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Increasing quality of learning experience using augmented reality educational games

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Abstract
Adequate pedagogical approaches for integration of technology in the learning process create new opportunities for improving the quality of teaching and learning experiences, raising students' interest and motivation for the classroom activities at the same time. Game-based learning implemented with different technologies can utilize students' energy and enthusiasm for educational purposes. In order to increase the quality of experience of the learning process, elements of popular games (e.g., mobile games and augmented reality games) should be used in the educational context. This paper proposes methodological guideline that can be used for the integration of games in education. The methodological guideline defines the two steps process of creating educational games starting from students' attitudes and needs, and then incorporates educational outcomes. As a case-study augmented reality educational games platform was designed in order to illustrate the possibilities and benefits of the proposed approach.

Keywords Augmented reality educational games · Quality of experience of learning · Game-based learning · Interactive learning environments

1 Introduction

The rapid development of technology determines the direction in which education is going to be focused in the future. Students are becoming increasingly dependent on technologies to

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communicate, gather information, extend social experiences, and be entertained [1]. As students are always surrounded by technology, its integration in the classroom through different approaches is more than necessary.

The educational change must be tied to the tools and resources students use in their everyday lives. Proper integration of such tools and resources in the classroom can increase the students' interests and motivation in the educational process [2].

The fact that students are continually playing different digital games (on a computer or mobile device) and are dedicated to the process of playing the game should also be used in the educational process. Fun as part of the learning process is essential since the learner is then relaxed and motivated and, therefore, more willing to learn. The principal role of fun in the learning process is to create relaxation and motivation. Relaxation enables a learner to take things in more efficiently, and motivation enables them to put forth effort without resentment [3].

By using digital games, new ways of learning in the classrooms can be created. These interactive experiences can increase the engagement of students in the learning process, and thus, learning outcomes can be achieved more easily [4]. Digital games enable students to reach goals that are not focused just on learning facts but enable the development of skills such as problem-solving, decision making, and strategic planning at the same time [5].

Mobile devices are part of our daily activities and have made their entrance into the world of education [6]. The technology used in mobile devices allows the integration of additional functions when playing a game (geolocation, Wi-Fi, email, video, discussion blogs, etc.). The learning potential of mobile and location-based technologies lies in the possibility to foster learning outside traditional formal educational settings [7]. The use of mobile games in education combines situated and active learning with fun.

Augmented reality (AR) is an approach that uses a mobile phone camera in order to add additional information to the top of the camera view. Learning based on augmented reality can be implemented on different mobile platforms. Since its introduction, augmented reality has been shown to have good potential in making the learning process more active, effective, and meaningful [8, 9]. This is because it enables users to interact with virtual objects in real-time and thus brings the natural experiences to the user [10]. Also, the AR games have the potential to alter how players view their physical realities [11].

The merging of AR with education allows students to be immersed in realistic experiences [12]. Mobile augmented reality learning-based systems are focused mostly on games or simulation, and with the mobile devices' features and properties such as portability, social interactivity, connectivity, context-sensitivity, and individuality, they make a learning experience more meaningful and fun [13]. This is the main motivation for our work as well.

There are many games that are used in an educational context but are not enjoyable for the students. On the other hand, it is challenging to match popular games to the curriculum in order to use them in the educational process. The purpose of this paper is to address these issues by providing students insight into the process of developing educational games to be used in classrooms. The students' insights are provided using methodological guidelines inspired by design thinking.

The main goal of this paper is to provide methodological guidelines for the involvement of the end-users (students) in the process of development of serious games by using already proven industry-based concepts in order to increase students Quality of Experience (QoE).

In this paper, QoE is defined as a multidisciplinary concept about students' acceptance of using games in education based on game popularity, cognitive experience, and subjective

feeling. QoE is focused on determining the individual quality requirements, needs, and expectations from the educational game. Furthermore, the early identification of the determinants that influence students' QoE is vital to the educational process, considering that they play an essential role in achieving learning outcomes. The quality of learning experience combines the quality of the experience of the students, and the possibility to fulfill the educational goal provided by the educational support system.

The main outcome of this paper is the AR educational games platform. Mobile AR educational game is an educational game that can be played using a mobile phone camera in order to add additional information to the camera view.

The next section explains the theoretical background of introducing games in education. In section 3, different approaches and benefits of using mobile educational games and AR games for learning are presented. First phase of proposed methodological guidelines for the design of the educational game is described in section 4. The section 5 presents a second phase of proposed methodological guidelines – development of educational AR game platform. The section 6 draws conclusions.

2 Theoretical background

Teaching nowadays is shifting to the learner-centered approach where the teacher is just guiding students in the learning process, enabling them to progress with their own pace, taking into account different learning styles of the students. There is no more "one approach for all", so teaching should be more concentrated on directing each students' learning according to their previous knowledge, abilities, and skills. Students' learning should upgrade while they carry on to advantage from fostering, mentorship, and direction of their teachers.

Teaching and learning experiences should be structured to challenge students' thinking so that they could construct new knowledge. According to Zaibon & Shiratuddin [14], learning from a constructivist perspective is the active process of acquiring and constructing knowledge through meaningful ways and interactions based on prior experience.

Today's students are commonly referred to as the Net generation, were born into social and educational environments where information and communication technology is embedded in their daily lives. School-aged children worldwide are growing up immersed in a media-rich, ubiquitous, "always connected" world [15]. These students bring different skills, interests, and needs to the classroom, and educators are grappling to understand these unique attributes in order to design instruction accordingly [1].

Schools must implement digital teaching solutions to involve the Net generation and to make the classroom atmosphere broader and more participatory. Currently, students live in a world that is continuously linked and alive outside the classroom; they find information online, communicate, and collaborate, so traditional teaching methods are complicated to be applied. The real revolution in education could only be achieved via the digitization of education that will enable students to learn at their speed both within and outside the classroom.

An important point in creating a technology-enhanced classroom is establishing a partnership among students and teachers, where everyone is an active participant in the learning process. Teachers must find ways to make the learning process more attractive and entertaining for the students. Learning should not be based just on one-way transmission of the facts. There should be different sources which will encourage students on critical thinking and making conclusions on their own. To make learning exciting and involving for the students, different

technology-based approaches can be used. Digital learning tools have the potential of being customized to fit the abilities of the individual student and can engage him with interactive tasks and simulate real-life situations. As students today are mainly playing games in front of computers or on mobile devices, it is natural to try to involve games in the learning process.

Game-based learning (GBL) can be successfully developed and implemented in the learning environment by combining both game design and instructional design approaches and by considering various issues such as learning theories, a theory of play, mobile platform and technologies (for mobile games), game design, and instructional [14].

Students use games to explore, discover, and question. These "learning by doing" and "active learning" concepts are important principles, which underlie game-based learning [16]. GBL more adequately addresses how students learn today and engage them in meaningful learning more successfully than traditional learning methods [17]. According to Van Eck [18], the popularity of games together with ongoing research on the power of digital game-based learning, on the one hand, and increased disengagement students from traditional instruction, on the other hand, are factors which explain the widespread interest in GBL.

In recent years, technology-enhanced learning has been increasingly focused on emergent technologies such as augmented reality, ubiquitous learning, mobile learning, serious games, and learning analytics for improving the satisfaction and experiences of the users in enriched multimodal learning environments [19]. Different mobile and location-based technologies provide opportunities to embed learning in authentic environments and thereby enhance engagement and learning outside traditional formal educational settings.

Augmented reality is currently considered to be one of the key emerging technologies in education, providing new opportunities for teaching and learning by allowing a virtual world of digital content to be overlaid and mixed into the learner's perceptions of the real world, thus creating an enhanced and augmented reality. Recent technological progress added to the proliferation of affordable hardware and software has made AR more viable and desirable in many domains, including education [20]. This offers an innovative learning space by merging digital learning materials into the format of media with tools or objects, which are direct parts of the physical space, therefore creating "situated learning". This is revolutionizing the way we teach and learn, making learning experiences more entertaining and rewarding [21].

