MIT Scratch: A Powerful Tool for Improving Teaching of Programming

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Abstract

Programming has been taught for many years to High School students in Greece. Despite this fact, the results are poor. Many students find programming boring and difficult. In contrast, using of computers in students' everyday life is very popular. Most of the students use the Internet, the Social Media and the computer games in a very effective way. MIT Scratch has been proposed as a solution to this educational problem. In this paper we attempt to investigate whether this is true.

Keywords: Scratch, programming, curriculum, variable.

1. Introduction

Teaching programming to high school students has become a challenge for the teachers. Despite the fact that most of the students are familiar with Informatics in everyday life, it is observed that only few of them are familiar with programming. According to the curriculum, high school students in Greece should be taught programming at the age of fifteen (third class of High school).

Programming is taught with the "traditional" way until nowadays. Poor results of this way of teaching raise questions about the effectiveness of the method used (Tew & Guzdial, 2010). There is a great contrast between using of computers in students' everyday life and the use of computers in school life. Students often consider that teaching of programming is difficult and that it is a problem for them (Monroy-Hernández & Resnick, 2010; Dagdilelis, Satratzemi & Evangelidis, 2004). In contrast, they are excited of using computer games and social media.

These observations create questioning among Informatics teachers and generally in the educational community. Recently, an American scientist of MIT, Mitchel Resnick has proposed the use of Scratch program as a solution to this problem. According to him, Scratch can transform the 'boring' traditional way of teaching programming into a creative learning experience (Brennan & Resnick, 2012; Maloney et al., 2008).

This has become our motivation for a research designing in order to investigate whether this is really happening in the Greek High schools.

This paper is organized as follows: in Section 2 we present the Scratch environment, the topic and game selection and the revised Scratch game. In Section 3 we refer to the research design, including the materials, the participants, the objectives, the procedure and the measuring instruments. In Section 4 we present our pilot implementation and after that we continue with the Results Section, before we finish with our conclusions.

2. Scratch

In fact, Scratch is an online community where children program and share interactive stories, games, and animations (Monroy-Hernández & Resnick, 2008; Sylvan, 2007). Users do not need to know any particular language program. Coding is developed through the use of 'bricks'. Each brick is a command, so the user has only to place the bricks in the right order to create a program. That makes it familiar and easy to use. Children can use it easily, even if they are at the first steps of their school life.

The most attractive feature of Scratch is the easiness of creating games. Students can create their own games easily and share them with the Scratch community. Members of the community can also revise and improve these games.

This opportunity of revising and improving Scratch games is been proposed by M. Resnick to be used in the teaching of programming (Brennan & Resnick, 2012; Maloney et al., 2008). Revision of a game is preferred than creating a new one from the beginning, as it is easier for the high school students.

That has become our motivation and we decided to search for appropriate Scratch games. This investigation is been described in the next sections.

2.1 Topic and game selection

After completing our investigation for appropriate Scratch games we chose the following:
Game 1: Insect Maze
http://scratch.mit.edu/projects/smiller4/2733440
Game 2: Robox
http://scratch.mit.edu/projects/TheExplodingCheez/957022
Game 3: Electricity
http://scratch.mit.edu/projects/zubblewu/2618266

These games are interesting from educational aspect because of their simplicity. In particular, their code is comprehensive and clear. Pupils of secondary education can easily change the code of only one "sprite" (a character or an object) and the principles of structured coding can be effectively introduced (Maloney et al., 2008, p.1). According to the Greek ICT curriculum, the concepts of variables, logical

operators, conditions (if, if…else) and repeating actions (repeat, repeat until, forever) can be learned and assimilated by observing, altering or even adding code.

While the Insect Maze is quite simple and extensible, the students may be addicted to the Robox game and surprised by its simplicity. The Electricity game offers a real time variable changing depicting the difference in a straightforward way.

The students involved in the process were expected to improve their perception and cognitive skills. For example, by changing a variable value could slow down the game or even the whole game procedure and results. Furthermore, the students should be motivated to add sprites, change the sounds, the colors and the way of movement and design similar backgrounds and user interface.

