Meni Tsitouridou
José A. Diniz
Tassos A. Mikropoulos (Eds.)

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Tablets and Geography. Initial Findings from a Study in Primary School Settings

Emmanuel Fokides(✉)

University of the Aegean, Rhodes, Greece
fokides@aegean.gr

Abstract. The study examines whether the use of tablets can improve the performance of sixth-grade primary school students in the course of Geography. Four teaching interventions were planned and carried out in three groups of students (twenty-two in each), in primary schools in Athens, Greece. While students in all groups worked in pairs, the first used the textbooks, the second used computers and the third was taught exclusively through the use of tablets and micro-applications developed by the class's teacher. The learning outcomes of the third group were equally good compared to the ones of the second, while both groups outperformed the first one. No notable differences regarding students' misconceptions were observed. The results can be attributed to a number of factors such as students' increased motivation and autonomy, but also highlight the need for finding more efficient methods for integrating tablets into the teaching process.

Keywords: Geography · Misconceptions · Primary school

1 Introduction

One of the challenges science education faces is that of poor students' performance. Indeed, students of all ages have significant problems in science-related courses and their performance level is far from being considered as optimal [1]. On the other hand, it is widely accepted that ICT offers noteworthy advantages and opportunities for improving students' learning compared to conventional teaching. This also holds true for science courses; numerous ICT applications do exist, covering a wide range of topics. Moreover, due to technological advancements, devices with educational potential, such as tablets, are becoming increasingly affordable, allowing their en masse use in education.

Based on the above, it was considered an interesting endeavor to design and implement a project for examining the learning outcomes when teaching Geography to sixth-grade primary school students using tablets. The ultimate goal is to examine all the topics/units included in Geography's program of study for primary school and to test a variety of teaching methods. In the coming sections, the results of the first stage of this effort are presented.

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2 Geography as a Teaching/Learning Subject

The goals of teaching Geography to primary school students are -more or less- the same in every educational system. Among them are to inspire students' curiosity about the world and its people, to equip them with knowledge about diverse places, people, resources, natural, and human environments, and to help them understand the Earth's key physical and human processes [2]. Because of the above, three major domains of desired learning outcomes are identified (a) knowledge (e.g., facts, concepts, and theories), (b) skills (e.g., work with maps, make observations, ask geographical questions, and perform field work), and (c) attitudes (e.g., enjoyment, pleasure, interest, confidence, and effort) [3]. Alas, there are many problems related to the teaching of Geography in primary level, with the first one being its weakening position within the curriculum, because more emphasis is put on the core subjects [4]. Indeed, in Greece's primary education, Geography is taught just for one hour per week and only to the last two grades.

While teachers report minor or no problems when teaching Geography [5], the truth is quite the opposite. Research suggested that the depth of their geography subject knowledge and understanding is shallow [6] and that they have the tendency to avoid teaching causal explanations, reasoning, and higher order thinking within geography lessons [7]. In other words, the majority of teachers are not experts in geography, probably because during their studies they received little (or no) training in this subject [8].

Students' misconceptions are another cause for concern. For example, they think that earthquakes occur only in tropical regions, that there is no snow in volcanoes, and that there is a giant magnet in the center of the Earth [9]. Geographical terms such as "valley", "river", and "mountain" are sometimes hard to define or understand [10]. Bisard, Aron, Francek, and Nelson [11], noted several errors when students were asked to identify continents or countries on a map. For overcoming these problems, Catling and Martin [12] suggested that teachers have to stimulate students' interest so as to view Geography as a subject which relates to their daily spatial experiences and to view Geography as a way of thinking. Sadly, in reality, students associate this course with a lot of reading and writing and do not enjoy answering questions from worksheets or textbooks and taking notes. Thus, another way to overcome problems related to the teaching of Geography is to provide powerful learning environments to them. Such environments (a) contain authentic and rich contexts and tasks, (b) stimulate active, cooperative as well as independent learning, and (c) the curriculum is adapted to the needs of the individual students [13].

