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The Little ones, the Big ones and the Code: Utilization of digital educational games in primary school pupils

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Abstract

This paper is a case study on the use of educational digital games to elementary pupils and deals with games that promote algorithmic thinking as well as the basic principles of programming. The study involved 94 young pupils who worked in pairs (Pair Programming) trying to solve puzzle games from code.org website during their visit to the University of Peloponnese in the context of the European Code Week. Factors such as satisfaction, evaluation of perceived knowledge and willingness to use games in future in the learning process were examined. Furthermore it's discussed whether a short activity like this can result to long term motivation of pupils. The article concludes that: (a) the pupils enjoyed the games and wished to repeat corresponding activities. (b) They considered that by playing, they acquired basic skills and knowledge as far as programming principles were concerned. (c) They preferred Pair Programming and estimated that they could learn better by assisting one another. Finally, it seems that the few hours visit was not enough to motivate most pupils to carry on with the activities at home by themselves.

Keywords: Pupils Programming, Pair Programming, Game Based Learning, European Code Week

1. Introduction

The present article describes a case study of digital educational games utilization that promote algorithmic thinking as well as basic principles of programming in primary school pupils. In the context of the European code week of 2014 (http://codeweek.eu), pupils of 5th and 6th grade of Greek primary schools visited a public university and with the help of undergraduate computing pupils they played digital educational games from code.org website and specifically the activity "K-8 Introduction to Computer Science" (https://code.org/educate/20hr) which was designed for the global "Hour of Code' (http://hourofcode.com/gr). After having finished with the computer gaming activities the pupils answered a brief questionnaire with the purpose to discover their perceptions about Game Based Learning, Computer Science and Pair Programming. Furthermore, the research examines whether a rather short term action that

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is to say a brief visit to the university (http://goo.gl/klxetg), can result in long term motivation of pupils in order to continue the digital gaming activities at home.

From the bibliographical research it is widely admitted that digital gaming can support learning in a rather positive way (De Freitas & Oliver, 2006; Hong, Cheng, Hwang, Lee, & Chang, 2009; Pivec, 2007; Williamson, 2009). The great advantage in using digital games in education is that they add a pleasant experience during the learning process (Blackman, 2005; Prensky, 2005). Apart from being pleasant, they can be very effective and useful as plenty of research studies have already shown (Lepper & Cordova, 1992; McFarlane, Sparrowhawk, & Heald, 2002; Papastergiou, 2009). The terms Game Based Learning (GBL) and Digital Game-Based Learning (DGBL) describe learning through gaming and digital gaming respectively and have already been established in modern pedagogical and educational technology, consisting an undoubtedly promising field of research (Prensky, 2003).

Adopting digital environments with games can be put into action in formal or/and in informal education either on games usages created specifically for fulfilling educational purposes or by non-educational gaming (that is to say for fun) but still used for the aspiration of the learning aims (Kirriemuir & McFarlane, 2004). Code.org website hosts a lot of "serious" games given the fact that they are not purely entertaining but mainly educational (Djaouti, Alvarez, & Jessel, 2011). In our research we made the most of our gaming activities using the lesson entitled "K-8 Intro to Computer Science", which was actually the most popular of the action. Every activity-game hosted at the Code.org website is free. The particular game series aims at demonstrating to pupils the idea that programming can be fun as well as to demystify Computer Science. During the activities pupils learn to cooperate and be creative (https://code.org/educate/20hr). Neither do the activities require prior knowledge nor programming dexterity. The games in question also strengthen the ability of problem-solving and therefore have been developed according to the international educational standards. (Common Core NGSS: http://goo.gl/zj1D5o and CSTA standards: https://goo.gl/5kirUK). As far as the programming field is concerned all activities are based on virtual programming Languages. Pupils are able to learn programming without bearing in mind how to use syntax, but simply by focusing on the rational of how to write programs.

