers and students to establish enhanced pedagogical experience, are central.

This final report's main purpose is to provide teachers with a progressive overview of basically how AR and gamification strategies can be coupled with LA to provide indicators and thus interventions that target the enhancement of student engagement on all three levels (behavioural, emotional, & cognitive) while also considering their differential affective state with a customizable tendency. This in turn has the potential to transform the average classroom nowadays by adapting to the current technologically-coloured generations. The examples presented in the document aim to help teachers to understand how LA can be used in the context of AR and gamification to provide teachers with information that helps to assess and predict the performance of the students. Therefore, enabling teachers to evaluate their predefined pedagogical objectives of their STE(A)M class. Furthermore, the crucial elaboration of basic terms in this report could represent a valid starting point for teachers training programs on the subject of enhancing pedagogy in classrooms with the utilization of AR technologies and gamification strategies. Finally, this report's content will be exemplified and further explained in IO2, the "Online Teacher Training Programme" where teachers will be supported in designing their own learning activities using gamification strategies and AR technologies in STE(A)M class.

Conclusive Checklist

We have seen there are many creative ways to create gamified learning content STE(A)M classes. After collecting ideas of how to implement AR and/or gamification strategies into one's own teaching, the following check-list of key questions shall help to create a schedule and process map for designing a learning activity of one's own. It should be the basis for the teacher to start developing a learning activity with answering a few preliminary questions that will need to be elaborated in the process:

- What content do I want to learn in a playful setting (learning outcome)?
- What are the related goals of the activity? The short-term goals and the overarching ones within which the activity is placed in the planned curriculum?
- What is the concrete gamification strategy applied to reach these goals?
- What is the content that needs to be generated (output)?
- How long shall the exercise be? Will it be a continuous learning experience or single-result activity? (duration)
- What means of support will I need to first prepare and design, then to execute and lastly to monitor the activity in class with the indicators identified for my learning activity?

Please see Annex 5 in the following for the Indicator Matrix to plan the activity and how to monitor it as well to reach the educational goal of the activity drawing on technical feedback support.

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Annex 5

Indicator Matrix for Monitoring Gamified Learning Activities

Indicators	**Game Analytics**	**Implementation**
Badges earned [15]	As a rewarding and an orientation system (each badge has a set of criteria that must be accomplished in order for a student to earn it)	Displayed on dashboards within Learning Management Systems(LMS)
Gamification [16]	Usage of visual effects/feedback (for current progressing performance)	Puzzle-based game model integrated in a location-based learning activity
Learning strategy (Game) [17]	Log file data mining shows that learning strategies that explore one game rule at a time yields the most successful outcomes.	TugLet: a tug of war game that teaches weight estimation and problem-solving strategies (applicable on similar games)
Predict performance (Game) [17]	-Probabilistic models of strategies, improve the detection of `shallow' learning -Analysis of student performance within game predicts out of game performance (implicit knowledge transfer)	Tuglet (applicable on similar games)
	Engagement Measure	**Implementation**
Engagement and disengagement (Multimodal) [21]	Multimodal sensors: -Xbox kinect (skeletal tracking) -High definition web camera (positioned overhead)	In an engineering design task
Engagement and disengagement [21]	Generalized classifier	For identifying disengagement in online learning tools (e.g., MOOCs,Connect)

Engagement [10]	IP Address	Evaluation of engagement in an online educational system
Long term engagement [24]	Counts of posts, post views, and video lectures played or downloaded.	With the help of exponential random graph models (ERGMs) in MOOcs
Measure engagement [25]	Quantifying 'Engagement': -Peak on day hour intra-day -Peak on week day intra-week -Weeks similarity measure 1 -Weeks similarity measure 2 -Weeks similarity measure 3 -Periodicity of day hour -Periodicity of week hour -Periodicity of week day -Delay in lecture view ***see appendix I**	In MOOCs (also applicable outside of MOOCs context)
Keystroke analytics [26]	Javascript keyboard events: -Keystrokes timing	Custom-built platform (also applicable on other platforms like Moodle)
Clickstream analysis [27]	-Preview Event (file views or downloads before the event start date) -Review Event (file views or downloads after the event end date)	Canvas learning management system (clickstream recordings)
	Affective State	**Implementation**
Affective state [13]	-Individual differences (e.g., literacy skills cognitive ability) -Keystroke analysis (e.g., total number of keystrokes, number of keystrokes per essay, number of backspaces per essay, the longest time between keystrokes per essay, the smallest time between keystrokes per essay etc.)	In writing tasks
Self-reported affective state [18]	Used as input for visualising affective states on dashboards (promoting emotional awareness during learning)	Hidden Markov Models (self reports train the HMMs, which in turn infer future emotions)
Measure a fixed mindset [20]	Usage of self reports (Being a math person or not) and online learning system data to identify students with a negative mindset	Within a LMS (preferably at the beginning of the

		course for early identification)
Measure belonging uncertainty [20]	Usage of self reports (feeling of belonging or not to the school/class) and online learning system data to identify students with belonging uncertainty	Within LMS (preferably after a while of being enrolled in course for a sense of belonging to build up)
Measure stereotype threat (Questionnaires) [20]	Usage of self reports (others at school would be surprised or not if they succeed) and online learning system data to identify students with a negative stereotype image.	Within a LMS (preferably at the beginning of the course for early identification)

Appendix I

Table 1: Regularity patterns in time domain

ID	Description
P1	Studying on certain hours of the day.
P2	Studying on certain day(s) of the week.
P3	Studying on similar weekdays, over weeks of the course.
P4	Same distribution of study time among weekdays, over weeks of the course.
P5	Particular amount of study time on each weekday, over weeks of the course.
P6	Following the schedule of the course.

Table 2: Regularity measures and corresponding regularity patterns

Measure	Description	Dimension	Pattern
PDH	Peak on day hour	intra-day	P1
PWD	Peak on week day	intra-week	P2
WS1	Weeks similarity measure 1	intra-week	P3
WS2	Weeks similarity measure 2	intra-week	P4
WS3	Weeks similarity measure 3	intra-week	P5
FDH	Periodicity of day hour	intra-day	P1
FWH	Periodicity of week hour	intra-week	P1
FWD	Periodicity of week day	intra-week	P2, P3
DLV	Delay in lecture view	intra-course	P6

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AR4STE(A)M - Use gamification strategies and augmented reality for innovative STE(A)M learning