Gender differences in students' feedback and performance in Scratch programming

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Abstract
This research project studies primary school pupils' feedback and performance in an introductory lesson to Scratch Programming Language. Two questionnaires were created, studied in terms of reliability and distributed to gather feedback on the Scratch introductory lesson and collect background information on the participants. To get more insight into pupils' feedback, focus group discussions were carried out while, pupils' performance in every lesson part was tracked through an evaluation report. The data collected show that the pupils enjoyed the lesson, liked Scratch interface, valued the learning outcomes of the session and performed well in all three parts of the lesson. Interestingly, it was observed that female participants achieved slightly higher scores than male participants, however, they considered all Scratch lesson parts less easy and fun than males did. This could suggest that females tend to underestimate their programming skills- they feel less confident about programming and this implies the existence of a confidence gender gap in programming skills.

Keywords: Scratch, programming, feedback, performance, gender.

1. Introduction

Over the past decade, a variety of programming software has emerged as a learning opportunity that reinforces students' Computational thinking. Nowadays, in primary school educational contexts, visual programming languages are used together with educational robots to increase students' interest in Computer Science and Science, Technology, Engineering, Mathematics (STEM) careers.

One of the most widespread visual programming languages designed specifically for children is Scratch that was developed by the MIT Media Lab. Scratch displays a block-like interface: the learners just drag and drop the blocks, they don't need to write any text; as a result, programming errors related to syntax and punctuation are avoided. Scratch offers an intuitive way into programming and leaves lots of space for creativity (Romeike, 2008), reinforces pupils' understanding of mathematical and computational concepts and urges pupils to think creatively, reason systematically, all essential skills for the 21st century (Resnick, 2009). Scratch is an engaging programming environment that makes the learning procedure fun and arouses learners' interest and enthusiasm (Wilson, 2010 & Saez Lopez, 2016). Scratch has received really positive feedback from the learners, however, they report difficulties regarding the interface (e.g. recording and adding audio, editing and moving the characters) and

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programming (e.g. problem-solving process and understanding the variables) (Kalelioglu, 2014). Main objective of the present research is to collect:

- Feedback on the learners' first contact with Scratch programming
- Study the factors that may affect the learners' performance.

According to recent research in the field, gender does not seem to have an impact on learners' performance in programming (Tekerek, 2014 & Qian, 2016). Instead of gender, students' performance differences in programming seem to be better explained by their academic performance in non-programming subjects (Qian, 2016). Factors that could also influence learners' performance in programming could be their computer-tablet use habits and self-perceived ICT skills. In this research we will study pupils' performance in the Scratch lesson in correlation with gender, performance at school subjects-mathematics and literacy, computer/tablet use habits and self-efficacy with ICT.

2. Context

2.1 Sample and lesson content

Our study was conducted in March and April 2017 in a non-formal educational institution, located in Thessaloniki, Greece. The content of the lesson and the teaching strategies are outlined in Esteve-González, (2017). The participants were in total 27 and represented a sample of primary school pupils between the ages 9 and 12. By gender, the participants were 15 boys and 12 girls. The study was conducted in the context of an introductory lesson to Scratch programming language of an hour and half. The introductory lesson was delivered to eight different groups of primary school students. The introductory lesson to Scratch programming was divided into 3 parts: in the first part pupils were introduced to Scratch digital environment and experimented with the basic programming blocks, in the second part of the lesson the students had to solve basic programming problems, and in the third part of the lesson the pupils created an animation in Scratch using algorithms creatively (Esteve-González, 2017). The delivery of the sessions was based on exploratory, story-telling and project-based teaching approaches. Objective of the introductory lesson was to introduce students to Computational Thinking and reinforce students' skills in the area of STEAM education (Esteve-González, 2017).

2.2 Materials and procedure

Four different materials were designed to study pupils' performance and feedback: an evaluation report, two questionnaires and a focus groups discussion. Regarding pupils' performance, an evaluation report was designed to be filled out by the teacher as soon as the lesson was over. The teacher assigned grades per lesson part, an average grade and in some cases made comments about the pupils' performance. The evaluation report was employed in order to tack pupils' performance in the lesson.