Augmented reality is well aligned with constructivist notions of education where learners control their learning, through the active interactions and inquiries with the real and virtual environments. Augmented reality in the context of inquiry-based learning is mostly implemented successfully to achieve cognitive and, less often, motivational and emotional learning goals [22].

Implications of game design involve the creation of virtual environments, where the player can gain knowledge through exploration and by practice (e.g., manipulating objects), possibly in collaboration with other people. Further, well-designed contextual augmented reality experiences align with social constructivist tenets of teaching and learning [23]. Lee [24] summarizes these attributes well, stating that augmented reality has the potential to motivate learners in discovering resources from a variety of different perspectives.

Several pedagogical attributes make augmented reality an ideal instructional tool for a variety of subject areas. Augmented reality drew substantial public attention because it provides a new perspective for learning by allowing learners to visualize complex spatial relationships and abstract concepts [25]. When information is presented using augmented reality in a contextually relevant environment, it can enable a understanding of how new information is applied in realistic settings [26, 27]. Contextual learning increases the relevance

of new information for students and allows them to see how new knowledge can impact their environment [28, 29].

3 Related work

Gamification is the process that introduces elements of games (points, a game like interaction, storytelling). Gamification of learning, especially using mobile applications and augmented reality games, have been topics of many educational kinds of research in the last decade. All of them emphasized the benefits of using games in the learning process and agree that the future of education is going to be pointed in that way. The rapid evolution of technology had changed the face of education, especially when technology was combined with adequate pedagogical foundations [30].

Despite the intense interest in games, it is important to realize that developing games for learning can be very complicated and costly and still provides significant challenges. One of the biggest problems of educational games to date is the inadequate integration of educational and game design principles, and this is also since digital game designers and educational experts do not usually share a common vocabulary [31].

In the attempts to address the challenge of making games for education enjoyable, yet effective, researchers and educational practitioners are increasingly turning their attention towards so-called serious games for education [32]. Well-designed serious games teach by stimulating the imagination, sparking curiosity, fostering discussion, and encouraging a spirit of competitive exploration across a variety of domains. By exploiting the latest simulation and visualization technologies, serious games are able to contextualize the player's experience in challenging, realistic environments, supporting situated cognition. Quinn & Neal [33] studied the fact that serious games create a hands-on, minds-on opportunity that allows players to actively focus, create and change a scenario while simultaneously learning about consequences of choice in the situation. As students become more engaged and committed to succeeding in the game, they become more willing to learn about the scenario the situation is taking place in. Serious games allow students to become active participants in discovering new ideas, information, and solutions to problems while also allowing them to feel the tension and suspense of the crisis.

Mobile learning offers numerous opportunities as well as challenges in education. Considering the trend towards ubiquity of smartphone and tablet devices in school systems augmented reality, they have the potential to be the devices on which these experiences are developed [34].

Despite the ubiquity and flexibility of these devices, there has been minimal use of mobile learning approaches in some education sectors and developments have tended to be more about the design of the tools than of the ensuing learning [35]. There is an ongoing need to examine the pedagogies that are suitable for mobile learning, and to conceptualize mobile learning from the perspective of learners' experiences, needs, and expectations rather than the affordances of the technology tools.

Augmented reality is one of the emerging technologies that might have potential and impact on learning and education. Augmented reality as a learning experience represents more than just the merging of hardware, software, and contextually relevant information [36]. When applied to education, augmented reality is best defined as a concept, rather than any specific combination of technologies and design strategies [37]. According to Cerqueira and Kirner

[38], there are several advantages of using augmented reality techniques for educational purposes. For example, it can minimize the misconceptions that arise due to the inability of students to visualize concepts (for ex. chemical bonds) because it allows detailed visualization and objects animation. Augmented reality also has the advantage of allowing macro or micro visualization of objects and concepts that cannot be seen with the naked eye. It displays objects and concepts in different ways that help the students to better understand the subjects [38].

The power in augmented reality lies in truly augmenting the physical landscape using digital technologies in order to enable students to see the world around them in new ways [39]. Bennett [40] overemphasized the power of games and play to facilitate deep and meaningful learning where most productive and motivating learning experiences are taking place outside of school through playing and participation, where children do enjoy learning via having a sense of their progression and where the learning is relevant and appropriate. For example, Annetta et al. [34] describe a contextual augmented reality experience that was implemented as a game focused on the subject of recycling. The game explains how recycling impacts landfill waste while adhering to environmental science teaching standards. The augmented content at each location was related to the location in which it was presented.

Instructors can use tools such as different maps of their surroundings to plan the location of the triggers that activate the augmented information. One practice is to focus on items that are easily overlooked and use those items as triggers. In general, the augmented reality design should help learners view typically overlooked elements in their environments with a more critical eye [41].

Besides, the research conducted on augmented reality shows that students are interested to learn using this technology. For example, in research conducted by Klopfer and Squire [42], students gave positive feedback about their experience of the combination of virtual and real environments. Burton et al. [43] also reported a similar result, with the participants in their study being excited about the potential of this technology for sharing information and learning about new concepts. Thus, it encourages students to think critically and creatively, which, in turn, improves their experiences and understanding. Research on augmented reality has also demonstrated its extreme usefulness for increasing student motivation in the learning process [22, 44].

Augmented reality has been labeled an emerging technology with the implication that there are still barriers that need to be addressed [20, 45]. According to Saidin et al. [12], even though a lot of research has been conducted on augmented reality, relatively few studies have been conducted on augmented reality in the education field. Augmented reality educational experiences are mostly the ad hoc creations of educators with an inadequate understanding of the technology or developers with little understanding of education. Thus, some researchers tend to develop applications that they think will be useful for education, whereas educators bemoan the lack of suitable applications for relevant courses. Therefore, a collaboration between educators and game designers is necessary to facilitate the development of favorable augmented reality games for teaching, as well as the design of reasonable teaching schemes according to social psychology principles, taking into account students' wishes, curiosities, and needs [13]. This would allow AR to play a fuller role in education [8, 9, 46].

4 Methodological guideline phase 1: Educational game prototype

Most of the games that are nowadays used in the teaching process are boring and not motivational for the students, and consequently, they do not want to use this kind of game

for achieving learning goals. On the other hand, games that are interesting and involving for the students are typically used just for entertainment, without educational value. The main concern of the proposed methodology for mobile AR educational game development was how to link the pedagogical approaches and curriculum from the one side and entertainment from the other.

By using a design-thinking approach, we changed the focus of our research from problem to solution-focused and action-oriented towards creating a preferred future. Design thinking as a methodology is aimed upon logic, imagination, intuition, and systemic reasoning, exploring possibilities of what could be and creating desired outcomes that benefit the end-user. It is a human-centered approach, so the process of designing a mobile educational game started with students' needs and attitudes toward this topic. The main idea is that educational game designers should start from some popular game and use its concepts, adding pedagogical approaches according to the curriculum in order to create a new game that will be stimulating and involving for the students.

In this paper, we were using the five-stage design thinking model proposed by the Hasso-Plattner Institute of Design at Stanford. Design thinking is defined as a methodology for innovation that combines creative and analytical approaches and requires collaboration across disciplines. The five stages of design thinking are as follows: Empathize, Define (the problem), Ideate, Prototype, and Test [47]. For our research, we consolidated Empathize and Define in one stage - Identity, that gave us an understanding of the problem from the students' perspective and helped in defining the problem in a student-centered manner.

These stages of design thinking were the most appropriate for this research because we wanted to start with students' opinions about using AR games in education, their needs, what they think that should be created, what they would like to use for learning. This information was used for creating a simple educational game in line with students' needs; the game was tested by students, and after that, students' opinion was surveyed again. Students' opinion, as the most important one in the learning process, was the primary concern during the research.

