Work in Progress: Improving Learning Performance using Programming Methodology

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***Abstract*— The program "Introduction to programming in the first cycle of basic education" initiated in 2015 has provided the opportunity to develop computational thinking and digital literacy among students. The existing literature suggests that Scratch programming language may have a strong influence on the skills acquired by students in classroom. In this context, it is intended to build an intervention with objectives that fit into the Student Profile leaving compulsory education and developed within the scope of curricular flexibility, recommended for the 1st year of basic education. The applied methodology aims to evaluate the impact on students' knowledge (mathematics and mother tongue), attitudes (in relation to knowledge and citizenship) and on the capacities (cognitive, emotional and practical) as well as in the school community (students, teachers and families).**

Keywords*— *Student Profile, Curricular flexibility, Scratch, Education.

I. INTRODUCTION

In a society that is increasingly dependent on new technologies, it is impossible not to recognize the importance and presence of computers, mobile devices and other forms of technology in the daily lives of our students. In the classroom, programming software has been used as a way to develop fundamental skills for the 21st century, namely computational thinking. Literature presents numerous examples of the use of programming software, dedicated to skills development in children.

Scratch is a basic programming software developed by Lifelong Kindergarten Group at the Massachusetts Institute of Technology (MIT) Media Laboratory, which allows the creation of animated projects such as games or stories. This software complements and enriches the creativity of children by teaching them how to work collaboratively. It is a simple and intuitive programming language, and its used usually by children, young people or adults, who wants to start in the world of computer programming, helping them to gain interest for programming languages and developing skills that are transversal to their education.

Since the launch of Scratch in 2007, new initiatives have been implemented around the world to teach children and youth how to program. In addition to extracurricular activities [1] and summer camps [2], teachers at all levels of education, both in primary schools [3], secondary schools [4] and even universities [5], began to introduce programming in classrooms.

Literature also highlights activities built to learn different disciplines, such as mathematics, science, arts, music or languages. In [6] is presented a study aiming to evaluate students' competences in mathematics using Scratch. Scratch is referred to in [7] for the use of geometric and measurement concepts, facilitating creative problem solving and logical reasoning. In this article, Scratch is described has a tool with the potential to be used to design games and develop mathematical concepts. We also studied the ways in which mathematical thinking emerged when children worked with Scratch in classroom situations, and it was concluded that also facilitated the problem-solving process.

In addition to competence analysis at mathematics and abstract concepts level, literature also describes other studies in the area of programming. Several studies use Scratch to incorporate problem-solving scenarios based on tasks that aim to study and optimize programming learning [7]. It also demonstrates' that applications such as Scratch are effective in educational environments [8]. This study purpose was to evaluate the use of Visual Programming Languages, using Scratch in classroom practice in Spain, 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 educational environments is fundamental through a mandatory curricular implementation.

In [9] they describe the use and application of Scratch software in skills development related to problem solving and in [10] were analysed and compared several articles that present Scratch as a tool capable of helping and motivating students acquiring skills at various levels. The article concludes that although these studies describes promising results in relation to the use of programming as an educational resource, this review highlights the need to conduct more empirical research in the classroom, using larger samples of students to obtain clear conclusions about the types of learning that could be improved through programming.

A. Programming in Basic Education

Through "Introduction to programming in the first cycle of basic education" program launched by the Ministry of Education in 2015 in our country (omitted for review), the importance of Information and Communication Technologies (ICT) at that level of education was evidenced, presenting these as tools to support the developed work by teachers in an educational context as responsible for the introduction of ICT-based innovation as pedagogical and didactic tools.

Following these new approaches, our institution (omitted for review) has promoted since 2015 the IProg project in basic education schools complementing the educational offer. The developed work allowed us to demonstrate that

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Scratch programming language was evidenced as a platform that facilitates student learning. From the obtained data and the observations made during the activities it was possible to verify that when students are in a motivational environment and in which the users themselves (children) are the producers, the learning arises naturally and objectively [11] .

The purpose of this intervention is related with a learning improvement, particularly in mathematics and mother tongue development. It is intended to promote digital literacy, satisfaction with the above-mentioned learning and the integration of these knowledge in a critical and reflexive reading of the environment and community that surrounds them.

The adopted methodology is based on the design and projects development, the pedagogical itinerary that best fits the achievement of the defined objectives, supported by the construction of games, stories and animations in Scratch, all of them different, allowing a great diversity of works. The projects are carried out by students and for students, developing several skills, not only programming, but also directly related to their curricular areas, while they program, play and use their projects and share them with their colleagues.

Strategies were also created to make it possible to change the activities plans, with the concern of always being able to respond to the expectations and needs of the students and to promote their school success.

