DESIGNING AND IMPLEMENTING A STEAM LESSON: PUPILS FEEDBACK AND PERFORMANCE IN AN INTRODUCTORY SCRATCH LESSON

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ABSTRACT

This project proposes a well-structured lesson plan for an introductory lesson to Scratch Programming Language for Primary School pupils from 8 to 11 years old. The lesson plan incorporates exploratory, story-telling and project-based teaching approaches and it is based on STEAM educational framework and Computational Thinking Practices. The present research follows the Design Based Methodology and the lesson designed is implemented in one context- a Greek non-formal educational institution. The lesson designed is implemented several times in the same context but with different pupils. In total, 27 pupils participate to the research (15 boys and 12 girls) and the research instruments and teaching materials and approaches are being amended and improved throughout the research cycles. The quantitative and qualitative data collected throughout this process, demonstrate that the pupils enjoyed the lesson, liked Scratch interface and valued the learning outcomes of the session. In addition, the pupils' performance and the difficulties they encountered were thoroughly studied and conclusions were drawn.

KEY WORDS: Scratch, STEAM, Computational Thinking, pupils' feedback, pupils' performance

INTRODUCTION

A lot of initiatives have been taken promoting the STEAM teaching model and its integration to school curriculum. STEAM education combines 5 specific disciplines; Science, Technology, Engineering, Arts and Mathematics. STEAM originates from STEM teaching model in which the discipline of Art is not included. STEM is a teaching model that is a currently recognized application in cross-content-area disciplines to create knowledge as a whole (Bazler, 2017). STEAM education is not in opposition to STEM education but, it enriches and expands the scope of STEM education by integrating the discipline of Art (Taylor, 2016). The present research proposes the design of a STEAM lesson using Scratch programming language as a primary resource. Scratch programming language was developed by the MIT Media Lab and can be used in the framework of STEAM education. Scratch is distinguished for the following characteristics; it is suitable for children, it is specifically designed for young programmers (Resnick, 2009), it makes the learning procedure fun and arouses learners' interest and enthusiasm (Wilson, 2010), (Saez Lopez, 2016), Scratch offers an intuitive way into programming and leaves lots of space for creativity (Romeike, 2008). Scratch also promotes the learning of important mathematical concepts (Resnick, 2009), (Calao,2015) and promotes pupils' computational thinking skills (Saez Lopez, 2016), (Calao,2015). In the present research, Scratch was used as a tool to expand pupils' skills in the area of STEAM Education. In addition, in this study primary school pupils expanded their skills related to Weintrop's Computation Thinking Practices (2016).

RESEARCH OBJECTIVES/ QUESTIONS

The research objectives are outlined below. O stands for general objectives while SO stands for specific objectives.

O1. Design an introductory lesson to Scratch to teach *primary school pupils* how to (1) use Scratch digital environment and basic programming blocks (2) solve basic programming problems and (3) use algorithms creatively in the framework of STEAM Education.

SO1.1 Explore in which way the teaching materials, research instruments and teaching strategies should change to improve the lesson.

SO1.2 Find out pupils' opinions about the (1) introductory lesson to Scratch and (2) Scratch interface.

O2. Evaluate pupils' performance at the introductory lesson to Scratch in terms of their ability to (1) use Scratch digital environment and basic programming blocks, (2) solve basic programming problems and (3) use algorithms creatively.

SO2.1 Explore the difficulties that the pupils encountered throughout the 3 parts of the lesson.

SO2.2 Study if pupils' profile, computer/tablet use habits and perceptions about computers/tablets has an impact on their performance in Scratch introductory lesson.

METHODOLOGY

The present research follows a Design Based Research methodology. As defined by Plomp (2007), educational design research is the systematic study of designing, developing and evaluating educational interventions (such as programs, teaching-learning strategies and materials, products and systems) as solutions for complex problems in

educational practice, which also aims at advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them.

The DBR methodology will be used as the goal of the research is to design an effective introductory lesson to Scratch that will bring the best possible learning outcomes to the pupils and give reliable results that will allow comparison and interrelation of the achievement rates of the pupils. Qualitative and quantitative methods will be applied. This project does not have a tight linear structure but, it is open-ended and iterative; it evolves as improvements are introduced in every cycle from the research itself or from other resources. The research process in design research is cyclical in character: analysis, design, evaluation and revision activities are iterated until a satisfying balance between ideals ('the intended') and realization has been achieved. (Plomp, 2007). That means that lesson was designed, implemented, then the problems that came up and the difficulties that the children encountered were studied and then the lesson was redesigned and improved. The cyclical process goes on until the lesson is considered to be suitable. According to Susan McKenney and Thomas C Reeves (2013), the interventions of educational research design evolve over time through multiple iterations of investigation, development, testing and refinement. The research is divided in several stages according to the following scheme of work - Figure 1 (de Benito & Salinas, 2016). First, the situation was analyzed and the problem was defined, then, the solutions were developed and the research instruments were selected. Typically, several cases are selected to implement the research, however, due to limited amount of time, the present study only reaches its implementation in one case. In this study, the researcher has the double of teacher-researcher.