2.2 Revised Scratch game

We suggest that in the "Insect Maze" game, the students will be asked to add, remove or change the way the variable "Score" increases. They could also change the kind of problems (e.g. general educational questions) to be answered which results to changing the logical conditions in the loop "repeat until...".

In "Robox" game, the students can easily experiment with the variables "speed" (to slow down or accelerate the sprite' s movement) and "level". Alternatively, they could be asked to change the key pressed (e.g. a, w,d,x) in the "if...else..." conditions.

Finally, the "electricity" game is offered to test the variables in real time, or even to use other pen color and change respectively the logical conditions.

3. Research design

Since we had chosen the three Scratch games, we designed our research as follows.

3.1 Materials

The materials needed for our research were:
- PCs with Scratch program preinstalled and
- Scratch game

3.2 Participants

The participants in our research were:
- Secondary school teacher
- Secondary school students separated in two (2) groups under the following conditions:

1. Each team consisted of the same number of students
2. Male members (boys) were equal to female (girls)

3. Members of each team had approximately similar grades in overall performance (1/3 of them had maximum grade up to 13, 1/3 had grades between 14-16 and the last 1/3 had grades over 17)
4. We should note that grade deviation in Informatics between the members of the three above mentioned subgroups should be as small as possible (Bruce, 2006; Cohen, Manion & Morrison, 2007; Savenye W. & Robinson, 2001).

3.3 Objectives

The objectives of the experiment were:
1. to investigate whether the teaching of programming through modifying a game affects the attitude of students towards programming and
2. to investigate whether the students think that Scratch is an attractive tool to be used at school.

3.4 Procedure

One group was been taught the new concept with the "traditional way". The teacher introduced the "new" knowledge in theory. Students did consolidation exercises and expressed their queries.

In the second group a Scratch game was presented. Initially, the students played the game and became familiar with its operation. Then the teacher presented to the students the code of the game, saying that they could modify the code, and eventually modify the game. He guided the students to modify the sector of the code aiming at the new concept teaching. Students experimented by making changes and observing the results of them. At the end of the process the teacher introduced the new concept theoretically. He theorized the knowledge that the students had already experienced in practice (Mordechai, 1998).

3.5 Measuring instruments

Both groups were given a questionnaire. Control group filled in questionnaire A in order to investigate their attitude towards programming. Students were asked to express their opinions about the teaching of programming (if they thought that programming should be taught at school and if they hoped that teaching of programming would be continued in the future). They were also asked about the programming (if they were interested to learn programming in the future, if they would continue to learn programming and if they would study programming regularly). Treatment group filled in questionnaire B. This questionnaire included questionnaire A, but also contained additional questions in order to investigate the attitude of students towards Scratch (Giannakos, Hubwieser, & Chrisochoides, 2013). Students were additionally asked to express their opinions about the use of Scratch (if they were intended to use Scratch in the future, if they thought that Scratch should be

taught at school and if they hoped that using of Scratch at school would be continued in the future).

Data gathered from questionnaires were analyzed using IBM SPSS statistics tool. We compared the two groups that were selected with equivalent criteria (number of members, sex, general performance, performance in Computer Science) using the collected data and drew conclusions. We also used the chi-square index in order to investigate the correlation between the gender and the collected data.

4. Pilot Implementation

Before the final establishment of the research project we collaborated with our partner school teacher that executed the experiment. Once we got into the existing practical limitations, we were led to the final form of the project and the restatement of objectives.

The game chosen for teaching with Scratch was "Electricity". This game was basically chosen because of its simplicity, since the participants (students) in our research were at the age of thirteen (first class of High school) and had no prior experience on programming.

In the next stage we proceeded to the pilot implementation.
1. We chose 4 High school students (2 boys and 2 girls).
2. We divided the students into groups of 2 (1 boy-1 girl in each group).
3. One group was taught a lesson with traditional methods (introduction to programming). The other group was taught the same subject (introduction to programming) using Scratch.

