An Innovative Augmented Reality Educational Platform Using Gamification to Enhance Lifelong Learning and Cultural Education.

Chantzi Athanasia Eleftheria, Plessa Charikleia, Chatziparadeisis Gkanas Iason, Tsakalidis Athanasios
Department of Computer Engineering and Informatics
University of Patras
Patras, Greece
{chantzi, plessa, chatzipara, tsak}@ceid.upatras.gr

Tsolis Dimitrios
Cultural Heritage Management and New Technologies Department
University of Western Greece
Agrinio, Greece
tsolis@upatras.gr

***Abstract*-This paper proves that Life-long learning and Cultural Education can be supported through the use of technological advances and techniques which so far were extensively used in Games and immersive applications. In order to promote learning, this research proposal focuses on Augmented Reality (AR) and on Gamification for the creation of an educational AR book. The suggested learning subject is Science aimed at children between the ages of 10-12 years old, although the platform can be easily applied also to Culture, Arts and History. In our project, users interact with a virtual laboratory and are able to perform experiments and complete challenges through gaming so as to expand and test their knowledge. Using AR and gamification techniques, the aim is to deliver a more comprehensive understanding of the subject matter while at the same time engage learners and increase their enjoyment during the learning process. By engaging learners in cultural subjects, the cultural heritage is delivered to next generations and remains alive.**

Keywords-Augmented Reality; gamification; education; culture; e-learning; AR book; engagement

I. INTRODUCTION

The evolution of technology has affected the way people perceive many aspects of their lives, including the way they learn. Since learners have constant exposure to a variety of immersive technologies, the role of the educational process becomes more challenging and learning environments, such as classrooms or museums in their traditional form, fail to engage and motivate them.

Further more efficient feedback and fastest assessment during the learning process are required, as well as the ability for learners to work at their own pace, without losing the element of interactivity and personalized education. The introduction of technology in education and e-learning are not meant to substitute live tutors and classrooms but instead enhance the educational process and become an essential supporting component. Two significant, upcoming technological concepts that can serve these purposes are Augmented Reality (AR) and Gamification.

II. AUGMENTED REALITY AND GAMIFICATION THEORY AND TECHNIQUES

A. Augmented Reality

Augmented reality (AR) is a live, direct or indirect, view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as audio or visual content, as well as GPS data. With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the real world surroundings of the user becomes interactive and digitally manageable. Artificial information about the environment and its objects can be overlaid on the real world [1, 15].

B. Augmented Reality in Education and Culture

Augmented reality applications can complement a standard curriculum or the way people get informed about cultural matters. Text, graphics, video and audio can be superimposed into a student's real time environment. Textbooks and other teaching reading material can contain embedded “markers” that, when scanned by an AR device, produce supplementary information to the learner rendered in a multimedia format. Learners can participate interactively with computer generated simulations of various events, exploring and learning each significant detail of the event. AR can give learners a more comprehensive understanding of the subject matter, since it allows them to visualize the spatial structure of a complex model by virtually interacting with it, at minimal cost and zero health risk. Augmented reality technology also permits learning via remote collaboration, since learner and instructors at different locations can share a common virtual learning environment populated by virtual objects and learning materials that they can use to interact with one another within that setting [16].

C. Gamification

Gamification is the use of game thinking, game mechanics, game dynamics and frameworks in a non-game context in order to engage users, solve problems, improve

user experience, and promote desired behaviors [16, 8].This can be achieved by using techniques from the fields of psychology and game design. It is used to improve, timelines and learning [16]. Gamification has found its way into domains like marketing, politics, health, fitness [8], market research, business management and education, with analysts predicting that it will become a multi-billion dollar industry by 2015.

D. Gamification in Education and Culture

Gamification techniques leverage people's natural desires for competition, achievement, status, self-expression, altruism, and closure [16]. A core strategy for gamifying is to provide rewards to players for accomplishing desired tasks. Types of rewards include points, achievement badges or levels [6] the filling of a progress bar, unlocking bonus content/higher levels, and providing the user with virtual currency [6]. Competition is another element of games that can be used in gamification. Making the rewards for accomplishing tasks visible to other players or providing leader boards are ways of encouraging players to compete [10]. Another approach to gamification is making existing tasks feel more like games. Some techniques used in this approach include adding meaningful choice, onboarding with a tutorial, increasing challenge [9] and adding narrative [16].