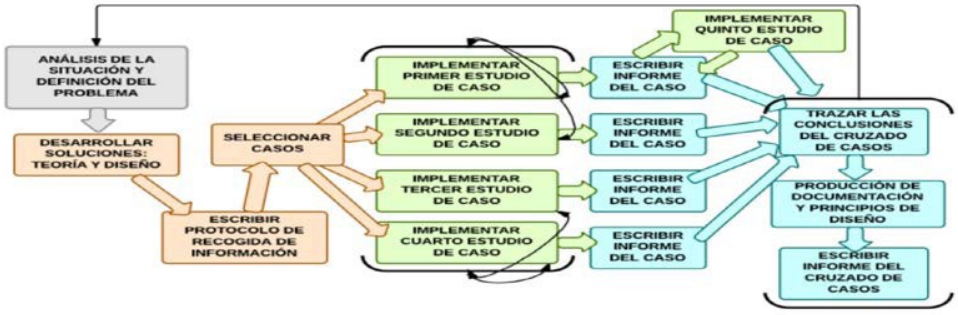

Figure 1. Source: La investigación basada en diseño en Tecnología Educativa., by De Benito, B. y Salinas, J.M., 2016, RIITE. Revista Interuniversitaria de Investigación en Tecnología Educativa, 0, p. 54.

The present research takes place in 5 research stages;

Research stages	**Description**
Stage 1: Definition of the problem and documentation	Carrying out literature review, looking into the context, setting the research problem, objectives and questions.
Stage 2 Functional Analysis	Selecting instruments and materials that would fulfill the research objectives.
Stage 3 Design and Validation of Research Materials and Instruments	Designing and Validating the followings; lesson plan, worksheets, observation sheet, evaluation sheet, questionnaires, focus groups questions.
Stage 4 Implementation	Carrying out the lessons and implementing changes per cycle.
Stage 5 Production of documentation and principles design	Studying the results and draw conclusions.

RESULTS

O1. When it comes to the design of an introductory lesson to Scratch the results of the research are outlined below;

1. A three-part Scratch introductory lesson was designed according to the National and European Curriculum, proposing the development of skills in STEAM Education, integrating Computational Thinking Practices as defined by Weintrop, (2016) and activities from Kotsopoulos' (2017) Pedagogical Framework.

2. The teaching materials and teaching strategies were being improved throughout the process of the three cycles. The instructions of Worksheet 1 were improved and a supplementary poster was designed to support children during the learning process. In the 3rd cycle of the research, collaboration was added to the existing teaching approaches (exploration, tinkering, project-based teaching and story-telling).

3. This study has shown that the children really liked Scratch interface and the Scratch introductory lesson, valued the learning outcomes and particularly enjoyed designing and creating project-based activities that are related to the creation of a story (3rd Part of the lesson). In this study, male participants seem to enjoy Scratch lessons more than female participants do.

O2. As far as pupils' performance the results are outlined below.

1. Pupils performed very well in the lesson designed and the great majority achieved the learning objectives of the lesson.

2. Pupils achieved their highest scores in the 1st Part of the lesson (using Scratch digital environment and basic programming blocks), which also seemed to them to be the easiest part of all.

3. Pupils encountered difficulties throughout lessons in the area of Weintrop's (2016) Computational Thinking Practices (using computational Models to understand a concept, understanding the relationships within a system, investigating a complex system as whole, trouble-shooting and debugging, Choosing Effective Computational Tools, Defining Systems and managing complexity), understanding instructions, making decisions and creating a coherent story.

4. Pupils' profile possibly influences performance in a Scratch course. Age seems to be a factor influencing performance, the older the pupils, the higher scores they get. Gender may also have an impact on performance; female primary school pupils achieved higher results in Scratch than male pupils. No correlations could be drawn in terms of academic performance. The results of the research cannot be generalized.

5. In this study, male participants found Scratch easier than female participants, however, they got lower scores than them. This could suggest that in this study male participants overestimate their abilities or that female participants underestimate theirs, or both.

6. No correlations have been drawn in terms of computer-tablet use habits and perceptions about computers and tablets and performance.

CONCLUSIONS

The use of Scratch programming language expands pupils' skills in the framework of STEAM Education and Computational Thinking.

The lesson designed was suitable for primary school as the pupils found it enjoyable and were able to meet the objectives of the lesson, without confronting considerable difficulties.

Pupils' profile, academic performance, computer use habits and perceptions should be further analyzed in future research to determine which factors influence performance in Scratch programming language. Age and gender seem to influence performance in this research but that should be further studied.

It is highly recommended to implement this research in other contexts. For example, to carry it out in a formal educational context, in a public school and with a larger sample for a longer period of time.

Researchers are also advised to increase the validity of the research by not being involved in the teaching of the lesson. Researchers would be advised to remain observers.

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