Scratch on Road Pedagogical Model: study of learning perception

Maria Emília Bigotte de Almeida
Coimbra Polytechnic - ISEC
Coimbra, Portugal
ebigotte@isec.pt

Ana Rita Assunção Teixeira
Coimbra Polytechnic - ESEC
IEETA, Aveiro University
Coimbra, Portugal
ateixeira@ua.pt

Ricardo Almeida
CASPAE
Coimbra, Portugal
ricardo.almeida@caspae.pt

***Abstract* — This paper presents Scratch on Road pedagogical model, that is been used in several 4th grade classes. This model foresees the participation of both the community and higher education institutions, with active roles in classes and consequently in students' projects – stories, animations or games.**

This pedagogical model has an investigation component aiming to comprehend students' perceptions relating their own learnings. The study, conducted in three classes, reveals that students don't have a clearly perception relating their learnings, with focus on specific Scratch contents.

Keywords—Scratch, Pedagogical Model, Learning, Perceptions.

I. INTRODUCTION

In recent years, the education system has found different ways to evolve, where technology has taken an important role. In technological developed countries it is usual to find computer programming as an integral part of the student curriculum. In fact, this focus on training different programming languages is also related to the emergence of new job opportunities.

Scratch programming software is used around the world today as a tool for teaching young students how to program. The literature already presents several studies using this and other software to compare and evaluate the benefits of activities that include computer programming in the academic development of young students.

Information and Communication Technologies (ICT) have potential at different levels for schools and therefore to improve the teaching-learning process [1]. ICT has also enabled new and different ways of learning, changing the teaching-learning paradigm, where the problem lies in creating pedagogical models that can follow this evolution [2].

We can say that in recent years, different software has been developed supporting different educational strategies, always with the purpose of substantially improving students' skills and promoting school success.

This evolutionary process has been a constant. From the first room-size computers that are only programmable by a few specialists to today's laptops, tablets and smartphones that can deliver software that even allows children to program the computer, a long way has been made not only technologically but also in terms of reflection on the pedagogical use of technology in formal, informal and non-formal education [3].

This same use of ICT is undoubtedly an asset in the teaching-learning process, accompanied by a change in the practices of all actors in the process, both teachers and students, as well as the institution itself. According to Dias [4], the use of digital technologies, both in terms of teaching and learning, does not necessarily mean a scenario of pedagogical innovation. On the contrary, the use of digital technologies, without conceptual change and the practices of actors, teachers and students, is largely one of the reasons for resisting the development of new scenarios for education, as it is not supported by the change in thinking and pedagogical practices.

The evolution of educational practices regarding the use of new software has received positive criticism from different researchers, leading to several articles and discussions. The role of technology in classrooms is to provide support so that students can also learn autonomously, solving problems and overcoming difficulties, with the teacher as the advisor [5]. The author states that the role of new technologies is crucial, making them a highly efficient means for students to discover and learn. In addition to tools such as the internet, there are also analysis tools, authoring tools, social tools, among many others.

This potential for seeking information adjacent to new technologies makes it essential to understand the contributions to enriching learning contexts, making it essential for students to learn to use ICTs and for teachers to make them available, contributing to educational development. Thus, an appropriate use of ICT is one that enables the broadening, enriching, differentiation, individualization and implementation of all curriculum objectives.

It is therefore important to organize the curriculum so as to promote a multiplicity of educational opportunities that respond to the needs of each context. The challenge is related with the curriculum integration, proposals that allow students to develop work based on challenges establishment. This is a process that, according to Machado, should not be limited to "a classroom, a teacher, or a school". Curriculum flexibility can thus be understood as the organisation of learning in an open manner, framed in a context.