4.1 Control Group

Students were taught the introduction to programming in the following way. The teacher raised the problem of handling a robot (with voice commands). He presented himself as the robot and encouraged the students to give him the appropriate instructions needed to reach to a target destination. Students experimented by expressing commands executed by the teacher. If there was an ambiguity the teacher was saying: "I do not understand."

The process ended when he reached at the target destination.

Then a student took the role of the robot, set a different destination target and his classmates tried to direct him properly. The teacher intervened in the process in order to set standard command language directives.

In the next step of the process they followed the same model with one variation: each student recorded in his notebook all the necessary instructions which he considered to

be given to the robot. The process ended with checking by the students for the correctness of their recorded commands.

At the end, students were given questionnaire A for completion.

4.2 Treatment group (Scratch)

First step included a presentation of the program environment to the students. They were encouraged to play the game, to experiment and familiarize themselves with it.

Then the teacher posed the problem of the way the program was structured (Mordechai, 1998). Students were concerned, they made assumptions. They were gradually introduced into the game code and were encouraged to change a command (color) to see the changes this will bring. They observed these changes and continued experimenting and trying out with other colors.

At the end, questionnaire B was given to students for completion.

4.3 General observations of Pilot Implementation

1. One teaching hour (forty five minutes) were marginally sufficient for the experiment.
2. The students showed great interest in the Scratch and wanted to use it more than the available time allowed.
3. Students had a positive opinion about the application.
4. The process of changing the code wasn't difficult for the students, although it took a little help to locate the exact point where the code should be changed.

In conclusion, it was not observed any particular problem. So the pilot was considered as successful and we proceeded to the final implementation of the research project.

5. Research details

Our research took place in a High school of Corfu, during the spring semester. Twenty students participated in it. They all were at the first class of High school and were divided in two groups. The 'between groups' method was chosen (Bruce, 2006; Cohen, Manion & Morrison, 2007; Savenye W. & Robinson, 2001). After collecting the data the two groups were compared and we extracted our results.

6. Results

Scratch seemed to be very interesting for the students. As seen in figure 1 *there was not any negative attitude against it*.

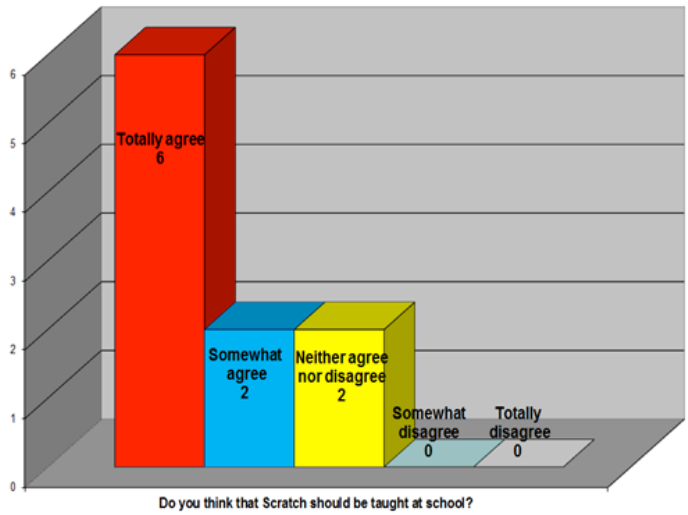

Figure 1. *Do you think that Scratch should be taught in school?*

In contrast, *students of the control group did not have the same positive attitude against the traditional teaching method.*

Furthermore, the majority of the Scratch group expressed their interest in learning how to code, while students of the control group seemed to be cautious. Similarly, Scratch group declared that they will definitely continue to learn how to code. In control group a *clear refusal* was observed (figures 2, 3).

