Learning to think like a trainer: bringing Scratch for Educational Sciences professional's formation

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***Abstract*—This Research to Practice Full Paper presents a study proposal with the intent of knowing Scratch potential in Educational Sciences students' training. In this study, we analyse, through different phases, using Kirkpatrick Evaluation Model (KEM), the benefits of Scratch inclusion in Educational Sciences degree and in its students' future professional activities. In this work an action-investigation methodology is used. This investigation will allow to improve the education curriculum at different levels, in a technological way, with impact on the teaching and learning process, involving students and teachers of all levels. In higher education this software has been especially associated with programming and computing disciplines as a tool for motivating students or as a learning facilitator. This work presents not only an innovative approach of the Scratch utilization, the improvement of learning skills and competences of design regarding the production of educational materials, but also its use in a new area - the idea of a programmer-educator concept. This paper also presents a pre-study regarding the necessary skills to the use of Scratch and its use among first level students focusing in their satisfaction and motivation for this software use.**

Keywords—Scratch, Educational Sciences, ICT, Programmer Educator; Computational Thinking.

I. Introduction

Scratch, developed by the Lifelong Kindergarten Group at the Massachusetts Institute of Technology (MIT) Media Laboratory, is a software/programming environment that allows the creation of animated projects such as stories and games [1]. In elementary and secondary education there are already enough experiments and studies with the use of this programming environment [2-5] evidencing the importance of this software as a tool to support the most diverse learning. Although there is indication of the importance of using Scratch in the development of skills in children [6][7], it is also important to understand the impact of the use of this tool on future professionals in education, university students in initial training, who will work with children and young people.

In higher education this software has been mainly associated to curricular units of programming and computation, as a tool for motivation [8] or learning facilitator [9][10][11], especially with regard to the development of computational thinking.

For future educators, digital competences are nowadays fundamental competences, especially with regard to their position in society. As professionals, educators are role models, and it is therefore important that they be equipped with skills that enable them to participate actively in a digital society [12].

Studies show that the vast majority of professionals that work with Scratch in an educational context are not only primary school teachers [13][14], but also technicians specialized in different areas of education, including special education [15][16] needing training in the use of these tools.

In this project it is intended that the students of the degree in Educational Sciences of the University of Coimbra be able to plan actions using Scratch software as an educational resource, playing the role of programmer educator. Additionally, it is expected to verify transferences of this learning in the development of innovative educational actions made possible through the skills acquired by Scratch.

The programmer educator will not only be able to handle Scratch effectively but will also be able to create more enriching pedagogical materials more easily, through his/her own training and skills acquired through learning with this tool.

These competences are directly related to the competences promoted by Computational Thinking also related to the essential skills most valued for a citizen of the 21st century [17]. The literature does not reveal a consensus on exactly what these competences are, pointing different authors to different designations, stages and differentiated concepts, often referring to the same practical aspects [18]. However, there is greater agreement regarding the skills inherent in Problem Solving (Decomposition, Pattern Recognition, Abstraction, Realization of Algorithm) that are essential to the programming process, underlying the use of Scratch to produce relevant materials.

Taking into account the study that is intended to develop, the methodology of action-research is predicted as the most appropriate. According to reference [19], "different strategies that can be characterized as action research have proved effective in solving various problems in education, especially those related to teacher training". Thus, as future trainers of teachers and technicians specialized in special education, it is crucial the training of professionals in the pedagogical use of this tool. Also understanding the dimensions of this training

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and its implications in the practices and development of these futures professionals is needed.

II. Computational Thinking

Computational Thinking is a term that has received attention from the scientific community in recent years, largely due to the lack of agreement regarding its definition and the strategies that involve the development of this type of thinking [20]. It is a fundamental competence of the 21st century, such as writing or reading. It refers to a series of capacities and skills that can be stimulated, facilitating the teaching-learning process in several areas, such as mathematics [21]. Studies [22][23] show that the Scratch programming tool is a stimulator of this kind of thinking, helping students to develop computational thinking.