II. Scratch and Curricular Flexibility

Failure in school learning, especially in the area of mathematics, is common for basic education students. This is a concern that has been emerging over the years [12]. According to the literature, different solutions have been proposed, but the situation remains practically unchanged [13], [14]. From our point of view, this is a problem that must be tackled early even in the first year of primary education.

The most recent changes to the educational system of our country foresee the assumption of principles, values and areas of competence for the Students Profile Out of Compulsory Schooling (SP) [15] which implies changes in pedagogical and didactic practices in order to adapt the educational action globality to the purposes of the proficiency students profile.

The document refers that "It is about finding the best form and the most effective resources for all students to learn, that is, for effective ownership of the knowledge, skills and attitudes that have been worked out, together and individually, and which allow the development of the competences foreseen in the SP throughout compulsory schooling."

The autonomy and curricular flexibility project (Office no. 5908/2017 of July 5, 2017) "defines the principles and rules guiding the conception, operationalization and evaluation of the curriculum of primary and secondary education, in order to reach the Students Profile out of compulsory schooling." In this way, is given to the school the possibility to manage the curriculum and, consequently, to organize the basic curricular matrices, based on the assumption of reaching the competences associated to the student profile that are associated with the knowledge, abilities and attitudes.

To this end, through a set of interdisciplinary instruments that make possible a pedagogical differentiation, the school has the opportunity to organize school times and schedule in order to develop students' skills and attitudes and to deepen this acquired knowledge.

In basic education degrees, learning must be active, meaningful, diversified, inclusive and socialising. At this level of education, "the curriculum is regulated by an integration code, mainly because there is only one teacher and there is no predetermined time and space for each subject area" [15]. In addition, the principle of curricular flexibility, which, through the implementation of an effective exercise of curricular autonomy, enables schools to identify curricular options, allows the valuation of experiential learning, through the integration of different areas of knowledge and regional and local components (Office No. 5907/2017 of July 05, 2017). As mentioned by Palmeirão and Alves [15], it is now important to organize the curriculum in order to promote a multiplicity of educational opportunities that respond the needs of each context. The challenge is the curricular integration, through proposals that allow students to develop research work, guided by the establishment of challenges [16]. This is a process which, according to Machado, should not be circumscribed "to a room, to a teacher, or to a school". Curriculum flexibilization can thus be understood as the organization of learning in an open way, framed in a context.

Associating the influence of Scratch programming language, evidenced in the literature, in the development of children competences, we can consider that, at SP level, we can group them (competences) into three levels. Thus, we will consider the specific competences associated to the use of the tool and the desired results; the general ones that are related to the effective use of codes that allow to express, represent, select and disseminate knowledge; and finally, the transversals that refers to the decision-making, interaction with others and their integration into society:

1. Specifics: S1-Critical thinking and creative thinking/ S2-Scientific, technical and technological knowledge/ S3-Aesthetic and artistic sensitivity;
2. General: G1-Languages and Texts / G2-Information and communication;
3. Transversals: T1-Reasoning and problem-solving / T2-Interpersonal relationship / T3-Development and autonomy

For the project that has been developed over the years with 1st cycle schools – IProg – and within curriculum flexibility framework were defined the following integrated competences in the SP:

- To generate and apply new ideas in specific contexts (S1);
- To conceptualize, test and decide on the application scenarios of your ideas (S1);
- To relate technical, scientific and sociocultural knowledge (S2);
- To mobilize techniques and resources that make it possible to perceive the aesthetic value of their

creations from artistic and technological intentions (S3);

- To use proficiently different languages and symbols (G1);
- To transform the available information into knowledge leading to the realization and dissemination of the product (G2);
- To develop processes leading to the construction of products and knowledge, using diversified resources (T1);
- To work in a team and use different means to communicate in person and in a network (T2);
- To suit behaviours in contexts of cooperation, sharing, collaboration and competition (T2);
- To establish relations between knowledge, emotions and behaviours (T3);

In this context, given the potential of Scratch software and based on the work already done, we started a more targeted monitoring of the IProg intervention, which allows us to infer which skills does students acquire at the end of the basic education.

III. Methodology

A. Study Description

This monitoring intends, over four years, to understand the benefits of using Scratch software in the classroom as an educational complement in the development of skills considered essential in SP and the impact of its role in the community (teachers and families) aiming to replicate the practice to other schools.

Within the scope of curricular flexibility, throughout the school year, once a week, lasting from 60 to 90 minutes, students from three classes will have the opportunity to use computers and Scratch software to develop different activities. These activities are planned in strict relation with the curricular contents covered throughout the school year. Students are expected to be able to work on the same content in a playful and motivating way, achieving better results, especially in what concerns the competence development contemplated in the SP.

The project is based on four fundamental pillars: the intervention, the mechanisms, the parameters and the objectives.

