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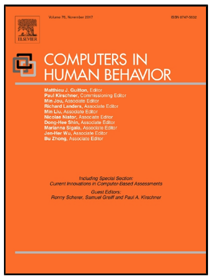

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Learning Computational Thinking and Scratch at Distance

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The design and implementation of a distance education course

The course is about CT and Scratch programming

The course is for elementary school teachers

Learning Computational Thinking and Scratch at Distance

Abstract

Learning Computational Thinking concepts by all has gained quite importance in last years. Scratch is also one of the most used products to promote it worldwide. Yet, most teachers face difficulties when using it in the classroom with their students. With this idea in mind we developed and run a distance education course under the Project of Distance Education of the University of Coimbra specially designed for elementary school teachers to learn both Computational Thinking concepts and Scratch via an e-learning course using Moodle as a Learning Management System. In this paper we describe this first experience of teaching and learning online, the results obtained and also our future work about this course. Results of this first experience showed that it was possible for the trainees to learn Computational Thinking concepts and Scratch programming and also to develop useful products for their classroom practice using this modality of teaching and learning. As such, a second edition of the course is already planned to take place shortly.

Keywords: Computational Thinking; Scratch; teacher training; e-learning; Pedagogical Innovation

1. Introduction

Computer science and communications play an inevitable role in today's society. In fact, the 21st century society is massively computerized and networked and it will require that everyone has computational knowledge and skills, although at varying levels. It should be noted that children who do not know how to read yet, at the age of 3 or 4, already use and manipulate computing devices, such as tablets and smartphones, quite easily.

Also, the development of Computational Thinking (CT) and programming can be seen as an added value for anyone, since they allow to develop important competencies that are transversal to many areas of knowledge (García-Peñalvo, 2016b).

On a daily basis we often find ourselves performing tasks or solving problems using the capabilities that CT promotes as when we are asked to go from our house to the nearest post office or want to sort any kind of data...

These same problems can easily arise in the classroom when students have to use a map to give directions from one location to another, organize data, write a text, from its planning to the final phase (Settle et al., 2012), build a musical instrument (Barr, Harrison, & Conery, 2011), or prepare a presentation on any subject. But there are many other examples that can be thought (CS Unplugged, 2017).

We find in the literature reports on several efforts that have been made worldwide to develop these competencies in schools. We can refer, for instances, the TACCLE 3 project, an European project to support elementary school teachers to introduce computing to students aged from 4 to 14 years old (TACCLE 3 Consortium, 2017; García-Peñalvo, 2016a). In this project several materials and approaches have been developed for teachers to use in the classroom from lessons to activities and games, other artefacts and tools. Another initiative is the one described in (Ouahbi, Kaddari, Darhmaoui, Elachqar & Lahmine, 2015) where a study about using Scratch to create games by high school students in Morocco is presented. In (Curzon, Peckham, Settle & Roberts, 2009) the authors pointed out that CT can help develop problem-solving skills of preuniversity students and that it can bring benefits beyond the area of Information and Communication Technology (ICT) itself. Another study presents the findings of a two year project of using CT and Scratch in five elementary schools that showed that programming concepts learning, logic and computational practices have improved with it (Sáez-López, Román-González & Vázquez-Cano, 2016). In Portugal there are also several initiatives going on. We mention the EduScratch project, a project to promote the educational use of Scratch by offering support, training and sharing of experiences to the educational community (EduScratch, 2017) and the project "Iniciação à Programação no 1.º Ciclo do Ensino Básico" from the Ministry of Education which main objective is to contribute to the development of CT, digital literacy and transversal competences (IniProg, 2017).

Naughton (2012) defends that this knowledge and skills will be better developed and exploited if their learning starts at a very early stage, preferably in elementary school. Therefore, it is desirable that the teachers of the various grades and areas are exposed to the theme, as well as to its principles, so as to be able to apply them in the best way in the classroom and in learning activities, since their learning may require diverse approaches (Yadav, Zhou, Mayfield, Hambrush & Korb, 2011). It is also important to realize what activities may be more challenging for students and how they can be structured, what tools can be easier and are more appropriate to use, etc. (Guzdial, 2008). In this respect Scratch is much used worldwide, as the literature attests, which includes Portugal. The distance education course described herein on CT and Scratch, especially designed for Portuguese elementary school teachers, aims to provide them with the needed training and tools for doing it more easily and more adequately in the classroom with their students.