The proposed project does not refer to the possible benefits of using Scratch and Scratch materials/projects in children and youngsters. Its intention is to train and initiate the professional practice of the graduate in Educational Sciences in the skills promoted by the Scratch tool which are directly related with the competences promoted by Computational Thinking. These are considered the most valued essential competences for a citizen of the 21st century. For example, for Wing [24], one of the most proficient scholars in the subject, these are related to problem solving, recursive thinking, sequential and parallel thinking, abstraction, automation, decomposition, modelling, simulation, creative thinking, communication with clarity, analysis and effective collaboration. However, there is greater agreement regarding the skills inherent to Problem Solving such as Decomposition (Separation of data, processes or problems into smaller parts), Pattern Recognition (Observation of patterns, trends and regularities in data, processes or solutions), Abstraction (Identification of the general principles that generate the identified standards) and Algorithm Realization (Development step-by-step problem-solving instructions). These are also essential skills to the act of programming for the generation of digital products such as animation or games. The use of Scratch to produce educational materials with some quality and complexity, necessarily implies the mastery of these phases. Being able to think and act according to these phases will characterize how we perceive the specificity of a programmer educator. In this way, in spite of what is intended to be the evaluation of the knowledge and learning of the graduate in Educational Sciences in these crucial competences, acting and directing their practices based on them, can also promote these competences in their students. One of the major topics of discussion around Computational Thinking today is "How to train and prepare a generation of teachers and trainers, without background in this type of thinking, and thus prepare their students to develop and acquire them".

The benefits inherent to the ability of programming for those who do not have knowledge in this area refer directly to the skills promoted and mentioned before. The benefits are now recognized at a governmental level through the support given to the following projects of the Portuguese Ministry of Education to promote this type of skills: "Initiation to Programming in the 1st Cycle of Basic Education", started in the academic year 2015-2016; "Probotic", started in 2017-2018.

III. Programmer Educator

In the scope of this project a pre-study was already carried out with the objective of understanding the satisfaction and the involvement of the students of the degree in Educational Sciences, regarding the most relevant aspects of the use of this tool.

The presentation of the Scratch software to these students was structured in accordance with the objectives of the curricular unit, namely the development of competences related to computational thinking and the concept of “programmer educator”.

The concept of “programmer educator” intends to differentiate a professional of the 21st century, equipped with technological competences, distinct from the traditional educator. Its focus is directed to the development of materials, using programming languages. According to references [25][26] the main characteristics of an educator are related to “Being Prepared”, “Being Positive”, “Maintaining High Expectations”, “Being Creative”, “Being Fair”, “Maintain a Sense of Humour”, “Demonstrate Compassion”, or “Admit mistakes”. The concept we propose adds to the above characteristics the Digital and Technological Autonomy. This autonomy is related to the underlying characteristics of Computational Thinking, the development of digital pedagogical materials and support to students, both related with the technological component. This technological component is not possible without the competences of Computational Thinking.

According to the European Digital Competence Framework for Citizens (DipCom), in the area of Digital Content Creation competences, programming emerges as one of the four core competences [27]. In the same document, the levels of proficiency are distinguished mainly by the autonomy with which the subjects deal with certain situations and the competences necessary to solve different problems.

The effective use of technology by educators is becoming more and more a reality in schools and institutions of developed countries, and it is in this sense that educational policies continue to be developed [28].

Basic programming languages, such as Scratch, are also increasingly focusing on the training of teachers and educators, who seek to develop skills and principles in the area of Computational Thinking, the exploration of basic programming tools and their application in classroom context.

In this way, the concept of Programmer Educator that we present is based on the idea that training in basic programming languages, such as Scratch, for future professionals in different areas of education is fundamental in the 21st century. This promotes digital and technological autonomy and its access for all educators, especially during the academic training in higher education.

IV. GENERAL FRAMEWORK

The project we present intends to identify the potential of Scratch in the training of graduates in Educational Sciences. The study, an action research, divided into different phases, to develop over 36 months, provides different moments, to be developed with two groups of different students. The work program differs according to the specific characteristics, the objectives of the training program and the contexts of each of the groups (namely the academic year in which they are).

Phase 1 ("Diagnosis and Training") provides, in the first year of the project and in a first moment, a diagnosis of Information and Communications Technology (ICT) skills to all students involved in the study, through a questionnaire survey (an instrument developed in partnership with a foreign university and already in the validation phase). In the second stage, for 1st year students (Group 1), a first training/workshop Scratch (O.F.1 - "Initiation to Programming"), in the 1st semester. For the 2nd year students (Group 2), a Scratch workshop/training (O.F. 2 - "Educational Material Development") will be held where students will have the opportunity to develop Scratch skills already acquired in a workshop held the previous year.

Therefore "Phase 1" is divided in two moments: Moment 1A (where the evaluation of the ICT skills of the students involved is done) and Moment 1B (including a Scratch Workshop (about 3 hours each O.F.) with students involved in the study). In "Phase 1" the expected outputs are the production of reflection articles related to the work developed as well as the production of an e-book based on the students work developed during this phase.