3 Geography as a Teaching/Learning Subject

Mobile devices (including tablets) provided unparalleled access to communication and information due to their increased affordability and functionality. In an educational context, they enabled new forms of learning known as mobile learning [14] and/or ubiquitous learning [15]. That is because their portable nature allows them to be used virtually everywhere and anytime. Mobile learning can easily and effectively enhance traditional teaching models by providing additional/alternative teaching activities [16].

The existing body of research acknowledges mobile devices' positive impact on students' learning even at very young ages [17]. The key benefits include, but are not limited to, personalized and independent learning, development of metacognitive skills [18], motivation for learning and enjoyment [19, 20], increased degree of collaboration [18], the opportunity to constantly assess and reflect on the learning progress, and greater autonomy [21]. On the negative side, mobile devices can be a source of distraction for students because they tend to use them for non-educational purposes during lessons [22].

Coming to tablets, much of the research on them replicates the findings from studies on other mobile devices. On the other hand, it seems that they have certain advantages over other mobile devices (e.g., larger screens, greater processing, and battery power) and each year they are becoming more affordable since their prices constantly decline. Despite this fact, their educational impact is still largely unknown because of the absence of thorough empirical studies which assess their impact on learning/teaching [23].

The tablet-to-student ratio is also an issue in which research has not given a definite answer. While it is true that low device-to-student ratio may act as a barrier for fully realizing the potential of tablets [24], it is also true that when shared and not used as personal devices, a positive impact on learning was observed [22]. Also, personal ownership and/or the ability to take tablets at home, increased students' motivation, autonomy, and self-efficacy [25].

4 Method

Based on what was presented in the preceding sections, a project was designed for teaching Geography using tablets, having as a goal to examine the learning outcomes. The whole effort was based on the assumption that tablets can function as mediators between students and the learning material, allowing the former to have a better understanding of the subject while working in an environment which encourages engagement, cooperation, and self-regulation of the learning process. On the basis of the above, the following research hypotheses were formed:

- H1. The use of tablets, yields better learning outcomes, compared to other teaching approaches which may or may not be technologically enhanced.
- H2. The sustainability of knowledge is also better.
- H3. The results are also better regarding students' misconceptions.
- H4. Students form positive views and attitudes for their teaching using tablets.

4.1 Participants and Duration of the Project

A quasi-experimental design, with one experimental and two control groups, was chosen because data were collected from intact classrooms. The target group was sixth-grade primary school students (ages 11–12) who (a) never before used tablets as part of their teaching, (b) reflected the spread of ability in a typical Greek sixth-grade class, and (c) the ratio of boys and girls was close to that of a typical Greek primary school. Thus, an “ordinary” and “typical” sample was achieved [26]. The majority of schools which responded affirmatively to the relevant email invitation to participate in the project (addressed to primary schools in Athens, Greece) had to be excluded because they were (a) too far apart and (b) private schools and the sample would be heterogeneous in terms of the socioeconomic status of students. As a result, a total of sixty-six students were recruited from three sixth-grade classes of three neighboring public primary schools. In each class, a teaching method described in the “Procedure” section was randomly assigned. Written consent from students’ parents for their children’s participation was obtained.

The project lasted for about a month (four sessions in each class, from mid-October to late November 2017). Each session lasted for two teaching hours (instead one) so as students to have enough time at their disposal for conducting the session’s activities.

4.2 Materials

Four teaching units from the sixth grade’s school textbook were selected for the project, namely Earth’s (a) continents and oceans, (b) atmosphere, (c) climate zones, and (d) vegetation zones. Since there is an official and freely available online/interactive version of the textbook, it was decided to use it as a basis for the project’s material and not deviate from it (i.e., by adding additional information). Thus, for reasons elaborated in the coming section, four presentations were developed (one for each unit) which included all the multimedia features (images, videos, interactive maps, etc.) of the corresponding units in the online e-book.

The next step was the development of the tablets’ applications. For that matter, Blippbuilder (https://web.blippar.com/) was used, which enables the rapid (and easy) 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 [27]. A marker (an image) is used for triggering/starting an AR application. Thus, a total of 32 images were used as markers and an equal number of AR micro-applications were developed (an average of 8 micro-applications per unit). Each AR micro-application presented a short passage from the textbook (usually a paragraph, a set of terms or definitions) together with the relevant Google interactive maps, videos, and images. Also, a number of Google forms was developed for the corresponding activities in the e-book. Finally, links were provided so as students to be able to run the external applications which were included in the e-book. The markers were later printed and handed to students who were going to use the tablets. It has to be noted that the micro-applications were not developed by a group of experts but by the class’s teacher who had no previous experience in the development of such applications. The development of the micro-applications required around forty hours (an average of ten hours per unit).

