Mobile Learning Applications in Early Childhood Education

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Chapter 3
Teaching Natural Sciences to Kindergarten Students Using Tablets:
Results From a Pilot Project

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ABSTRACT

The chapter presents the results of a project in which tablets were used for teaching natural sciences to kindergarten students. The classification of animals depending on certain characteristics was the subject matter. Forty-five students participated, divided into three groups. The first used printed material, the second used computers and webpages, and the third used tablets and AR applications. Bybee's 5Es provided the teaching framework for all groups. Data were collected using evaluation sheets and structured interviews. The students in the tablets' group performed better in all the evaluation sheets compared to the ones who were taught using printed material, but there were no statistically significant differences compared to the computers' group. A positive impact on motivation and enjoyment was noted in the tablets' group. Thus, it can be concluded that tablets are an interesting alternative teaching tool for very young students. Implications for research and practice are also discussed.

INTRODUCTION

In recent years, the importance of introducing concepts related to natural sciences in early childhood education has been acknowledged, as it contributes to the cognitive development of very young students (Eshach, 2006; Harlen, 2018; Trundle, 2010). Indeed, the exploration of the natural world is the source

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of children's primary experiences; their innate curiosity and effort to comprehend the world that surrounds them compels them to build their original understanding/perceptions for it. As a result, children establish a body of ideas, in the form of interpretative models, before they even enter formal education (Akerson, Flick, & Lederman, 2000; Driver, Squires, Rushworth, & Wood-Robinson, 2014). Then again, studies have confirmed that many concepts related to this field are difficult to understand; both preschool and primary school children face serious problems. The plethora of their misconceptions, as recorded in the relevant literature, serves as a proof of the above statement (e.g., Driver et al., 2014). An area in which students face significant difficulties is the classification of living organisms on the basis of scientific criteria (Allen, 2015; Braund, 1998; Chen & Ku, 1998; Cinici, 2013; Gelman & Meyer, 2011; Kattmann, 2001; Kubiatko & Prokop, 2007; Papadopoulou & Athanasiou, 2015). Usually, their classifications are arbitrary, random, uncorrelated, and lack hierarchical reasoning (Driver, 1985). It has to be noted that most of the above studies involved primary or high-school students; kindergarten students were not that well studied.

Contemporary views for learning and teaching, such as mobile learning, highlight the role of digital technologies and introduce new instruments into instruction. Tools such as smartphones and tablets combine game and learning while offering students a better visualization of phenomena related to natural sciences. This, in turn, allows them to have a better understanding of these concepts. Children come into contact and are attracted to these devices from a very young age (Shuler, 2009). Since very young children view the school environment as a natural extension of their family environment, the use of mobile devices at school is self-evident, at least in their own eyes. Additionally, their interest, as well as their enthusiasm and enjoyment for lessons are amplified (Blackwell, 2013; Fokides, 2018; Fokides & Mastrokoukou, 2018). The learning outcomes of preschool children who participated in tablet-assisted projects were encouraging, to say the least (Al-Zu'bi, Omar-Fauzee, & Kaur, 2017; Bebell & Pedulla, 2015; McManis & McManis, 2016; Papadakis, Kalogiannakis & Zaranis, 2016; Zaranis, Kalogiannakis, & Papadakis, 2013; Zomer & Kay, 2016). At the same time, other advantages that emerged from tablets' use included opportunities for the development of fine motor skills and practical training of functional capacities (Bebell & Pedulla, 2015; Blackwell, 2013), fostering of students' creativity and imagination, and development of problem-solving skills (Blackwell, 2013). Kindergarten teachers can benefit from the use of mobile devices as well. They can record the teaching process for evaluating it at a later time, develop students' digital portfolios indicative of their progress, and save important incidents/observations that could help them to plan and organize their teaching (Parnell & Bartlett, 2012).

Taking into account that: (a) although kindergarten students face quite a lot of problems in animals' classification, (b) the issue is understudied and (c) tablets are considered effective teaching tools, a pilot project was designed and implemented in order to study whether tablets can indeed be effective tools for teaching kindergarten students subjects related to animals' classification. The rationale, methodology, and the results of the project are presented and analyzed in the coming sections.

BACKGROUND

Animals' Classification and Kindergarten Students

Children have an innate interest in animals. Indeed, even before entering formal education, preschoolers have already developed various perceptions for animals, either from their direct experiences (e.g. through contact with pets) or from other sources such as TV series, books, and the Internet (Kubiatko & Prokop, 2007; Patrick et al., 2013). These perceptions, although they reflect children's true beliefs (Carey, 2000), are far from being scientifically correct (Chyleńska & Rybska, 2018) and are persistent to change even after organized instruction (Kubiatko, 2012). Quite a large number of studies examined children's ideas about living organisms. Children did not find it difficult to identify animals as living organisms, although, when asked, they gave examples of large mammals, such as elephants and cows (Chen & Ku, 1998). Interestingly, children did not classify humans as animals (Papadopoulou & Athanasiou, 2015). On the other hand, they classified "living things" based on morphological and functional characteristics that are readily recognizable to humans (Martínez-Losada, García-Barros, & Garrido, 2014). For example, movement was the most commonly reported trait that children used for identifying humans and animals as being alive, but also for justifying why plants are not (Cardak, 2009).

Moreover, most children face serious problems when it comes to animals' classification (Braund, 1998). Usually, they form groups of animals that are arbitrary or illogical (Driver, 1985), using criteria derived from the so-called "Folklore Biology" (Patrick et al, 2013). The persistence of biological thinking based on an instinctive understanding of biological issues does not change even when children enter puberty (Coley, Arenson, Xu & Tanner, 2017). As Kattmann (2001) noted, young students classified animals according to the place they live and the way they move; morphological or anatomical characteristics were, mostly, ignored. As they grow older and having learned a few things related to Biology, students' misconceptions exist side-by-side with scientific knowledge, meaning that they classify animals using both scientific and unscientific criteria. Similar were the findings of Kubiatko and Prokop (2007) regarding the classification of mammals by six-years-old students and Cinici's (2013) findings regarding the classification of vertebrates and invertebrates by high-school students. In an older study, Chen and Ku (1998) noted that young students classified animals on the basis of their differences rather than on their similarities.

As far as kindergarten students are concerned, little research has been carried out, as it appears to be an age group that researchers did not include in their studies. Nevertheless, the results of relevant studies indicated that preschool children based their animals' classification in accordance to the level of their cognitive development and on the basis of their past experiences (Allen, 2015; Gelman & Meyer, 2011). The classifications they carry out involve criteria of similarity and correlation, but they tend to use causal relationships when they cannot find similarities. Also, as they cannot fully understand the classification process or the scientific criteria that are used, children use inductive reasoning for "labeling" animals (e.g. a fish is not a mammal) (Gelman & Meyer, 2011).