Since the launch of Scratch, new initiatives have emerged around the world to teach programming to children and young people. In addition to extracurricular activities, teachers at all levels of education, both in elementary schools [6] secondary schools [7] and even universities, began introducing program content into classes. Activities to learn different subjects such as math, science, arts, music or languages are evidenced in the literature. In [8] is presented a

978-1-7281-3182-5/19/$31.00 ©2019 IEEE

study that aims to evaluate the skills of students at the level of mathematics using Scratch. The ways in which mathematical thinking arises when children work with Scratch have been studied. It was concluded that this software facilitated an authentic problem-solving process. The ways in which children's mathematical thinking emerged through this process were outlined, along with other suggestions, for using Scratch in classroom situations.

In addition to the analysis of mathematical skills and abstract concepts, other studies in the area of programming are described. Several studies use Scratch to incorporate problem-solving scenarios based on tasks that aim to study and optimize programming learning [9]. In the article [10] it is demonstrated that applications like Scratch are effective in educational environments. The aim of the study was to evaluate the use of a Visual Programming Language using Scratch in the Spanish classroom curriculum for 5th and 6th grade students. Due to the positive results obtained in this research, it was concluded that the implementation of a Visual Programming Language in 5th and 6th grade educational environments is fundamental through a mandatory transversal implementation. In [11] several articles that present Scratch as a tool capable of helping and motivating students in the acquisition of competences at various levels were analysed and compared. The article concludes that while studies described in the literature provide promising results regarding the use of programming as an educational resource, this review highlights the need for more classroom empirical research using larger student samples to provide clear conclusions about the types of learning that could be enhanced through programming.

In addition to the impact of Scratch on learning children and young people, studies have been conducted to understand the impact of Scratch on teaching by teachers. In [12], according to the results presented, there was a significant increase in the average self-efficacy perceptions of IT teachers regarding almost all complex programming tasks following their experience in Scratch programming.

II. SCRATCH ON ROAD PROJECT

In the 2015-2016 school year, the Portuguese Government's Directorate-General for Education launched to the 1st cycle Schools to implement the pilot project "Programming Initiation to 1st Cycle" which aimed at promoting and improving children's problem-solving skills. The implementation of the program was based on assumptions that would have to be assumed by the School Groups, regarding human resources (1 teacher who would guarantee the teaching of the programming language course in weekly sessions of 1h) and equipment (1 computer for every 2 students) that can be integrated into the teaching component or as a curriculum enrichment activity. In this context, an intervention project was developed in Coimbra, in schools that guaranteed the required implementation conditions, which aimed to stimulate young children computational thinking, while combating failure in mathematics and Portuguese, using the Scratch software.

This project (iProg) involved different entities, all of them contributing directly to its implementation and forming a vast multidisciplinary team. Given the success of the initiative despite the manifestly small number of students reached, due to the needs of execution, the Scratch on Road project emerged which allowed the scope to be extended to other schools and to provide other children with the same opportunities, regardless the schools location and material conditions of the school they attend.

In fact, within the scope of the social responsibility of Higher Education Institutions, the Polytechnic Institute of Engineering of Coimbra (ISEC), a partner of Iprog, has committed to the purchase of 24 laptops and established a collaboration protocol with the Social Support Centre of Parents and Friends of the School (CASPAE) for the implementation of the project, thus making it possible to bring the computer equipment to schools that did not meet the required material conditions. In the optimization of material resources, the project was implemented as a teaching component, with the supervision of the class teacher, and it is necessary to invite companies that were constituted as social investors and to sponsor each class, under the patronage law, regarding the payment of the technician responsible for the promotion of the Scratch programming sessions.

In January 2018, with the support and funding of local companies, CASPAE launched the Scratch on Road initiative with two mobile units, equipped with all the necessary technological material, which allowed the technician to travel to more schools and the consequent expansion of this activity to more students. This initiative focuses responses on the quality and innovation of the education and training system, the reduction and prevention of early school leaving and the establishment of equal conditions in access to education, for children in the 4th year of the 1st cycle of elementary schools in the municipality of Coimbra, which due to its size, distance from technological centres or lack of human and material resources, could not have included this activity in its educational programs.