4.1 Identifying the problem

The first stage of design thinking was to gain an emphatic understanding of the problem we wanted to solve - how to create a game-based learning environment that will be interesting and educational at the same time. We assumed that the main problem (why the benefits from using educational games are missing so far) is because when creating an educational game, nobody is taking consideration of students' attitudes, wishes, and needs.

We started with identifying a popular game among the students; a survey was created in order to see the extent to which mobile AR games have occupied students' lives and to examine their attitudes toward using this kind of games in education. The survey was conducted among 40 students from VIII and IX grade in primary school "Krste Misirkov", Skopje.

The survey was also used for gathering demographic information about the participants (students' age, gender, and school year) and their experience in playing games, especially AR games. The second part was designed to measure students' attitudes toward playing AR games, using a five-point Likert scale, with answer choices ranging from "strongly disagree" (1) to "strongly agree" (5). Information about game's features like playing on mobile devices and open space, safety while playing the game, motivation in using applications (games) with the educational purpose, and interest to learn outside the classroom were obtained. In the end,

the survey had two open-ended questions in order for students to have the possibility to express their opinion concerning the usage of AR games in education.

The students were asked whether they play some augmented reality games, and they all indicated one - Pokémon Go. Pokémon Go as an augmented reality game is an outstanding example of how an augmented reality game can spread through people's life. At the moment when the research was done, it was viral, and most of the students were preoccupied with playing this game.

Pokémon Go is a free-to-play, location-based game where players use a mobile device's GPS capability to locate, capture, battle, and train virtual creatures, called Pokémon, that appear on the screen as if they were in the same real-world location as the player. It is a GPS, data collection, and journaling tool and requires math skills to play. These features can be used to link the game with learning and curriculum. Critical and creative thinking, personal and social capability, and, of course, information and communications technology, could also be taught using Pokémon Go as students manage their school and social lives, build relationships with others, work effectively in teams and make responsible decisions.

Gathered information from the conducted survey was analyzed, and the problem was defined in a human-centered manner, where students' needs and requirements, as end-users, were set as the most important in the process of creating the educational game. Survey results were used for understanding students' needs and attitudes concerning using AR games for educational purposes. Many types of research analyze the drivers of attitudinal and intentional reactions, such as continuance in gaming using gratification and flow theory [48], but our intention was much simpler; we were only interested in the reasons why students like that game, in order to mimic those features in our prototype.

The results presented in Table 1 showed that most of the surveyed students played games every day, and they very often played Pokémon Go. This was undoubtedly a thought-provoking fact, which raised the question of how to use something that is an essential part of students' life for learning. Students pointed that they are familiar with the characteristics and features of Pokémon Go, which were easy to learn and emphasized that if there is another similar application (created for educational purposes), they would not have a problem using it.

The results concerning students' attitudes towards the characteristics of Pokémon Go and their interest in playing mobile application games in an educational context (Table 2) were encouraging.

Students liked the fact that Pokémon Go is played on mobile devices (82.5%) and would like to use mobile games and applications that will broaden their knowledge and educate them. They thought that mobile apps and games would help them to learn in more interesting and stimulating way. Furthermore, students (87.0%) considered that using games, especially mobile phone apps, for achieving learning goals is a good idea. They pointed out that these kinds of games will expand the learning outside the classroom and traditional teaching methods, that will make learning more exciting and stimulating. This showed that in addition to PCs and consoles, students very often used mobile devices for playing games and was an indicator that should encourage programmers to develop mobile applications with educational content.

When asked about topics that could be learned by the mobile app, students stated that they would like to discover some information about landmarks and history, mainly thinking about the possibilities offered by Pokémon Go. Students suggested that it would be nice to have mobile games that will facilitate learning in different subjects, too. Different topics concerning geography, biology, mathematics, physics, chemistry were mostly mentioned.

Table 1 Demographic information of the participants

Demographic variable		Frequency	Percentage
Gender	Male	29	72,5%
	Female	11	27,5%
Age	13	22	55,0%
	14	18	45,0%
Grade	8th	17	42,5%
	9th	23	57,5%
How often do you play video games	Every day	25	62,5%
	Very often	6	15,0%
	Sometime	7	17,5%
	Rarely	2	5,0%
	Not at all	/	/
How often do you play Pokémon Go	Every day	1	2,5%
	Very often	20	50,0%
	Sometime	12	30,5%
	Rarely	7	17,5%
	Not at all	/	/

Students highlighted safety as the only problem with using this kind of game. Almost half of the students (45.0%) didn't feel safe while playing Pokémon Go because they had reduced attention to the surroundings while playing. That was the main reason why some students didn't like the fact that Pokémon Go is played outside. This must be taken into account for the future development of a mobile game that will be designed for open space. Students didn't like the idea that this game uses the mobile Internet and quickly consumes the battery of the mobile device. Some noticed that Pokémon Go, can force the players to enter another's property to catch a Pokémon. The other negative features of the game mentioned by the students are long distances outdoors that should be passed and lack of educational content. All these answers were reasonable and should be considered during the development of the mobile educational game that will be popular among students and will have educational value.

Table 2 Results of students' attitude towards playing AR mobile games

Item	Agree or strongly agree		Neutral		Disagree or strongly disagree		Mean	SD
	N	%	N	%	N	%		
1. I like the fact that Pokémon Go is played outside	26	65,0%	11	27,5%	3	7,5%	3,55	1,26
2. I like the fact that Pokémon Go is played on mobile devices	33	82,5%	6	15,0%	1	2,5%	4,18	0,78
3. I feel safe while playing Pokémon Go	12	30,0%	10	25,0%	18	45,0%	3,78	0,97
4. I found interesting places/ objects while playing the game	26	65,0%	12	30,0%	2	5,0%	3,85	0,86
5. I would like to use mobile apps with an educational purpose	35	87,5%	4	10,0%	1	2,5%	4,63	0,77
6. I would like to go outside to explore using a mobile app	30	75,0%	4	10,0%	6	15,0%	4,05	1,08
7. I would like to use the mobile app outside to find some interesting information	34	85,0%	3	7,5%	3	7,5%	4,30	0,91

This research showed up that students have a great interest and willingness to learn and deepen their knowledge using mobile applications (games) like Pokémon Go. For them, it was a connection between learning and something interesting - games. They considered that these games could help them to learn in the more relaxed and exciting way. In general, students like to go out, explore, and learn by mobile devices, but they are worried about safety. So, the best recommendation in this context was to create applications limited to a specific area, such as school building, a museum, historical site, etc. It would allow students to explore in groups under the supervision of competent persons to educate and learn about a specific topic interestingly. For that reason, we decided to create a prototype game that can be played in a controlled surrounding controlled (schoolyard, zoo, or a museum).

When students had to choose the subjects where they would like to use augmented reality games, they highlighted history, geography, and biology because they thought that it would be interesting to expand their knowledge in these areas by games. They considered that games could be used in mathematics, physics, and chemistry for an easier understanding of certain aspects of the topics.

4.2 The idea for problem solution

After understanding students' needs, analyzing and synthesizing the survey's information, and defining a problem, an approach that could lead to qualitative integration of games in education was identified. Following the user-oriented approach from the design thinking methodology, in order to propose a model for integration of games in education, positive students' Quality of Experience (QoE) was studied as a critical driver of technology acceptance, adoption, and innovation use.

The students' acceptance process was driven by the most significant acceptance model present in the literature – the Technology Acceptance Model (TAM) [49], used to explain the factors affecting user perceptions and acceptance of games in education. According to Davis [49], perceived usefulness and perceived ease of use are important factors in determining one's acceptance of using new technology for a specific purpose. Different studies have already used the TAM model to explain users' acceptance and ease of use of games for learning [50].

