Executive Summary Of The Compendium

AR4STE(A)M

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- **Preface**

The first intellectual output of this project includes the design of a 'Compendium of gamification strategies based on Augmented Reality for STE(A)M learning' in a digital format, that aims to identify and collect the most relevant learning practices in 6 EU countries (Belgium, Germany, Greece, Italy, Netherlands, & Turkey). These examples act as catalyst instruments for enhancing enjoyment during STE(A)M class lessons as well as raising the level of engagement among students.

This executive summary of the Compendium is developed in order to give a general overview of the compendium that aims to disseminate 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 programmes. Additional details regarding the methodologies applied and the results achieved, are also included
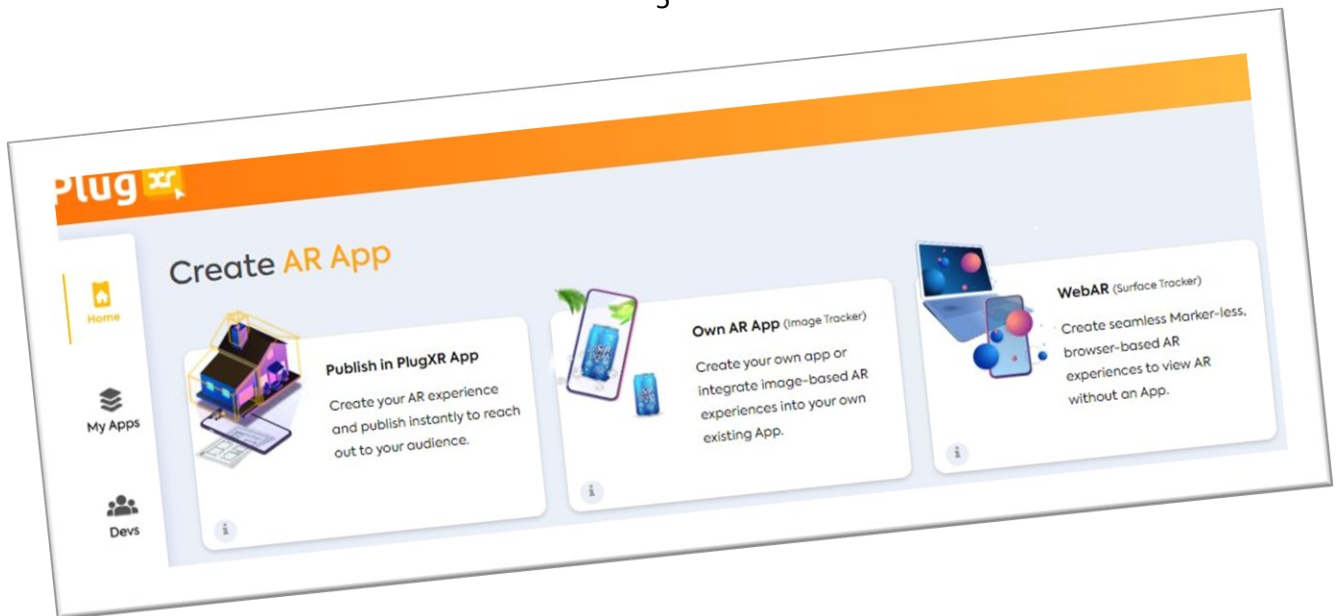
This publication is divided into three chapters. The introductory chapter presents the general and specific objectives of the project; the second chapter is dedicated to highlight the most important definitions regarding AR; the third and final one represents the 'heart' of the compendium, as it describes the AR-based games and the AR technologies used for developing game-based learning activities, which are collected from the 6 EU-Partner countries.

- **Project Objectives**

- The 30-months project titled "AR4STE(A)M" is a project that uses Gamification Strategies and Augmented Reality For Innovative STE(A)M Learning and is co-funded by the Erasmus+ Programme.

- The overall aim of the project is to raise awareness about the importance of choosing STE(A)M studies for pursuing successful STE(A)M careers. In particular, the project wants to encourage secondary schools to integrate immersive technologies and game-based learning in their curricula. Furthermore, the project seeks to foster teachers' capacity to teach STE(A)M effectively, by the creation of engaging trainings, based on ICT (Information & Communication Technologies) during their STE(A)M lessons.

- The project envisages to strengthen the link between science education and creativity through providing upper secondary schools with immersive technologies (Augmented Reality) for teaching and learning STE(A)M, thus providing quality access and opportunities to a huge mass of students to perform experiments and practice their skills in a collaborative and risk-free learning environment.

- **Compendium of gamification strategies based on Augmented Reality for STE(A)M learning**

- At the very beginning of the project the Consortium set up a methodology for the identification and collection of examples of AR games and AR technologies used to develop games that could be integrated in upper secondary schools' programmes. This was carried out according to some quality criteria defined on the basis of the need analysis conducted at the proposal stage.

- The practices selected represent a starting point for school teachers in using innovative ICT technologies during their STE(A)M lessons in order to overcome and improve the traditional method of teaching and learning in class and to increase students' motivation "learning by playing".

