Design Thinking Methodology for Increasing Quality of Experience of Augmented Reality Educational Games

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***Abstract*— Integration of technology in education with adequate pedagogical approaches creates 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' collaboration, energy, and enthusiasm. 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 describes how design thinking methodology can be used to propose a model for the integration of games in education. The methodology defines the process of creating educational games starting from students' attitudes and needs and moving towards needed educational outcomes. As an example case study augmented reality prototype game was designed in order to illustrate the possibilities and benefits of the proposed methodology. The achieved results confirm that the proposed methodology ensures a powerful gaming experience and high-quality learning experience.**

Keywords*— *Augmented Reality Educational Games, Quality of learning, Design Thinking Methodology, Collaborative Learning Environments,

I. Introduction

By using digital games, new and powerful ways of learning in the classrooms can be created. These interactive collaborative experiences can increase engagement of students in the learning process and thus, learning outcomes can be achieved more easily. Digital games offer students opportunities to reach goals that are not focused just on learning facts, but enable development of skills such as problem solving, decision making and strategic planning at the same time [1].

Mobile devices have made their entrance in the world of education [2]. The learning potential of mobile and location based technologies lies in the possibility to embed learning in an authentic environment, enhance engagement and foster learning outside traditional formal educational settings [3]. Augmented reality (AR) is one of the technological tools recently mostly associated with mobile platforms. Learning based on augmented reality can be implemented on different mobile devices. Since its introduction, augmented reality has been shown to have good potential in making the learning process more collaborative, effective and meaningful. This is because its advanced technology enables users to interact with virtual and real-time applications and brings the natural experiences to the user [4]. In addition, the merging of augmented reality with education has recently attracted research attention because of its ability to allow students to be immersed in realistic experiences [5]. 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 [3].

There are a lot of games that can be used in educational context, but not all are enjoyable for the students. It is very difficult to match popular games to the curriculum in order to use them in educational process. This paper addresses these issues by providing students centered collaborative process of developing educational games to be used in classrooms. The potential benefits and issues related to integrating games in education using methodology inspired by design thinking, are explored. The main goal of this paper is to present an approach that can enable qualitative integration of games in education and increase students Quality of Experience (QoE).

The International Telecommunications Union defines Quality of Experience as "the overall acceptability of an application or service, as perceived subjectively by the end-user" [6]. In this paper, QoE is recognized as a multidisciplinary concept about students' acceptance of using games in education based on game popularity, cognitive experience and subjective feeling. QoE is focused to determine 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 important role in achieving learning outcomes.

Next section explains theoretical background of introducing games in education. In the third section different approaches and benefits from using mobile educational games and AR games for learning are presented. Proposed methodology for design of AR educational game is described in fourth section. The fifth section presents results and

discussion of the results. The last, sixth section concludes the paper.

II. Theoretical background

Learner-centered approach enables students to progress learning with own pace. In that context, teachers should be 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 [7]. Teaching and learning experiences should be structured to challenge students' thinking so that they could construct new knowledge. According to Zaibon and Shiratuddin [8] 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 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 [9]. These students bring different skills, interests, and needs to the classroom. The true revolution in education could only be achieved via digitization of education that will enable students to learn both collaborative and at their own speed, both within and outside the classroom.

Game based learning (GBL) can be successfully developed and implemented in learning environment by combining both game design and instructional design approaches and by considering various issues such as learning theories, theory of play, mobile platform and technologies (for mobile games), game design, and instructional design [8]. Students use games to explore, discover, and question. These "learning by doing" and "active learning" concepts are important principles, which underlie game based learning [10]. Games teach students about goals, rules, adaptation, problem solving, and collaboration using different forms of story-telling. They satisfy students fundamental need to learn by providing: enjoyment, passionate involvement, structure, motivation, ego gratification, adrenaline, creativity, social interaction and emotion in the game itself while the learning takes place [11]. Computer games do not only integrate knowing and doing, but they also "bring together ways of knowing, ways of doing, ways of being, and ways of caring: the situated understandings, effective social practices, powerful identities, and shared values that make someone an expert" [12].

An attractive element of the gaming experience, as a learning tool, is that it provides opportunities for continued practice because negative consequences are not typically associated with failure. In that way, failure serves as an integral part of the learning experience. This encourages students as players to improve through repeated practice either by advancing within a game or replaying parts of a game. This constructive feedback enables students to improve their work [9].