This paper is structured in the following way: first we start by describing what is CT. Then we move on by pointing out some learning issues and pedagogical strategies that can be applied in school settings to help promote CT development. After we focus on Scratch and the course we have developed and run, including the presentation of result analyses and course future improvements.

2. Computational Thinking

Since Jeannette Wing has launched the idea that Computational Thinking is a fundamental skill for everybody and transversal to all areas of knowledge that the subject has attracted the attention of many researchers and teachers (Wing, 2006). The idea was not new, since the term had already been used by Papert, in 1980, but in spite of much of the work done in this area with the LOGO language, it was from 2006 onward that the debate gained a new breath (Papert, 1980).

According to Jeannette Wing CT "involves solving problems, designing systems, and understanding human behavior" (2006, p. 33) and "Conceptualizing, not programming, ... requires thinking at multiple levels of abstraction, ... a way that humans, not computers, think, ... ideas, not artefacts." (2006, p. 35). But also thinking recursively and in parallel, using decomposition, modelling, planning, etc. ((Wing, 2006).

These Wing statements more than a definition are a first attempt to depict an idea that is not yet totally matured accordingly to a recent study on the subject (Kalelioğlu, Gulbahar & Kukul, 2016). However, from 2006 onwards, several researchers and institutions have tried to define, apply and develop the concept from diverse points of view. Herein we are going to mention just a few.

According to Barr and Stepheson (2011) CT involves several concepts and capacities. The core ones are: data collection, data analysis, data representation, abstraction, problem decomposition, algorithms and procedures, automation, parallelization and simulation. They see CT as an approach to problem-solving that can be automated in some way and that can be applied in many subjects or areas. For that to be effective application examples and materials should be provided for teachers.

Focusing only on mental processes, Selby and Woollard (2013) define CT as a cognitive or mental process, of humans, not of machines, of problem solving in the broad sense, and involving abilities such as:

- Abstraction - It consists of hiding the inherent complexity of reality to represent only its essential aspects
- Decomposition - It consists of dividing a task or problem into simpler parts so that they can be solved
- Algorithmic thinking - It consists of defining a task as a set of simple step-by-step instructions
- Evaluation - It consists of assessing the advantages and limitations of a solution
- Generalization - It consists of being able to move from a specific situation to more general ones.

Several companies like Microsoft and Google have also developed several projects and programs around CT and programming learning. Google (2017), for instance, has defined a concept guide on CT that distinguishes mental processes from tangible outcomes. The former involve: abstraction, algorithm design, decomposition, data analysis, pattern recognition. The latter: automation, data collection, data representation, parallelization, generalization of patterns, simulation.

In a recent and intensive study about the literature on CT it was identified that the most mentioned words in this scope are abstraction, problem-solving, algorithmic and thinking which is in agreement with all the above. However it was also found that the concept is not yet mature enough and that discussions are needed on how to teach and to assess students about effective CT skills development in practice (Kalelioğlu, Gulbahar & Kukul, 2016).

3. The development of CT: learning issues and pedagogical strategies

Objectivist epistemology has dominated teaching and learning practices for years, where the main objective was to transmit, in the most effective and efficient way, the knowledge to the students and ensure its acquisition by exercise. These principles, which still underlie most of today's educational practices, are believed to explain correctly behavioral changes, but not so much conceptual or mental changes.

There is also a movement to another perspective, constructivism, that has as its fundamental principle the primacy of the subject in the construction of knowledge. Learning is a developmental process in which subjects construct knowledge, construct logical-mathematical knowledge, learn to think critically, and learn to solve problems, with creativity, that arise in real contexts. In this respect there are diverse approaches like problem-based learning and modelling that can ask for and develop these skills. Also playfulness can have an important role in learning as it can foster it.

3.1 Learning issues

Children think differently from adults and the construction of logical-mathematical knowledge can and usually begins very early. According to Piaget, young people have a cognitive development that is done in several stages (sensorimotor period, prelogical step, concrete operations and adequate logical reasoning). By receiving adequate stimulation, the child is able to perform this cycle quickly. It is in the action and manipulation of objects by the child that his/her logical mathematical knowledge is constructed (McLeod, 2015).

