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Tablets, Very Young Primary School Students, and Basic Programming Concepts

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ABSTRACT—*The study presents the results of a project in which tablets and a ready-made application were used for teaching basic programming concepts to young primary school students (ages 7-9). A total of 135 students participated in the study, attending primary schools in Athens, Greece, divided into three groups. The first was taught conventionally. The second was taught using a board game, while the third was taught using tablets and an application. Students' performance was assessed using evaluation sheets. Data analyses revealed that students in the tablets/application group outperformed students in the other two groups in three out of four tests. Students' views regarding the application were highly positive. The learning outcomes can be attributed to the combination of the application's game-like features and to the tablets' ease of use. On the basis of the results, educators can consider the use of tablets and mobile applications for teaching basic programming concepts to young primary school students.*

Keywords—board game, Kodable, primary school, programming concepts, tablets

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1. INTRODUCTION

The benefits students have when they learn how to program were noted since the early days of the integration of computers in education (Papert, 1980). It helps them to develop their analytical and synthetic thinking, fosters their skills in designing and solving algorithms, and has a positive impact on their creativity and imagination (Fessakis, Gouli, & Mavroudi, 2013; Liu, Cheng, & Huang, 2011). In view of the above benefits, many researchers suggested that the teaching of programming should start as early as possible (Kalelioğlu, 2015).

In recent years, the use of smartphones and tablets and their applications has exponentially increased; people of all ages (adolescents included) routinely use them. These mobile devices, because of their specific characteristics (e.g., low cost, portability, and connectivity), can become a valuable educational tool. Consequently, their educational uses are the subject of an increasing number of studies and the relevant literature is becoming more and more extensive (e.g., Goodwin, 2012; Henderson, 2012).

Taking into account that: (a) there is the need for more innovative methods for teaching programming concepts and (b) the mobile devices have an interesting educational potential, it was quite logical to wonder whether tablets -or other mobile devices for that matter- can be used for teaching programming concepts to primary school students. Thus, a pilot project was designed and implemented in order to study exactly this. The main research objective was to examine what the learning outcomes might be after teaching programming concepts in a playful way using tablets. Moreover, it was considered as an interesting endeavor to have as a target group very young students (7-9-year-olds). The rationale, methodology, and the results of this intervention are presented and analyzed in the coming sections.

2. PROGRAMMING AS A TEACHING/LEARNING SUBJECT IN PRIMARY SCHOOL

The existing literature suggests multiple benefits for students when they learn how to program. Besides learning fundamental programming concepts (Zhang, Liu, Ordóñez de Pablos, & She, 2014), they develop a positive attitude toward learning computing in general (Fessakis et al., 2013; Keren & Fridin, 2014). A better understanding of mathematical concepts and improvement of their social skills (Fessakis et al., 2013), improvement of their problem-solving skills (Akcaoglu & Koehler, 2014), as well as an impact on their creativity and imagination (Liu et al., 2011), were also noted. On the other hand, the teaching of this subject is not an easy task and students do face problems when they try to develop programs. Their poor understanding of how programs are executed (Pea, 1986), and of the rules, logic, and syntax of the programming languages (Kristi, 2003), are major problems. In addition, some concepts, for example, variables, are not easy to grasp (Pane and Myers 1996). For children, the lack of logical reasoning and the -still- undeveloped algorithmic and critical thinking, are the main reasons for the above issues (Robins, Rountree & Rountree, 2003). There is a variety of instructional tools and techniques for teaching programming, ranging from drag and drop applications to programming robots. Research has shown that students prefer drag and drop applications, visual presentations, verbal explanations, discovering things on their own, and trial and error practices (Liu et al., 2011; Zhang et al., 2014). Furthermore, researchers suggested that the teaching of programming should have game-like characteristics, so that the whole process becomes an enjoyable experience (e.g., Margulieux, Guzdial & Catrambone, 2012).

In many countries and across all levels of education, the curriculum includes the teaching of programming concepts (e.g., Grgurina, Barendsen, Zwaneveld, van Veen, & Stoker, 2014; Grout & Houlden, 2014; Lee, Martin, & Apone, 2014). Also, worldwide efforts, such as The Hour of Code (https://hourofcode.com/) try to demystify coding and to show that anybody, regardless of their age, can learn the basics of programming. Coming to the Greek educational system, and with regard to primary school, programming concepts are taught only to the last two grades (ages 10-12) as -a rather small- part of the computers' curriculum, which, in turn, is taught just for one hour each week. The objectives are students to understand algorithms and variables and to be able to solve programming problems using Logo-like applications. One can easily understand that the above objectives cannot be achieved with such a minimal time allocation (Grigoriadou, Gogoulou, & Gouli, 2002) and, quite logically, students face problems.