In the recent years, technology enhanced learning has been increasingly focused on emergent technologies such as augmented reality, ubiquitous learning (u-learning), mobile learning (m-learning), serious games and learning analytics for improving the satisfaction and experiences of the users in enriched multimodal learning environments [13]. 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. 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 [14].

Well-designed contextual augmented reality experiences align with social constructivist tenets of teaching and learning that argue knowledge is shaped in part by the environment in which it is derived [15]. Lee [16] summarizes these attributes well stating that augmented reality has the potential to further engage and motivate learners in discovering resources and applying them to the real world from a variety of different perspectives that have never been implemented in the real world. There are a number of pedagogical attributes that make augmented reality an ideal instructional tool for a variety of subject areas. Augmented reality drew huge public attention because it provides a new perspective for learning by allowing learners to visualize complex spatial relationships and abstract concepts [17]. When information is presented using augmented reality in a contextually relevant environment it can enable a greater understanding of how new information is practically applied in realistic settings [18]. Contextual learning increases the relevance of new information for students and allows them to see more clearly how new knowledge can impact their environment [19].

III. Related work

The rapid evolution of technology has changed the face of education, especially when technology was combined with adequate pedagogical foundations [20]. Gamification of learning, especially using mobile games and augmented reality games have been topics of many educational researches in the last decade. All of them emphasized the benefits from using games in learning process and agree that the future of the education is going to be pointed in that way.

Despite the intense interest in games, it is important to realize that developing games for learning can be very complex and costly and still provides significant challenges. Analyzing the impacts and outcomes of computer games in education, researches shows that there has been a move away from using commercial games for learning, due to difficulties in integrating them into the curriculum. Thus it has been accepted that it is more useful to develop games that address specific curricular objectives [21]. One of the biggest problems of educational games to date is the inadequate integration of educational and game design principles due to the fact that digital game designers and educational experts do not usually share a common vocabulary [22].

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 [23]. 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. Quinn and Neal [24] 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 are being used in a variety of training and educational settings ranging from elementary schools to universities. However, methods and tools for effectively and deeply infusing pedagogy and instruction inside digital games are still missing [25].

Considering the current trend towards ubiquity of smartphone and tablet devices in school systems, it is clear that if augmented reality is implemented by classroom instructors on a broad scale, smartphones and tablets have the most potential to be the devices on which these experiences are developed [26]. Despite the ubiquity and flexibility of these devices, there has been minimal use of m-learning approaches in education and developments have tended to be more about the design of the tools than of the ensuing learning [27]. There is an ongoing need to examine the pedagogies that are suitable for m-learning, and to conceptualize m-learning from the perspective of learners' experiences, needs and expectations rather than the affordances of the technology tools.

Augmented reality as a learning experience represents more than just the merging of hardware, software, and contextually relevant information [28]. When applied to education, augmented reality is best defined as a concept, rather than any specific combination of technologies and design strategies [29]. The power in augmented reality, which sets it apart from traditional curricula and even from purely virtual learning environments, lies in truly augmenting the physical landscape using digital technologies to enable students to see the world around them in new ways and engage with realistic issues in a context with which the students are already connected [30].

In addition, most of the research conducted on augmented reality shows that students are excited and interested to learn using this technology. For example, in research conducted by Klopfer and Squire [31], students gave positive feedback about their experience of the combination of the virtual and real environments. Burton et al. [32] also reported a similar result, with the participants in their study clearly 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 the student motivation and collaboration in the learning process [33].

Augmented reality has been labeled an emerging technology with the implication that there are still barriers that need to be addressed before large-scale adoption will occur [34]. According to Saidin et al. [5] 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 largely the ad hoc creations of educators with 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, collaboration between educators and game designers is necessary to facilitate the development of favorable augmented reality applications for teaching, as well as the design of reasonable teaching schemes according to social psychology principles, taking into account students' wishes, curiosities and needs. This would allow AR to play a fuller role in education [35].