For Ennis critical thinking is "a reasonable reflective thinking focused on deciding what to believe or do." (1987, p.10). There are several capacities defined and operationalized in the Ennis taxonomy that are grouped into five main categories (Elementary Clarification, Basic Support, Inference, Clarification, Strategies and Tactics). To each one corresponds several activities that can be done (Tenreiro-Vieira & Vieira, 2001). As Tenreiro-Vieira and Vieira say critical thinking generally implies "seeking to be well-informed, using and mentioning credible sources, looking for reasons, seeking alternatives, having an open mind and seeking as much precision as the subject allows" (2012, p. 5).

We can find several definitions of creativity (Batey, 2012). For Plucker, Beghetto & Dow (2004, p.90) it is "the interaction among aptitude, process, and environment by which an individual or group produces a perceptible product that is both novel and useful as defined within a social context". Sternberg & Lubart (1999, p.3) define it as "the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning task constraints)". Ochse (1990, p.2) says that is something that is "original (new, unusual, novel, unexpected) and also valuable (useful, good, adaptive, appropriate)". Originality, appropriateness and usefulness are, in fact, crucial concepts in the creative process. But, this is a complex one that involves several components, namely a creative environment, a personality open to experience, some knowledge, intrinsic motivation and imagination.

3.2 Pedagogical strategies

Educational systems usually appeal to active methodologies that develop logical reasoning, critical thinking and problem solving skills and that can be applied in many areas. There are several approaches (see Table 1). The several approaches are differentiated by the way they understand knowledge and the role of the student in their development, as well as in what concerns a more directing or facilitating role of the teacher (Fartura, 2007; Savin-Baden & Major, 2004). Some authors distinguish between problem-based learning and project-based learning. In the latter, the project does not have to necessarily arise from a problem. In the former, the problem situation is motivated by a situation presented by the teacher that mobilizes the whole process (Fartura, 2007; Barrows & Tamblyn, 1980).

	Knowledge Organization	Forms of Knowledge	Student Role	Teacher Role
Problem-based Learning	Open Issues Open Situations	Contingent Constructivism	Active	Facilitator
Project-based Learning	Tutor Orientation Structured Tasks	Performative Practical	Project Members	Task organizer Supervisor
Problem-solving Learning	Step-by-step logic P.S. with	Propositional	Practical and	Guide

	theoretical basis	Practical	Problem Solvers	
Active learning	Group Discussion Reflection on action	Performative Personal	Self-sufficient and with its own objectives	Facilitator

Table 1 - Several Approaches for Active Methods | Different approaches with problems (adapted from Savin-Baden, M. & Major, C., 2004, p. 7).

Learning can occur either actively or indirectly, that is, by observing the performance of models, living or symbolic. Modelling refers to behavioral changes that occur by observation of a model (Rosenthal & Bandura, 1978; Schunk, 1987; Zimmerman, 1977) and can add significant value and dimension to the learning process. The observation of a model, even in a digital scenario, facilitates the general acquisition of information and, in particular, information about the consequences of certain actions motivating (re)production as we have capacities to symbolic represent reality that enables to learn indirectly and to self-reflect (Silva, 2009).

Ludic can be defined as: "An inner state of the subject who fully experiences an experience. (...) Ludic is not directly related to games and play (...) Ludic is, rather, related to the inner attitude of the individual who experiences an integration between his feeling, his thinking and his doing" (Silva, 2015, p. 104).

Children's learning can be done through the experimentation of playing, because playful environments allow them to assimilate concepts more easily and languages progressively more abstract and also achieve greater success and school adaptation as several research studies have shown (Neto, 2001).

4. Scracth

Scratch is an environment and programming language especially developed for children by the Lifelong Kindergarten Group of the MIT Media Lab (https://scratch.mit.edu) that can be used to develop CT (Resnick et al., 2009; Brennan & Resnick, 2012).

Although there are other examples of similar environments (Hughes, 2016) and languages (Alice, LOGO, etc.) and approaches like simulations (Ahamed, Brylow & Early, 2010), 3-D modeling and visualization environments (Morreale, Joiner & Chang, 2010) and robots (Lee et al., 2011; Pinto-Llorente, Casillas-Martín, Cabezas-González & García-Peñalvo, 2017), Scratch has been much used as the number of references found in the literature reveals.

Scratch has been developed with the aim of being very easy to use by anyone, regardless of age, background, or interests. To attain these objectives the language commands are similar to LEGO® blocks (https://www.lego.com/en-us) that "get" or fit together. In a society of digital natives, however, it is important that users are more than just technology consumers and become creators. To this end, Scratch enables users to create their own projects like interactive stories, games, animations, simulations, etc. A Scratch project consists of a set of actors that may have behaviors, defined through the language commands, and that act on a stage or screen. These projects can be personalized, through the inclusion of photographs, voice excerpts, music clips, etc., and shared, reused, or developed in collaboration with others through the environment website (Resnick et al. 2009).