The archetypal representations of animals, which were established through their prior experiences, are one of the criteria they used. Classification problems arise when toddlers have not developed archetypes for some animals (e.g., for insects). Moreover, archetypal representations may lead either to right conclusions (e.g., a crab is not a fish although it lives underwater) or wrong ones as some animals do not fit the general appearance of the species they belong to (e.g. the hippocampus is not a fish since it does not look like a fish) (Allen, 2015). The appearance, motion, behavior, nutrition, physiology and anthropomorphic elements were also the criteria most commonly encountered in the animals' classifications by preschool children (Allen, 2015; Papadopoulou & Athanasiou, 2015). As observed in older students, preschool children find it difficult to make hierarchical categorizations (i.e., in phyla, classes, orders, families, genera, and species), as they seem unable to focus on multiple elements, but rather use one or two individual and unrelated criteria that often contradict each other (Allen, 2015). Cultural elements and language also offer children of young age directions for their categorization without using visual observations (e.g. a goldfish is immediately perceived as a fish since part of its name is “fish”) (Gelman & Meyer, 2011).

Tablets and Kindergarten Students

Children, from very early on, come into contact with mobile devices, as parents often share their smartphones and tablets with their offsprings (Shifflet, Toledo & Mattoon, 2012). Such devices are omnipresent and ready to use in almost every place where small children dwell. So, children, when entering pre-school education, are already skilled users of mobile devices (Shuler, 2009). Especially tablets’ large touchscreens, ease of use, responsiveness to voice commands, easy to navigate menus, portability, and access to the Internet, are some of the features that render them an ideal learning tool in the hands of young children (Cavus & Ibrahim, 2009). In the eyes of toddlers, the use of tablets in the school environment is self-evident, since the school is viewed as an extension of their family environment. Thus, the educational exploitation of these devices is a legitimate (and feasible) objective (McManis & McManis, 2016).

Tablets offer preschool children unique opportunities to develop functional and fine motor skills (Bebell & Pedulla, 2015; Bedford, Urabain, Irati, Cheung, Karmiloff-Smith, & Smith, 2016; Blackwell, 2013). Tapping, double-tapping, dragging, and other gestures are performed with ease and almost instinctively (Shifflet et al., 2012); more complex ones (e.g., shaking and resizing) can be learned by mimicking others or by following instructions (Hiniker, Sobel, Hong, Suh, Irish, Kim & Kientz, 2015). The above, enable them to successfully perform a variety of tasks using tablets. For example, children aged three to six can practice skills necessary for the development of writing (Vatavu, Cramariuc, & Schipor, 2015). What is more, tablets are considered easier to use compared to a keyboard or mouse, as the use of the latter requires already developed motor skills (Blackwell, 2013; Hirsh-Pasek, Zosh, Golinkoff, Gray, Robb, & Kaufman, 2015).

The early familiarization of toddlers with tablets promotes their autonomy and independence from adult supervision. Their self-esteem and self-confidence can also benefit. The confidence that they feel when they become skilled users of these devices, motivates them to experiment and further explore their competences (Couse & Chen, 2010). Preschool children who participated in programs in which tablets were used, showed more interest (Strouse & Ganea, 2017), enthusiasm, and enjoyment for the learning activities (Blackwell, 2013). At the same time, they became more persistent in achieving their goals (Couse & Chen, 2010; Flewitt, Messer & Kucirkova, 2014), especially when the activities were presented in the form of games (Papadakis et al., 2016). Preschoolers’ social and collaboration skills, as well as their responsibility toward others, were also fostered (Blackwell, 2013). Studies indicated that toddlers rarely use tablets by themselves. They prefer to share ideas with their classmates, help each other, and ask or answer questions (Shifflet et al., 2012), at least more than when working with paper and pencil (Bebell & Pedulla, 2015).

At the same time, kindergarten students, through the use of tablets and by conducting activities of escalating difficulty, displayed signs of cognitive enhancement and readiness in fields such as linguistic development (Zomer & Kay, 2016), attention (Strouse & Ganea, 2017), recognition of letters and words, and preliminary writing skills (Bebell & Pedulla, 2015; McManis & McManis, 2016; Neumann & Neumann, 2013). Promising results were achieved regarding the development of reading skills (McManis & McManis, 2016), creativity, critical thinking (Flewitt et al., 2014), imagination (Laidlaw & Wong, 2016), and metacognitive skills (Al-Zu’bi et al., 2017). The development of all the above can be accelerated if similar activities are conducted at home, under the supervision or help of parents or older siblings. This has also been proven to be an effective strategy for the smooth and successful transition to formal education (Wong, 2015).

Correspondingly, positive were the results regarding the understanding of mathematical concepts, numbering, measurements, spatial orientation, as well as in geometry (Bebell & Pedulla, 2015; McManis & McManis, 2016; Zaranis et al., 2013, Zaranis, 2019). That is because tablets support personalized learning and incorporate a multitude of learning strategies (e.g., blended learning) (Highfield & Goodwin, 2013); thus, supporting children with different needs (Papadakis et al., 2016). Even when tablets were used for recreation, in transitional periods between learning activities in kindergarten, they created opportunities for practice, so that even this period of time can be productive (Blackwell, 2013). Finally, tablets' educational impact seems to be correlated with students' age; students aged five to six benefited more than students aged three to four (Al-Zu'bi et al., 2017; Huber, Tarasuik, Antoniou, Garrett, Bowe, Kaufman, & Team, 2016; Vatavu et al., 2015; Zomer & Kay, 2016).

Although the relevant literature is rather limited, studies concluded that the use of tablets for teaching subjects related to natural sciences, helped kindergarten students to initiate the process of understanding more abstract concepts, the teaching of which was avoided in the past, as they were considered advanced (and unsuitable) for students of this age. For example, Cascales, Laguna, Pérez-López, Perona, and Contero (2013) in their study regarding the teaching of animals, reported increased learning gains with the use of tablets compared to conventional material. Students were also able to recognize more new animals (Strouse & Ganea, 2017) or name them (Silawati & Rachmania, 2016). To the best of the authors' knowledge, there are no studies in which animals' classification was examined using tablets and having kindergarten students as a target group.

Given the problems kindergarten students face in animals' classification, the lack of relevant studies, and the educational potential of tablets, the following research hypotheses were formulated:

H1. The use of tablets for teaching kindergarten students subjects related to animals' classification, produces better learning outcomes compared to the use of other teaching tools such as computers and printed material.