IV. Methodology

Most of the games that are nowadays used in the teaching process are boring and not motivational for the students, and consequently they don't want to use this kind of games 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 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 [36]. It is a human-centered approach, so the process of designing a mobile educational game started from students needs and atttudes toward this topic [37]. The main idea was 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 are 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 [38]. For the purpose of our research, we consolidated Empathize and Define in one stage - Identify, that gave us understanding of the problem from the students' perspective and helped in defining the problem in a student-centered manner. This information was used for creating simple educational game in line with students' needs. The game was tested by students and after that students' opinion was surveyed again.

A. Identifying the problem

The first stage of design thinking is to gain an emphatic understanding of the problem we want to solve - how to create 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 based on the fact that when creating an educational game nobody is taking consideration about students' attitudes, wishes and needs.

Starting from 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.

First part of the survey was 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 on 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. At the end, the survey had two open ended questions in order students to have possibility to express their opinion concerning usage of AR games in education.

Gathered information from the conducted survey were 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 educational game.

B. Idea for problem solution

In order to propose a model for integration of games in education, positive students' Quality of Experience (QoE) was studied, as a key driver of technology acceptance, adoption and innovative use. The students' acceptance process was driven by the Technology Acceptance Model (TAM) [39], used to explain the factors affecting user perceptions and acceptance of games in education. According to Davis [39], 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 [40].

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 one. We extended TAM to describe necessary condition 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 integration of games we added elements from TTF (Task-Technology Fit) model. Consideration of the fit between task (in our case the educational goals that should be reached) and technology (game) was central to the model. We considered 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 the results of game utilization in educational context.

The TAM and the TTF offer distinctive explanations of the mechanisms behind the user's choice to accept a technology. However, in our case TAM in combination with the TTF provided more explanative power over either the TAM or the TTF model alone. Several empirical studies are notable with respect to their attempts to integrate the TAM with the TTF in a complementary manner [40].

C. Prototype stage

After defining a model for integration of games in educational process, a prototype for mobile AR educational game based on the proposed approach was designed. The concept of popular mobile AR game among the students at given moment was used and adopted to students' surrounding, keeping in mind their expectations and needs. The prototype game was designed for young students and we expected that the game will be enough interesting to stimulate them to play it again and again.

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

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

D. Test stage

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 semi-structured 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, 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 educational context, in order to determine whether the game is used both for learning and entertainment. By using these findings, different approaches for re-creation of the game could be implemented. Namely, the game possibilities could be expanded in future work when additional subjects, number of students, type of activities can be considered.

The information that we gathered using design thinking approach served as a base for proposing theoretical model for integration of games in education and were very useful for understanding the type of game that could be used in educational process.

V. Results and Discussions

A. Identifying the problem

Augmented reality is an example of a technology that can make classroom learning more transformational and engaging, real life connected, student centered and interesting. It enters more and more in students' everyday life. Pokémon Go as an augmented reality game is an outstanding example of how an augmented reality game can spread through people life. In the moment when the research was done, it was very popular and most of the students were preoccupied with playing this game.

In order to see the extent to which Pokémon Go has occupied students' lives and to examine their attitudes toward

using this kind of augmented reality games in education short survey was conducted among the primary school students. The first reason for choosing Pokémon Go was that this game has become a real phenomenon by allowing users to play outside their homes, that unlike others encourages physical activity. The second reason was game's popularity especially among the students. Survey results were used for understanding students' needs and attitudes concerning using AR games in educational purpose.

Information concerning students' age, gender and school grade are presented in Table 1.

TABLE I. DEMOGRAPHIC INFORMATION OF THE PARTICIPANTS

Demographic variable		***Frequency***	***Percentage***
Gender	Male	29	72.50%
	Female	11	27.50%
Age	13	22	55.00%
	14	18	45.00%
Grade	8th	17	42.50%
	9th	23	57.50%
How often do you play video games	Every day	25	62.50%
	Very often	6	15.00%
	Sometime	7	17.50%
	Rarely	2	5.00%
	Not at all	/	/
How often do you play Pokémon Go	Every day	1	2.50%
	Very often	20	50.00%
	Sometime	12	30.50%
	Rarely	7	17.50%
	Not at all	/	/

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 certainly thought-provoking fact, which raised the question how to use something that is very important 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 other similar application (created for educational purposes) they would not have a problem to use it.

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

Students liked the fact that Pokémon Go is played on mobile devices (82.50%) and would liked to use mobile games and applications that will broaden their knowledge and educate them. They thought that mobile apps and games will help them to learn on more interesting and stimulating way. Furthermore, students (87%) 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 interesting 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.

