Using a Non-educational Mobile Game for Learning in Biology, Geography and Mathematics: Pokémon Go as a Case Study

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Abstract. ICT offers new perspectives in teaching and learning. In this paper a popular non-educational mobile game, "Pokémon Go", is used as a background for the design of educational activities in Biology, Geography and Mathematics and as a means of informal learning. Five secondary level students (14–15 years old) participated in this study. Data were collected through observation, field notes and interviews. The participants described the activities as attractive, pleasant and creative and stated that there is a lack of engaging learning and technology use in school. The results show that an effective integration of mobile technologies can enhance learning and students' attitude.

Keywords: Non-educational mobile apps · STEM · Mobile learning · Augmented reality · Game-based learning

1 Introduction

In this study activities about several subjects were designed using the 'Pokémon Go' mobile game environment. Pokémon Go is an application designed primarily for entertaining and socializing purposes, and is considered as a great example of disruptive technologies [1]. This decision of using a non- educational application brought to the fore the following reflection: commercial games are considered far more interesting and attractive than educational ones but they lack of support for the learning experiences [2]. In order to solve this questioning our study attempts to provide an educational setting, in which participants are playing and constructing knowledge through interaction with the game universe [2]. Apart from implementing the activities in a variety of subjects, effort was made to use different key features of mobile gaming which could be useful in an educational context.

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2 Theoretical Background

2.1 Mapping the Area of Mobile Learning

New possibilities and challenges in learning and pedagogy connected with changes in technology continue to appear. The notion that mobile learning (ML) is more than just integrating mobile technologies and mobile devices [3] is reinforced by El-Husein and Cronje [4] who refer to ML as 'any type of learning that takes place in learning environments and spaces that take account of the mobility of technology, mobility of learners and mobility of learning. Student engagement seems to increase when mobile technologies are incorporated in instruction, also due to their capability of intersecting learning styles [5]. The most significant factors that are considered to negatively affect learning and students' perceptions about learning are the instructional design and comfort with technology, if they are not properly arranged [5].

Tu and Sujo-Montes [3] suggest integrating mobile technologies through transforming students' mobile devices into learning devices and learning tools. This transformation is oriented to the personalized, context specific and easily mobilized features that enhance learning in innovative ways. Students have the opportunity to reach larger range of content and approach the educational process and material from anywhere, anytime [5]. This flexible, ubiquitous character of mobile devices opens the picture for mobile learning advantages. Educators play a key role in the design of activities, implementation of new technology, cultivating mobile information literacy in students and finally adapting the technology in specific learning goals and outcomes [5].

Mobile technologies, and particularly mobile games, have been used in a variety of settings, both formal and informal, in support of student learning [6]. Recently, mobile games earned a prevailing place among other gaming platforms (PC, consoles, arcade games), thanks to the mobility, networkability, accessibility and simplicity of mobile devices [6]. Although research must focus on the situated nature of game-player interactions, factors such as the instructional design and the facilitating role of the teacher should also be included.

2.2 Augmented Reality

Pokémon Go, the selected app for the study, bears an embedded AR feature. The consideration of AR as a concept rather than a certain type of technology provides opportunities for exploiting AR for educational purposes. According to Wu et al. [7] AR affordances in education could be summarized in the following: (a) learning content in 3D perspectives, (b) ubiquitous, collaborative and situated learning, (c) learners' senses of presence, immediacy, and immersion, (d) visualizing the invisible, and (e) bridging formal and informal learning. AR is a live, direct or indirect, view of a physical, real-world environment allowing mobile users augment their interaction with their surroundings by providing elements such as video, graphics or Global Positioning System (GPS) data [3].

2.3 Game-Based Learning

According to Qian and Clark [8] the term game-based learning describes an environment with two main characteristics: First, knowledge and skills are enhanced through game content and gameplay. Secondly, a sense of achievement is provided to players, through problem solving incorporated in game activities.

The explosive development and popularity of video and mobile games has directed educational research to focus on digital gaming, as a possible effective educational tool. Findings that support this assumption indicate that video games provide a learning environment which increases students' interest and motivation [9].

Motivational mechanisms used in game-based learning interventions include badges, leaderboards, points, levels and virtual goods [10]. These design principles have a great emotional and social impact on students, as reward systems and competitive social mechanisms seem to be motivating for them [11]. While analyzing the motivational effect of game-based learning, it becomes obvious that a major aspect in this context are performance goals. Mastery goals contrary, which refer to the desire to master new knowledge play a minor role.

In order for game-based learning to step to the next level meaningful implementations, not limited in extrinsic rewards should be developed [12]. Some elements which could be considered are providing players a strong sense of autonomy by giving different routes to the ultimate goal [13] and recursive play through failure [14].