H2. When tablets are used, students find their use easy, are more motivated to learn, enjoy lessons more, and collaborate better.

Development and Evaluation of the Project

For examining the study's hypotheses, a pilot project was designed and implemented. A quasi-experimental design with one experimental and two control groups was applied, as data were to be collected from intact classrooms. Students in the experimental group used tablets, in the first control group they used printed material and in the second they used computers. The project's theme was the classification of animals divided into three teaching units/sessions. These sessions presented the classification of animals according to (i) their habitat (jungle, forest, desert, etc.), (ii) diet (carnivores, herbivores, and omnivores), and (iii) body characteristics (teeth, paws-nails, ears, eyes, etc.). Details for the procedure that was followed, for the materials, and instruments used, are presented in the coming sections.

Participants and Duration of the Project

The target group was kindergarten students (aged four to six) who: (i) never before used tablets as part of their teaching and (ii) were not taught subjects related to animals' classification (or similar subjects). As a result, a total of forty-nine students were recruited from three kindergarten schools in the city of Agrinio, Greece. In each school, a teaching tool (printed material, computers, and tablets) was randomly assigned. As the research involved minors, permission from the University's ethical committee was granted. The parents of the participating students were also contacted and their written consent was obtained. The teachers of the participating schools were briefed for the study's objectives and methods. Also, they were asked to strictly follow the teaching method that was assigned to each, as described in the "Procedure" section. The project lasted for about a month (three sessions in each school, from mid-October to late November 2018). Each session lasted for three teaching hours, so as students to have enough time at their disposal for conducting the sessions' activities.

Materials

The teaching material for each session's subject matter (animals' habitat, diet, and body characteristics) was developed in three different forms, as there were three teaching tools/students' groups. Maps, charts, images, photos, animations, diagrams, and videos of animals, animal habitats, diet-feeding behaviors, and characteristics, were gathered and edited. Because students were very young and could not read (at least fluently), audio files were recorded, including narrations and descriptions. It has to be noted that for facilitating students' understanding of animals' classification, the animals that were selected had easily identifiable characteristics (e.g., sharp teeth and claws). Insects, birds, and amphibians were excluded.

For the development of tablets' applications Blippbuilder (https://www.blippar.com/) was used, which enables the rapid development of applications for mobile devices that fall into the category of Augmented Reality (AR) applications. In short, AR is a technology that merges the real with the digital world by presenting to the user, in real-time, a combination of real and virtual objects, multimedia elements, and information, while allowing his/her interaction with the above (Billinghurst, Clark, & Lee, 2015). A marker (an image) is used for triggering/starting an AR application. The markers were printed and handed to students who were going to use the tablets. A total of nine applications were developed, three for each session. For example, in the session discussing the body characteristics of animals, a crocodile was chosen for presenting the characteristics of carnivores. After triggering the relevant application, students were able to watch videos describing crocodiles, tap on thumbnail images of their teeth and claws (and simultaneously hear the relevant narrations), and see a comparison of these characteristics with the corresponding characteristics of other animals (Figure 1). It has to be noted that the applications were not developed by a group of experts but by one of the researchers who had no previous experience in the development of such applications. The development of the applications required around fifty hours.

Following the same logic and using the same material, a website was developed. The website was later packed into a self-contained application, consisting of a single, installable bundle including all the web-pages and necessary files. Therefore, the website could be locally executed to any computer as a stand-alone application without the need for an Internet connection. For the group that used printed material, the website's material was printed on paper in the form of three booklets. Extensive screenshots from the videos replaced the video files. The audio files were transcribed on documents so as to be read/narrated by the class's teacher.

Figure 1. Screenshot from the development of tablets' applications Source: The authors

Procedure

For science subjects, it is recommended students to work in small groups (Harlen, 2018). Accordingly, it was decided students (of all groups) to work in pairs (Figure 2). Bybee's 5Es (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook, & Landes, 2006) is an instructional model commonly used when teaching science-related subjects. Consequently, it was followed, though its five phases were slightly modified so as to suit the study's needs:

- The purpose of the "Engage" stage is to excite students' interest, to encourage them to get personally involved in the lesson, and sets the groundwork for the activities to follow. The teachers provided the necessary stimuli, by making a short introduction and by engaging in conversations with students related to the session's theme.
- During the "Explore" stage students explore ideas through activities and the "Explain" stage allows students to communicate what they have learned. These stages were merged and were conducted using either the printed material or the webpages or the tablets' applications. For example, in the session in which animals were classified according to their habitat, the first screen of the corresponding tablets' application presented an assortment of animals. A similar webpage was presented to students who used computers and the website. As for the group that used the printed material, animals' photos were given to each pair of students. Students discussed what they might have in common. Each pair of students "recorded" their views by sticking animals' pictures in a piece of cardboard. Students were then asked to proceed to the next pages of the application (or the next webpages), in which each habitat was presented. Students in the printed material group were given the corresponding booklet and the teacher was given the task to narrate/read the accompanying text. Following that, students revisited their "recorded" views, re-discussed, and, if necessary, they made corrections.
- The "Extend" stage allows students to further explore the implications of what they have learned. The purpose of the "Evaluation" stage is to determine how much learning has taken place. Both stages were also merged. In the above example, the next screen of the tablets' application (or the following webpage or the next pages of the booklet) presented yet more animals, but this time, a

Figure 2. Screenshots from students' groups Source: The authors

world map was also presented (in which jungles, deserts, forests, and the polar regions were specified using images). Once again, students "recorded" their views by sticking animals' pictures in a printed word map. During the "Evaluation" stage, each pair presented their recorded views to the whole class and engaged in discussions until a common consensus was reached.

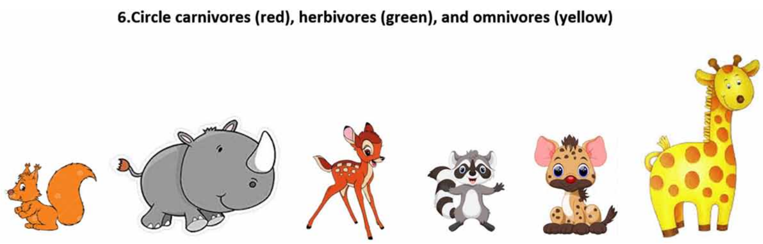
- It has to be noted that during all stages and most of the time, students were free to work by themselves. The teachers acted as facilitators of the process by starting or joining in students' discussions, by drawing their attention to important aspects of their work, and by providing guidelines (but without enforcing their views).