5. Scratch@Ensino Básico course

The Scracth@EnsinoBásico course was designed for Portuguese elementary school teachers, has a total workload of 54 hours, corresponding to 2 ECTS (according to the European Credit Transfer and Accumulation System), is accredited by the CCPFC, the Portuguese Scientific and Pedagogical Council for Continuing Training, and was developed under the Project of Distance Education of the University of Coimbra. The course is carried out at distance, which allows, on the one hand, some flexibility of time and space, and on the other, enhancing discipline and self-learning by the trainee.

The course objectives are:

- **To develop the awareness for the Scratch's role in promoting CT.**
- **To develop the sensitivity to children's ability to learn serious things, such as computer thinking, playing and being challenged.**
- **To know new pedagogical strategies, including reasoning and problem solving skills, collaborative work, and interpersonal skills.**
- **To experience various learning situations, mediated by Scratch, that facilitate the creation of pedagogical strategies appropriate to the curricular objectives of elementary education.**

Taking into account the objectives described, the course combines theoretical training with a strong practical component, encouraging the active participation of the trainee.

Communication in the course is synchronous and asynchronous, and the trainee is able to access to and participate in the course at any time (within the temporal deadlines defined), from any place where it has access to the Internet. In addition to the follow-up of the trainees in the clarification of doubts and support in the accomplishment of the activities, the teachers try to build a learning community based on collaboration, reflection and sharing. In order to help this development synchronous sessions are arranged on the first day of the course, to provide some general information about the course and get acquainted to each other (both teachers and trainees), and at the end of the course, to present and discuss the final projects together.

The course is structured in 3 themes and a final project. Content is available in various formats, allowing to understand the basic concepts of CT and of Scratch programming. The course themes are:

THEME 1: Fundamentals and principles of CT with the duration of 8 hours. This involves what is CT (theoretical and practical references of CT in school); concepts, practices and perspectives associated with CT; and with logical reasoning, critical thinking, creativity, problem solving, modelling and playfulness.

THEME 2: Areas of exploration of CT in school with Scratch (6 hours). In this theme several examples of projects supporting the various curricular areas are presented and can be explored by the trainee.

THEME 3: Scratch and applications built in Scratch, which is 26 hours long. This theme is divided into two parts. The first one is about the Scratch environment, basic commands, control structures and some advanced commands. The second part is about the construction of animations, interactive stories and educational games in Scratch.

Finally the project takes 14 hours and consists of building an application in Scratch that can be an animation, an interactive story, an educational game or a mixture of some of these.

In the light of the Legal Framework for Continuing Training and Circular Letter 3/2007 of the CCPFC, the evaluation of the trainees is based on an analysis of their performance - both quantitative and qualitative - and takes into account their participation in the activities and assignments that are proposed during the course. These are directed to the needs of the trainee, in order to produce useful materials for their pedagogical practice.

There are several small activities as well as a project that should have a transversal and interdisciplinary approach to the curriculum of a given grade of elementary education, with the aim of improving students' learning. In the end, each project is shared, discussed and presented, creating a space for sharing experiences and curricular materials.

For a successful completion of the course and to obtain the respective certification issued by the University of Coimbra it is required to carry out all the activities and obtain a minimum of 5 points in a scale of 1 to 10.

The course starts with a first activity, not graded, for adaptation to the course and to the electronic platform (Moodle) using a forum where the trainees present themselves and get acquainted to the system. At the same time they are training how to use a forum, namely posting a message and viewing others' messages.

Theme 1 involves two activities – a collaborative construction of a glossary of pedagogical terms related to CT (A1) and the design of a lesson plan to promote the development of CT concepts (A2). This last one involved submitting a file in the electronic platform.

In Theme 2 there is only one activity – the critical analyses of two Scratch resources (A3 - by submitting a file).

In Theme 3 there are six activities. The first three are for training Scratch concepts, basic commands (A4 - movement, pen, etc.), control structures (A5 - conditions and cycles) and advanced concepts (A6 - variables, sensors and interactions). The other three activities are to build a small animation (A7), an interactive story (A8) and a game (A9). All these activities are completed by submitting a file in the LMS provided.