In our context, perceived ease of use was defined as the degree to which the user believes that games in education would be free of effort, and perceived usefulness was defined as the degree to which the user believes that using this kind of games in education would lead to increased learning outcomes. Ease of use and usefulness are important factors that influence students' attitudes toward using games in education but are not the only ones. We extended TAM to describe the necessary conditions to achieve QoE concerning using educational games among students. The motivational theories have recognized motivation as an important factor for students' engagement with the educational process. Also, TAM has a lack of task focus. In proposing a model for the integration of games, we added elements from TTF (Task-Technology Fit) model [50]. Consideration of the fit between task (in our case, the educational goals that should be reached) and technology (game) was central to the model. It is concerned with the extent to which a game provides features and support that "fit" the requirements of the educational goal. We used TTF in order to describe how the characteristics of educational goals (task) and game (technology) will affect together with the results of game utilization in an educational context.

The TAM and the TTF offer distinctive explanations of the mechanisms behind the user's choice to accept technology. However, in our case, TAM, in combination with the TTF,

provided more explanative power over either the TAM or the TTF model alone. A similar approach to integrating the TAM with the TTF in a complementary manner is shown in the work of Lee and Lehto [50].

In this study we considered the importance of game rating (popularity of the game among the students), students' motivation for using games in education, TTF model (to make a correlation with the curriculum) and we combined them with certain variables from TAM (ease of use, usefulness, and attitude) while defining factors that influence elementary students' QoE during the integration of AR games in education. Furthermore, this research went beyond mere technology acceptance by incorporating different factors and curriculum characteristics that could influence a higher level of positive students' QoE in using AR games in education.

Starting from the results obtained from the survey conducted among the students regarding the usage of augmented reality games in education, the following model (Fig. 1) concerning the integration of games in education was suggested. It shows relationships among important variables influencing game-based learning approach and students' QoE, according to adopted TTF (e.g., educational goal alignment) and TAM (e.g., ease of use).

In the proposed model, relevant factors that influence students' experience during the use of augmented reality educational games were identified. These factors are complex variables, and we divided them into two categories: game rating as the necessary element for a game to be adopted by the students (popularity of the game, which influence on games' ease of use) and students' motivation and attitudes (which are affected by educational elements, too). Research carried out by Koivisito and Hamari [51] shows that age can influence the student motivation and attitude to learn using a specific game.

The main idea of this model is that designing an educational game should always start from the game rating because students emphasized that they would like to use some popular and interesting games in the process of achieving learning outcomes. They play games every day and are very familiar with the gameplay and features of the games with a high rating. Students stated that if the educational game is designed according to some high rating game, they would not have a problem using it. This influenced their motivation to play the game and their attitudes towards using the game for achieving learning outcomes.

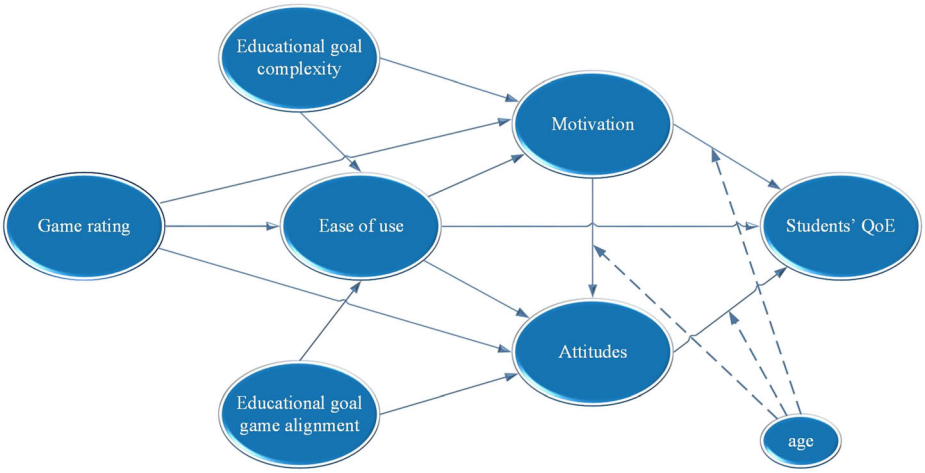


Fig. 1 A model for integration of games in the educational process

Educational game's ease of use is determined by the good alignment of the educational goal with the game, too. Characteristics of a game and educational goal must fit together in order to achieve better results of game utilization in an educational context. Students' emphasized that they would like to use mobile apps with an educational purpose. Starting from this, fitting educational goals in the game would contribute to the easier achievements of the learning outcomes, and usefulness from the other side would lead to the enhanced beliefs regarding the using games in education.

We concluded that game rating influence on forming positive attitudes toward playing it in an educational context. Students' attitudes toward playing mobile app games in educational contexts were positive because they think that it will help them to learn on more interesting and stimulating way that is very familiar to them. Competitiveness in games influences students' motivation for playing it over and over again in order to achieve better results.

Students' motivation is one of the most important factors in the process of creating an educational game. If the game is too challenging, the player will be frustrated, and if it's too simple, the player will lose interest. In either case, players are very likely to become disengaged and quit the gameplay. That's why students must always be kept motivated by allowing them to progress through different levels of the game according to the levels of learning outcomes that they should achieve. Educational goal complexity should determine the number of levels in the game and how they should be passed. Namely, each level of learning outcomes should be the appropriate level of the game, which will motivate students to play it. This can be implemented by indicating different degrees of success, which could be achieved while mastering a given level.

Educational goals must fit easily in the game. We considered that the creation of the educational game should start from the game's analyzes and to see how different levels of learning outcomes can fit in it. Alignment between an educational goal and a game, from one side, and designing a game level according to the goal complexity from the other, must be achieved. The ultimate tenet of the TTF model is that the greater support a given technology provides for a task, the higher the perception of task-technology fit, and the higher technology utilization by the user.

Students' motivation towards playing games and using the game in the educational process leads to their positive attitude toward the use of similar games in learning as a new teaching approach. Games rating, motivation towards using educational games, and students' attitudes toward this new teaching method directly influence QoE.

The proposed model provides relevant information about necessary issues concerning the successful implementation of augmented reality games in the learning process, for increased students' motivation and QoE. According to this approach, to achieve positive students,' QoE game designer should start from finding a game with high game rating, try to align educational goals to the game and to adapt the game to the educational goal complexity. The game designed in this way, starting from the good technology acceptance, will have a positive influence on students' motivation to play the game and their attitudes towards using a game for achieving learning outcomes.

4.3 Prototype stage

After defining a model for the integration of games in the educational process, a prototype for mobile AR educational games based on the proposed approach was designed. The concept of popular mobile AR games among the students at a given moment was used and adapted to

students' environment, keeping in mind their expectations and needs. The prototype game was designed with a focus on implementing quality of experience features selected by students, and we expected that the game would be interesting enough to stimulate them to play it.

Educational elements, according to the curriculum, were then added in the game. This was an experimental stage, so the prototype game was very simple, covering only the achievement of a few educational outcomes.

The game was quick and cheap to create, but the primary aim was to provide useful feedback from students (in the next test stage) about their thinking, behavior, expectation, opinions concerning using this kind of game in achieving learning outcomes.

According to feedback in the test stage, if it is positive, we can further develop the prototype into a platform for AR mobile games, with a focus on the possibility to scale up the possibility to include different elements that can be transformed into educational goals. If the feedback is negative, we should develop a new simple game in order to investigate whether the quality of experience has been achieved.

Table 3 presents different elements from the model for integration of games in the educational process that should be merged into a prototype game, and what, once the students approve the game, should be integrated into the final game platform.