2. European Code Week

The European Code Week was held for second consecutive year between 11 and 17 October 2014. Over 150.000 children, parents, teachers, businessmen and politicians participated in events and took part in seminars on how to acquire basic programming principles and interrelated skills (http://codeweek.eu). Code Week aims at familiarizing the public with programming principles, providing opportunities for learning and bringing people with similar interests in contact with one another. According to digi-

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tal agenda for Europe (http://ec.europa.eu/digital-agenda/en/coding-21st-century-skill) computer science and programming promote computational thinking and according to Wing (Wing, 2006) they consist basic skills for the 21st century.

In Greece, the Computer Science school counselors under the auspices of the Ministry of Education (ruling 148023/Γ2 /17-09-2014), supported and encouraged computer teachers participation in the European code week https://cseduweek.wordpress.com/ (Figure 1). Consequently there were plenty of primary and secondary education teachers who volunteered in this call and in turns put some activities for the promotion of learning and programming into action. The activities held in Greece for 2014 surpassed 460 (http://goo.gl/xvwHCi) ranking the country among those with the most actions in a European level.

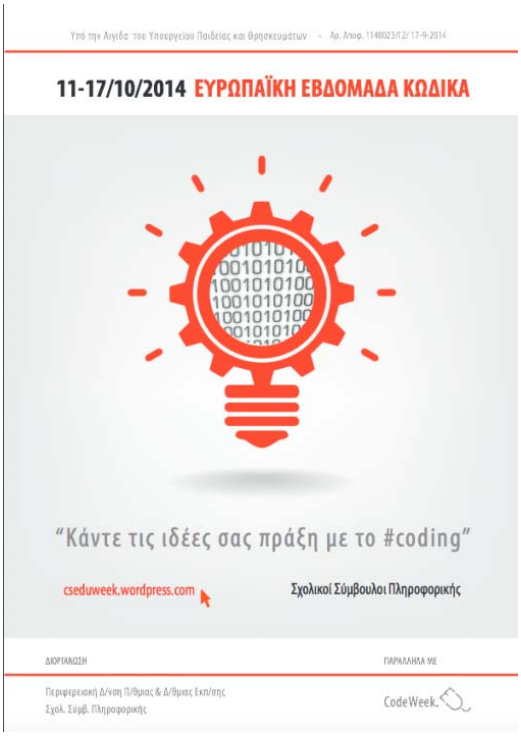

Figure 1. *The Greek poster of CS teachers' counselors*

3. Methodology

In the present research 94 pupils from public primary schools participated and paid a visit to the University of Peloponnese and particularly to the Department of Informatics and Telecommunications (Figure 2). The participants were between 10 and 11 years old attending 5th and 6th grade of the primary school then, and through this ac-

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tion they had the chance to acquire their very first experience with programming. The venue took place at the modern computer laboratories of the department at the University.

Figure 2. *The university's poster about the coding event*

Initially, the pupils were presented with a short video relevant to the value of Programming and Computer Science. Next, the young pupils met the elder ones, the undergraduates volunteers who were members of the pupil branches of ACM and IEEE of the department (http://uop-acm.blogspot.gr). The undergraduate pupils informed the young visitors about the department and CS and answered all questions.

Afterwards, the more experienced programmers led the new-comers to their first steps with the code, via educational environments which were game-based. At first they assisted children to create electronic accounts on the webpage http://goo.gl/xvwHCi in order to make them able to move on with their activities even when they would leave the university. For this reason, pupils kept records with every account data on a piece of paper which was the same for both of the two group members. On this sheet one could also read a short description of the purposes and activities of the European Code Week, in order to inform the pupils' parents.

After creating personal accounts the pupils could start playing. This stage lasted for about 2 hours. Pupils worked in pairs (Figure 3) which were randomly selected and in some circumstances coordinated by their teachers' recommendations. So, there were 47 pupil-pairs. This way of working known as Pair Programming and pupils get advantages as they help each other (Cockburn & Williams, 2000; Hanks, 2006; Howard, 2006). Pair Programming also allows pupils to comprehend that Computer Science can be societal and cooperative (Begel & Nagappan, 2008; Williams & Kessler, 2001).