4.3 Procedure

For science subjects, it is recommended students to work in small groups [28]. Accordingly, it was decided students to work in pairs, but since the project was able to provide a sufficient number of tablets, students had their own at their disposal. Also, students were free to take their tablets at home, totally replacing their textbooks (which were left at school during the duration of the project), as other researchers suggested [29]. Increased autonomy and control over their learning pace were also considered as essential [30]. Thus, in each session, after a very short introduction by the class's teacher, students used the tablets and studied the relevant material totally by themselves. They were free to run any micro-application in any order and for as long as they liked, keep notes, collaborate, discuss, and exchange ideas, while the class's teacher provided only technical assistance. The only prerequisite was that each pair of students, by the end of each session, had to be able to present to the rest of the class the answers to the relevant exercises or activities.

In order to compare the learning outcomes of the above teaching scheme, two more groups of students were formed. The teaching scheme in the first group was exactly the same as in the tablets' group with three exceptions (a) instead of using tablets, students used computers (one for each pair) for viewing the relevant units from the online/interactive e-book, (b) the textbooks could also be used (either at school or at home), and (c) the class's teacher acted as facilitator of the process by constantly discussing or collaborating with students. To the second group, the teacher made a short introduction, followed by presentations (using the class's video projector) regarding what students were about to learn. Next, students worked in pairs by studying the relevant unit in their textbooks and by completing the exercises and activities. As in the previous group, the class's teacher acted as facilitator of the process by discussing or collaborating with students. This method is -more or less- the prevailing one in Greece's primary schools.

4.4 Instruments

For data collection purposes, a total of six evaluation sheets were devised (pre- and delayed post-tests, and one for each of the four teaching units), consisting of multiple choice, yes-no, fill-in-the-blanks, and open-ended questions. All evaluation sheets were structured so as (a) to fully cover the content of each unit, (b) questions to be of escalating difficulty, and (c) about half of the questions to check knowledge acquisition and the other half to check whether students could apply this knowledge and required a certain degree of critical thinking and skills, thus, covering two of the major domains of desired learning outcomes [3]. Also, a questionnaire was administered used in previous studies for evaluating students' experiences and views regarding the use of tablets [31, 32], consisting of fifteen five-point Likert-type questions (worded "Strongly Agree", "Agree", "Neutral", "Disagree" and "Strongly Disagree").

Finally, two more tests were formulated in order to check whether the teaching approaches had an impact on students' misconceptions. The questions were inspired by common students' misconceptions regarding the Earth's continents, oceans, atmosphere, climate, and vegetation zones (which were the teaching units that students were taught), as discussed in the relevant literature [33–36]. It has to be noted that the questions in these tests were four-tier multiple-choice questions. For each question, the first tier had a set of three possible answers. The third tier had a set of three possible explanations for each answer to the first tier. In the second tier, students were asked to give their confidence level (sure/not sure) for the first tier, while the fourth asked students to give their confidence level (sure/not sure) for the third one. This was done because the literature suggests that such tests can accurately measure students' misconceptions [37]. For example, a question related to oxygen was the following:

- Most of the Earth's oxygen comes from (a) land plants, (b) sea plants, (c) volcanoes. Are you sure? Yes, I'm sure, Well, not so sure
- You selected (a) because: (i) rain and boreal (snow) forests cover huge areas (more than 1,000,000,000,000 trees), this means a lot of photosynthesis, (ii) there are more land plants (including grass and other small plants) than sea plants, (iii) water blocks sunlight; sea plants' photosynthesis is limited.
- You selected (b) because: (i) there are more plants in the sea (including the microscopic ones) than in the land, (ii) the chemical structure of sea plants' chlorophyll is more complex; sea plants photosynthesize more efficiently, (iii) water facilitates photosynthesis; sea plants photosynthesize far more than land plants.
- You selected (c) because: (i) volcanic eruptions release into the atmosphere tremendous amounts of gases trapped into the Earth's crust, including oxygen, (ii) lava's temperature breaks down carbon dioxide; huge amounts of oxygen are released during this process, (iii) in fact, the most common element found in the Earth's rocks is oxygen (46.6%); when rocks are melted (lava) this oxygen is released.
  Are you sure? Yes, I'm sure, Well, not so sure