Table 3 Fitting the model for integration of games in the educational process into prototype game and game platform

Feature	Prototype game	Game platform	When in development focus	Why
Game rating	YES	YES	Prototype game	Game rating features, if successfully implemented, will ensure the quality of experience of the gameplay
Educational goal complexity	NO	YES	Game platform	Educational goals increase the overall cost of the development of the game; thus, they should be implemented once we indicate that the students will accept the gameplay
Ease of use	YES	YES	Prototype game	This feature will enable students to focus on educational goals, so it has to be implemented correctly in the initial gameplay with simplified educational goal
Educational goal game alignment	YES	YES	Prototype game	Educational goals should be part of the gameplay. If this is not a case, students will see no purpose of learning while playing the game
Motivation	YES	YES	Both	Gameplay should be implemented in such the way that motivates students to compete or/and collaborate
Attitudes	NO	YES	Game platform	The educational challenge should match the student age. The proper educational challenges should be developed by an educational expert, once the game is in active usage by the students.

In order to describe the differences presented in Table 3 and illustrate their importance, we can elaborate on a simple use case. The mobile platform that can support different subjects or integration of different subjects (e.g., informatics, biology, or their combination) is typically costly to create. If we create a platform without prior approval regarding the "gameplay rating" from students, we risk developing an expensive game that students will have no interest in playing. Similarly, if the game is no "ease to use", students will have difficulties in playing the game, so they will not be able to focus on educational challenges, and thus, will not fulfill the educational goals. On the other hand, if the game is easy to play and interesting for students from a gameplay point of view, we can dedicate more resources to create the possibility to integrate different learning scenarios. For example, we can create different sets of questions for biology and informatics, and different locations, and combine them according to specific educational needs. More details on this will be given in the next section of the paper. In this way, we can develop many simple (and cheap) game prototypes with a focus on gameplay, and once it is proved to be fun for students, develop more complex (from the educational point of view) and more expensive game platform.

Starting from the previous discussions, in order to achieve a balance between pedagogy and game, a prototype for educational augmented reality game was developed. Using the popularity of Pokémon Go among the students, some of this game's features were used, and simple educational elements in the form of the quiz were inserted in the game. Achieving learning outcomes from biology, as one of the subjects mentioned by students where games should be used, was part of the game.

The game was created for the Android platform as a more frequently used platform by students. The information for the appropriate sensors was taken using a few lines of code, and the used mobile resources were released when the application shuts down. The most commonly used sensors and resources were a camera, accelerometer, and compass.

To play this game, students only needed a mobile phone with the Android operating system. The game consists of five questions, hidden in different parts of the zoo in Skopje, North Macedonia. Questions referred to the living habits of animals in the zoo. Players should find the questions (physical activity) and answer them (mental activity). The idea was a real safe space (zoo) to be used for raising physical activities and stimulating mental activity by answering some simple questions where the answers will be easily reachable. The game starts at the zoo's entrance and ends when the player passes all the spots and answers the questions. The fastest player with all answered question wins.

The developed prototype gameplay is presented by a diagram of activities (Fig. 2). It starts with the initialization of the sensors, timer, GPS, and camera. After initializing the sensors, their values are read, and maps are displayed depending on the gravity of the phone's Z-axis (orientation of the phone - horizontally or vertically). By playing the game, movement and navigation to the questions can be achieved in two ways (according to the mobile phone orientation):

- While the mobile phone is oriented horizontally, the map of the zoo with all the spots where the questions are hidden is shown. In this map view (Fig. 3a), red points are not passed yet, yellow is passed, and the black point is the current position.
- While the mobile phone is oriented vertically, spots that should guide players' movements are drawn, achieving augmented reality. These spots change their size depending on the distance of the player from the destination spot (the closer, the bigger point), as shown in Fig. 3b and Fig. 3c.

Interactivity starts when the application checks if there is any spot in the range closer than 10 m. When that kind of spot is found, a dialogue with a multiple-choice question and provided answers is displayed (Fig. 3d). If the player tries to move away too much (over 15 m), the dialogue is closed. So, if the player answer is canceled, he/she must move from the spot so the question could arise again.

When the player answers in a correct way, his/her response is marked, and that spot does not appear in the augmented reality view of the camera anymore, but it still

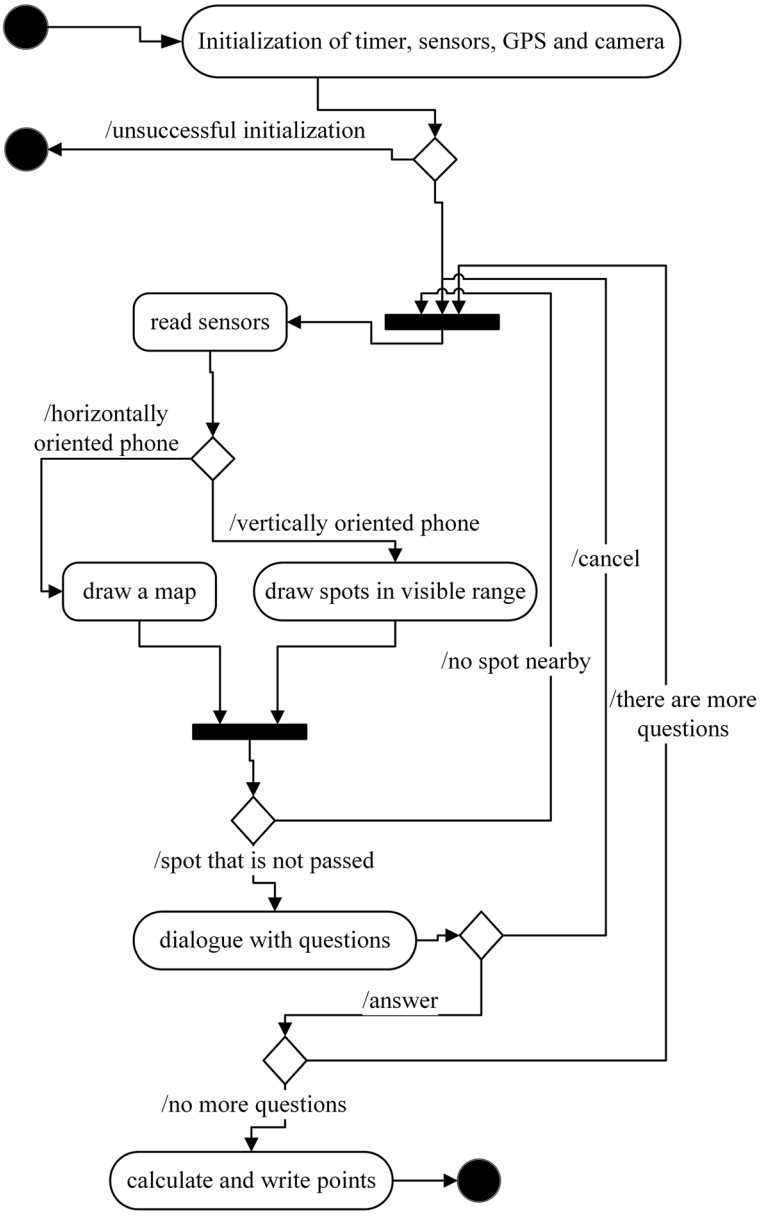
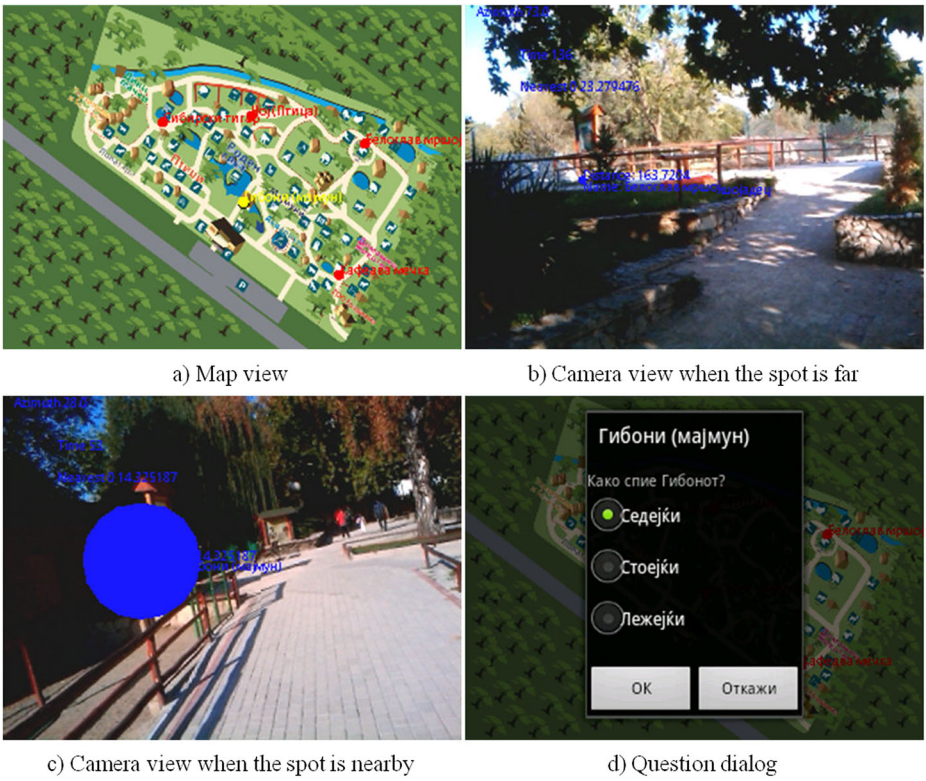