B. Sample

The sample for this project is made up of three distinct audiences: students, teachers and students' families. During four years, the project intends to accompany three classes from the first degree of basic education. The sample is composed by 55 individuals, aged between 5 and 6 years, mostly living in socially disadvantaged areas. Together with the three class teachers, they will be the direct beneficiaries of the project. The families, mainly in social risk situations, compose the indirect beneficiaries' group.

C. Instruments

Figure 1 shows the methodological performance of the project that relates to each other: Objectives, Intervention, Mechanisms and Parameters.

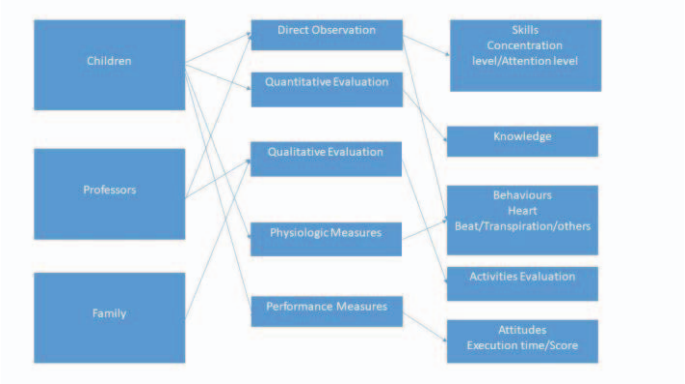

Figure 1 – Methodology

1) Objectives

The defined objectives are related to the competencies of the SP, framing the curricular flexibility in the project that has been developed over the years with schools – IProg.

- To use languages to build knowledge and share meanings in different areas;
- To encourage creativity and collaborative work by designing scenarios to apply your ideas;
- To design learning environments that promote interest in science, mathematics and technology through a creative, experimental and exploratory approach;
- To enable free exploitation by fostering an environment of peer cooperation;
- To enjoy programming as a rich resource offering, problems and themes for an integrated understanding of knowledge;
- To foster digital and technological knowledge;
- To develop computational thinking and digital fluency;
- To evaluate and validate available information for products preparation and presentation;
- To test model's consistency, analysing different references and constraints;

2) Intervention

The intervention is carried out at children, teachers and family levels. This intervention is directly related to the mechanisms, where children are present in all of them, teachers are related to direct observation and qualitative evaluation and the family only with qualitative evaluation.

3) Mecanisms

Direct observation aims to collect information on behavioural problems level and working capacities in carrying out the activities. The quantitative evaluation will be used to collect information on the evaluation of students' knowledge (data collection that will allow the comparison

between traditional paper activities and Scratch programming). In addition, they will allow the characterization of the sample, in particular as regards computational literacy (games), behavioural problems, special needs, among other essential characteristics in the project framework.

The qualitative evaluation will be carried out through semi-structured interviews, individual and shared reflections aiming to characterize the problem more accurately and effectively.

Regarding the physiological measures, we highlight the collection of non-invasive measures during the protocolized scenarios accomplishment for the data collection related with behaviours.

Finally, the performance measures associated to each of the scenarios through Scratch will be a fundamental measure to interpret attitudes at the level of the interaction dynamics with the programming language over time. Automatic data collection software will be used to monitor the interaction.

4) Parameters

It will be considered as parameters the competences, foreseen in the SP and in the objectives (capacities, knowledge and attitudes), and evaluation of the practices with regard to the perception of the intervention impact.

Regarding the physiological measures we highlight:

a) Heart Beat level [17]

b) The level of attention and concentration based on EEG signal analysis [18]

c) Cortisol level [19]

In the performance measures associated to each of the scenarios through Scratch, we can highlight:

1. Number of mouse clicks
2. Execution time for each task
3. Activity score
4. Mouse movement on the screen.

The correlation of all mode of action parameters will be used to perceive and interpret the evolution of the children throughout the project.

Methodologies, tools and own devices (sensors) properly tested and validated in the literature will be used.

IV. Discussion and Conclusions

The objective of the proposed work is to construct an intervention within the Student Profile leaving compulsory education and developed within the scope of curricular flexibility recommended for the 1st year of basic education. The adopted methodology is a symbiosis of several techniques and methods described in the literature that intends to frame and motivate the student in an individual way, suppressing adaptation school problems, concepts acquisition problems and community insertion problems.

The methodology aims to evaluate the impact on knowledge (mathematics and mother tongue), attitudes (in relation to knowledge and citizenship) and the capacities (cognitive, emotional and practical) as well as in the school community (students, teachers and families). The existing literature suggests that Scratch programming language may have a strong influence on students acquired skills in the classroom. Thus, Scratch will be used in a protocol manner considering several scenarios and measuring various physiological measures. The main objective will be to find measures to characterize students' profiles in order to dynamize the class and provide a real framework. In addition, it is intended to demonstrate the usefulness of inserting an activity such as Scratch programming as being useful, effective, necessary, and sufficient, providing a substantial increase in school success.

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