Phase 2 ("Training and Follow-Up") foresees, in the second year of the project, the continuation of the training/workshop for students in Group 1 (O.F. 2 - "Development of educational materials") and the beginning of the follow-up for Group 2, based on the Kirkpatrick Evaluation Model (KEM). This model advocates four levels of evaluation organized sequentially in a cause-and-effect relationship, where all can relate to the phases of the project to which we propose. Level I (Reaction) relates to what participants think and feel about training (Scratch workshops); level II (Learning) is related to the knowledge and learning that the participants acquire thanks to the training; Level III (Behaviour) refers to the knowledge and competences effectively retained and applied in the exercise of their functions from initiation to professional practice - follow up; Finally, Level IV (Results) relates to improvements in performance of the activity, resulting from the regular use of foreground and skills [29].

Therefore, "Phase 2" is divided in three moments: Moment 2A (where the follow-up of Group 2 in the Observation and Intervention Units of the 1st and 2nd semester is done), Moment 2B (including a Scratch Workshop: O.F.2 - "Development of educational materials", for Group 1, in the second semester) and Moment 2C (where the satisfaction, benefits, learning and difficulties of the students involved are analysed and evaluated).

Phase 3 ("Follow-Up") predicts, in the 3rd year of the project, the follow-up of Group 1 that happens during the observation units of the 1st and 2nd semesters (Moment 3A), as it happened in the previous year for Group 2. In order to carry out the evaluation of the follow-up moments, it is expected to observe the participants behaviours and elaborate performance analyses, as well as the use of monitoring and evaluation techniques.

During the follow-up phase, these are the learning experiences expected to be observed and the consequent behaviours: ability to plan, perform and evaluate activities with different audiences using Scratch software, develop and create digital educational materials that meet the needs of children and young people, and apply the knowledge acquired during the training and already described above.

Using techniques of data collection, direct observation, observation grids and listening to the participants in the process, it is expected to understand the benefits of forming the previous phases. As a result of "Phase 1" the production of a Case-Book using narrative and experiences of students in Educational Sciences is an expected output.

V. THE PILOT STUDY

A pre-study was carried out in the first semester of the 2017-2018 academic year, to study the importance and benefits of the involvement of programming languages, such as Scratch, in higher education and training in pedagogy for young students. The pilot study was conducted in the curricular unit of Educational Technology in degrees directly related to education in higher education, namely the degree in Educational Sciences.

A. *Goals and Objectives*

This study contributes to a bigger one that intends, in general terms, to study the importance, benefits and satisfaction of students regarding the use of programming languages, such as Scratch. Therefore, to know the potential of Scratch in the training of graduates in Educational Sciences. However, this particular experiment is intended to understand the satisfaction of a group of students regarding the use of Scratch software for the planning and development of educational activities and for the development of digital educational resources.

B. *Sample*

The course was taught to students of the Educational Technology course of the degree in Educational Sciences of the University of Coimbra. The sample was composed by 65 students of the 1st year of the degree in Educational Sciences. Table 1 represents the number of students involved in the study according to gender.

TABLE I.

Number of students by gender		**Total**
Gender	Male	7
	Fem.	58
		65

C. Development

The Scratch programming language course had a total duration of 18 hours, divided into different phases.

1. Phase 1 – Contents Assimilation

During this phase, of 6 hours, key content related to the Scratch software, the development of educational materials and the objectives of the work to be done were taught. These contents are fundamental concepts like the concept of Events, Sequences, Selections or Loops.

The objectives for this phase are related with software learning, how it should be used, its potentialities, what students can and cannot develop and how they can do it.

2. Phase 2 – Development of Digital and Technological Autonomy

During this phase the main objective is related to the students increased autonomy in performing tasks, overcoming obstacles, identifying and solving problems and developing programming skills, while planning and developing a project in Scratch. Phase 2 has no defined duration. The work was done in a free regime without control of the variables, namely the time spent for the development of their work.

3. Phase 3 – Face-to-Face Support

The third and last phase, with a total duration of 12 hours, had the objective of supporting students in an oriented way to solve problems that they managed to identify, but for them with no apparent solution.

D. Instruments

To carry out the evaluation of the pre-study, a questionnaire evaluation instrument was elaborated with four questions based on the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. The instrument was applied only once, at the end of the Scratch course, in order to understand the participants satisfaction and involvement in the activities performed. Students were asked to comment and give their opinions on the following:

1. Refer to the positive aspects of this course: (Ex: Did you have a positive attitude, for example, were you attentive, motivated, when asked for help, completed all exercises proposed for training);
2. Describe negative aspects of this course: (Ex: Did you have negative attitudes, for example, were you distracted, unmotivated or did not finish any proposed exercise formation).
3. Refer Efforts (outside the course) for the training to be successful: (Ex: Did you frequently attend the course classes, tried new resolutions of the Scratch exercises/codes made in the previous training classes, clarified doubts, practiced using the software).
4. Refer Faults (outside the course) so that the training was not successful: (Ex: Did you miss training classes, not practice enough, not try new Scratch exercises/Scratch codes).