When gamifying any task, a designer's goal is to guide the user in a state called "flow". Flow is a psychology concept introduced by Mihaly Csikszentmihalyi in 1975 described as "the satisfying, exhilarating feeling of creative accomplishment and heightened functioning" [4]. In order to achieve a state of flow, the user's skill must be approximately equal to the challenge offered by the task. A challenge level that exceeds the user's skills results in a state of anxiety, causing them to quit whereas the opposite leads them to a state of boredom and fails to engage them. According to the "Flow Theory", people learn in eight different dimensions (See Fig.1). Those dimensions are:

1. Clear goals or immediate feedback, which is when students understand why they are learning what the subject matter.
2. Equilibrium between challenge and personal skill. Learners should be challenged in accordance to their skill level. When both skill and challenge are at the desired level, the student's productivity is maximized.
3. Merging of action and awareness. Learners need to be involved and aware of what they are doing to achieve involvement.
4. Focused attention. Learners need to be focused while they are learning and should not be distracted, otherwise the optimal learning level is gone.
5. Control. When students feel that they are in control, they are motivated to learn.
6. Loss of self consciousness. Learners need to be able to not worry about themselves and overcome their boundaries.
7. Time distortion. Engaging learners in an activity is the key to time distortion. Once they are engaged fully, time will seem to pass very quickly while involved in the activity at hand.
8. Self rewarding. Learners need to be intrinsically motivated and in order to achieve this, teachers need to stay away from extrinsic rewards as much as possible.

The optimal area to be learning is the flow area. There are two other areas that could also be considered optimal or ideal areas and those are:

- Arousal: It is the area that most people learn from. The learners are pushed beyond the comfort zone of their skill, however they are challenged enough to be learning at an idea level.
- Control: It is the area where learners have a high level of skill so they feel comfortable. However, they are not being challenged enough. People learn in this area but could be challenged more.

An important aspect of game design that has to be taken into consideration when gamifying a task, is Richard Bartle's theory [2] which categorizes players in 4 types, according to the way they interact within a game's environment. These types of players are:

- Achievers: Players that view the game as a challenge they must overcome.
- Explorers: Players that are interested in experiencing every facet of the game and discover all of the game's secrets.
- Socializers: Players view the game and its objective as a catalyst for social interactions.
- Killers: Players that derive enjoyment from defeating other players.

It is important to notice that these types are mutually inclusive, meaning a player can display characteristics from all types at the same time [7, 13].

Gamifying education and culture can be beneficial for both learners and teachers. By adding game elements, such as rewards, leaderboards etc, in a syllabus the learning process can become a more joyful experience [7]. Learners can be more motivated to explore and study subjects that otherwise would be unattractive, or seem difficult to them. Instead of passively learning by reading text or attending lectures, learners are actively participating in the learning procedure. The gamified experience increases learners' awareness by providing additional information and by putting them in scenarios that will make them do and understand things which in a traditional or normal computer based training may be 'tuned out' [20]. From a tutor's perspective, adding interactivity to course or any teaching procedure and creating a spirit of healthy competition, keeps learners more engaged and increases their productivity. Also, by receiving constant feedback from their learners, educators can track and report their progress in order to more efficiently tailor their courses to meet the specific needs of both their audience and each individual learner. Gamification gives a more dynamic character to education and promotes lifelong learning [8].

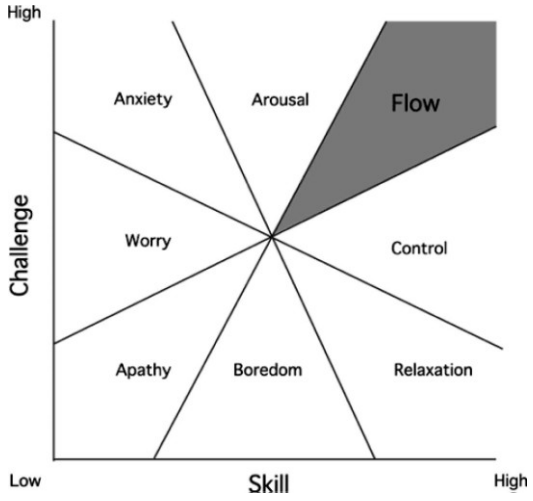

Figure 1. The Flow Diagram

III. STATE OF THE ART RESEARCH

An attempt to bring Augmented Reality in education was made by the Augmented Reality Development Lab (ARDL) in their website [14]. This website provides a variety of AR markers that contain virtual objects relevant to a multitude of courses. Through the use of these markers students can better visualize their subject matter and gain a more complete understanding of their lessons. This project is similar to our own in its use of AR, however it is not in the form of an AR book and it does not contain any gamification elements that would contribute to make the educational process more fun.