In the school year 2017/2018 5 companies/institutions participated in the initiative, supporting 7 classes, in a total of 140 beneficiaries. In the 2018/2019 school year, 14 companies/institutions participated, sponsoring 18 classes and 328 beneficiaries. In this school year the area of operation was extended to 2 schools in the districts of Aveiro and Leiria.

The initiative is based on a tripartite responsibility process, in which companies participate, with the role of social investor, sponsoring classes within their social responsibility dimension; CASPAE as project promoter and responsible for its technical and pedagogical coordination; and ISEC as a Higher Education Institution that provides the equipment framing this project within the scope of a corporate social responsibility policy.

III. METHODOLOGY

The Scratch programming language enables the development of logical thinking through the ability to solve real-world problems in a creative, motivating way by creating stories, games or animations. It is a software used as a motivating factor for learning specific content, promoting the development of pedagogical strategies and the implementation of logical sequences for the resolution of problems associated with programming logic.

The pedagogical model advocated by the Scratch on Road project is divided into three distinct phases, which can be related to the academic periods. Activities are held regularly throughout the school year, with a weekly session lasting 60 minutes.

During the first phase, which corresponds in time to the first term, students have the opportunity to get familiar with the software and its main operating characteristics, while emphasizing both the expository and practical method. Students start by performing small activities, framed in 4th grade curriculum content, namely in mathematics and Portuguese, which allows them to acquire skills transversal to the software. In this phase, simpler content is approached, such as the notion of event and sequence.

The second phase, corresponding to the second term, is a phase of greater autonomy for students, where they put into practice most of the concepts learned, solving problems and creating simple projects. In this phase different contents are approached, focusing on the notion of cycle, condition, decision structures and variables. In addition, different challenges are posed for students that allow the development of personal and social skills related to the chosen themes within the action of the sponsor (social investor). The objective is to stimulate students to specific areas of interest according to their environment, developing skills not only in the area of programming, but also in areas such as environmental sustainability, citizenship, road prevention, health, financial education, among others.

The third and final phase corresponds to the third term, and is dedicated to the planning and development of the educational product in Scratch that reflects the lessons learned in the previous phases. Students have complete autonomy to imagine, plan and develop a complex project, following previously established guidelines, in groups of 2 or 3, which they must present at the end of the school year. Planning is an important phase, where the reasoning to be applied involves terms directly related to problem solving, namely abstraction and decomposition. According to previously developed support templates, the different groups establish the phases, goals and deadlines to be reached during the project they intend to build. In this third and last phase, the work team members present in the classroom act as advisors, intervening only when requested by the students, thus providing an autonomous learning based on trial and error.

The study we present aims to understand students' perceptions of their learning. Two research instruments were developed: a self-assessment and an assessment of the students involved. Both consist of 40 multiple choice questions that relate directly to each other. By relating the IA self-assessment instrument and the IP assessment instrument, we can directly match each of the IA questions to the IP by obtaining the following protocol IA1-IP1, IA2-IP2, IA3-IP3, and so on.

IA is a self-assessment tool that aims to understand students' perceptions of their learning from Scratch. Students should answer the questions posed with "Yes" (if their perception of learning certain content is positive) or "No" (if this perception is negative).

The IP is a traditional assessment tool, using multiple choice questions, where we evaluate students' real knowledge.

IA was applied before the beginning of the third phase of the Scratch on Road pedagogical model and IP at the end of the school year. Since at the entrance to the third phase students' knowledge is consolidated in relation to the questions presented, during the development of the final project (third phase of the pedagogical model) the proposed research will not risk bias.

The sample consists of three classes of students of the 4th grade of the first cycle of primary education, A, B and C, where the number of individuals in each class is: A=14, B=14 and C=17 (n=45). The next section presents the experiment results.