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Figure 3. *Pupils working together*

To increase working efficiency between group members, the following rules were given:

- One pupil in each pair would have the guide's role, who controls the mouse and keyboard.
- The other would have the navigator's role, who makes suggestions.
- Pupils were obliged to reverse the above roles at least twice.

During the entire process, the undergraduate pupils played the role of coordinators, who motivated and assisted the young pupils whenever there experienced a difficulty (Figure 4). Young and elder cooperation was extremely fascinating.

Figure 4. *The undergraduate pupils help the little ones*

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When the activities came to an end, pupils filled in an anonymous questionnaire, containing close ended questions in order either to confirm or refute the research hypotheses (H1-H2-H3). The answers were based on the Likert's scale and ranged between 1 (surely not) to 5 (surely yes) containing intermediate values which indicated relevant grading, as well as value 3 indicating a neutral attitude.

Pupils were also awarded a participation certificate by the University of Peloponnese which demonstrated with great happiness and pride (Figure 5).

Figure 5. *Pupils showing their certificates*

In the present research four main hypotheses were studied:

Hypothesis 1 (H1) - Pupils would be interested in programming activities and would find them very important and relevant for their lives.

Hypothesis 2 (H2) - Pupils would find digital games appropriate for the teaching of programming. In particular, H2 depended on the following questions:

- Whether they liked the activities.
- Whether they believe they have learnt some basic programming principles.
- Whether they wish similar actions to be repeated in future.
- Whether they believe they have higher motivation in learning, by playing digitally.

Hypothesis (H3) – pupils would prefer to work in pairs while programming and have the sense that they learn better when they cooperate.

Hypothesis (H4) – Can a short duration programming activity motivate the pupils to continue programming after the end of the session? As far as the H4 is concerned, the researchers used the teacher's dashboard application https://code.org, where the pupils' progress in gaming was recorded (Figure 6).

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Figure 6. *Teacher's dashboard showing pupils' process*

4. Results

In this section the research findings are presented according to the hypotheses, as well as the purposes described above.

4.1 Computer Science and Programming (H1)

According to the pupils' answers, the greatest percentage (76.6%) thought that it was important to learn programming. More analytically, the 57.4% of pupils declared "probably yes" and the 19.1% "surely yes". On the contrary, just 1.1% (a single pupil) answered "surely no" and 13.8% answered "probably not". Similar results were found for the statement "I want to learn more about the Computer Science". The majority of 81.9% of pupils expressed a positive view and just the 9.5% of them a negative one. Thus H1 was supported.

4.2 Digital Educational Games (H2)

The activities that have to do with the digital gaming received 86.2% of positive answers, while just the 5.3% declared "probably not". It is quite remarkable that no pupil declared "surely not".

Moreover, it is also highly noticeable that an amount of 60.9% believed that they had learnt some basic programming principles through games. Even if the figure is not too high, nevertheless the majority of pupils estimated that the games were effective. For the same question the 8.7% declared "surely not" and finally the 16.3% (that is to say 15 pupils) had a neutral opinion.

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Also, most of the pupils expressed the desire for a repetition of similar actions in future (88.3%).

Finally, it is clear that the digital games give great motivation to pupils since 66% of them declared that they prefer learning through these. Therefore, H2 was supported.

4.3 Pair Programming (H3)

According to the pupils' answers the majority (56.4%) preferred working together with a co-pupil on the computer for programming through games. Contrary to this, the 21.3% expressed a negative view but the amount of the neutral view is considered to be a high one (22.3%).

Similar to the above were the results to the statement "I believe that I learn better when I work together with a fellow-pupil on the computer". 59.6% of them had a positive view, the 23.4% a negative one, while 17% a neutral one. Thus, H3 was also supported, although it was not a strong positive majority of answers.