TABLE II. RESULTS OF STUDENTS' ATTITUDE TOWARDS PLAYING AR MOBILE GAMES

Item	***Agree / strongly agree***	***Neutral***	***Disagree/ strongly disagree***	***Mean***	***SD***
I like the fact that Pokémon Go is played outside	65.00%	27.50%	7.50%	3.55	1.26
I like the fact that Pokémon Go is played on mobile devices	82.50%	15.00%	2.50%	4.18	0.78
I feel safe while playing Pokémon Go	30.00%	25.00%	45.00%	3.78	0.97
I found interesting places/ objects while playing the game	65.00%	30.00%	5.00%	3.85	0.86
I would like to use mobile apps with educational purpose	87.50%	10.00%	2.50%	4.63	0.77
I would like to go outside to explore using mobile app	75.00%	10.00%	15.00%	4.05	1.08
I would like to use mobile app outside to find some interesting information	85.00%	7.50%	7.50%	4.30	0.91

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.

Students highlighted safety as the only problem with using this kind of games. Almost half of the students (45%) didn't feel safe while playing Pokémon Go because they had reduced attention on 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 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 battery of the mobile device. There are those who noticed that Pokémon Go in some cases is forcing 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 really reasonable and should be considered during development of mobile educational game that will be popular among students and will have educational value.

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 of the learning and something interesting - games. They considered that these games could help them to learn on easier and interesting way. In general, students liked 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 on interesting way. For that reason we decided to create a game that can be played in a controlled surrounding controlled (school yard, 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 easier understanding of certain aspects of the topics.

B. Idea for problem solution

Starting from the results obtained from the survey conducted among the students about using augmented reality games in education the model concerning integration of games in education was suggested. The model based on the work on quiz game [41] shows relationships among important variables influencing game-based learning approach and students' quality of experience, according to previous discussion.

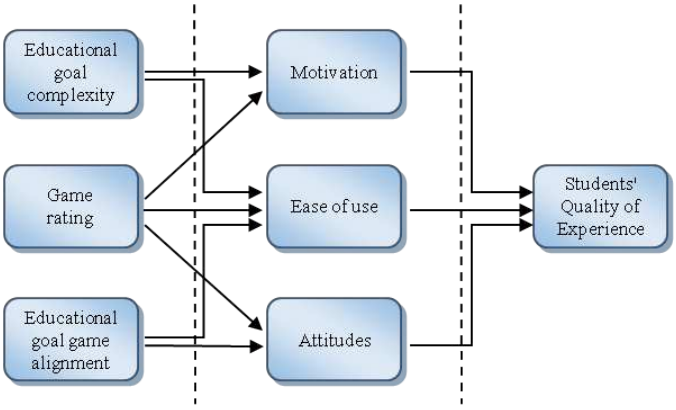

Fig. 1. A model for integration of games in educational process [41]

In the proposed model, relevant factors that influence students' experience during use of augmented reality educational game were identified. These factors are complex variables and we divided them in 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). We believed that age can influence the student motivation and attitude to learn using certain game. This should be investigated in further research.

The main idea of this model is that designing an educational game should always start from the: game rating, alignment of the educational goal with the game, and educational goal complexity.

Students emphasized that they would like to use high rating game in the process of achieving learning outcomes. Students stated that if the educational game is designed according to some high rating game, they would not have problem to use it. This influenced their motivation to play the game and their attitudes towards using game for achieving learning outcomes. Game rating influences on forming positive attitudes toward playing it in educational context.

Characteristics of a game and educational goal must fit together in order to achieve better results of game utilization in educational context. Students' emphasized that they would like to use mobile apps with educational purpose. Students' attitudes toward playing mobile app games in educational context were positive because they think that it will help them to learn on more interesting and stimulating way that is very familiar to them. 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.

Competitiveness in game influenced on students motivation for playing it over and over again in order to achieve better results.

Educational goal complexity should determine the number of levels in the game and how they should be passed. Namely, for each level of learning outcomes should be appropriate level of the game which will motivate students for playing it. This can be implemented by indicating different degrees of success which could be achieved while mastering a given level.