IV. RESULTS ANALYSIS

The data collected aims to compare the variability of the mean values for the three classes, A, B, C in two different evaluation moments. For IA (at the beginning of the third phase of the pedagogical model) and for IP (at the end of the school year). To compare the variability between the three classes, the arithmetic mean of the 40 answers given by the individuals was performed. Fig. 1 shows the variability of the mean responses for the three classes A, B and C in IA and Fig. 2 shows the variability of the average responses for the three classes A, B and C in the IP.

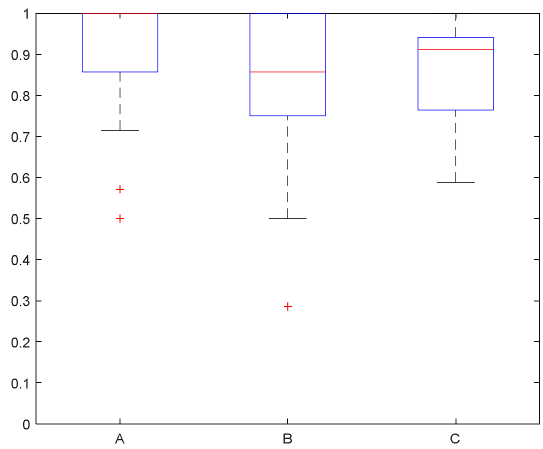

Fig. 2 – Initial average response per school and its variability

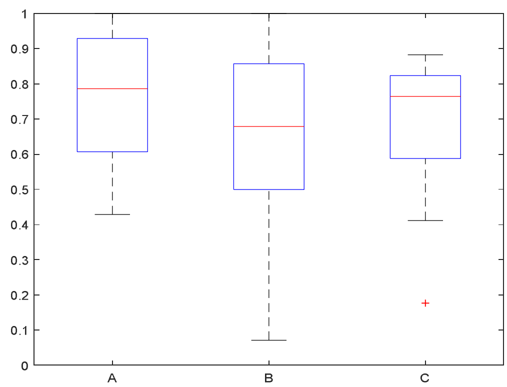

Fig. 1 – Average responses variability for the three classes A, B and C.

From the analysis of Fig.1 we can conclude that the class B presents greater variability in the values of the answers given in the IA and that the class A presents smaller variability and higher values. A 95% confidence t-test with t-test revealed that groups A and B are statistically different on average for IA, with the null hypothesis rejected (h=1) with an associated probability of p=0,0372. The analysis of Fig.2 shows that there is greater variability in class B for the IP. However, the average values for the three classes are not statistically different. Comparing the mean values between the two moments IA and IP for all questions, it was found that they are statistically different from each other for the three classes.

For a better understanding of the answers given in IA and IP, a study per question was presented (1-40). The analysis of the variability of responses per individual between each pair of questions of the two instruments (according to the presented model IA1-IP1, IA2-IP2, etc.) is presented in Fig. 3-5, class A, class B and class C respectively.

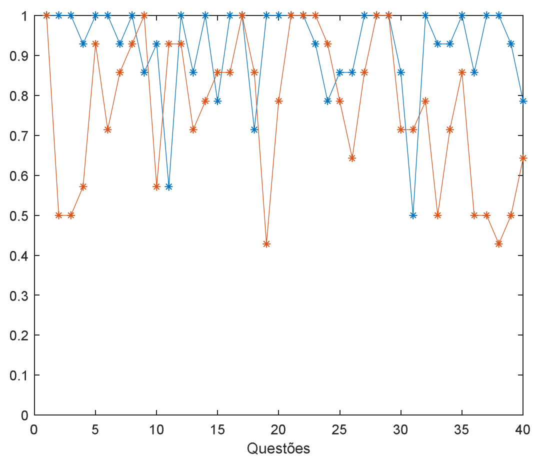

Fig. 3 – Average of the answer values given by class A considering IA questions (*-) and IP questions (*-)