Pupils' feedback about the lesson was collected through a questionnaire and a focus group discussion. The questionnaire was filled out online by each pupil right after the lesson and consisted of 11 three-point Likert scale items. This questionnaire collected pupils' feedback on Scratch interface, on the overall Scratch lesson, the learning outcomes and last but not least it collected feedback on every part of the lesson regarding easiness and fun as perceived by the pupils. The questionnaire was validated by experts on the field – they provided us with feedback and suggestions for improvement. The reviewers rated the first version of the questionnaire in terms of Importance and Pertinence and Cron-

bach's alpha test was run in order to measure the consistency and the reliability of the items. The alpha coefficient was 0,878 suggesting that the items have relatively high internal consistency. Additionally, Focus Groups were introduced into our research to obtain more insight into pupils' opinions about the Scratch lesson. Focus group discussions were held between the teacher and the group of students right after each lesson and lasted around 10 minutes- the teacher asked the group of learners questions related to their enjoyment in class, their willingness to recommend this class to their friends and take another Scratch class in the future.

To study in greater depth pupils' performance and feedback, the pupils were asked to provide us with their background information through an online questionnaire before the lesson. The questionnaire consisted of 16 items about their biodata (items 1-6), academic performance (item 7), computer/tablet use (items 8-9) and perceptions (items 10-16 in a three-point Likert scale). The questionnaire was validated by experts on the field and rated in terms of Importance and Pertinence. Cronbach's alpha test was run and the alpha coefficient for the items of the questionnaire was 0,867 suggesting that the items have relatively high internal consistency. The initial version of the questionnaire was amended according to the reviewers' suggestions.

3. Results and Conclusions

3.1 Feedback

The sample consisted of 27 pupils - 15 boys and 12 girls. Participants' age varied from 8 to 12 years old, while the average age was 9,5 years old. The quantitative data collected from the questionnaire were analyzed with SPSS 24. More than 90% of the pupils declared that they liked the lesson and qualitative data acquired through Focus Groups come to confirm and enrich the quantitative data. The pupils declared that it was a pleasure for them to take this class; they were also eager to recommend the Scratch lesson to their classmates and insisted that their classmates would enjoy it. In addition, all pupils stated that the learning outcomes of the lesson were substantial and in the focus group discussion they outlined and explained exactly what they had learned in details (e.g. control sprites, give instructions, create algorithms etc.). Regarding Scratch interface, it was clearly displayed that it is fun to use Scratch as around 95% of the pupils indicated so. However, it is not always easy to use Scratch as 60% of the pupils agreed that it is not always easy to find what you want to do in Scratch.

Below, in Figure 1 pupils' feedback on the easiness and enjoyment of every lesson part is presented. It is clearly displayed that all 3 Parts of the lesson were considered easy by the majority of the pupils; the first one seemed to be the easiest of all (93% of the pupils stated that it was easy) while the 2nd and 3rd part of the lesson were considered to be easy by 78% and 70% of the pupils respectively. However, focus group results contradict quantitative results as it was reported that the pupils mostly found Scratch hard in the beginning of the lesson, presumably meaning part 1. Regarding the aspect of fun, all three parts received really high percentages of enjoyment feedback from the pupils, Part 1 and 3 above 90% while part 2 slightly less than 90%. Based on the findings displayed in Figure 1, we may conclude that the second part was slightly less fun than the other two parts, actually, some pupils pointed out during the focus group discussions that they did not like Part 2 because they do not enjoy writing. In Part 2 students had to solve some programming problems on a worksheet. The great majority of the pupils stated that they preferred the 3rd Part of the lesson that consisted of the creation of an animation on Scratch- the learners liked designing and creating a project at their own pace, by applying knowledge previously acquired. All in all, this study has shown that the children really liked Scratch interface and the Scratch introductory lesson, valued the learning outcomes and mostly enjoyed designing and creating project-based activities that are related to the creation of a story (part 3).