To summarize, in all groups of students: (i) the same teaching procedure was followed, (ii) the same subjects were taught, and (iii) the number of sessions was the same. The only difference the three groups had, was the teaching tool that each used.

Instruments

For data collection purposes, five evaluation sheets (pre- and delayed post-tests, and one for each of the three teaching units), as well as structured interviews were used. The pre-tests were administered prior to the beginning of the project for recording students' previous knowledge on animals and their classification. The delayed post-tests were administered two weeks after the end of the project and checked knowledge retention, while the other three evaluation sheets were administered at the end of each session and examined what students were able to understand. All evaluation sheets consisted of yes-no and multiple-choice questions and were structured so as: (i) to fully cover the content of each unit, and (ii) questions to be of escalating difficulty. Then again, having as target group kindergarten students, imposed the same problem as in the project's material, text could not be used. Instead, it was decided to use images, to voice, and verbally explain each question. To avoid questions' oversimplicity, in most, there was more than one correct answer and, in others, there was no correct answer at all (Figure 3). Moreover, in all the evaluation sheets, students were asked to draw animals highlighting certain

Figure 3. Example of a question in an evaluation sheet Source: The authors



characteristics, depending on the session's subject matter. For example, in the session in which animals were classified according to their body characteristics, students were asked to draw a carnivore, using black color for indicating why it is a carnivore (Figure 4). The drawings were later examined for their accuracy and were graded accordingly.

As a substitute for questionnaires, structured interviews were used for recording students' views regarding the three teaching tools. The interviews' questions (presented in the Appendix) were drawn from the Learning Experience Questionnaire, a validated modular scale for examining users' views for educational software (Fokides, Kaimara, Deliyiannis, & Atsikpasi, 2019). Although this scale examines a total of twelve factors, four were selected: motivation, enjoyment, collaboration, and ease of use (not applicable for printed material). The method for obtaining quantitative data from students' responses is presented in the coming section.

Data Screening and Data Processing

Out of the initial forty-nine students, four had to be excluded from the study because they were absent in one or more sessions, reducing the final sample size to forty-five students. As already mentioned in the "Instruments" section, for examining students' views and attitudes for the tools that were used, structured interviews were utilized, with questions coming from a validated scale. In order to statistically analyze students' responses, the qualitative raw data for each question were transformed into quantitative ones,

Figure 4. Example of a student's drawing Source: The authors

namely, to Likert-type scales (anchored at 1-low and 5-high). For that matter, a multi-step procedure was followed. First, a thematic coding analysis was applied (Saldaña, 2015). In short, this method allows the indexing of the text into categories/codes and the establishment of a framework of thematic ideas/themes (Gibbs, 2007). The recordings were transcribed verbatim on three documents (one for each group). Two individuals with expertise in educational software acted as coders and Atlas Ti was used for extracting/labeling the codes. The coders were trained and their reliability was assessed: (a) in a pilot test using a randomly selected quarter of the responses and (b) formally during the coding of the full sample. For determining consistency among raters an interrater reliability analysis was conducted using Cohen's kappa coefficient and it was found to be very good [$\kappa = .890$, $p < .001$, 95% CI (.878, .902)] (Landis & Koch, 1977). Responses were viewed once, for identifying the main ideas. Then, they were re-viewed in more detail and the ideas were labeled with codes. This process was repeated one more time to reduce overlap and redundancy of codes and a small set of themes emerged. As all responses were labeled with themes, the two coders viewed them once again, assigned ranking scores, and an average of the two scores was calculated. For example, the response "It was so much fun playing with tablets" was labeled as "high enjoyment" and received a score of 5. Finally, as there was more than one question examining each factor (motivation, enjoyment, ease of use, and collaboration), a composite score for each factor was calculated, by averaging the scores of its corresponding questions.

In order to determine if the three groups of students had any statistically significant differences in their scores (in both the evaluation sheets and the interviews), one-way ANOVA tests were to be conducted. Prior to conducting these tests, it was checked whether the assumptions for ANOVA testing were violated. It was found that: (i) all groups had the same number of participants ($N = 15$), (ii) there were no outliers, (iii) the data were normally distributed, as assessed by Q-Q plots and the Shapiro-Wilk test, and (iv) the homogeneity of variance, as assessed by Levene's Test of Homogeneity of Variance, was violated in one case (first evaluation sheet). As in this case, heteroscedasticity was a concern, it was decided to proceed using the Brown-Forsythe test (1974).

Results

As already mentioned, the final sample size was forty-five students (twenty boys and twenty-five girls), divided into three groups of fifteen students each (students' mean age was almost identical in the three groups and the same applied for the ratio of boys and girls). Each group was taught using a different tool (printed material-Group1, computers-Group2, and tablets-Group3). Mean scores and standard deviations per group of participants and per evaluation sheet are presented in Table 1.

For determining whether the scores of the three groups had any statistically significant differences, one-way ANOVA tests were conducted. It was found that in the pre-test there were no statistically significant differences [$F(2, 42) = .076$, $p = .927$], while to the rest of the tests there were statistically significant differences [ES1: Brown-Forsythe $F(2, 36.219) = 9.577$, $p < .001$; ES2: $F(2, 42) = 10.444$, $p < .001$; ES3: $F(2, 42) = 16.071$, $p < .001$; delayed post-test: $F(2, 42) = 5.573$, $p = .007$]. Post-hoc comparisons were conducted on all possible pairwise contrasts in cases where statistically significant differences were noted. The results of these test are presented in Table 2.

Taken together, the above results suggested that Group3 (tablets group) outperformed Group1 (printed material group) in all cases, including the delayed post-test. Then again, Group3 did not outperform Group2 (computers group) in any case. Also, Group2 outperformed Group1 in two out of four cases. Given the above, H1 is partially confirmed; the use of tablets for teaching kindergarten students subjects

Table 1. Means and standard deviations for the evaluation sheets

Test	Groups					
	Group1 (N = 15)		Group 2 (N = 15)		Group 3 (N = 15)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Pre-test (max = 30)	14.80	2.48	14.67	2.19	15.00	2.39
ES1 (max = 30)	13.20	1.97	14.93	2.19	16.13	1.25
ES2 (max = 30)	14.80	2.57	17.80	2.48	18.40	1.81
ES3 (max = 30)	17.80	1.66	20.13	1.92	21.20	1.42
Delayed post-test (max = 35)	22.33	2.19	23.73	1.87	24.60	1.50

Notes: ES = evaluation sheet; maximum scores for each ES are presented in parenthesis

related to animals' classification, produces better learning outcomes compared to the use of printed material, but compared to the use computers, the results are the same.