In the field of culture, a remarkable attempt of an AR book is "PARIS, The Great Saga", written by Didier Busson [3]. It is an AR book tracing back the history of the City of Lights from prehistoric times to the present day, as seen from urban, sociological, political, economic and cultural perspectives. Another noticeable effort is the AR book "Die kelten - Eine lebendige geschichte" by Marius Hügli and Martin Kovacovsky [17]. The book was specially made for a permanent archaeological exhibition of the Museum zu Allerheiligen in Schaffhausen (Switzerland) and involves Celtic culture. User learns about Celtic history, art, living and warfare. The AR events range from informative motion graphics to complex interactions, such as conducting an archeological dig. Both of the books are very well structured but do not include any gamification elements.

One of the few empirical researches on the subject of Gamification is the master's thesis "Game mechanic based e-learning" [5]. This project involved the creation of a web platform for a gamified e-learning experience where students created and answered questions as an alternative way to study and revise topics. Apart from the collaborative aspect, the only gamification mechanism is experience points and evaluation results showed that it only caused a marginal increase in student motivation and engagement.

IV. AN INNOVATION SYSTEM IN AUGMENTED REALITY AND GAMIFICATION IN EDUCATION

The goal of this project is to use AR and Gamification technologies for the creation of an educational platform based on interactive and AR learning books. This system can be applied in a wide range of educational fields. In art, culture or history, for instance, a gamified AR book can augment the real world by adding three dimensional (3D) virtual objects, such as sculptures, statues or monuments. By being able to observe these models, one can examine them in detail from multiple angles and watch animated simulation of various events. This is a very important aspect of the system proposed, as learners are able to watch the progress of the deterioration of historic buildings or monuments that lead to their current state, or even become witnesses of a battle that took place many years ago to a setting that has been transformed through the time. Gamification can bring the user's experience to a whole different level, whereas game mechanics and dynamics can engage them and bring educational outcomes that last longer while motivating users to become more active learners. In the case of school courses, gamified AR books can be applied as a supplementary tool in the learning process.

As an applied example of the latter, we chose to create a gamified AR book for science. It contains a series of simple science experiments aimed at children between the ages of 10-12. Part of the book is in the form of a traditional science textbook and the rest consists of embedded markers that when scanned by an AR device produce a 3d simulation of a related experiment. An example is shown in Fig.2 and 3. Through the use of an AR device, the user is able to interact with the experiment and have a more hands on experience with the subject matter in order to assimilate it more effectively. Each chapter has a different AR "virtual lab" with the necessary tools to perform experiments that help the student gain a deeper understanding of the subject matter. The methodologies and technologies implemented could be used for enhancing the learning experience in cultural subjects. In this case, the experiments could be replaced by 3D artifacts, monuments and sites. Additionally, game elements are implemented in each experiment to help, motivate, guide and engage students. The game elements chosen to be applied in this project are:

- Onboarding
- Points
- Levels
- Badges
- Challenges
- Replay or do over
- Unlockable content
- Customization

Onboarding is the act of bringing a novice into your system [11, 12]. A virtual guide (See Fig.4) teaches new users how to interact with each virtual lab and continues to support them either by giving them instructions or by posing challenges for them to solve. The challenges set by the virtual guide are of increasing difficulty and guide the user

in discovering the potential uses of each lab. These challenges give students goals and a feeling of achievment. As rewards for these challenges the gamified application includes a point system, proficiency levels and achievement badges that help the users track their progress, motivate them and reward their effort. Additionally a "Free mode" allows users to freely experiment with each virtual lab and earn extra badges exclusive to this mode. These badges were implemented in order to reward players that are willing to step outside the constraints of the structured game.

Performing experiments in a virtual environment has the advantage of giving the student a replay button which affords them the option of failing with minimal consequences. This encourages exploration, curiosity and discovery-based learning. Another feature implemented in the game that contributes to student engagement is the inclusion of unlockable content either in the form of extra challenges or in the form of virtual goods such as customization options for the virtual guide or special badges.

The game elements described above were implemented in order to appeal to Bartle's player types. Challenges of increasing difficulty, rewards and experience levels are features that appeal to achievers since they give them the sense of accomplishment they want from playing a game. Some hidden badges and rewards that are obtainable by experimenting in the game's free mode as well as the virtual goods and customization options given to players, are elements that cover the needs of explorer types. Since this project has no connectivity or multiplayer features, there are no elements to appeal directly to socializers. However since the application can also be used for collaborative learning, it can become a catalyst for social interaction and this way meet some of socializer types' needs. Since killer types derive enjoyment not only from winning but mainly by lessening other people's enjoyment of the game [13], it has been chosen not to include any elements appealing to them because this is not the desired behavior to promote within a learning environment.