2.4 About Pokémon Go

Pokémon Go is a location-based augmented reality game for Android and iOS, developed by Niantic, that incorporates the above-mentioned characteristics. It ranks as one of the most downloaded apps of all time. The player has the opportunity to find, encounter and capture small monsters (Pokémon) of the well-known Pokémon franchise in the real world. Certain places of interests, such as landmarks, parks, statues etc. serve as either gyms, where the battles take place, or PokéStops, which provide players with useful items. Almost every move in the game rewards the players with experience points (XP) that help them level-up and become more competitive. AR mode uses the camera and the gyroscope on the player's mobile device to display the Pokémon in the real world. Different species of them can be encountered in different areas. For instance, water- type Pokémon are most likely to be found near lakes or seas. Despite its massive success, there is a scarce of studies with actual use of Pokémon Go for educational purposes. In this study, Pokémon Go is used as a learning tool in the fields of Mathematics, Geography and Biology and its educational potential is investigated.

3 Research Methodology

This study aims to explore the point of intersection between mobile apps and their educational affordances when integrated into the learning process effectively. The study had the following research questions:

1. In which ways can a non- educational mobile application work as a background for designed activities that support learning?
2. What are the participants' perceptions and attitudes about such applications and the designed activities?

The convenience sample included four secondary level students, 14–15 years old, from public schools of Thessaloniki. All of them had previous experience with the game. Every student got involved in one of the three activities. Each of them lasted approximately 2 h. Data were collected through observation and field notes during the implementation and through interviews after the completion of the activities. The interviews were semi- structured and had the following three sections: student's relation with technology (school and every-day life), student's impressions and attitudes towards the game and the activities, student's views about the use of gaming applications at school. In order to achieve greater validity, each researcher undertook one activity and worked separately. The results of these three sources were then compared and discussed and the final conclusions were drawn.

4 Activities

4.1 Biology

The concept of evolution is described as a delicate, complex teaching objective, particularly exposed to confrontations with the ideas belonging to the public domain and beliefs influenced by cultural factors [15]. However, due to its prodigious ability to enable people make sense of the natural world, a proper understanding of evolutionary theory is a critical aspect of scientific literacy [16]. In the same direction lies the need for providing chances for scientific skills development in the teaching of science subjects is highly supported by [17]. The designed activities aim to support biology content but also its facet as a scientific process. The game's universe works ideally as a basis for practicing inquiry skills such as identifying common characteristics and exploring how these characteristics affect and being affected by environmental factors.

In the first series of activities the two participants organized their catching activity in lists and discussed their ideas about making categories out of this number of collected Pokémon based on a criterion (e.g. size, type, level, class). Then, they were asked to identify similarities between different groups of Pokémon and differences between Pokémon that they have placed in the same category. Observation and classification, as well as the decisions taken in the game's context were at the heart of the activity. In the second series of activities students were asked to describe external characteristics of Pokémon and link specific characteristics with the natural habitat of the organisms. Students had the opportunity to collect information about Pokémon characteristics in order to identify which of these are based in real life organisms. In this way students are triggered to explain how these features provide organisms the collateral of their survival, such as natural ways of protecting themselves, helping them collect their food etc.

The context of the activities, the mobile app environment, is closely related with students' interests and experiences and framed by historical information about Darwin's work. Learning goals referring to knowledge background and scientific processes (such as observation) function as motivating structures and can be used as a basis for further cognitive and skill development. It must be mentioned that the understanding of those rather challenging concepts such as natural selection is far from the proposed activities' impact.

4.2 Geography

Urban landscapes and the historical-cultural context of their landmarks, provide a perfect field for students to exercise their orientation and map-reading skills. The Pokémon Go interface provides a very usable digital map that is enriched with features that underline important landmarks of the city like Pokéstops. Apart from that, Pokémon Go provides a rich arsenal of gaming mechanics that include reward systems like the collection of experience points through a variety of actions (Fig. 1).

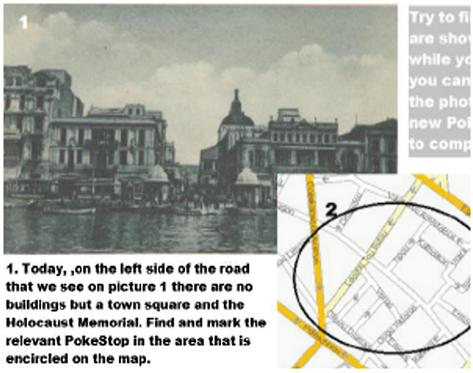

Fig. 1. Part of the worksheet used for the geography activity.

