

# Design and Development of Educational Platform in Augmented Reality Environment using Gamification to enhance Traditional, Electronic and Lifelong Learning Experience

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## ABSTRACT

The advent of technological advances can be used to improve many aspects of everyday life, including education. In order to enhance education in the optimal way, we chose to combine Augmented Reality (AR) and Gamification in the creation of an educational AR book. The proposed subject is Science aimed at children between the ages of 10-12 years old. Users interact with a virtual laboratory and are able to perform experiments and complete challenges in a game format meant to expand and test their knowledge. Using AR and gamification techniques, we aim to deliver a more comprehensive understanding of the subject matter while at the same time engage learners and increase their enjoyment during the educational process.

## Categories and Subject Descriptors

K.3 [Computers and Education]: Miscellaneous

## General Terms

Theory and application

## Keywords

Augmented Reality, gamification, education, e-learning, engagement, AR book

## 1. 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 traditional teaching environments 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.

## 2. AR AND GAMIFICATION THEORY AND TECHNIQUES

### 2.1 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 surrounding real world of the user becomes interactive and digitally manipulatable. Artificial information about the environment and its objects can be overlaid on the real world. [6] [1]

### 2.2 Augmented reality in Education

Augmented reality applications can complement a standard curriculum. Text, graphics, video and audio can be superimposed into a student's real time environment. Textbooks

and other educational reading material can contain embedded "markers" that, when scanned by an AR device, produce supplementary information to the student rendered in a multimedia format. Students can participate interactively with computer generated simulations of various events, exploring and learning each significant detail of the event. AR can give students a more comprehensive understanding of science, 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 students 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. [1]

### 2.3 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. [2] [12]. This can be achieved by using techniques from the fields of psychology and game design. It is used to improve, timelines and learning [2]. Gamification has found its way into domains like marketing, politics, health, fitness [12], market research, business management and education, with analysts predicting that it will become a multi-billion dollar industry by 2015

### 2.4 Gamification in Education

Gamification techniques leverage people's natural desires for competition, achievement, status, self-expression, altruism, and closure. [2] A core strategy for gamifying is to provide rewards to players for accomplishing desired tasks. Types of rewards include points, achievement badges or levels, [10] the filling of a progress bar, unlocking bonus content/higher levels, and providing the user with vir

tual currency. [10] 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. [14] Another approach to gamification is to make existing tasks feel more like games. Some techniques used in this approach include adding meaningful choice, onboarding with a tutorial, increasing challenge [13] and adding narrative. [2]

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" [8]. 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. An important aspect of game design that has to be taken into consideration when gamifying a task, is Richard Bartle's theory which categorizes players in 4 types, according to the way they interact within a game's environment [7]. 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

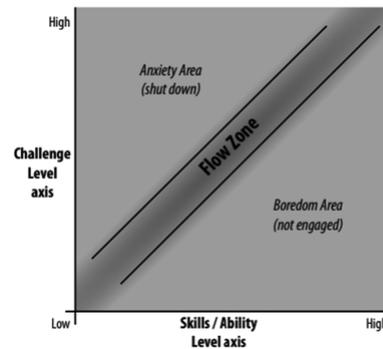


Figure 1: The Flow Diagram.

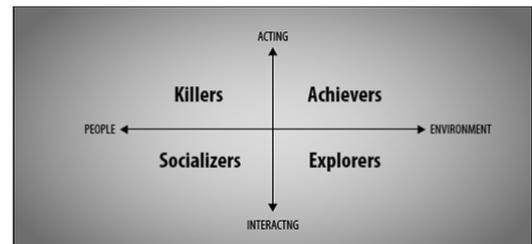


Figure 2: Player types.