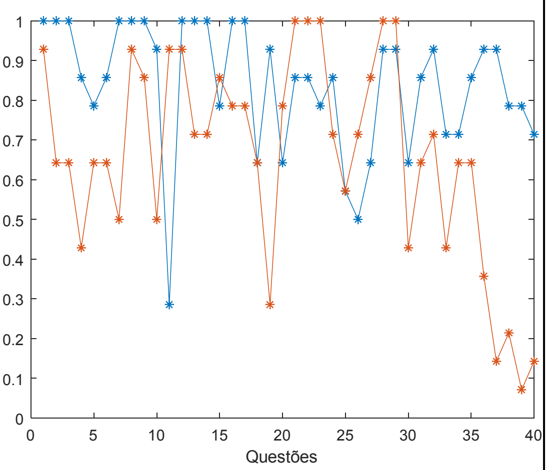

Fig. 4 - Average of the answer values given by class B considering IA questions (*-) and IP questions (*-)

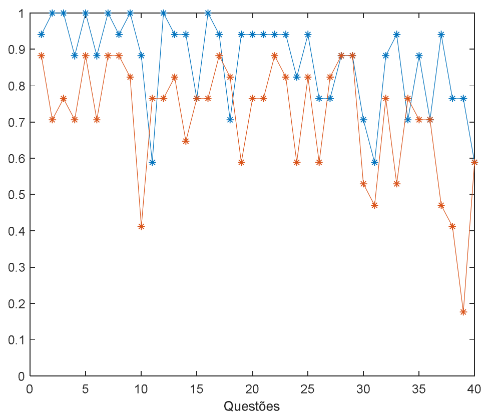

Fig. 5 – Average of the answer values given by class C considering IA questions (*-) and IP questions (*-)

In the mentioned figures, the blue line represents the average values of each question per individual relative to the questions they think they know (instrument IA), and the red line represents the average values of each question per individual relative to the moment of assessment, IP.

From the analysis of the graphs we can conclude that there are questions common to all classes where there is a large discrepancy between the two instruments and there are others where the difference is residual.

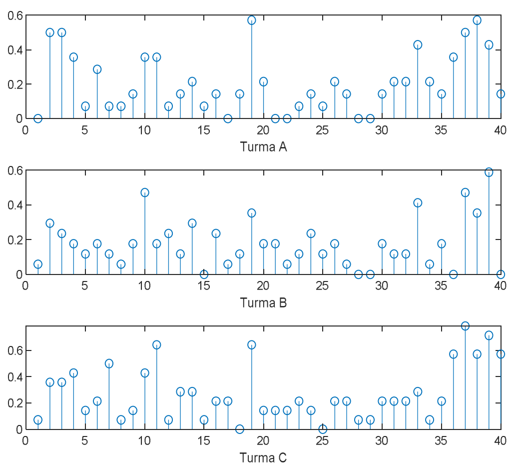

Fig. 6 - Difference of the mean values of the answers given by classes A, B and C considering the IA questions and the IP questions.

For a better interpretation of the differences between the answers given, the absolute difference of the mean values of the answers of the classes A, B and C, Fig. 3, 4 and 5 respectively was calculated considering the IA questions and the IP questions, Fig. 6. From the analysis of the figure we can highlight the questions 9, 19 and 38 as questions with the greatest difference between the answers given in the two distinct phases, IA and IP. These questions correspond respectively to:

- I know how to add a scenario?
- I know how to reduce an actor?
- I know what a variable is?

However, there are a considerable number of issues where the difference between IA and IP is less than 0,2.

Regarding the consistency of each class, class C is the most consistent with a correlation between the question averages of 0,378.

V. CONCLUSIONS

Scratch on Road is a digital inclusion project with a strong research component. We intend throughout the project to develop materials and instruments that allow us to evaluate and test the implementation of its pedagogical model in different aspects. One of its research components relates to the perception of learning by project participants.