Mean scores and standard deviations per group of participants and per questionnaire's factor are presented in Table 3. As previously, for determining whether the scores in the questionnaire were statistically significantly different, one-way ANOVA tests were conducted. It was found that in collaboration and ease of use there were no statistically significant differences [$F(2, 42) = 1.41$, $p = .255$; $F(1, 28) = 0.71$, $p = .673$ respectively]. On the other hand, there were statistically significant differences in the other two factors [motivation: $F(2, 42) = 13.59$, $p < .001$; enjoyment: $F(2, 42) = 9.35$, $p = .001$]. Again, post-hoc comparisons were conducted on all possible pairwise contrasts, as presented in Table 4.

Taken together, the questionnaire's results suggested that students in Group3 were more motivated to learn and enjoyed lessons more than students in the other two groups. As for collaboration between students and tablets' ease of use, there were no differences with the other two groups. Thus, H2 can be

Table 2. Pairwise comparisons for evaluation sheets

Evaluation sheet	Groups	Mean Difference	Sig.	Interpretation
ES1	1-2	-1.73	.075	NS
	1-3	-2.93	< .001	Group3 outperformed Group1
	2-3	-1.20	.178	NS
ES2	1-2	-3.00	.003	Group2 outperformed Group1
	1-3	-3.60	< .001	Group3 outperformed Group1
	2-3	-.60	.758	NS
ES3	1-2	-2.33	.001	Group2 outperformed Group1
	1-3	-3.40	< .001	Group3 outperformed Group1
	2-3	-1.07	.203	NS
Post test	1-2	-1.40	.114	NS
	1-3	-2.27	.005	Group3 outperformed Group1
	2-3	-.87	.423	NS

Table 3. Means and standard deviations for the interviews

Factor	Groups					
	Group1 (N = 15)		Group 2 (N = 15)		Group 3 (N = 15)	
	M	***SD***	***M***	***SD***	***M***	***SD***
Motivation	3.02	1.01	3.74	0.72	4.49	0.50
Enjoyment	3.45	0.87	3.51	1.12	4.62	0.28
Ease of use	NA	NA	3.67	0.90	3.89	0.74
Collaboration	3.76	0.76	3.31	1.18	3.14	1.14

Note: NA = not applicable

partially accepted; when tablets are used, students are more motivated to learn and enjoy lessons more. On the other hand, collaboration and easiness of use are not that different compared to other tools.

SOLUTIONS AND RECOMMENDATIONS

The study sought to examine the learning outcomes from the use of tablets by kindergarten students when teaching them the classification of animals. For that matter, three groups of students were formed; one used printed material, the second used computers and webpages, while in the third tablets were used. As far as the learning outcomes are concerned, the results indicated that the use of tablets produced better results compared to the use of printed material. On the other hand, compared to the use of computers and webpages, the two groups did not have any statistically significant differences, meaning that the learning outcomes did not differ that much. The same applied for the delayed post-tests, which examined knowledge retention. Consequently, the study's results are in support of the finding of previous studies which concluded that the use of tablets results in better learning outcomes compared to conventional tools (e.g., Al-Zu'bi et al., 2017; Bebell & Pedulla, 2015; McManis & McManis, 2016; Zomer & Kay, 2016). At the same time, however, the results are in line with those studies that reported neutral results when tablets were compared to other -digital- media (e.g., Dündar & Akcayir, 2012).

A number of factors may have contributed to the above results. A fact that should be taken into account is the study's learning subject. Students, of all ages, have trouble classifying animals; their mis-

Table 4. Pairwise comparisons for the interview's factors

Factors	Groups	Mean Difference	Sig.	Interpretation
Motivation	1-2	0.72	.038	Group2 outperformed Group1
	1-3	2.16	< .001	Group3 outperformed Group1
	2-3	0.75	.029	Group3 outperformed Group2
Enjoyment	1-2	0.06	.979	NS
	1-3	1.17	.001	Group3 outperformed Group1
	2-3	1.11	.002	Group3 outperformed Group2

conceptions are notable (Coley et al., 2017; Martínez-Losada et al., 2014; Patrick et al, 2013) and are hardly lifted even after systematic teaching (Kubiatko, 2012). This was confirmed by the results in the evaluation sheets of all groups. In both the pre-test and the first evaluation sheet (animals' classification according to their habitat) about half of the students' answers were wrong (see Table 1). Slightly better were the results in the second evaluation sheet (animals' classification according to their diet), but still rather disappointing. On the other hand, it would be unrealistic to expect dramatic -positive- changes, in such a difficult learning subject, after a small number of interventions.

A second thing to consider is the teaching method. It has to be reminded that it was based on Bybee's 5Es, that students worked in pairs, that they had quite an increased autonomy, and that the teacher's role was active and supportive. A large number of researchers support the view that the satisfactory learning outcomes resulting from the use of tablets are due to students' increased autonomy and control over their learning pace (e.g., van Deurse, ben Allouch, & Ruijter, 2016). Other studies concluded that the learning outcomes can also be attributed to the reinforcement of collaborative learning through the use of tablets (e.g., Blackwell, 2013; Shifflet et al., 2012). The above cannot be supported by the findings of the present study. Indeed, by examining Table 3, it becomes clear that collaboration in the tablets group was the worst among the three groups, although not statistically significantly different. The short duration of the project together with the fact that students were not used in working with tablets are plausible explanations for this result. Another finding that contradicts the findings of previous research is related to tablets' ease of use. While researchers suggested that tablets are easier to use compared to a keyboard or mouse (Blackwell, 2013; Hirsh-Pasek, Zosh, Golinkoff, Gray, Robb, & Kaufman, 2015), in this study students regarded both computers and tablets as equally easy to use. Again, the project's short duration might have not allowed students to familiarize themselves with the use of tablets (and the applications that were used).

The relevant literature suggested that tablets allowed the development of an attractive and pleasant learning environment which made learning an enjoyable process (e.g., Blackwell, 2013). Indeed, this was confirmed by the interviews' results; the enjoyment students felt during lessons was far greater in the tablets' group than in the other two groups (see tables 3 and 4). The interviews' analysis also revealed that students were more motivated to learn, thus, confirming research pointing to this direction (e.g., Strouse & Ganea, 2017).

To summarize and on the basis of the study's results, fun/enjoyment and motivation proved to be the advantages of tablets over other teaching tools. Then again, these advantages were not enough for producing better learning outcomes compared to the use of other digital tools, namely, computers and webpages. Furthermore, the use of tablets resulted in clearly better learning outcomes compared to printed material (as the tablets' group outperformed the printed material group in all cases), while the use of computers and webpages also produced good results (as the computers' group outperformed the printed material group in two out of four cases). Thus, a legitimate conclusion is that digital learning tools, in general, are more preferable than conventional material, as they are expected to produce better learning outcomes.