3. TABLETS IN EDUCATION

Mobile devices, such as tablets and smartphones, enabled users to have unparalleled access to communication and information, due to their increased affordability and functionality. In an educational context, they can be used in a variety of teaching and learning situations and for almost all teaching/learning subjects (Goodwin, 2012). The term that aptly describes the educational uses of these devices is mobile learning (Shuler, Winters, & West, 2012), which refers to all forms of learning that take place through the mediation of a mobile device (Quinn, 2011). Since the mobile devices can be used virtually everywhere and anytime, they can facilitate both formal and informal learning (Seipold & Pachler, 2011), leading to what has been termed as "ubiquitous" or "seamless learning" (van't Hooft, 2013).

Because, compared to computers, mobile devices can fit easily into the daily teaching practices, they motivate students and increase their independence (Goodwin, 2012). Also, students feel more confident in their IT skills, as they consider them easy to handle (Heinrich, 2012). Increased collaboration among students (Kearney, Schuck, Burden & Aubusson, 2012), more creative work, development of IT skills (Karsenti & Fievez, 2013), and a more personalized learning experience (Vavoyla & Karagiannidis, 2005) were noted. The development of metacognitive skills was also acknowledged (Kearney, Schuck, Burden, & Aubusson, 2012). Also, mobile devices give students the opportunity to constantly assess and reflect on their learning progress (West, 2013). However, provisions should be taken so as students to familiarize themselves with the devices' features and functions, learn how to manage their applications, how to share content and for understanding how and when these devices can support the learning process (Henderson & Yeow, 2012).

Coming to tablets, although their educational impact is still largely unknown, much of the existing research replicates the findings from studies on other mobile devices (Dhir, Gahwaji, & Nyman, 2013). Then again, it can be argued that tablets have certain advantages over other mobile devices (e.g., larger screens, greater processing and battery power). On the negative side, and during teamwork, the simultaneous use of a tablet is problematic (Henderson & Yeow, 2012). Research has also pointed out that tablets may be a source of distraction for students because, during lessons, they tend to use them for non-educational purposes (Kinash, Brand, & Mathew, 2012). Tablets are not educational tools per se; suitable interactive learning content is needed to render them as such. Researchers stress that currently there are only a few studies on the impact of educational applications for mobile devices and that this is a field where academia and the industry must closely collaborate (Shuler et al., 2012).

4. RESEARCH RATIONALE AND METHODOLOGY

On the basis of what was presented in the previous sections, a pilot project was designed and implemented for teaching programming concepts, in a playful way, to primary school students, using tablets and for examining the learning outcomes. It was decided that the target group should be very young primary school students (ages 7-9, 2nd and 3rd grades), in an attempt to explore the possibility of teaching programming to earlier ages than the Greek curriculum dictates. The following research hypotheses were formed: (a) the learning outcomes when teaching programming concepts to young primary school students using tablets and an application are better compared to other conventional teaching methods, and (b) students form positive attitudes and perceptions regarding the use of tablets as part of their teaching.

It was decided to teach sequences, conditions (if/then) and loops, which are very basic and, at the same time, very important programming concepts. An extensive search for applications for teaching programming using tablets, revealed that, while there are several of them, very few are available in Greek, free of charge, and suitable for very young students. It was also found that some applications come with detailed lesson plans, learning/teaching material, and in-classroom activities, features which were considered crucial for the implementation of the project. Eventually, SurfScore's Kodable (https://www.kodable.com/) was chosen, that met the following criteria: (a) simple to use, (b) game-like features, (c) complete sets of lesson plans and teaching material, and (d) many levels for practicing the use of the programming concepts. While it is not totally free of charge, the concepts that were selected for the pilot program did not have this limitation. Also, although it is in English, the interface and the whole philosophy of the application is such, that it is very easy for the user to understand what he/she has to do, rendering the knowledge of English unnecessary.