From the presented study we can conclude that effectively the students do not have a significant perception of their learning, compared to the assessment performed. The assessment has negative results compared to what students perceive as acquired knowledge. In other words, from the results obtained, the vast majority of students seem to have great knowledge in Scratch programming, when in fact they do not have.

Questions 9, 19 and 38 stand out because they are those where the results differ the most, that is, where students may have greater difficulties compared to their own perceptions. In these questions most students think they know the contents, and when they are tested, they respond incorrectly.

The negative evaluation results, in IP instrument, could probably be due to the typology of the traditional instrument, distinct from the digital and technological use that participants make of the software.

Regarding the experience, the contents presented as common to all classes, where the correlation is lower, are related to the choice of objects (actors, scenarios), the design (reduction and increase of actors) and the identification and construction of variables.

Effectively identifying and constructing variables is content of moderate complexity for the participants' age, involving complex logical reasoning for their effective use.

In short, the results will allow us to change the Scratch on Road pedagogical model, focusing on the average class results.

VI. REFERENCES

[1] L. Calao, Moreno-Leon, H. Correa, & G. Robles. Developing Mathematial Thinking with Scratch: an experiement with 6th grade students. Lecture Notes in Computer Science, 17–27, 2015.

[2] C. Morais, L. Miranda, P. Alves, & D. Melaré. Modelos Pedagógicos e Utilização das TIC no ensino superior. In Colóquio Luso-Brasileiro de Educação à Distância e E-learning (pp. 1-17). Lisboa: Universidade Aberta, 2013.

[3] M. Area & T. Pessoa. De lo sólido a lo líquido: Las nuevas alfabetizaciones ante los câmbios culturales de la Web 2.0. Comunicar, XIX, 38, 13-20, 2012.

[4] P. Dias. Comunidades de educação e inovação na sociedade digital. *Educação, Formação e Tecnologias,* 5(2), 4-10, 2012.

[5] J. Ponte. As TIC no início da escolaridade: Perspetivas para a formação inicial de professores. In João Ponte (org.). A formação para a integração das TIC na educação préescolar e no 1º ciclo do ensino básico (Cadernos de Formação de Professores, nº 4, pp. 19-26). Porto: Porto Editora, 2002.

[6] A. Wilson, T. Hainey, and T. Connolly, "Evaluation of Computer Games Developed by Primary School Children to Gauge Understanding of Programming Concepts."

[7] O. Meerbaum-Salant, M. Armoni, and M. (Moti) Ben-Ari, "Learning computer science concepts with scratch," in *Proceedings of the Sixth international workshop on Computing education research - ICER '10*, 2010, p. 69

[8] T. Ferrer-Mico, M. À. Prats-Fernàndez, and A. Redo-Sanchez, "Impact of Scratch Programming on Students' Understanding of Their Own Learning Process," *Procedia - Soc. Behav. Sci.*, vol. 46, pp. 1219–1223, Jan. 2012.

[9] H. Y. Wang, I. Huang, and G. J. Hwang, "Effects of an Integrated Scratch and Project-Based Learning Approach on the Learning Achievements of Gifted Students in Computer Courses," in *2014 IIAI 3rd International Conference on Advanced Applied Informatics*, 2014, pp. 382–387.

[10] J.-M. Sáez-López, M. Román-González, and E. Vázquez-Cano, "Visual programming languages integrated across the curriculum in elementary school: A two year case study using 'Scratch' in five schools," *Comput. Educ.*, vol. 97, pp. 129–141, Jun. 2016.

[11] J. Moreno-Leon and G. Robles, "Code to learn with Scratch? A systematic literature review," in *2016 IEEE Global Engineering Education Conference (EDUCON)*, 2016, pp. 150–156

[12] E. Yukselturk & S. Altiok. An investigation of the effects of programming with Scratch on the preservice IT teachers' self-efficacy perceptions and attitudes towards computer programming. *British Journal of Educational Technology*, *48*(3), 789–801, 2017.