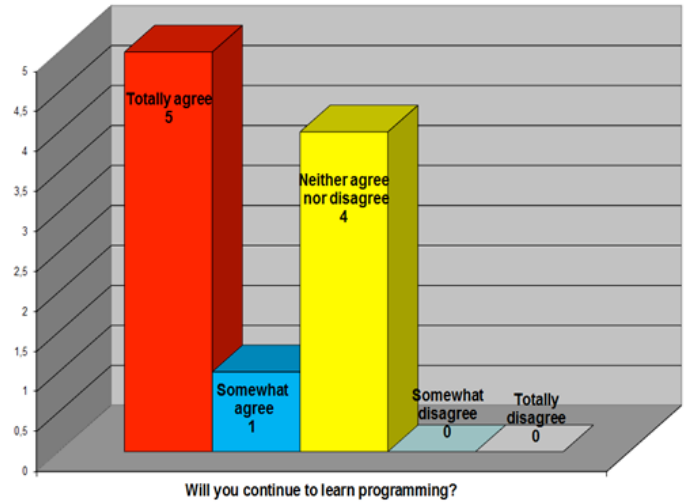

Figure 2. *Will you continue to learn programming? (Scratch group)*

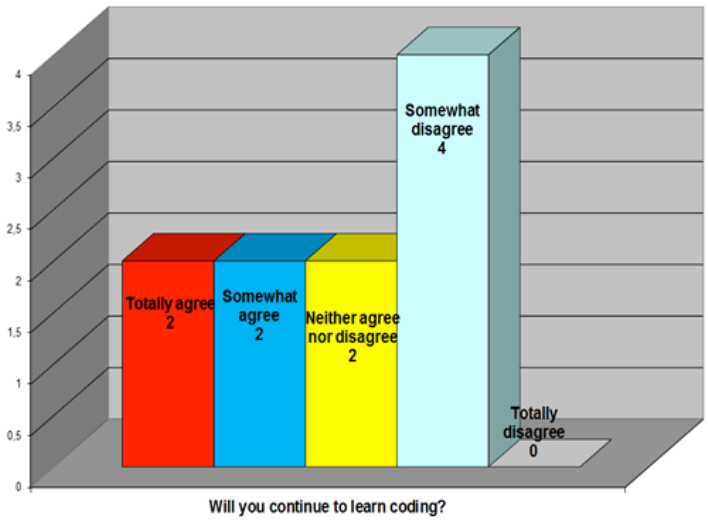

Figure 3. *Will you continue to learn programming? (Control group)*

It is also observed that Scratch might help girls to have a more positive attitude towards programming and increase their intention to continue learning to code in the future.

7. Conclusion

Conclusions of our work focused on the specific data set and we cannot generalize. But we consider our experiment as important because it shows an opportunity for improving teaching of programming. Scratch seems to offer a solution to the students for learning how to code.

Despite the limitations coming of the small sample, we consider it as an extended pilot and we can suggest that there is *a strong indication that MIT Scratch can affect positively the attitude of students towards programming*. Furthermore, *students believe that it is an attractive tool* that should be used at school.

Another indication of its usefulness is *the positive effect that seems to have on the attitude of girls towards programming.*

For all those reasons we consider Scratch as a very effective and powerful tool for teaching of programming. While there is a challenge of testing it in a broader sample, we suggest that it should be used broadly, while more data could be collected and evaluated.

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Περίληψη

Ο προγραμματισμός διδάσκεται για πολλά χρόνια στους μαθητές της δευτεροβάθμιας εκπαίδευσης. Παρά το γεγονός αυτό, τα αποτελέσματα είναι πενιχρά. Πολλοί μαθητές βρίσκουν τον προγραμματισμό βαρετό και δύσκολο. Αντίθετα, η χρήση των υπολογιστών στην καθημερινή ζωή των μαθητών είναι πολύ δημοφιλής. Οι περισσότεροι από τους μαθητές χρησιμοποιούν το Διαδίκτυο, τα Κοινωνικά Δίκτυα και τα παιχνίδια στον υπολογιστή με έναν πολύ αποτελεσματικό τρόπο. Το MIT Scratch έχει προταθεί ως μια λύση σε αυτό το εκπαιδευτικό πρόβλημα. Στην παρούσα εργασία προσπαθούμε να διερευνήσουμε κατά πόσο αυτό ισχύει.

Λέξεις κλειδιά: Scratch, προγραμματισμός, πρόγραμμα σπουδών, μεταβλητή.