In Kodable, the user guides the application's character through labyrinthine levels, collecting as many coins as possible. Each level is completed when the character reaches the exit (Figure 1). The guidance is done by using the available commands (top right corner of the screen) as many times as the user wants. The commands are placed by dragging and dropping them at the top left, where there is a limited number of empty spaces, suggesting that the program must be completed using a limited number of commands. After completing the syntax of the commands, the user executes the program and sees the results. In case of an error, he/she can redo the programming. The levels are of escalating difficulty (e.g., more complex paths, fewer available commands). It is worth mentioning that there is no single correct solution to each level and the only incentive is the collection of coins for "unlocking" new characters.

Figure 1: A Kodable's indicative level (source SurfScore Inc.)

Note: The arrows (top right corner) indicate a sequence and the colored squares a condition.

Constructivism provided the teaching framework. According to this theory, learners build personal interpretations of the world based on their experiences and interactions, knowledge has to be embedded in the situation in which it is used, effective use of knowledge comes from engaging the learner in real-world situations, and knowledge is validated through social negotiation (Ertmer & Newby, 2013). At the beginning of each session, teachers made a short introduction about the programming concept that they were about to teach, drawing examples from students' everyday lives. Next, students worked, in pairs, with the tablets, resolving the levels of the corresponding concept. In-classroom activities followed, which, in most cases, required teamwork and included worksheets and games. Each session lasted for two teaching hours and each programming concept required two sessions. Thus, the total duration of the project, for each grade, was twelve teaching hours (2 teaching hours X 2 sessions X 3 programming concepts).

Immediately following the end of the teaching of a programming concept, students completed an evaluation sheet/test (three in total). Each test consisted of three distinct parts. The first one had multiple choice, fill-in-the-blanks, and right-wrong questions. In each test, there were at least six questions of this kind. In the second part, students were instructed to transcribe, using programming terms and concepts, everyday life activities. For example, at conditions, the following exercise was included: "The headmaster said that tomorrow if the weather is nice, we will go on a field trip. We will visit a museum, play, eat lunch, and then we will return back. If the weather is not good, we will stay at school do our lessons and play during breaks. But, if it rains, we will stay indoors all day. Describe the above using the programming terms and concepts that you have learned." In each evaluation sheet, there were up to four such exercises. The third part followed

Kodable's philosophy and presentation layout. Students were presented with a level and they had either to complete the missing commands or to check whether the solution was correct (identifying any errors). About half of the questions were of this type. Also, about a month after the end of the project, students completed a delayed post-test which had the same structure as the evaluation sheets but included all the programming concepts that they were taught. They also completed a short questionnaire for the evaluation of their experiences and views regarding the use of tablets/application (15 Likert-type and open-ended questions). It has to be noted that a pre-test was not used since students were not previously taught anything related to programming and therefore, it was assumed that they had no prior knowledge on this subject.

For examining the significance of the project's results, two more groups of students were formed. The first one used board games instead of tablets. This method has been used by other researchers with noteworthy results (e.g., Mavridis, Siribianou, & Alexogiannopoulou, 2015). Each board game was a printed and enlarged Kodable's level. The same was done for the characters, the arrows (sequences), colored squares (conditions), and for all the other elements included in the application. The students, working in pairs, placed the various elements/commands on the board and the teacher "executed" the "program" determining if it "worked" properly. The in-classroom activities, as well as the way students worked, were the same as in the tablets group. The second group of students was taught conventionally, using notes instead of tablets or board games. For compatibility reasons, these notes followed Kodable's philosophy and way of presenting the learning material (using levels, symbols to represent commands, etc.). Once again, students worked in pairs. The in-classroom activities were also the same as in the previous groups. As a result, three groups of students were taught the same programming concepts, using the same teaching method and activities. Their only difference was the content delivery method (tablets/application, board games, and notes). The evaluation sheets and delayed post-tests were also the same in all groups.

Prior to the beginning of the project, students' parents were briefed about the project, its methodology, and objectives. Their written consent for their children's participation was obtained. Also, in one two-hour session, students of the tablets/application group explored the affordances and constraints of these devices (without using Kodable) in order to proactively face difficulties while using them. The initial sample of the study consisted of 142 students, coming from 3 neighboring schools in Athens, Greece. The project lasted for about two months (it was not implemented simultaneously in all schools), from late September to late November 2016.

5. RESULTS ANALYSIS

A number of students had to be excluded from the study because they were absent for more than one session. The final sample size was 135 students, divided into three groups (conventional-Group0, board game-Group1, and tablets-Group2) and into two sub-groups (2nd and 3rd grade students). The distribution of boys and girls was -more or less-equal to all groups (65 boys and 70 girls in total). For the analysis of the results, scores on the basis of the number of correct answers in each evaluation sheet were computed. Mean scores per group of participants and per test are presented in Table 1.