5 Results

As presented in the preceding section, the study's sample (sixty-six students) was divided into three groups of equal size: Group1 conventional teaching, Group2 teaching with computers, and Group3 tablets group. Scores in all the evaluation sheets were computed on the basis of the number of correct answers. Mean scores and standard deviations per group of participants and per evaluation sheet are presented in Table 1.

One-way ANOVA tests were to be conducted to compare the scores of the three groups, in order to determine if they had any statistically significant differences. Prior to conducting these tests, it was checked whether the assumptions for ANOVA testing were violated. It was found that: (a) all groups had the same number of participants ($N = 22$), (b) there were no outliers, (c) the homogeneity of variance was not violated, as assessed by Levene's Test of Homogeneity of Variance, and (d) in some tests the data were not normally distributed, as assessed by Q-Q plots and the Shapiro-Wilk test. On the other hand, the literature suggests that ANOVA is robust to moderate deviations from normality and the false positive rate is not affected very much by this violation

[38]. Since the violations were minor, they were considered as acceptable deviations from the assumptions for ANOVA testing.

Given that all the other assumptions were met, the analysis was conducted. It was found that in the pre-test [$F(2, 63) = 0.95$, $p = 0.39$], pre-misconceptions test [$F(2, 63) = 1.14$, $p = 0.33$], ES1 [$F(2, 63) = 2.90$, $p = 0.14$], and post-misconceptions test [$F(2, 63) = 2.42$, $p = 0.10$] there were no statistically significant differences between groups. In contrast, in ES2 [$F(2, 63) = 11.18$, $p = 0.001$], ES3 [$F(2, 63) = 15.85$, $p < 0.001$], ES4 [$F(2, 63) = 12.42$, $p < 0.001$], and delayed post-test [$F(2, 63) = 15.09$, $p < 0.001$] there were statistically significant differences between groups.

Table 1. Means and standard deviations per group of participants and per evaluation sheet.

	Group					
	Group1 (N = 22)		Group2 (N = 22)		Group3 (N = 22)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Pre-test (max = 35)	13.75	2.48	14.46	2.22	13.38	3.15
Pre-misconceptions test (max = 20)	6.55	2.31	7.16	2.55	6.18	1.55
ES1 (max = 25)	14.18	4.15	16.54	3.84	16.89	4.19
ES2 (max = 25)	16.11	3.45	18.52	2.99	20.66	3.12
ES3 (max = 25)	13.78	4.15	17.12	3.20	20.04	3.66
ES4 (max = 25)	17.69	3.50	21.51	3.18	22.88	4.01
Delayed post-test (max = 35)	19.87	3.12	23.11	4.02	25.98	3.87
Post-misconceptions test (max = 20)	11.85	2.19	13.58	3.11	12.66	2.44

Note. ES = Evaluation sheet

Post-hoc comparisons (using the Tuckey HSD test) were conducted on all possible pairwise contrasts in the tests where statistically significant differences were noted. It was found that:

- ES2. Group3 ($M = 20.66$, $SD = 3.12$) outperformed Group1 ($M = 16.11$, SD = 3.45, $p < 0.001$) but not Group 2 ($M = 18.52$, $SD = 2.99$, $p = 0.075$). Also, Group2 outperformed Group1 ($p = .039$).
- ES3. Group3 ($M = 20.04$, $SD = 3.66$) outperformed both Group2 ($M = 17.12$, $SD = 3.20$, $p = 0.029$) and Group1 ($M = 13.78$, $SD = 4.15$, $p < 0.001$). Also, Group2 outperformed Group1 ($p = 0.011$).
- ES4. Group3 ($M = 22.88$, $SD = 4.01$) outperformed Group1 ($M = 17.69$, $SD = 3.50$, $p < 0.001$) but not Group2 ($M = 21.51$, $SD = 3.18$, $p = 0.418$). Also, Group2 outperformed Group1 ($p = 0.002$).
- Delayed post-test. Group3 ($M = 25.98$, $SD = 3.87$) outperformed both Group2 ($M = 23.11$, $SD = 4.02$, $p = 0.032$) and Group1 ($M = 19.87$, $SD = 3.12$, $p < 0.001$). Also, Group2 outperformed Group1 ($p = 0.014$).