Finally the project involves two stages – a first one about its specification (A10), where teacher feedback is given to guarantee that the project is going on a good track, and a second one where the whole project should be delivered (A11).

In the next section we will describe and analyse in detail the performance of the trainees in all these activities as well as the satisfaction analyses done and the course future improvements proposed.

6. Results

In this section we present and analyse the course results in terms of trainees' performance, trainees' satisfaction and course continuous improvement.

6.1 Performance analyses

Of the 9 trainees who enrolled in the course, 6 were women and 3 men. The majority of the trainees affirmed to be Portuguese (6), 2 were Brazilian natives and another was from Ecuador. Only one of them was not living in Portugal, she was in Brazil. The majority of the trainees were teachers, some of them working in special education (3). There were also one from Informatics and another from Engineering. One trainee just completed two activities and gave up the course (the one from Informatics) for personal reasons. The other eight completed all the activities, a requirement to conclude the course.

For each activity information regarding activity objectives, description, recommended strategies for achieving its goals, evaluation criteria, support material and tools was provided. Also a time period was allocated, finishing which it was no longer possible to do the activity.

Activities contributed to the final grade of each trainee as shown in Table 2:

A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8	A 9	A 10	A 11
5%	10%	10%	2.5%	5%	2.5%	5%	5%	5%	10%	40%

Table 2 - activities weight for the final course grade.

Activity A1 consisted of the collaborative construction of a glossary of concepts and definitions related to the pedagogical issues underlying the use of CT, logical reasoning, critical thinking, creativity, problem solving, modelling and playfulness. Each participant should contribute with at least four and a maximum of eight entries to the glossary. Sources used should be included. The evaluation took into account the number, quality and relevance of the participations generated by each trainee and the quality of the sources used. At the end they included 60 terms in the glossary.

Activity A2 was the individual development of a lesson plan, applying, in a correct and coherent way, some concepts and definitions related to pedagogical issues and CT. A template was provided and the evaluation considered the quality and relevance of the fields filled in the template and the correct and coherent use of the concepts used. Among the more interesting were a plan for a French lesson about food vocabulary using newspaper images and prospects. The idea was that students from those data developed a glossary of terms and a question and answer game. This activity was developed for the 5th grade. Another one was for Mathematics also for the 5th grade for students to develop a coding scheme for coding and decoding sentences. Other trainees developed plans for English lessons and for learning CT concepts for children, for instances.

In activity A3 trainees had to individually plan two learning activities based on two available Scratch resources (several were provided) and do a critical analysis of each one. One of the resources chosen should be in the trainee's area. The other should be from another area at their choice. Again a template was provided and the evaluation checked the quality and relevance of the fields filled in the template. Here, examples from Mathematics, History, Geography, Language learning, Art and Music were chosen.

Activities A4 to A6 involved the development of small Scratch programs. In A4, the trainee was asked to build a program that drew a star of David in which in the end the cat changed its suit and played a sound. This activity involves only very basic commands. In A5 the program should allow to move the cat up, down, left and right, according to the arrows pressed, and leave a track of a different colour according to the direction of movement. When the cat touched a screen border, it should play a sound and the cat should reappear on the other side of the screen. The program should end when the user selected the space key. Here control structures are to be used. In A6 a program should be developed that calculates the sum and average of a set of n numbers introduced by the user. In all these activities evaluation asserted the appropriate use of commands and the quality of the solution obtained.

Activities A7 to A9 involved the development of an animation, an interactive story and a game for integration in trainee's pedagogical practice. As such, activities' themes were free. In A7 at least 2 actors should be included. In A8 at least 2 different scenarios should be used. In A9 variables should be used. In all 3 with the program a file identifying the subject area, the level of education for which it was intended, what were the main learning objectives and a brief description of the context and the strategies for using the program developed should be provided. Evaluation took into account the validity of the criteria, objectives and strategies proposed in the accompanying file and the verification of its implementation in the program, the use of appropriate commands to implement the solution, and its global quality. Several products were developed that varied a lot in terms of topic covered or educational area - from Mathematics to Natural Science, from History to English learning, etc.