Table 1. Means and standard deviations on all evaluation sheets

Test	**Group0 (*N* = 45)**				**Group1 (*N* = 45)**				**Group2 (*N* = 45)**			
	2nd grade (N = 23)		*3rd grade (N =22)*		*2nd grade (N = 23)*		*3rd grade (N =22)*		*2nd grade (N = 23)*		*3rd grade (N =22)*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
ES1 (21)	12.48	2.42	13.05	1.88	15.35	1.85	15.18	1.59	17.88	1.34	18.25	1.68
ES2 (20)	6.54	1.68	7.15	1.55	9.85	1.48	10.18	1.35	10.56	1.57	10.82	1.36
ES3 (20)	9.56	1.52	10.55	1.69	11.38	2.12	11.84	1.45	13.46	1.70	14.05	1.85
Delayed post-test (22)	10.13	2.45	11.08	2.18	13.58	2.91	14.01	2.57	16.85	2.17	17.15	2.28

Notes. Maximum scores for each test are reported in parenthesis. ES1 = evaluation sheet sequences, ES2 = evaluation sheet conditions, ES3 = evaluation sheet loops

One-way ANOVA tests were to be conducted to compare the scores of the three groups in all tests, in order to determine if they had any significant differences. Prior to conducting these tests, it was checked whether the assumptions of ANOVA testing were violated. It was found that: (a) all sub-groups had the same number of participants, (b) there were no outliers, (c) the data were normally distributed in all tests, and (d) the homogeneity of variance was violated in two tests, as assessed by Levene's test of homogeneity of variance. In the cases where all assumptions for ANOVA testing were met, this analysis was conducted. In the cases where the assumption of the homogeneity of variance was violated, the Brown-Forsythe test (1974) was conducted, which is robust in cases of heteroscedasticity. The analyses showed that the teaching method had a significant effect on the scores in all tests, as presented in Table 2.

Table 2 One-way ANOVA results

Test	Grade	Result
ES1	2nd	Brown-Forsythe $F(2, 51.45) = 35.78$, $p < .001$
	3rd	$F(2, 63) = 50.76$, $p < .001$
ES2	2nd	$F(2, 66) = 42.47$, $p < .001$
	3rd	$F(2, 63) = 41.76$, $p < .001$
ES3	2nd	$F(2, 66) = 27.10$, $p < .001$
	3rd	Brown-Forsythe $F(2, 50.89) = 37.54$, $p < .001$
Delayed	2nd	$F(2, 66) = 40.63$, $p < .001$
post-test	3rd	$F(2, 63) = 37.74$, $p < .001$

Post-hoc comparisons were conducted using the Tuckey HSD test on all possible pairwise contrasts in all tests except the ones where the homogeneity of variance was violated. To those, the Games-Howell test (1976) was conducted. It was found that:

- ES1, 2nd grade. The mean total score for Group2 (M = 17.88, SD = 1.34) was significantly higher ($p < .001$) than that of Group1 (M = 15.35, SD = 1.85), while both were significantly higher than that of Group0 (M = 12.48, SD = 2.42) ($p < .001$ in both cases).
- ES1, 3rd grade. The mean total score for Group2 (M = 18.25, SD = 1.68) was significantly higher ($p < .001$) than that of Group1 (M = 15.18, SD = 1.59), while both were significantly higher than that of Group0 (M = 13.05, SD = 1.88) ($p < .001$ in both cases).
- ES2, 2nd grade. The mean total score for Group2 (M = 10.56, SD = 1.57) was not significantly higher (p = .286) than that of Group1 (M = 9.85, SD = 1.48), while both were significantly higher than that of Group0 (M = 6.54, SD = 1.68) ($p < .001$ in both cases).
- ES2, 3rd grade. The mean total score for Group2 (M = 10.82, SD = 1.36) was not significantly higher (p = .302) than that of Group1 (M = 10.18, SD = 1.35), while both were significantly higher than that of Group0 (M = 7.15, SD = 1.55) ($p < .001$ in both cases).
- ES3, 2nd grade. The mean total score for Group2 (M = 13.46, SD = 1.70) was significantly higher ($p < .001$) than that of Group1 (M = 11.38, SD = 2.2), while both were significantly higher than that of Group0 (M = 9.56, SD = 1.52) (p = .003 and $p < .001$ respectively).
- ES3, 3rd grade. The mean total score for Group2 (M = 14.05, SD = 1.85) was significantly higher ($p < .001$) than that of Group1 (M = 11.84, SD = 1.45), while both were significantly higher than that of Group0 (M = 10.55, SD = 1.69) (p = .034 and $p < .001$ respectively).
- Delayed post-test, 2nd grade. The mean total score for Group2 (M = 16.85, SD = 2.17) was significantly higher ($p < .001$) than that of Group1 (M = 13.58, SD = 2.91), while both were significantly higher than that of Group0 (M = 10.13, SD = 2.45) ($p < .001$ in both cases).
- Delayed post-test, 3rd grade. The mean total score for Group2 (M = 17.15, SD = 2.28) was significantly higher ($p < .001$) than that of Group1 (M = 14.01, SD = 2.57), while both were significantly higher than that of Group0 (M = 11.08, SD = 2.18) ($p < .001$ in both cases).