4.4 Long-term Motivation (H4)

On the code.org website via the automated dashboard teachers can see some general statistics for each pupil account with the stages completed. The researchers connected to the administrative account three times with a week-interval between those times. During these three weeks, most of the pupils did not connect at all to their created accounts. The accounts were as many as the pairs of pupils (47 in total), meaning that there was one account for each pair, but the pupils individually could log in at a later stage and from a different location and play the games as they wished. Just 10.6% of the pair-accounts that were registered during the visit to university, connected at least once and tried to play and complete some stages more (it could be just one member or both connecting). On the contrary, the 87.2% did not carry since the accounts were not activated after the visit. Therefore, H4 was rejected.

5. Conclusions

In order to succeed in obtaining positive educational effects, one of the basic prerequisites is the motivation of the pupil. Especially in computer science the full participation of the pupils is required. In this light, tools and methods need to be implemented in order to motivate the pupils and enhance their active participation. Digital games in education can be supportive towards this effort.

Through the bibliographical review, it was found that a lot of researchers support their use as a subsidiary means for the attainment of the learning aims. As it was shown by the present research, games have an important effect on the young population and promote the cooperative spirit. Especially as far as programming is concerned, including digital gaming, the value of cooperation and learning from another

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pupil is very important and is getting more and more popular (Cooper & Kagel, 2005; McDowell, Werner, Bullock, & Fernald, 2003).

However, even when the pupils declared they had a high motivation in order to learn through educational games, there were only few who actually continued, by doing so at home. Therefore it seems that short duration actions are not capable by their own to motivate the pupils in the long run. On the other hand, the incorporation of digital games at school environments can improve the school image in the eyes of the pupils (Ames & Archer, 1988) and could lead to long term effects.

Our future research will focus on the development of a theoretical framework for digital games for CS and their incorporation in formal education. Specifically, it will be a theoretical framework for the design and development of educational environments, taking into account the possible different pupils' characteristics, exploiting all these games features that are capable of encouraging and motivating, making the learning procedure effective. Learning programming from a young age can very well reinforce the pupils' success in any career of the 21st century and in this case, digital games could be the basic tool in this endeavor.

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Περίληψη

Η παρούσα εργασία αφορά μια μελέτη περίπτωσης, της χρήσης εκπαιδευτικών ψηφιακών παιχνιδιών σε μαθητές δημοτικού, σχετικά με παιχνίδια που προάγουν την αλγοριθμική σκέψη και τις βασικές αρχές του προγραμματισμού. Στην έρευνα συμμετείχαν 94 μαθητές, οι οποίοι εργάστηκαν σε ζεύγη (Pair Programming) προσπαθώντας να λύσουν παιχνίδια από την ιστοσελίδα Code.org κατά την επίσκεψή τους στο Πανεπιστήμιο Πελοποννήσου στα πλαίσια της Ευρωπαϊκής Εβδομάδας Κώδικα. Εξετάζονται παράγοντες όπως η ικανοποίηση, η εκτίμηση λαμβανόμενης γνώσης και η πρόθεση να χρησιμοποιήσουν παιχνίδια στο μέλλον στη διαδικασία της μάθησης. Επίσης εξετάζεται κατά πόσο μια σύντομη δράση σαν αυτή μπορεί να επιφέρει μακροπρόθεσμα κίνητρα στους μαθητές. Τα αποτελέσματα έδειξαν ότι οι μαθητές: α) απόλαυσαν τα παιχνίδια και επιθυμούν να επαναλάβουν κάτι αντίστοιχο, β) θεωρούν ότι παίζοντας απέκτησαν βασικές δεξιότητες και γνώσεις αρχών του προγραμματισμού, γ) προτιμούν τον προγραμματισμό σε ζεύγη και εκτιμούν ότι μαθαίνουν καλύτερα βοηθώντας ο ένας τον άλλον. Τέλος, φαίνεται ότι η δράση δεν κινητοποίησε του περισσότερους μαθητές να συνεχίσουν τις δραστηριότητες μόνοι τους από το σπίτι τους.

Λέξεις - Κλειδιά: Προγραμματισμός με μαθητές, Προγραμματισμός σε ζεύγη, Μάθηση βασισμένη σε Παιχνίδια, Ευρωπαϊκή Εβδομάδα Κώδικα.

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