Fig. 2 Diagram of activities for the prototype game



a) Map view b) Camera view when the spot is far

c) Camera view when the spot is nearby d) Question dialog

Fig. 3 The user interface of the prototype game

appears on the map with yellow spots (answered), unlike others who are in red (not passed yet).

When the player answers the last question, the game is finished. The application immediately calculates how many points do the player won by the time spent, adding negative points for each wrong answer. After writing the points, the program closes.

This prototype game only initiates opportunities for using augmented reality games in education. It's a simple game that can be developed further for different subjects in different surroundings. For example, this game works only in the open space in the zoo, but it can be adapted in the classroom or other territory, which is safe and controlled. From the educational context, it can be used as a combination of physical education and any other subject (for example, in the case of biology, there can be questions in the botanical garden about some flowers or insects).

4.4 . Test stage

Following the design thinking approach, the prototype game was tested in the real environment and with different students from those in the first stage. The game was installed on the mobile devices of 20 students. Because the game was played for the first time, they were accompanied by the developer of the game who could answer the questions that may eventually raise.

In order to see whether this game met the expectations, a short interview with the students, after playing the game, was conducted. Information concerning ease of use of the prototype game, the way that educational elements are fitted in, the achievement of the learning outcomes, students' attitudes towards playing the game, motivation to play it, and beliefs regarding using games in education were obtained.

The main purpose of this methodology was to see the results from using the developed prototype game in the educational context, in order to determine whether the game is used both for learning and entertainment. By using these findings, different simple to implement approaches for the re-creation of the gameplay could be implemented. The information that we gathered using a design thinking approach served as a base for selecting the features of the game platform that will be developed.

In order to see whether this game met the expectations, a short interview with the students, after playing the game, was conducted. The fact that students understood the game very quickly was both surprising and evidence that students handle very well in the gaming environment.

Discussion with the students showed that they were delighted with the played game because they had a possibility to learn in natural surroundings. Students discussed that the learning was easy, and they interestingly learned a lot (they didn't even notice that they were learning while playing); they answered all questions from the game, learning, playing, and having fun at the same time. Game rating, especially competitiveness in it, influenced students' motivation for playing it over and over again in order to achieve better results. It was evident that learning goals can be easily achieved by putting some educational elements in the popular game. It was a confirmation that students' attitudes toward using the AR games in education are determined by the ease of use of that game (which directly depend on their interest of the game - game rating) and the usefulness of a game in an educational context (included educational elements in the game). Furthermore, learning was interesting and stimulating.

Discussion with the students confirmed our findings. According to the students' answers, they would like to play this game again. Students suggested that they would like this game to have more questions and maybe to have a similar game with the questions from other subjects in a different surrounding. They also suggested that they will like to play and learn together with other students more often. This information was proof of students' motivation, interest, and positive attitudes toward using these kinds of games for achieving learning outcomes.

Learning interesting facts about the zoo and animals that are living there was the main benefit of this game (educational value). Although students worked for the first time with a map, they liked it and didn't have any difficulties using it. So, as additional value, better orientation in space was another benefit from the game. Furthermore, students liked the ability to communicate with others, and they enjoyed physical activities (although they found running a little difficult because they are used to sit more while playing a game). The conclusion from this game and its testing is that the game served a purpose. The most important benefit was that students like this type of game, and they would like to use them for educational purposes. The balance between education and fun was achieved. The game was interesting, involving, motivating, and students were impatient to achieve learning outcomes, so we managed to create a game where students can enjoy while they are learning.

5 Methodological guideline phase 2: Educational game platform

The second face of the guideline starts once we confirm the positive quality of experience of the gameplay. This phase includes the development of the backend of the educational AR game platform, and further development of user interfaces (e.g., multilingual support, external map services, creation of data model). The focus of this phase is on the integration of the possibility to add different learning scenarios that can support different educational outcomes. This requires the involvement of the other type of stakeholders in the development of the educational AR game platform – educational experts.

Educational experts analyzed the results of the work done in phase one. They suggested the possibility to add: treasure locations with hints (e.g., distance and directions), ways to unlock treasures (solving quiz, or using collected prizes to obtain solution), and visual representation of the treasure (keyword or letter). The educational scenario from the student perspective will start with a hint of the first location. Then, the students will need to collect all treasures (key words) using the gameplay defined in the first phase according to the methodological guideline. Once all the keywords are collected, the students will have to create meaning out of them. In this way, the learning process can happen in multiple locations, and educators will have the possibility to enter different challenges needed to obtain different treasures. The educational scenario can be realized as an individual or team-based competition, and different treasures can be related to different topics from one or more subjects. This created general education scenario was presented for final approval to both students and the team of developers.

From the educational AR game platform point of view, the general educational scenario created a need to include management of users, user roles, items (treasures), item locations, user locations, collected items, and collected words and prizes. The simplified class diagram of the educational AR game platform is present in Fig. 4. The class diagram includes data attributes and set of methods related to the data items that need to be managed, as well as the relations between different data elements.

A sequence diagram can be used in order to present interaction between elements of educational AR game platform that needs to be done in order to execute educational scenarios.