The design and rendering of the 3D models required for the project is done using the Blender 3D computer graphics software [19]. The models created in Blender are exported to the Unity 3D game engine [18] where the interactive game environment is created and the gamification elements are implemented. Finally the Vuforia plugin for Unity 3D [21] is used to add the AR features.

V. CONCLUSION, EVALUATION AND FUTURE WORK

This project is an early approach to gamifying learning. Our aim is to use the technologies of AR and gamification in order to create an alternative method for students to learn in a more enjoyable and productive way. This was achieved through an Augmented Reality book that simulates a virtual laboratory. By interacting with the application students can visualize and absorb the subject matter while encouraging creativity and critical thinking.

For the evaluation of the project learners' and educators' feedback will be taken into account. Mobile phones and tablets will be handed to the learners so that they interact with the application during their science class or cultural project. Our research team, with the educator's help, will have an open conversation with the learners and discuss their experience with the software. The most important aspects of the feedback will be user interface intuitiveness, whether or not it motivated them to study and experiment with science, history, culture, etc., whether it kept them engaged and if the application helped the learning process. Since hardware will be recollected at the end of the training period, our research team will collect precise information regarding the usage of the software such as levels completed, average level time, average completion time, complete time spent at the application etc. Educators' criteria for evaluating the project will be their everyday feedback from the students.

The next step is to integrate social features to the application. Such features can include leaderboards, social media integration and the implementation of multiplayer features either locally or online. By adding social elements, collaboration within the classroom or the learning environment is promoted and learners are encouraged to exchange ideas and experiences making them an integral part of the educational process.

The application can also be expanded to be used as a teaching tool. By creating the equivalent to a teacher's handbook the educator will be able to receive feedback from his classroom in order to assess his student's knowledge level and plan his lesson accordingly. Additionally an intuitive platform for user generated content can be developed giving teachers the ability to create their own challenges. This feature helps expand the application's content and keep it relevant as the teaching curriculum changes [11, 13].

Figure 2. The AR book.

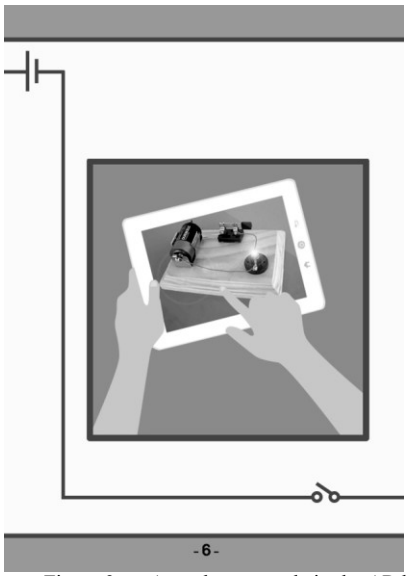

Figure 3. A marker example in the AR book.

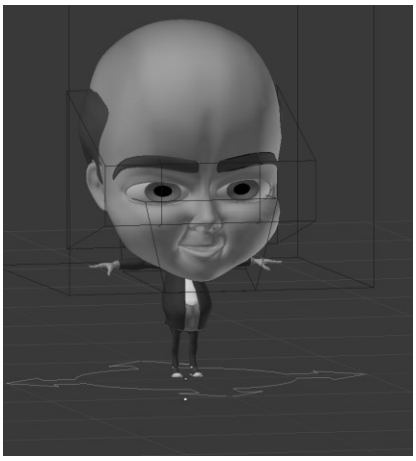

Figure 4. The virtual Guide.

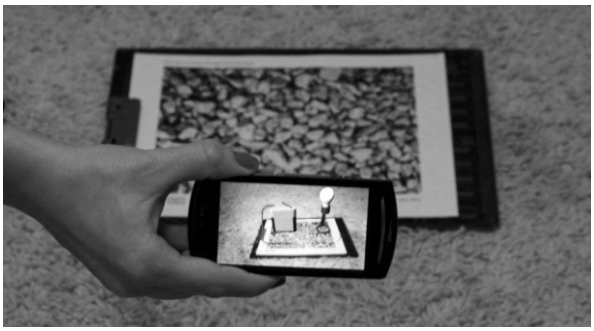

Figure 5. Early Implementation of a virtual lab.

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