During the activity the student searches for certain places or buildings of Thessaloniki while playing Pokémon Go and taking directions by a worksheet. On the worksheet the spots they have to find are shown through old photos. Text hints provide information and guidance and encircled areas in a modern Thessaloniki map indicate where they have to search each spot, which are Pokéstops. Apart from the Pokéstops, another feature of the game that is used is that students have to collect as many different Pokémon they can. For every one of the spots they find and mark correctly on the map, the students gain 30 points and for every different Pokémon they gain 1 point.

4.3 Mathematics

Problem Solving is among the most important concepts in school Mathematics. A mathematical problem should be attractive, comprehensible, interesting due its

intriguing context and allow students to apply their knowledge and skills in authentic, non-routine problem situations [18]. There are 3 types of quantitative estimation skill: numerosity, computational and measurement estimation [19]. The following problem is related to the last type, on which very few researchers and teachers have focused [20].

Thanks to the AR feature, one can take photos of the Pokémon in the real world, before trying to capture them. In this activity the participant was asked to take such photos and then to estimate the height of each Pokémon by comparing it with objects of the real world in its environment, whose size was known (e.g. about $2/3$ the height of the bench, about $1/4$ the height of the fountain). The sizes of the real objects were measured (e.g. bottle) or retrieved from the web (e.g. statues). Even based on accurate numbers, the final estimation could not be absolutely accurate, so the student was also free to estimate a size (e.g. tree) or round it up. The game provides information about the "real" height of each Pokémon, and the student could compare it with her estimation. The student was asked to interpret the comparison using the following calculations: the difference between the estimation and the exact height $(|a - e|)$, the fraction a/e (Approximate Value/Exact Value) and the respective percentage $(a/e \times 100\%)$, the percentage error: $(|a - e|/e) \times 100\%$. A table with these data was then constructed for each picture. For example, in the following photo taken by the student (Fig. 2) "Marowak" seems to be about the height of the car (approximately 1.8 m). However, according to the game it is 1 m tall. So for this Pokémon:

- $(|a - e|) = 0.8$
- $a/e = 1.8$
- $a/e \times 100\% = 180\%$
- $(|a - e|/e) \times 100\% = 44.44\%$

Fig. 2. An AR photo example for the mathematics activity.

5 Results and Discussion

According to the observation, the designed activities based on the game were proven to be very engaging for the students and thus they are considered to be successful. The biology activities attempted to integrate scientific processes with content and context related to the concept of evolution, which is considered rather exigent. The designed problem solving activity in mathematics helped participants comprehend and practice

measurement estimation, a concept seldom taught in classroom, in a joyful way. The geography activity evoked participants' active engagement with demanding orientation and map reading activities, while leading them to discovering unknown until then city spots. Examining the results of the analysis in a comparative way indications about the designed material and the whole experience lie in similar and complementary directions for each of the subject area.

More specifically, all participants were proven to be frequent users of technology, mainly smartphones and tablets, in their everyday life. On the contrary, technology is absent from their school subjects, except for the ICT lesson.

The effective integration of mobile technologies allowed students interact not only with content but also with information related to the environment these ideas were developed. Activities were described as attractive, pleasant and creative. All the interviewees were either positive or enthusiastic about the implementation of such activities in school. For example, two students said:

"School activities are never so pleasant. In this activity I had to do things on my own and not just solve a given task"

"The most interesting part was that I saw an app I use every day from a different perspective."

They believe that the main reasons this does not happen are the lack of time, the fact that many teachers do not care or do not know how to make their subject more interesting and the learning more pleasant. For instance, one student stated:

"It does not happen because most teachers don't know how to do it. Some of them may just avoid it, since such things need time. I am sure I would be more interested in the lessons and appreciate the teacher that devoted time to devise such a lesson and risk to go beyond the textbook and usual way of teaching."

6 Conclusions

In this paper the design, implementation and analysis of an informal learning setting using Pokémon Go as a non-educational mobile app was presented. Findings indicate that the designed material actively engaged participants, providing them with experience-based learning opportunities. The area of interest consisted of various subjects (mathematics, geography and biology). Each of the implementations was designed in order to support the nature and the content of the subject utilizing effectively the affordances of the mobile app environment (e.g. augmented reality features were used for informal estimations of height in the mathematics activity). The limitations of this study, such as focusing only in one mobile application, a short research period and a restricted number of participants, point in future research possibilities. One of the emerging 'quests' could be gaining deeper understanding of perceptions about the educational system and its impact to students' lives. Realizing instructors' role in learning is just one of the crucial elements. So, what are their proposals in bridging their out-of-school ICT experiences with learning inside school? Maybe this and other questions function as guidelines in upcoming research work. Finally, mobile apps open

the picture for new opportunities in teaching and learning. An ensemble of factors that extend from the learners and teachers role should be carefully considered in order to constitute a concrete setting for applying reforming pedagogical strategies and effectively integrating mobile technologies in learning.

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