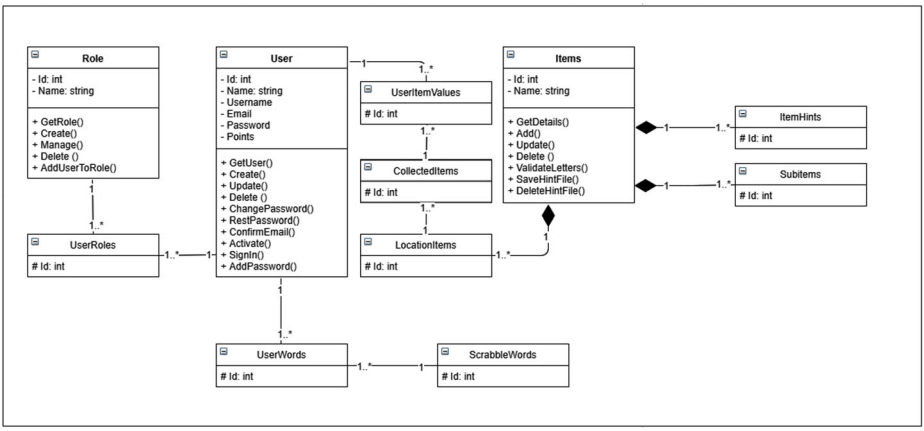


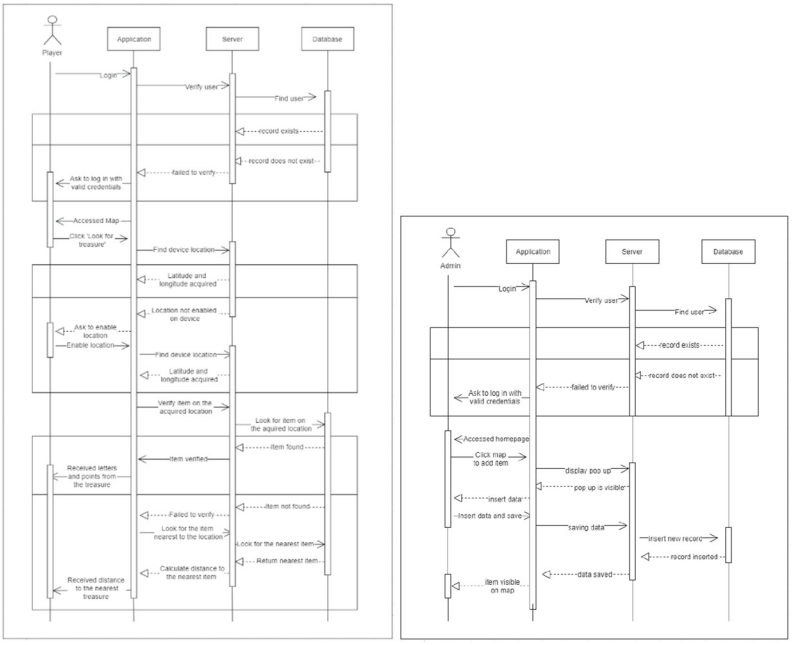
Fig. 4 Class diagram of educational AR game platform

Figure 5a presents interaction among the mobile application, backend server, and database from the students' point of view. In contrast, Fig. 5b elaborates action needed to be done by educational experts using backend server web application in order to add treasure into an educational AR game platform. The mobile application interface for students is very similar to the interface presented in Fig. 3. Corresponding web-based interface for actions that educational expert needs to perform are present on Fig. 6.

5.1 Behavior-driven testing of the mobile platform

Testing of the developed educational AR game platform includes different stakeholders that in general do not need to have a technological background, but are very important as both end-users (students) that need to have a satisfactory quality of experience using the platform, and experts (teachers) that need to ensure that platform, can provide support to achieving educational values. Both of them are focused on the behavior of users rather than the technical functions of the software.

Behavior-driven testing uses understandable language for creating automated tests. It is a relatively new agile software development approach that focuses on communication, so different stakeholders could join the testing process actively. The test scenarios are written to build up a clear understanding of the desired behavior through discussion with stakeholders. A total of 92 automated tests were created to test users' behaviors in the developed educational AR game platform. An example of a test scenario and the corresponding automated test is given in Fig. 7.



a) Finding treasure using mobile interface b) Adding the treasure on the AR game platform

Fig. 5 Sequence diagrams of educational AR game platform

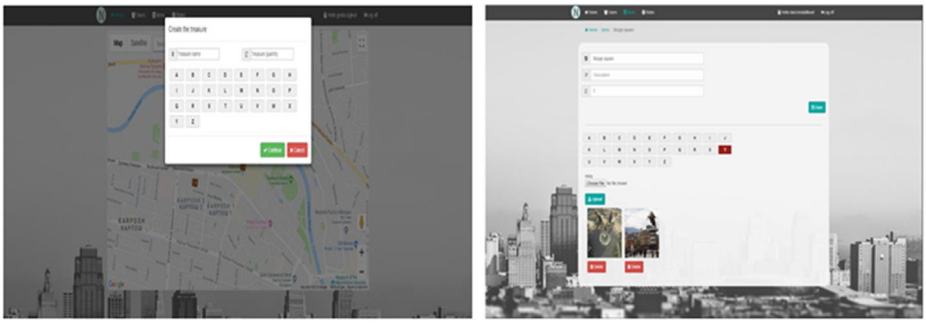
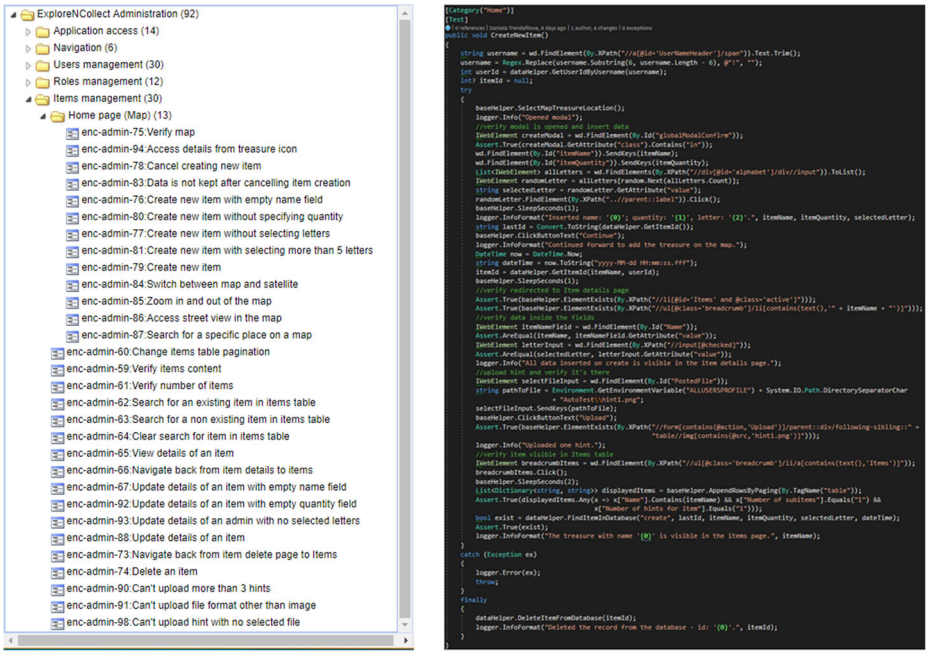


Fig. 6 Adding treasures in educational AR game platform

Although these tests guarantee the educational AR game platform to support that needed user behavior, they do not guarantee that the students achieve increased educational values. Further studies will need to be performed to investigate the influence of the platform on the potential increase in learning achievements.

6 Conclusion

Many games are used in education with no methodological approach, just for fun, because students like playing games. On the other side, there are a lot of educational games that are not



a) test scenario b) automated test for the scenario

Fig. 7 Example of test scenario and automated test for adding the treasure in the educational AR game platform. **a** test scenario **b** automated test for the scenario.

interesting for playing. Neither of these can help teachers in creating an inspirational and motivational environment where students can achieve learning outcomes. In order to achieve successful integration of games in the educational process, teachers need a link between pedagogical approaches and entertainment.

Design thinking-based methodological guidelines presented in this paper proved that interesting, entertainment games, with features popular among students, can be used as the basis for the development of a fun educational game that leads to the achievement of learning outcomes.

The first phase in developing such an educational game should be considering students' experience in playing the considered high rating game, their perceptions, needs, and attitudes toward the game. We propose to implement this phase using already proven industry-based concepts (TAM, TTF, and Design Thinking) in order to increase end-user satisfaction (quality of learning experience).

According to the students' feedback, the educational game should be created with putting educational elements in the game's play concepts during the second phase. In this way, we can ensure that different factors like ease to use, usefulness, students' attitudes, and motivation, proper fitting of educational components in the game, are provided, which will lead to the increased students' quality of learning experience.

The quality of learning experience combines the quality of the experience of the end-users (students), and the possibility to fulfill the educational goal provided by the educational support system. In the paper, that system is a platform for the development of augmented reality educational games. The initial feedback given from students implies their satisfaction from playing the game (positive quality of experience). The developed platform enables input on an unlimited set of locations, questions, and hints that ensure possible matching with different learning outcomes on different subjects.

In future work, we will perform a qualitative and quantitative study with students from multiple schools to investigate the level of increase in the quality of the learning experience.