Taken together, these results suggest that students who used the tablets/application outperformed students in the other two groups in three out of four tests, including the delayed post-test. Thus, the first research hypothesis was confirmed. On the other hand, in ES2 (conditions) the results of Group2 and Group1 were not statistically significantly different, although both outperformed students in Group0. It has to be noted that in this test the mean scores of all groups were significantly lower compared to other tests (Table 1). Indeed, by taking a closer look at this test, it was found that most students (in all groups) failed to transcribe, using programming terms and concepts, everyday life activities and also failed to complete the missing commands or to check whether the solution given to them was correct. Very few students (34 out 135) managed to complete the exercises where nested ifs should have been used (for an example of such an exercise, see section "Research rationale and methodology"). This finding will be further elaborated in the coming section.

The second research hypothesis was confirmed. That is because students made positive remarks regarding their experiences while using the tablets and the application. More specifically, they liked the:

- Application's game-like features (M = 4.65, SD = 1.14).
- Use of tablets (M = 4.15, SD = 1.34).
- The whole project (application and in-classroom activities) (M = 4.10, SD = 1.25).
- Group work (in-classroom activities) (M = 3.80, SD = 1.10).
- Working in pairs (application) (M = 3.75, SD = 1.42).

According to students' responses, conditions was the most interesting programming concept, followed by sequences and loops (N = 20, N = 14, and N = 11 respectively). At the same time, conditions were considered the most difficult one, followed by loops, while sequences were the easiest programming concept (N = 24, N = 13, N = 8 respectively). In addition, students stated that they learned quite a lot (M = 3.94, SD = 0.81) and quite easily (M = 4.27, SD = 0.66). They also found tablets easy to use (M = 4.15, SD = 1.20), motivational (M = 4.07, SD = 0.88) and they stated that they would like to use them in other lessons (M = 4.38, SD = 0.75). Only two students reported problems when using tablets, while none reported problems regarding collaboration or when working in pairs.

Some indicative responses to the relevant questions were:

- *It was fun. Even if I had to try many times before I was able to solve a puzzle it was still fun*. The student is referring to programming as "puzzle".
- *It was like playing a game but I was also able to learn about programming.*
- *With the student sitting next to me we were trying to figure out how to collect all the coins in the levels.*

6. DISCUSSION

Educators, researchers, and the industry are constantly seeking ways to integrate mobile devices into the everyday school activities, for supporting teaching and learning. The study shed some light toward this direction. It was found that tablets together with a playful, fun, and colorful application, outweighed other teaching methods. These results can be attributed to a number of reasons related to the application, to tablets, and to the teaching framework.

Students made highly positive remarks regarding the game-like physiognomy of the application. Also, it is worth noting that the results of Group1 were also interesting. Although they were not as good as the results of Group2, they were statistically significantly better than the ones of Group0. Considering that: (a) Group2 was taught using a game-like application and (b) Group1 was taught using board games, it can be argued that game-based learning outperforms conventional teaching methods, at least on the subject of programming, as others have noted (e.g., Wilson, Hainey, & Connolly, 2012).

Moreover, the application enabled students to constantly and easily evaluate their progress, because they were able to repetitively test if their programs were executed properly and correct their mistakes. Students who used the board games were also able to so, but to a lesser degree. The whole process was more laborious and time-consuming since they had to wait for the teacher to come, check if the program was correct, and redo the placement of the various game elements to the board. Thus, students who used tablets had more control over the learning process and more autonomy (West, 2013).