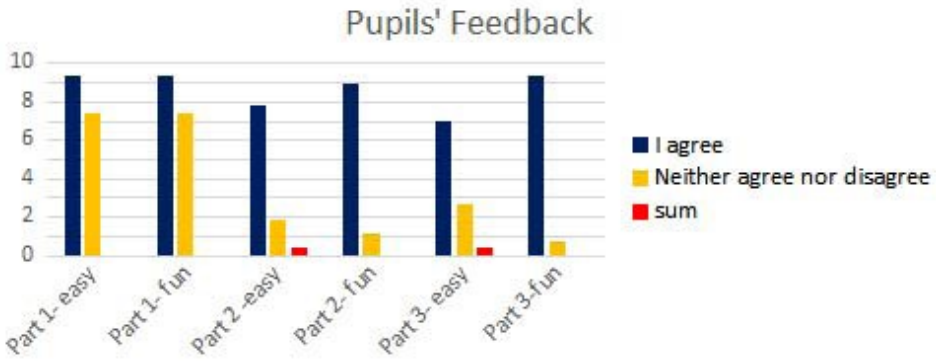

Figure 1. Pupils' Feedback regarding easiness and fun per part

3.2 Performance

The pupils attained quite high scores in all three parts: in the first part, they achieved on average a score around 8 out of 10, in the second part their score dropped a grade while in the third one they did slightly better than in part 2 (7.2/10). Regarding the factors influencing pupils' performance, age seems to have an impact on pupils' performance as in the mixed-level Scratch classes, older pupils seem to achieve higher scores than younger ones. The most striking performance difference is observed in the early stages, actually, 4th year primary school pupils outperformed 3rd year pupils for 1.3 points. Regarding computers and tablets use habits and perceptions, no correlations with performance rates have been drawn, due to the limited sample. In addition, regarding academic performance, no reliable conclusions have been be drawn as almost all pupils indicated that they attained the highest results in their school records in literacy and mathematics and as a result it has not been possible to draw any correlations.

Regarding gender, girls achieved higher scores than the boys, although the difference is not statistically significative- on average girls got M=7.88(/10); SD=0.93; while boys M=7.2; SD=1.62. The results obtained are in line with the research results of Qian (2016) in which middle school females outperformed peer males in an introductory programming course. Despite females' higher scores, it was observed that they gave slightly worse feedback in terms of enjoyment and easiness of the lesson compared to males as presented below in Figure 2.

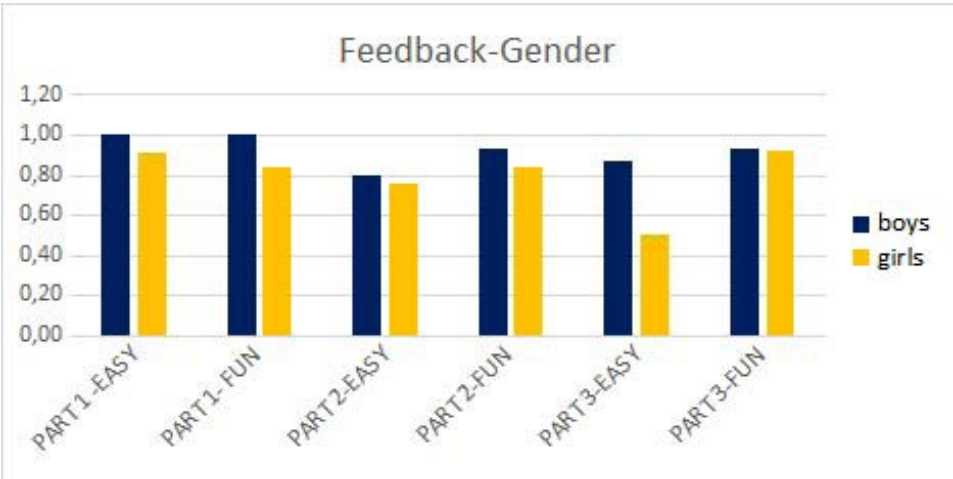

Figure 2. Pupils' Feedback per part- Gender

The most striking difference in feedback occurs in the item concerning the easiness of Part 3; 87% of the boys stated that it was easy, while only 50% of the girls stated so. Despite this considerable feedback difference between girls and boys- implying that girls found this part much harder than boys, it is observed that girls even in this part achieved slightly higher scores than boys. Boys' average grade was 7.27 while girls' 7.5. In this part, the differences between girls' and boys' performance are not important, however, the differences between girls' and boys' perceptions are considerable. The fact that girls have different perceptions to boys in terms of perceived ease of programming and enjoyment was also observed in Rubio, (2015). Male students enjoy programming more than female participants, while it seems that they tend to overestimate their programming skills. On the contrary, female participants seem to underestimate their programming skills and do not seem to enjoy programming as much as males do, possibly because of their lack of confidence. As also observed in Alvarado (2012), there is not a gender gap in computer use- females do as well as males - but there is a very big confidence gender gap in computer skills.

3. Future Research

In order to bridge the confidence gender gap in computer skills, Alvarado (2012) recommends to boost females' confidence in computer skills by applying changes to existing Computer Science courses to make them more meaningful. Alvarado (2012) also recommends to split classes by experience, not by ability and urges students to participate in conferences, competitions and celebrations of women in computing. In future research, we plan to further study increasing females' interest in programming and their confidence in programming skills by making further investigation based on Alvarado (2012) recommendations. In particular, we plan to study females' interest and perceptions about programming in the context of robotics competitions.

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