Implications for Research and Practice

The study's implications for research are, up to a certain degree, related to the teaching method that was followed, which was a modified version of Bybee's 5Es. It has to be reminded that this framework was developed before tablets became mainstream. As others suggested, we are still in need of a robust pedagogy in order to take full advantage of tablets' educational potential (e.g., Clarke & Svanaes, 2014). Consequently, it is necessary either to update the existing or to develop new teaching methods. Toward this end, the study's teaching method might provide some ideas.

The study's results also have implications for software developers and educators. As already mentioned in the "Materials" section, the applications were developed by one of the researchers; thus, they were far from reaching professional standards. Furthermore, it is quite probable that their flaws had a negative impact on the learning outcomes. On the other hand, commercial applications, suitable for the study, were simply not available. This problem is not uncommon in countries in which the software industry is not well-developed. Two are the possible solutions to the above issue. The first is teachers to become producers of educational applications. The feasibility of this solution is questionable, given the time and effort needed for the development of such applications. The second solution is software developers and education professionals to work hand in hand, as suggested by Shuler, Levine, and Ree (2012). The close collaboration between these two groups is probably the ideal arrangement for the development of technically, as well as educationally sound applications.

In this project, each session lasted for three teaching hours. Two were the underlying reasons. Given that students were very young, settling down, booting the devices, and loading the applications, was time-consuming; valuable teaching time was lost. Second, it was of utmost importance to provide students with enough time so as to study at their own pace and conduct all the activities. Indeed, on the basis of the results, three-hour sessions proved to be sufficient. Therefore, kindergarten teachers, for successfully integrating tablets (or any other ICT tool for that matter) into their teaching, are advised to carefully plan the activities and allocate enough time for conducting them.

FUTURE RESEARCH DIRECTIONS

Although the study's results were interesting, there are limitations that should be acknowledged but also provide several paths for future research. The sample size, although acceptable for the type of statistical analysis that was conducted, could have been larger. Moreover, it was limited to one city in Greece. The above might raise concerns for the generalizability of the results. The long-term retention of knowledge is also unknown. In future research, the sample, besides being larger, can be more diverse, encompassing even younger or slightly older students. A larger variety of subjects (not only related to natural sciences) will help to determine the disciplines in which tablets are more effective. Additional research tools can also be utilized; observations and unstructured interviews with students and teachers will allow an in-depth understanding of tablets' educational value. Professionally developed applications can also be used and examine whether there is a significant variation in the results. Other devices (e.g., smartphones) or other technologies (e.g., virtual reality) can be used and compare the results. Finally, it would be interesting to conduct research maximizing or minimizing the teacher's role. By doing so, it would be easier to determine the exact impact tablets have on knowledge acquisition.

CONCLUSION

In sum, despite the aforementioned limitations, the study provided an idea about how tablets might prove useful to kindergarten students. What is more, it contributes to the relevant literature by presenting evidence that, in subjects related to animals' classification, kindergarten students, through tablets: (i) can learn more and retain more knowledge compared to printed material and (ii) are more motivated to learn and enjoy lessons more. In conclusion, the study's findings might prove useful to researchers and teachers in understanding the pros and cons of tablets and effectively using these devices in kindergarten education.

REFERENCES

Akerson, V. L., Flick, L. B., & Lederman, N. G. (2000). The influence of primary children's ideas in science on teaching practice. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 37*(4), 363-385. doi:10.1002/(sici)1098-2736(200004)37:4<363::aid-tea5>3.0.co;2-#

Al-Zu'bi, M. A. A., Omar-Fauzee, M. S., & Kaur, A. (2017). The effect of iPad apps on creative thinking among preschoolers in Jordan. *International Journal of Multidisciplinary Education and Research, 2*(4), 29-35.

Allen, M. (2015). Preschool children's taxonomic knowledge of animal species. *Journal of Research in Science Teaching*, *52*(1), 107–134. doi:10.1002/tea.21191

Bebell, D., & Pedulla, J. (2015). A quantitative investigation into the impacts of 1: 1 iPads on early learner's ELA and math achievement. *Journal of Information Technology Education: Innovations in Practice*, *14*(1), 191–215. doi:10.28945/2175

Bedford, R., de Urabain, S., Irati, R., Cheung, C. H., Karmiloff-Smith, A., & Smith, T. J. (2016). Toddlers' fine motor milestone achievement is associated with early touchscreen scrolling. *Frontiers in Psychology*, *7*, 1108. doi:10.3389/fpsyg.2016.01108 PMID:27531985

Billinghurst, M., Clark, A., & Lee, G. (2015). A survey of augmented reality. *Foundations and trends in human-computer interaction*, *8*(2-3), 73–272. doi:10.1561/1100000049

Blackwell, C. (2013). Teacher practices with mobile technology integrating tablet computers into the early childhood classroom. *The Journal of Educational Research*, *7*(4), 231–255.

Braund, M. (1998). *The development of children's ideas on animal classification, form and function; Is school experience becoming increasingly impoverished?* (Report No. 143). East Lansing, MI: National Center for Research on Teacher Learning. (ERIC Document Reproduction Service No. ED436423).

Brown, M. B., & Forsythe, A. B. (1974). Robust tests for the equality of variances. *Journal of the American Statistical Association*, *69*(346), 364–367. doi:10.1080/01621459.1974.10482955

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scatter, P., Carlson-Powell, J., Westbrook, A., & Landes, N. (2006). *BSCS SE instructional model: Origins and effectiveness. A report prepared for the Office of Science Education, National Institutes of Health*. Colorado Springs, CO: BSCS.

Cardak, O. (2009). Science students' misconceptions about birds. *Scientific Research and Essays*, *4*(12), 1518–1522.

Carey, S. (2000). Science education as conceptual change. *Journal of Applied Developmental Psychology*, *21*(1), 13–19. doi:10.1016/S0193-3973(99)00046-5

Cascales, A., Laguna, I., Pérez-López, D., Perona, P., & Contero, M. (2013). An experience on natural sciences augmented reality contents for preschoolers. *Proceedings of the International Conference on Virtual, Augmented and Mixed Reality*, 103-112. Berlin, Germany: Springer. 10.1007/978-3-642-39420-1_12

Cavus, N., & Ibrahim, D. (2009). m-Learning: An experiment in using SMS to support learning new English language words. *British Journal of Educational Technology*, *40*(1), 78–91. doi:10.1111/j.1467-8535.2007.00801.x

Chen, S. H., & Ku, C. H. (1998). Aboriginal children's alternative conceptions of animals and animal classification. *Proceedings of the National Science Council Republic of China Part D Mathematics Science and Technology Education*, *8*(2), 55–67.