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References

1. Spires HA (2008) 21st century skills and serious games: preparing the N generation. In L.a. Annetta serious educational games. Sense Publishing, Rotterdam
2. Trajkovik V, Malinovski T, Vasileva-Stojanovska T, Vasileva M (2018) Traditional games in elementary school: relationships of student's personality traits, motivation and experience with learning outcomes. PLoS One 13(8):e0202172
3. Prensky M (2001) Digital game-based learning. McGraw-Hill, New York
4. Videnovik M, Kiønig L, Vold T, Trajkovik V (2018) Testing framework for investigating learning outcome from quiz game: a study from Macedonia and Norway. In 17th international conference on information technology based higher education and training (ITHET) pp 1-5
5. Lymbery J (2012) The potential of a game-based learning approach to improve learner outcomes. CINZS 24(1):21–39
6. Wali E, Winters N, Oliver M (2008) Maintaining, changing and crossing contexts: an activity theoretic reinterpretation of mobile learning. The Journal of the Association for Learning Technology. Res Learn Technol 16(1):41–57

7. Huizenga J, Admiraal W, Akkerman S, Dam GT (2009) Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. J Comput Assist Learn 25(4): 332–344
8. Wen Y, Looi CK (2019) Review of augmented reality in education: situated learning with digital and non-digital resources. In learning in a digital world pp 179-193
9. Karakus M, Ersozlu A, Clark AC (2019) Augmented reality research in education: a Bibliometric study. EURASIA J Math Sci Tech Ed 15:10
10. Barma S, Daniel S, Bacon N, Gingras MA, Fortin M (2015) Observation and analysis of a classroom teaching and learning practice based on augmented reality and serious games on mobile platforms. Int J Ser Games 69-88
11. Hamari J, Malik A, Koski J, Johri A (2019) Uses and gratifications of Pokémon go: why do people play mobile location-based augmented reality games? Int J Human Comput Interact 35(9):804–819
12. Saidin NF, Halim NDA, Yahaya N (2015) A review of research on augmented reality in education: advantages and applications. Int Educ Stud 8(13):1–8
13. Costa MC, Manso A, Patrício J (2020) Design of a Mobile Augmented Reality Platform with game-based learning purposes. Information 11(3):127
14. Zaibon SB, Shiratuddin N (2010) Mobile game-based learning (mGBL) engineering model as a systematic development approach. In Global Learn pp 1862-1871
15. McClarty KL, Orr A, Frey PM, Dolan RP, Vassileva V, McVay A (2012) A literature review of gaming in education (research report). Pearson, Iowa City
16. Nicholson S (2018) Creating engaging escape rooms for the classroom. Child Educ 94(1):44–49
17. Yang YTC (2012) Building virtual cities, inspiring intelligent citizens: digital games for developing. Comput Educ 59:365–377
18. Van Eck R (2006) Digital game-based learning: It's not just the digital natives who are restless. Educ Rev 41(2):16
19. Elmqaddem N (2019) Augmented reality and virtual reality in education. Myth or reality? Int J Emerg Technol Learn 14(03):234–242
20. Johnson L, Adams Becker S, Estrada V, Freeman A (2014) Horizon report 2014 - higher education edition. The New Media Consortium, Austin
21. Pedaste M, Mitt G, Jürivete T (2020) What is the effect of using Mobile augmented reality in K12 inquiry-based learning?
22. Wang X (2012) Augmented reality: a new way of augmented learning. Magazine eLearn, ACM, New York
23. Cheng KH, Tsai CC (2013) Affordances of augmented reality in science learning: suggestions for future research. J Sci Educ Technol 22(4):449–462
24. Lee K (2012) The future of learning and training in augmented reality. InSight J Sch Teach 7:31–40
25. Lin HCK, Chen MC, Chang CK (2015) Assessing the effectiveness of learning solid geometry by using an augmented reality-assisted learning system. Interact Learn Environ 23(6):799–810
26. Barrow J, Forker C, Sands A, O'Hare D, Hurst W (2019) Augmented reality for enhancing life science education. In Proc. of VISUAL
27. Dede C (2012) Customisation in immersive learning environments: implications for digital teaching platforms. In: Dede C, Richards J (eds) Digital teaching platforms customizing classroom learning for each student. Teacher's College Press, New York, pp 282–297
28. Sahin D, Yilmaz RM (2020) The effect of augmented reality technology on middle school students' achievements and attitudes towards science education. Comput Educ 144:103710
29. Dikkers S, Gagnon D, Martin J, Squire K (2014) Participatory scaling through augmented reality learning through local games. TechTrends 58(1):35–41
30. Nincarean D, Ali MB, Halim NDA, Rahman MHA (2013) Mobile augmented reality: the potential for education. Procedia - Soc Behav Sci 103:657–664
31. Bellotti F, Ott M, Arnab S, Berta R, de Freitas S, Kiili K, De Gloria A (2011) Designing Serious Games for Education: From Pedagogical Principles to Game Mechanisms. In Gouscos, D. & Meimaris, M. (Eds,.) Proceedings of the 5th European Conference on Games Based Learning pp 26–34
32. Hainey T, Connolly TM, Boyle EA, Wilson A, Razak A (2016) A systematic literature review of games-based learning empirical evidence in primary education. Comput Educ 102:202–223
33. Quinn C, Neal L (2008) Serious games for serious topics. eLearn Magazine
34. Annetta L, Burton EP, Frazier W, Cheng R, Chmiel M (2012) Augmented reality games: using technology on a budget. Sci Scope 36(3):54
35. Kearney M, Schuck S, Burden K, Aubusson P (2012) Viewing mobile learning from a pedagogical perspective. Res Learn Technol 20(1):14406
36. Holden C (2014) Homegrown augmented reality. TechTrends 58(1):42–48

37. Wu HK, Lee SW, Chang HY, Liang JC (2013) Current status, opportunities and challenges of augmented reality in education. Comput Educ 62:41–49
38. Cerqueira CS, Kirner C (2012) Developing educational applications with a non-programming augmented reality authoring tool. Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications, pp 2816–2825
39. Klopfer E, Sheldon J (2010) Augmenting your own reality: student authoring of science-based augmented reality games. New Dir Youth Dev 2010(128):85–94
40. Bennett A (2011) The role of play and games in learning. The 33rd earl V. Pullias lecture, University of South California (USC) USA
41. Dunleavy M (2014) Design principles for augmented reality learning. TechTrends 58(1):28–34
42. Klopfer E, Squire K (2008) Environmental detectives-the development for an augmented reality platform for environmental simulations. Educational Tech Research Dev 56:203–228
43. Burton EP, Frazier W, Annetta L, Lamb R, Cheng R, Chmiel M (2011) Modeling augmented reality games with preservice elementary and secondary science teachers. J Technol Teach Educ 19(3):303–329
44. Bacca J, Baldiris S, Fabregat R, Graf S (2014) Augmented reality trends in education: a systematic review of research and applications
45. Miller D, Dousay T (2015) Implementing augmented reality in the classroom. Issues Trends Educ Technol 3(2)
46. Wei X, Weng D, Liu Y, Wang Y (2015) Teaching based on augmented reality for a technical creative design course. Comput Educ 81:221–234
47. Melles G, de Vere I, Misic V (2011) Socially responsible design: thinking beyond the triple bottom line to socially responsive and sustainable product design. CoDesign 7(3–4):143–154
48. Rauschnabel PA, Rossmann A, Tom Dieck MC (2017) An adoption framework for mobile augmented reality games: the case of Pokémon go. Comput Hum Behav 76:276–286
49. Davis FD (1989) Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q 13(3):319–340
50. Lee DY, Lehto MR (2013) User acceptance of YouTube for procedural learning: an extension of the technology acceptance model. Comput Educ 61:193–208
51. Koivisto J, Hamari J (2014) Demographic differences in perceived benefits from gamification. Comput Hum Behav 35:179–188

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