The data collected to the above questions, shown in next section, was processed and analysed according to the research objectives, using a manual qualitative analysis technique.

VI. RESULTS

The pre-study carried out allowed us to acquire important data for the project development. For the formulation of results, we highlighted those that corresponded to the pre-defined parameters of analysis, namely motivation, the level of accomplishment and the collaboration. These parameters correspond to concepts that where most likely to be found and that we pre-defined regarding to this pre-investigation objectives. Analysing the answers obtained from the questionnaire we must highlight some that are relevant in the framework of this project, namely with regard to the degree in Educational Sciences and the characteristics of its students and future professionals.

1. Positive Personal Aspects of the Course

Regarding to the positive aspects of the course, at a personal level, our analyses revealed that most of the students were motivated trough this course. Their affirmations revealed that in spite of some difficulties, most likely regarding to the technical level of Scratch, they were able to use personal competences (like perseverance and personal motivation) and group collaboration to overcome their obstacles and achieved a satisfactory accomplishment level. The next sentences represent some examples of questionnaire students answers regarding the positive personal aspects of the course.

P.M.: "I have always seen technology as a challenge. Everything seems easy but in fact to do well it is necessary to spend several hours to practice and understand. In this way, in this training I was always motivated and ready to receive new information. I gave my best and managed to complete all the exercises proposed for the training."

C.S.: "It was a very different experience. I had never used any tools similar to Scratch, so whenever there were classes in this area, I had a careful attitude, so I could do the project with my colleagues. My doubts have always been clarified and there have been some exercises that have imposed difficulties but have been successfully overcome."

D.A.: "Regarding the personal positive aspects of this training, I think it has become quite positive and quite useful for a future life. It was something that from the beginning aroused my attention, being something different from what is usually done in class. Of course, it was not easy to do, my group and I had a lot of doubts, but they were always clear. Finally, we were able to complete our work in a simpler way, where all the members of the group did their part properly."

Regarding the positive aspects of the course, a descriptive analysis was carried out according to the participants opinions. Table II shows the answers already mentioned according to the established parameters of analysis.

TABLE II.

Positive Personal Aspects of the Course	
Analysis Parameters	***Answers***
Motivation	P.M.: "I have always seen technology as a challenge (...) I have always been motivated" D.A.: "It was something that from the beginning got my attention"
Accomplishment Level	P.M.: "I gave my best" C.S.: "It was a very different experience (...) there were some exercises that caused difficulties but were always successfully overcome."
Collaboration	D.A.: "My group and I had a lot of doubts, but they were always clarified (...) all the members of the group did their part properly."

2. Negative Personal Aspects of the Course

In this analysis, regarding to the negative personal aspects, students concentrate their answers in certain aspects, such as time. Time to learn how to use the software, or the time needed to develop a project, with a high level of detail. The analysis parameters reveal that only a few do not support the idea that Scratch is a difficult software to learn and use. In our opinion there are some student's characteristics that can support this data: they never worked with Scratch in lower levels of education, like middle school; the fact that they're first year students in an educational degree, can difficult some technological learning concepts. The next sentences represent some student's ideas about the negative personal aspects of the course.

S.C.: "As a negative aspect, I was not always motivated because it was a complicated and detailed project. The time was also a little scarce to understand all its complexity."

A.N.: "This training had few negative aspects. One that I think stood out, was the fact that there were few classes to learn how to work with Scratch. But at the same time, it was a positive aspect, as we learn from ourselves and from our mistakes."

I.M.: "Although I agree with the teaching method, I believe that we should be given a wider range of what can be done with the software, so that this training was aimed not only at the completion of the work done, but also at the possible use in future work"

Regarding the negative personal aspects of the course, the descriptive analysis with the opinions of the participants is expressed in table III, presenting the already mentioned answers according to the established parameters of analysis.

TABLE III.

Negative Personal Aspects of the Course	
Analysis Parameters	***Answers***
Motivation	S.C.: "I was not always motivated, it was a complicated and detailed project."
Accomplishment Level	I.M.: "I am of the opinion that we should be offered a wider range of what can be done with the software."
Collaboration	A.N.: "fact that there are only a few lessons to learn how to work with Scratch (...) so we learn from ourselves and from our mistakes."