Chyleńska, Z. A., & Rybska, E. (2018). Understanding students ideas about animal classification. *EURASIA Journal of Mathematics*. *Science and Technology Education*, *14*(6), 2145–2155. doi:10.29333/ejmste/86612

Cinici, A. (2013). Turkish high school students' ideas about invertebrates: General characteristics and classification. *International Journal of Environmental and Science Education*, *8*(4), 645–661.

Clarke, B., & Svanaes, S. (2014). *An updated literature review on the use of tablets in education. Tablets for Schools*. UK: Family Kids & Youth.

Coley, J. D., Arenson, M., Xu, Y., & Tanner, K. D. (2017). Intuitive biological thought: Developmental changes and effects of biology education in late adolescence. *Cognitive Psychology*, *92*, 1–21. doi:10.1016/j.cogpsych.2016.11.001 PMID:27865155

Couse, L. J., & Chen, D. W. (2010). A tablet computer for young children? Exploring its viability for early childhood education. *Journal of Research on Technology in Education*, *43*(1), 75–96. doi:10.1080/15391523.2010.10782562

Driver, R. (1985). *Children's ideas in science*. UK: McGraw-Hill Education.

Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (2014). *Making sense of secondary science: Research into children's ideas*. Routledge.

Dündar, H., & Akçayır, M. (2014). Implementing tablet PCs in schools: Students' attitudes and opinions. *Computers in Human Behavior*, *32*, 40–46. doi:10.1016/j.chb.2013.11.020

Eshach, H. (2006). *Science literacy in primary schools and pre-schools* (Vol. 1). Springer Science & Business Media; doi:10.1007/1-4020-4674-X

Flewitt, R., Messer, D., & Kucirkova, N. (2015). New directions for early literacy in a digital age: The iPad. *Journal of Early Childhood Literacy*, *15*(3), 289–310. doi:10.1177/1468798414533560

Fokides, E. (2018). Tablets in primary schools: Results of a study for teaching the human organ systems. *International Journal of Smart Education and Urban Society*, *9*(3), 1–16. doi:10.4018/IJSEUS.2018070101

Fokides, E., Kaimara, P., Deliyiannis, I., & Atsikpasi, P. (2019). Development of a scale for measuring the learning experience in serious games. Preliminary results. *Proceedings of the Digital Culture & Audiovisual Challenges International Conference*. Corfu, Greece: Ionian University.

Fokides, E., & Mastrokoukou, A. (2018). Results from a study for teaching human body systems to primary school students using tablets. *Contemporary Educational Technology*, *9*(2), 154–170. doi:10.30935/cet.414808

Gelman, S. A., & Meyer, M. (2011). Child categorization. *Wiley Interdisciplinary Reviews: Cognitive Science*, *2*(1), 95–105. doi:10.1002/wcs.96 PMID:23440312

Gibbs, G. R. (2007). Thematic coding and categorizing. In Analyzing qualitative data, 38-56. London, UK: Sage. doi:10.4135/9781849208574.n4

Harlen, W. (2018). *The teaching of science in primary schools*. David Fulton Publishers. doi:10.4324/9781315398907

Highfield, K., & Goodwin, K. (2013). Apps for mathematics learning: A review of "educational" apps from the iTunes app store. *Proceedings of the 36th Annual Conference of the Mathematics Education Research Group of Australia*, 378- 385. Melbourne, Australia.

Hiniker, A., Sobel, K., Hong, S., Suh, H., Irish, I., Kim, D., & Kientz, J. A. (2015). Touchscreen prompts for preschoolers: Designing developmentally appropriate techniques for teaching young children to perform gestures. *Proceedings of the 14th International Conference on Interaction Design and Children*, 109-118. ACM. 10.1145/2771839.2771851

Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps: Lessons from the science of learning. *Psychological Science in the Public Interest*, *16*(1), 3–34. doi:10.1177/1529100615569721 PMID:25985468

Huber, B., Tarasuik, J., Antoniou, M. N., Garrett, C., Bowe, S. J., Kaufman, J., & Team, S. B. (2016). Young children's transfer of learning from a touchscreen device. *Computers in Human Behavior*, *56*, 56–64. doi:10.1016/j.chb.2015.11.010

Kattmann, U. (2001). Aquatics, flyers, creepers and terrestrials-students' conceptions of animal classification. *Journal of Biological Education*, *35*(3), 141–147. doi:10.1080/00219266.2001.9655763

Kubiatko, M. (2012). Kindergarten Children's perception of animals focusing on the look and fear of animals. *Educational Sciences: Theory and Practice*, *12*(4), 3181–3186.

Kubiatko, M., & Prokop, P. (2007). Pupils' misconceptions about mammals. *Journal of Baltic Science Education*, *6*(1), 5–14.

Laidlaw, L., & Wong, S. S. H. (2016). Literacy and complexity: on using technology within emergent learning structures with young learners. *Complicity: An International Journal of Complexity and Education*, *13*(1), 30–42. doi:10.29173/cmplct24008

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159–174. doi:10.2307/2529310 PMID:843571

Martínez-Losada, C., García-Barros, S., & Garrido, M. (2014). How children characterise living beings and the activities in which they engage. *Journal of Biological Education*, *48*(4), 201–210. doi:10.1080/00219266.2013.849281

McManis, M. H., & McManis, L. D. (2016). Using a touch-based, computer-assisted learning system to promote literacy and math skills for low-income preschoolers. *Journal of Information Technology Education*, *15*, 409–429. doi:10.28945/3550

Neumann, M. M., & Neumann, D. L. (2014). Touch screen tablets and emergent literacy. *Early Childhood Education Journal*, *42*(4), 231–239. doi:10.100710643-013-0608-3

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2016). Comparing tablets and PCs in teaching mathematics: An attempt to improve mathematics competence in early childhood education. *Preschool and Primary Education*, *4*(2), 241–253. doi:10.12681/ppej.8779

Papadopoulou, P., & Athanasiou, K. (2015). Children ideas for "animal" compared to teachers' conceptions. *International Journal of Innovation and Research in Educational Sciences*, *2*(6).

Parnell, W. A., & Bartlett, J. (2012). iDocument: How smartphones and tablets are changing documentation in preschool and primary classrooms. *Technology and Young Children*, *67*(3), 50–59.