The concept of conditions (if/then) appears to have caused some trouble to students. The mean scores of all groups in the respective evaluation sheet were the lowest compared to the mean scores of the other evaluation sheets (see Table 1). It was also noted that students failed to grasp the idea of nested ifs. As others have pointed out, depending on the students' age, some concepts are a cause of problems and not easy to grasp (e.g., Pane & Myers, 1996).

The learning outcomes might have been strengthened by the use of a new teaching tool, namely tablets, which managed to attract the interest of students. Indeed, according to their responses, students were motivated and willing to use them as others have pointed out (e.g., Goodwin, 2012; Heinrich, 2012). The above appear to have resulted in a better understanding of the programming concepts, as Johnson and his colleagues (2013) suggested, which, in turn, led to better learning outcomes, as noted by other researchers (e.g., Snell & Snell-Siddle, 2013). According to students' responses, the use of tablets was not a cause of significant problems. In general, students are familiar with the use of electronic devices (Goodwin, 2012; Heinrich, 2012). Thus, it can be argued that it was the combination of tablets and of an application that promoted learning, as Quinn (2011) also pointed out.

The teaching method was based on the principles of constructivism. This theory supports that the learning environment has to encourage social interaction and the engagement of the learner in the learning process (Ertmer & Newby, 2013). Also, Doise, Mugny, James, Emler and Mackie (2013), supported the idea that when children work in pairs for solving a problem, they tend to generate more adequate solutions than when working alone. It seems that working in pairs and the in-classroom group activities played a role in achieving the satisfactory learning outcomes, as suggested by others (Kearney et al., 2012).

On the basis of the study's results, it is suggested that educators, as well as policy makers, can consider the use of tablets and mobile applications for teaching basic programming concepts to very young primary school students. The teaching framework can be based on the one used in this study; game-based learning, working in pairs when using tablets, activities that require collaboration, connecting programming concepts with everyday life. On the other hand, precaution is advised. It is suggested that young children lack the necessary mental schemas for fully understanding how programming works because their complex and critical thinking is not yet developed (Robins et al., 2003). Having that in mind and on the basis of the study's results, it is suggested that while the teaching of programming can start at a very early stage (primary school's 2nd or 3rd grades), this should be done in a playful and motivational way. Also, the programming concepts should be the ones that are compatible with students' age and mentality or if it is required to teach complex concepts, these should be explained more thoroughly.

The implications are not limited only to education. The study had to rely on a ready-made application. What became evident was that while there are quite a lot of relevant applications, not all of them were suitable for educational use or for very young students. Even so, the application that was eventually selected was not perfect; certain aspects of it could have been better. Therefore, it is imperative educators and software experts to work closely together as Shuler et al. (2012) suggested. The educators can set the instructional guidelines and software engineers can inform the educators of the technology's affordances and constraints. Sharing knowledge and experience, as well as close collaboration, are the keys to maximizing the educational potential of tablets and their applications.

7. CONCLUSION

Although the results are promising, the study has limitations that need to be acknowledged. Even though all necessary precautions were taken, one cannot be certain whether the tests and questionnaires accurately recorded students' knowledge and views. The study's sample, although sufficient for statistical analysis, was relatively small and the participating students came from one city in Greece. Therefore, the results cannot be easily generalized. Finally, since the focus was on students' performance, no data were collected on how well teachers were able to implement each teaching method.

Further studies are needed in order to identify differences or similarities to the findings of the present study. For example, the effectiveness of other game-like applications can be examined. The target group can be even younger students (e.g., kindergarten or 1st grade primary school students), so as to determine what programming concepts are suitable for teaching at each age and also to establish the appropriate teaching method. Future studies can use a combination of quantitative and qualitative research tools, such as interviews with students and teachers, that would allow an in-depth understanding of how they view the role of tablets and their applications. Finally, it would be interesting to conduct research maximizing or minimizing the teacher's role, and/or by using computers and/or other mobile devices and compare the results. By doing so, it would be possible to determine if the outcomes can be attributed to the medium used and/or to the method.

Nevertheless, taking into account all limitations and in conclusion, the experimental data that were obtained reinforced the view that tablets and a game-like application can yield satisfactory results, when teaching programming concepts to young students, compared to the other methods that were tested.

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