3. Efforts (Out of the Course)

Concerning the efforts, made by students, outside the course, the answers are focused in two analysis parameters: motivation and collaboration. They focus their answers in two major ideas: the fact that they needed to use and practice with Scratch in order to be succeeded, making other projects and playing with the software; and the help of all group members to overcome obstacles and difficulties. These ideas, specially the last one, reveals that group work method is appropriated when using new and differentiated concepts, like this software, that students aren't used to.

The next sentences are representative of the already presented ideas, showing student's opinions regarding to their efforts.

I.F.: "By installing Scratch on my computer, it allowed me to practice more with the program in my spare time. I was always present in the training classes, which made possible a broader knowledge of the project, where I could later practice exercises at home."

S.F.: "In order for my project to succeed, I had the need to use other supports to improve my work more and more, such as YouTube."

S.C.:" In order for the training to be successful, my group and I went to all classes, we always took the doubts we had, we always tried to discover and explore the various functions of Scratch and we exchanged several impressions with our colleagues, from other groups, in order to help each other."

Table IV presents the analysis performed on the Effort data (out of course) in relation to the established parameters of analysis.

TABLE IV.

Efforts (Out of the Curse)	
Analysis Parameters	***Answers***
Motivation	I.F.: "Installing Scratch on my computer enabled me to practice more with the program in my spare time." S.C.: "We always seek to discover and explore the various functions of Scratch."
Accomplishment Level	S.F.: "In order for the project to succeed I had to resort to other support in order to be able to improve my work more and more."
Collaboration	S.C.: "we exchanged various impressions with our colleagues, from other groups, so as to help each other."

4. Failures (Out of the Course)

When asked about failures, outside the course, students showed that often, the misuse of time, and the lack of practice, are one of the biggest concerns. In some of them we can point some feelings, like regret. In their answers some refer that with more practice they could made a better work. Motivation and Accomplishment Level are the analysis parameters with more results. In fact, any of these students refers the lack of Collaboration as a failure. One of the facts that can support this data is group formation. Groups were made by students, with only one guideline – maximum of four elements. They were able to gather elements to form their groups by friendship or strengths, helping each other to overcome their difficulties. Any of these students showed any concern about their group when questioned.

A.F.: "I think the only flaw outside the classroom was even the misuse of time, I feel that with a better use of it we would have carried out an even more elaborate work."

I.P.: "One of the failures, outside the training, that contributed to the lack of success was the fact that I had not tried several codes that showed to be interesting for the accomplishment of my project."

L.S.: "One of the failures was the fact that sometimes we did not ask for help to understand some situations to improve the work, remaining with some doubts in the end."

Regarding the Failures (out of the course) the descriptive analysis with the opinions of the participants is expressed in table V.

TABLE V.

Failures (Out of the Course)	
Analysis Parameters	***Answers***
Motivation	I.P.: "The fact that I had not tried several codes that proved to be interesting."
Accomplishment Level	S.F.: "(…) misuse of time" L.S.: "(…) not asking for help to understand some situations."
Collaboration	No Data

VII. CONCLUSIONS

In this paper we describe a study that intends to understand concretely the impact of teaching basic programming software, such as Scratch, in courses directly related to education, namely the degree in Educational Sciences.

During the first academic semester of 2017-2018, a pre-study was carried out with the main objective of understanding the motivation, level of accomplishment and collaboration that Scratch software has on students of the above-mentioned course, supporting future studies in this area.

Despite the ambiguous nature of this pre-study, we have been able to draw important conclusions that allow us to adapt and adjust future work, especially with regard to student's opinions.

The SWOT analysis allows us to conclude that students report extra motivation when they're in contact with this type of tool, especially when working in groups. They seek to identify problems and solve them using the opinions of the different elements of the group, or external elements. The difficulties they feel are also mentioned. The use of this software is, as they refer, complicated, difficult, confusing, and with too much information for the number of training hours. This information allows us to recalculate the number of hours of training related to Phase 1 - Assimilation and Contents. On the other hand, the increased difficulties stimulate fundamental behaviours, driven by trial and error, namely the identification of the problem and its solution – problem solving.

The obtained results allow us to conclude that the level of achievement of participants is very satisfactory. The creation of a personal digital resource, unlike any other, represents an additional stimulus in the involvement with the tool and consequently with the course.

Finally, it is worth mentioning that this important information will serve as a basis for restructuring the project that we present and that we propose to carry out, modifying small aspects that could benefit the research that we intend to implement.

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