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. [11] [17]

Gamifying education can be beneficial for both students and teachers. By adding game elements, such as rewards, leaderboards etc, in a syllabus the learning process can become a more joyful experience.[5] 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, students are actively participating in the learning procedure. The gamified experience increases students' 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'. [3] From a teacher's perspective, adding interactivity to a course and creating a spirit of healthy competition keeps students more engaged and increases their productivity. Also, by receiving constant feedback from their students, teachers 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 student. Gamification gives a more dynamic character to education and promotes lifelong learning. [12]

## 3. 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. This website provides a variety of AR mark-

ers 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 does not contain any gamification elements that would contribute to make the educational process more fun.

One of the few empirical researches on the subject of Gamification is the master's thesis "Game mechanic based e-learning". [9] 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.

#### 4. AN INNOVATION SYSTEM IN AUGMENTED REALITY AND GAMIFICATION IN EDUCATION

The goal of this project is to implement augmented reality and gamification technologies in the creation of an educational book. The chosen subject is 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 (figure 4) and the rest consist of embedded markers that when scanned by an AR device produces a 3d simulation of a related experiment (figure 5). 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. 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. [15] [16] A virtual guide 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 the feeling like they're working towards something. 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

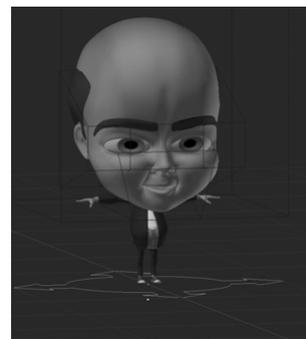


Figure 3: The virtual guide.

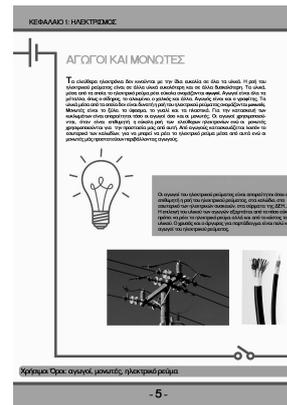


Figure 4: A textbook page of the AR book.

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 is meant to be used within a classroom, 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 [17], it has been chosen not to include any elements appealing to them because this is not the desired behavior to promote within a classroom environ-

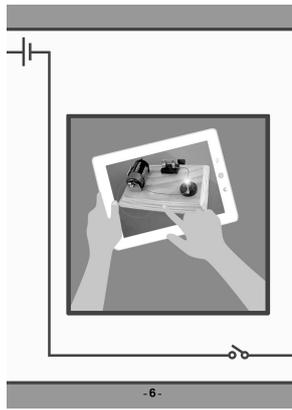


Figure 5: A marker page of the AR book.

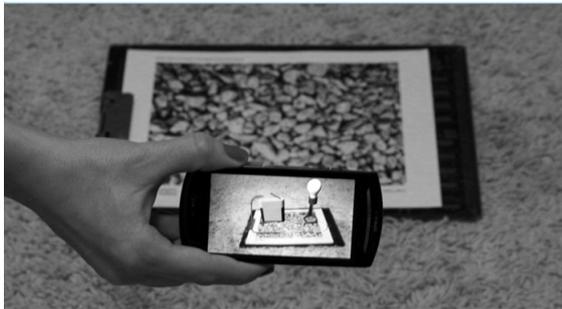


Figure 6: Early Implementation of a virtual lab.

ment. The design and rendering of the 3D models required for the project is done using the Blender 3D computer graphics software [4]. The models created in Blender are exported to the Unity 3D game engine [5] where the interactive game environment is created and the gamification elements are implemented. Finally the Vuforia plugin for Unity 3D is used to add the AR features.

## 5. CONCLUSION, EVALUATION AND FUTURE WORK

This project is an early approach to gamifying education. 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 student's and teacher's feedback will be taken into account. Mobile phones and tablets will be handed to the students so that they interact with the application during their science class. Our research team, with the teacher's help, will have an open conversation with the students 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, 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. Teachers' 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 is promoted and students 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 so teachers will have the ability to create their own challenges. This feature helps expand the application's content and keep it relevant as the teaching curriculum changes. [15] [17]

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