AR Game and AR Technology selection criteria accepted by all project partners:

✔ **End users:** AR games and AR technologies to develop games 'easy to use' for secondary school 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 *that serve* 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 in EU**

- **The Most Important Definitions Regarding the AR**

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 is computer-mediated, but it is 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 within games that make those games fun and motivating for players to continue playing. All while using those same elements in a non-game context in order 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 to as technologies designed to support the creation of Augmented Reality Applications.

- **Selected AR Application List**

PARTNER NAME	APPLICATION NAME	SHORT EXPLANATION	LINK
Dipf Leibniz-Institut für Bildungsforschung und Bildungsinformation	ARLearn	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.	https://arlearn-eu.appspot.com/#/ https://www.ou.nl/youplay
Agora Roermond - Stichting Onderwijs Midden Limburg	WWF Free Rivers	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.	https://www.worldwildlife.org/pages/explore-wwf-free-rivers-a-new-augmented-reality-app
Association Européenne Des Enseignants	Energy Roller Coaster	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.	http://mirage.ticedu.fr/
Istituto Tecnico Per Il Turismo Marco Polo	Ars Chimica	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.	www.arsbook.it
Samandira Mesleki Ve Teknik Anadolu Lisesi	Arloon	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.	http://www.arloon.com/
Finance & Banking, Associazione Per Lo Sviluppo Organizzativo E Delle Risorse Umane	Ars Chimica	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.	www.arsbook.it
Hearthands Solutions Limited	SchoolAR	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.	http://www.schoolar.gr https://play.google.com/store/apps/details?id=com.Samgeorg.GymAR&hl=en_US

- **Selected AR Tecnologies List**

PARTNER NAME	TECHNOLOGY NAME	SHORT EXPLANATION	LINK
Dipf Leibniz-Institut für Bildungsforschung und Bildungsinformation	Cospace Edu	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.	https://cospaces.io/edu/
Agora Roermond - Stichting Onderwijs Midden Limburg	Wikitude	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.	www.wikitude.com
Association Européenne Des Enseignants	Aria AR	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.	www.ariaplatform.com
Istituto Tecnico Per Il Turismo Marco Polo	MirageMake	The MirageMake platform project is aimed at allowing everyone to create their own augmented reality application. MirageMake 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.	http://mirage.ticedu.fr/

Samandira Mesleki Ve Teknik Anadolu Lisesi	PlugXR	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.	https://www.PlugXR.com
Finance & Banking, Associazione Per Lo Sviluppo Organizzativo E Delle Risorse Umane	MirageMake	The MirageMake platform project is aimed at allowing everyone to create their own augmented reality application. MirageMake 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.	http://mirage.ticedu.fr/
Hearthands Solutions Limited	Blippar	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	www.blippar.com

- ## Suitable Indicators for Gamification Strategies

Enhancing learning in STEAM courses through the integration of Augmented Reality (AR), gamification strategies are now more than ever applicable and furthermore personalizable 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 Learning Analytics (LA) and borrowing gamification features from the realm of Game Analytics (GA), are central to enable teachers and students to establish enhanced pedagogical experience.

Hence, we add on to the compendium a 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 identify three suitable indicators for the use of AR and game technologies for STE(A)M Learning. These indicators are: Game Analytics, Engagement, and Affective State. After some preliminary definitions derived from scientific literature, we contextualize them with examples to show their application range and give practical advice on how to use them

- ## Final Words

Compendium of gamification strategies based on Augmented Reality for STE(A)M learning is exactly for those who are engaged in promoting the use of AR and gamification techniques in STE(A)M curriculums. The use of AR and gamification techniques in STE(A)M curriculums empower students to pursue a career path related to STE(A)M studies with the guidance of enthusiastic teachers who are motivating students to actively participate in STE(A)M lessons and activities.

This compendium invites you to immerse into AR applications and AR platforms to get what you exactly need. For a more interactive and effective teaching while enjoying themselves It showcases the integration of immersive technologies and game-based learning in AR applications and platforms.

The selection of both existing AR games and AR technologies to develop game-based learning activities for innovative STE(A)M learning this Compendium is designed in a practical manner so that to allow for easy consultation by different stakeholders: Associated Partners, school staff, teachers, students, NGOs, educational organizations, Universities (departments of engineer, science, art, ICT, etc.), business sector, research institutes, public authorities, policy makers, etc.

The analysis of the existing Augmented Reality (AR) games and AR technologies, that have been contributed to game-based learning (GBL) activities for STE(A)M learning in upper secondary schools programmes will be the basis for an online teacher training program. Online training programme for school teachers in secondary education, aiming at providing them with the necessary skills and competences in order to learn how to use AR based gamified approaches when teaching STE(A)M.

This executive summary of the Compendium is designed for the users, in particular, for teachers involved in the training programme and for those students engaged in the STE(A)M laboratories.

6 European countries bring together 6 selected and collected AR applications and 6 AR platforms to be ready to meet the EU requirements to acquire new competences and digital skills for all students, teachers and educational organizations.

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