The three groups had the same initial knowledge level since there were no statistically significant differences in both pre-tests. Therefore, any differences found in the evaluation sheets can be attributed to the different teaching methods. Having that in mind, the results partially confirm H1, given that Group3 (a) was not outperformed by any other group in any case, (b) fared better than Group1 in all evaluation sheets but one, and (c) fared better than Group2 in two out of five evaluation sheets. The fact that Group3 outperformed the other groups in the delayed post-test, confirms H2. On the other hand, H3 has to be rejected because no statistically significant differences were noted in the post-misconceptions test.

Coming to the questionnaire, students' strong positive attitude towards the use of tablets was evident in most of their responses (Table 2), thus, H4 (students form positive views and attitudes for their teaching using tablets) was confirmed. Moreover, collaboration seems to have worked well ($M = 4.11$, $SD = .39$) and students acknowledged how important their partner was to the learning process ($M = 4.20$, $SD = .60$).

Table 2. Students' questionnaire.

Question	*M (SD)*
1. I collaborated with my fellow student nicely	4.11 (0.39)
2. I feel that working as a pair helped me to learn	4.20 (0.60)
3. I think that using tablets during the lesson is boring*	3.95 (0.76)
4. I think that using tablets during the lesson is an enjoyable activity	4.62 (0.50)
5. Working with tablets was fun	4.51 (0.42)
6. I enjoyed working with tablets	4.12 (0.76)
7. Working with tablets made me want to learn more about Geography	4.22 (0.40)
8. I was eager to conduct the project's lessons	4.05 (0.70)
9. I found the courses very interesting	4.07 (0.77)
10. I feel that I have learned nothing*	3.72 (0.48)
11. I believe that the lessons were like a game	4.20 (0.33)
12. Working with tablets was difficult*	4.41 (0.50)
13. I did not like the courses at all*	4.22 (0.60)
14. I would like to use tablets again in my teaching	4.44 (0.32)
15. It would be nice to use tablets in all lessons/courses	4.68 (0.28)

Note. * indicates a question for which its scoring was reversed

6 Discussion

The data analysis revealed that the performance of students who were taught with the use of tablets exceeded that of students who were taught conventionally (in all cases but one) and of students who were taught with the use of computers (in two out of five cases). These results are in agreement with previous studies, which compared conventional teaching with teaching using tablets [39]. Motivation for learning, students' active involvement in the learning processes when using tablets, and positive attitude towards their use are three factors that might have contributed to this outcome as suggested by others [40]. Indeed, students stated that they enjoyed working with tablets (see questions three through six) and that they felt motivated (see questions seven through nine). Also, an indication of students' positive attitude comes from questions thirteen through fifteen. The literature suggests that fun and enjoyment when using tablets act as facilitators of the learning process [41]. Indeed, students liked that they were having fun and, at the same time, they were learning (see questions five, six, ten, and eleven).

The animations, images, videos, interactive maps, and, in general, all of the micro-applications' multimedia features seem to have helped students to learn the relevant information. That is because the literature suggests that the visualization and interaction with the learning material that tablets and their applications offer, create a pleasant and attractive learning environment which, in turn, contributes to the learning outcomes [42, 43]. The second group of students also had access to rich audiovisual material since they used the interactive e-book. Given that both groups outperformed the first group in which only the textbooks were used, it is quite safe to assume that technology-enhanced teaching is expected to yield better learning outcomes compared to conventional teaching. On the other hand, and on the basis of the results, there was no clear advantage of tablets over computers, other than the lower cost, higher mobility, and their small form factor which result in easiness of use [15].