Students' motivation is one of the most important factors in the process of creating 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 game play. That's why educational goals must fit clearly in the game.

Alignment between educational goal and a game, from one side, and designing a games level according to the goal complexity from the other, must be achieved. The ultimate principle of the TTF model is that the greater support a given technology provides for a task, the higher perception of task-technology fit, and the higher technology utilization by the user.

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

Proposed model provides relevant information about necessary issues concerning 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 adopt the game to the educational goal complexity. The game designed on this way, starting from the good technology acceptance, will have positive influence on students' motivation to play the game and their attitudes towards using a game for achieving learning outcomes.

C. *Prototype stage*

Starting from the previous findings, in order to achieve balance between pedagogy and game, a prototype for educational augmented reality game was developed. Pokémon Go game features was used, with educational elements 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 presented prototype was expected to raise students' physical and mental activity at the same time using fun and entertainment. The game was created in Java for Android. Augmented reality in a powerful platform like Android was very easy to achieve. Most commonly used sensors and resources were camera, accelerometer and compass.

The game consists of five questions, hidden in different parts of the ZOO in Skopje, Macedonia. Questions refer to the animals in the ZOO. Players should find the questions (physical activity) and answer them (mental activity). The idea was real safe space to be used (ZOO) for raising physical activities and stimulating mental activity by answering some simple question where the answers will be easily reachable. The game starts at the ZOO's entrance and ends when player passes all the spots and answers the questions. The fastest player with all answered question wins.

Playing the game, movement and navigation to the questions can be achieved on two ways (according to the mobile phone orientation):

- While the mobile phone is oriented horizontally, map of the ZOO with all the spots where the questions are hidden and should be passed by is shown (fig. 2a).

- While 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 on fig. 2b.

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

Fig. 2. User interface of the prototype game

Interactivity starts when the application checks if there is any spot in the range closer than 10 meters. When that kind of spot is found, a dialogue with a multiple-choice question and provided answers is displayed. If the player tries to move away too much (over 15 meters), 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 correct, his/her response is marked and that spot does not appear in the augmented reality view of the camera anymore, but it still 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 and 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. The potential is unlimited. For example, this game works only on the open space in ZOO, but it can be adapted in the museums or other territories, which are safe and controlled. In the educational context it can be used as combination of physical education and any other subject (for example, in case of natural museum, the questions can be related to flowers or insects).

D. *Test stage*

Students had to answer five questions hidden on different places in the ZOO. At the beginning, students tried to understand how the game should be played on their own: to move and handle in the space, to understand the navigation, find the spots and answer the questions, at the same time developing competitiveness.

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 gaming environment. It was also a proof of the results from the first survey that students would not have a problem to play a game similar to Pokémon Go.

Discussion with the students showed that students were very satisfied with the played game because they had a possibility to learn in natural surroundings. They discussed that the learning was easy and they learned a lot in an interested manner (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 on students' motivation for playing it over and over again in order to achieve better results. It was evidence that learning goals can be easily achieved by putting some educational elements in 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 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' answer they would like to play this game again. Their attitude towards the played game is very important for the future researches. Students suggested that they would like this game to have more questions and maybe to have similar game with the questions from other subjects in different surrounding. They also suggested that they will like to play and learn together with other students more often. This information was a 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 main benefit from 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 other benefit from the game. Furthermore, students liked the ability to communicate with the others and they enjoyed physical activities (although they found running a little difficult because they are used to sit more while playing a game). It was very exciting to see that students really learn something, and they are inspired to think even further about their learning.

Final conclusion from this game and it's testing is that the game was successful and served a purpose. The most important benefit was that students like this type of games and they would like to use them for educational purposes. The balance between education and fun was achieved. 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.

VI. Conclusions

A lot of 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 interesting for playing. Neither of this can help teachers in creating 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 methodology presented in this paper, proved that interesting, entertainment game, popular among students, can be used for development of educational game which will have fun and methodological elements at the same time and will lead to achievement of the proposed learning outcomes. First step 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. According to the students' feedback, educational game should be created but putting educational elements in the high rating game's play concepts. 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' QoE.

Proposed model for integration of games in educational context is good starting point for development of educational games based on collaboration between different stakeholders: students, teachers and game designers. In our future work, we will try to utilize the design thinking methodology presented in this paper into a formal evaluation framework for educational games.

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