Patrick, P., Byrne, J., Tunnicliffe, S. D., Asunta, T., Carvalho, G. S., Havu-Nuutinen, S., ... Tracana, R. B. (2013). Students (ages 6, 10, and 15 years) in six countries' knowledge of animals. *Nordic Studies in Science Education*, *9*(1), 18–32. doi:10.5617/nordina.624

Saldaña, J. (2015). The coding manual for qualitative researchers. Atlanta, GA: *Sage*.

Shifflet, R., Toledo, C., & Mattoon, C. (2012). Touch tablet surprises: A preschool teacher's story. *Young Children*, *67*(3), 36.

Shuler, C. (2009). *Pockets of potential: Using mobile technologies to promote children's learning*. New York, NY: The Joan Ganz Cooney Center.

Shuler, C., Levine, Z., & Ree, J. (2012). iLearn II: An analysis of the education category of Apple's app store. New York: The Joan Ganz Cooney Center at Sesame Workshop.

Silawati, E., & Rachmania, S. (2016). Character building of early young learners through gadget as learning media in kindergarten. *Proceedings of the 3rd International Conference on Early Childhood Education (ICECE 2016)*. Atlantis Press. doi:10.2991/icece-16.2017.26

Strouse, G. A., & Ganea, P. A. (2017). A print book preference: Caregivers report higher child enjoyment and more adult–child interactions when reading print than electronic books. *International Journal of Child-Computer Interaction*, *12*, 8–15. doi:10.1016/j.ijcci.2017.02.001

Trundle, K. C. (2010). Teaching science during the early childhood years. Best Practices in Science Education. *Pridobljeno*, *18*(10), 2016.

van Deurse, A. (2016). Tablet use in primary education: Adoption hurdles and attitude determinants. *Education and Information Technologies*, *21*(5), 971–990. doi:10.100710639-014-9363-3

Vatavu, R. D., Cramariuc, G., & Schipor, D. M. (2015). Touch interaction for children aged 3 to 6 years: Experimental findings and relationship to motor skills. *International Journal of Human-Computer Studies*, *74*, 54–76. doi:10.1016/j.ijhcs.2014.10.007

Wong, S. S. H. (2015). Mobile digital devices and preschoolers' home multiliteracy practices. *Language and Literature*, *17*(2), 75–90. doi:10.20360/g2cp49

Zaranis, N. (2018). Comparing the effectiveness of using tablet computers for teaching addition and subtraction. In L. Daniela, & M. Lytras (Eds.), *Learning strategies and constructionism in modern education settings*. Hershey, PA: IGI Global. doi:10.4018/978-1-5225-5430-1.ch009

Zaranis, N., Kalogiannakis, M., & Papadakis, S. (2013). Using mobile devices for teaching realistic mathematics in kindergarten education. *Creative Education, 4*(7A1), 1-10. doi:10.4236/ce.2013.47a1001

Zaranis, N., & Valla, V. (2019). Tablets in learning mathematics for kindergarten students. In *Didactics of smart pedagogy* (pp. 267–284). Cham, Switzerland: Springer; doi:10.1007/978-3-030-01551-0_14

Zomer, N. R., & Kay, R. H. (2016). Technology use in early childhood education: A review of literature. *Journal of Educational Informatics*, *1*, 1–25.

ADDITIONAL READING

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, *20*, 1–11. doi:10.1016/j.edurev.2016.11.002

Bidin, S., & Ziden, A. A. (2013). Adoption and application of mobile learning in the education industry. *Procedia: Social and Behavioral Sciences*, *90*, 720–729. doi:10.1016/j.sbspro.2013.07.145

Chu, H. C. (2014). Potential negative effects of mobile learning on students' learning achievement and cognitive load-A Format assessment perspective. *Journal of Educational Technology & Society*, *17*(1), 332–344.

Coley, J. D., Arenson, M., Xu, Y., & Tanner, K. D. (2017). Intuitive biological thought: Developmental changes and effects of biology education in late adolescence. *Cognitive Psychology*, *92*, 1–21. doi:10.1016/j.cogpsych.2016.11.001 PMID:27865155

Fokides, E. (2018). Teaching basic programming concepts to young primary school students using tablets: Results of a pilot project. *International Journal of Mobile and Blended Learning*, *10*(1), 34–47. doi:10.4018/IJMBL.2018010103

Fokides, E., & Atsikpasi, P. (2017). Tablets in education. Results from the initiative ETiE, for teaching plants to primary school students. *Education and Information Technologies*, *22*(5), 2545–2563. doi:10.100710639-016-9560-3

Rikala, J., Vesisenaho, M., & Mylläri, J. (2013). Actual and potential pedagogical use of tablets in schools. *Human Technology*, *9*(2), 113–131. doi:10.17011/ht/urn.201312042736

Wilkinson, K., & Barter, P. (2016). Do mobile learning devices enhance learning in higher education anatomy classrooms? *Journal of Pedagogic Development*, *6*(1), 14–23.

KEY TERMS AND DEFINITIONS

Animals' Classification: A methodological grouping of animals that allows scientists to study the relationships in animal groups and to see the whole animal family tree as it has developed through time.

Augmented Reality: A technology that merges the real with the digital world by presenting to the user, in real-time, a combination of real and virtual objects.

Constructivism: A learning theory supporting the view that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences.

Kindergarten Education: A level of education preceding primary education. Depending on each country's educational system, it is either a mandatory or optional for a child to attend this level.

Natural Sciences: A branch of science which deals with the physical world (e.g. physics, chemistry, geology, and biology).

Quasi-experimental Design: An empirical interventional study used to estimate the causal impact of an intervention on the target population without random assignment.

Tablet: A mobile device, with a mobile operating system, a touchscreen display, a processing circuitry, and a rechargeable battery, in a thin, flat package.

APPENDIX

Table 5. The interviews' questions (as rephrased in order to suit the study's needs)

Factor	Item
Enjoyment	I think the lessons were fun I felt bored during lessons* I enjoyed lessons I really enjoyed studying It felt good to successfully complete the lessons' tasks I felt frustrated*
Collaboration	I was displeased because it was impossible to collaborate with others; everyone had a mind of his own* Doing things together with my fellow students was interesting. With my fellow students, we were able to jointly decide what to do
Perceived ease of use	I think it was easy to learn using the applications/tablets I found the applications/use of tablets unnecessarily complex* I imagine that most students will learn to use the applications/tablets very quickly I felt that I needed help from someone else in order to use the applications/tablets* It was easy for me to become skillful at using the applications/tablets
Motivation	The lessons did not hold my attention* During lessons, I did not have the impulse to learn more about the learning subject* The lessons did not motivate me to learn*

Note. * = Negatively worded question; responses and the corresponding scores were reversed