It should be noted that students in the experimental group were taught exclusively through tablets and without their teacher's assistance. In essence, they were forced to take control of their learning. On the basis of the results, it can be argued that the high degree of autonomy and control of the learning process can lead to good learning outcomes, as Falloon [44] suggested. At the same time, students worked in pairs, and this also contributed to the results. That is because tablets, due to their size and mobility, do not obstruct or interfere with face-to-face interactions, thus, allowing increased levels of interaction and cooperation between students [15, 18].

Students stated that working with tablets did not cause them any trouble ($M = 4.41$, $SD = 0.50$), confirming that they are compatible with students' ICT skills [45]. Although the use of tablets during teaching was something unprecedented for students, the smooth functioning of the classroom was not disturbed. Instead, a pleasant, fun, and collaborative environment was developed, which was verified by students' answers to the relevant questions (see Table 2, questions 1 and 2). This is somehow in contrast with the views of other researchers who suggested that the in-classroom use of tablets might be problematic since students can use them for non-educational purposes [22]. Presumably, the lessons' organization did not allow the occurrence of such phenomena.

In this study, students had their own tablets and they were allowed to take them home, thus, replacing their textbooks. It seems that this arrangement had a positive impact on the learning outcomes, confirming the views of other researchers who suggested that personal ownership leads to increased students' motivation, autonomy, and self-efficacy [22, 25, 29]. A probable explanation is that students were able to familiarize themselves with these devices and use them more effectively (in contrast to sporadic and time-limited in-classroom usage).

Coming to students' misconceptions, the results were inconclusive. In all groups an improvement was noted (see Table 1) but, still, about half of the answers in the post misconceptions test were wrong and this applied to all groups. In addition, no group was able to outperform the others. Misconceptions are persistent and hard to deal with [46]; it would be unrealistic to expect students to overcome all their misconceptions in the subjects they were taught, in the short period of time that the interventions lasted. Also, one has to keep in mind that the interventions were general purpose lessons and did not target students' misconceptions in specific.

6.1 Implications for Practice

The study's results have implications for educators as well as for software developers. An issue that had to be dealt at the early stages of the project was that of developing the micro-applications. Although Blippbuilder is not that difficult to learn and use, the development of the micro-applications by a non-specialist (the class's teacher), proved to be a quite time-consuming process. Moreover, the applications were far from reaching professional standards; it is quite probable that their flaws had a negative impact on the learning outcomes. Taking into consideration the project's results, one might argue that such an effort was not justified [47]. On the other hand, the idea of teachers being able to produce their own and diverse educational digital content is strongly supported. Therefore, we are in need of software tools that make the whole process much more efficient and appealing to non-experts [48].

The study's results can also lead to a number of suggestions to education administrators and policymakers. Students' positive attitude towards the use of tablets in teaching, together with the satisfactory learning outcomes (at least for the subjects that were examined in the present study), renders their educational exploitation an interesting idea. Also, time is a critical factor. Students need to have enough time at their disposal so as to use tablets at their own pace. Consequently, the primary school's curriculum and the hours allocated for subjects in which tablets are going to be used have to be reconsidered.

7 Conclusion

Despite the interesting results, the study is not without limitations. The sample (sixty-six students), though sufficient for statistical analysis, was relatively small; thus, the generalizability of the results is questionable. The number of teaching interventions was limited due to restrictions imposed by the schools. Other data collection tools, such as interviews and observations, would have allowed a more in-depth understanding of students' views regarding tablets.

Given that the present study presented the results of the project's first stage, the next stages will be conducted having larger sample sizes and a larger number of interventions. Further examination of students' misconceptions and if they can be eased with the use of tablets is also a very interesting topic. Finally, the use of other ICT tools (e.g., computers and smartphones) and other types of applications (e.g., multimedia and virtual reality) can provide useful information regarding the exact impact of tablets as an educational tool.

In any case, it can be concluded that tablets provide an interesting alternative method for teaching Geography to primary level. That is because students were more engaged in the learning process, increased levels of collaboration were noted, and the learning outcomes were good, compared to the other teaching methods. On the other hand, there is still a long way ahead before the full potential of tablets and their impact on pedagogy is realized.

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