In Table 3 we can see the trainees' activity and final grades in a scale 0 to 10. The last row presents the averages of the grades in each activity and in the course. The trainees from Brazil revealed more difficulty than the others in the activities that were connected to Scratch programming, activities number 5, 6, 7, 9 and 11 (the final project implementation). On the other hand the trainee that was not a teacher revealed more difficulty in the "more" pedagogical and less programming activities (A2 and A3):

Tr.#	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	Fin.
1	9	10	8	9	9	7	8	9	10	9	10	9,4
2	6	8	8	10	9	10	8	9	10	9	9	8,7
3	2	6	0	0	0	0	0	0	0	0	0	0,7
4	6	6	8	9	8	2	4	8	7	8	6	6,5
5	10	6	6	10	9	10	7	9	8	8	9	8,3
6	6	8	9	10	9	10	7	9	8	10	9	8,8
7	6	9	8	10	9	10	8	10	10	9	9	8,9
8	8	5	6	8	2	2	3	8	4	9	4	5,1
9	7	9	8	10	9	10	10	10	10	10	10	9,5
AVR	6,7	7,4	6,8	8,4	7,1	6,8	6,1	8,0	7,4	8,0	7,3	7,3

Table 3 - trainees' activity results and final grades (scale 0-10).

In Figures 1 to 3 we can see some of the best projects developed by the trainees, namely an interactive story, a game and an example of the final project that was a game too. The level of quality varied, but some attained an excellent level. The interactive story intends to develop children's reading habits and their taste for poetry. Several actors were created, along with diverse backdrops. The poem can be read or heard. In the food wheel game students have to put the different food in the right place of the wheel and gain some points that way. Finally in the animals' rights game they have to build three different puzzles about the theme. The types of products developed varied quite in terms of topic covered or educational area. These are just a few illustrative examples.

Figure 1 - an interactive story for motivating children to reading and poetry.

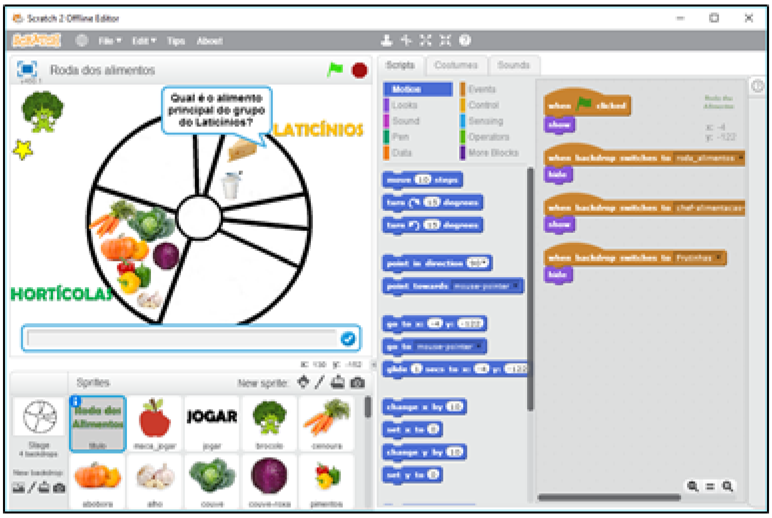

Figure 2 - a game for learning the food wheel.

Figure 3 - an example of the final project, a game about animals' rights.

We used Dr. Scratch (Moreno-León, Robles & Román-González, 2015), an automatic tool to assess the quality of Scratch programs in several aspects including the CT concepts used, to test the final projects and the results were:

Project n.	Rating (in a scale 0-21)	Level
1	18	Master
2	16	Master
3	13	Developing
4	15	Master
5	17	Master
6	It gave an error	---
7	not evaluated, because it has some errors	---
8	11	Developing

Table 4 - final project ratings according to Dr. Scratch.

From this analyses we can see that the learning has not occurred with the same depth in all the trainees, a fact that our observation of their performance during the course already has revealed.

6.2 Satisfaction analyses

After the course, all participants were asked to fill out a satisfaction questionnaire. Out of the 8 trainees who completed the course successfully 6 responded to this questionnaire, exhibiting a high level of satisfaction and offering a few suggestions.

The satisfaction questionnaire is composed of the following categories: usability of the learning platform; content and activities; bibliography and multimedia resources; pedagogical support; interpersonal relationships; expectations and evolution of knowledge; recommendations; strong and weak points. We analyse each of them below.

The usability of the learning platform corresponded to the needs of the trainees, being easy to access and to navigate. In the question "I easily found the information I needed", the answers were distributed by the positive and negative levels of the scale which is an aspect that should be addressed in the future.

Trainees considered that content has been useful and that the designed activities contributed to the consolidation of learning. We highlight the question "The planned time for carrying out the activities was sufficient" because two trainees were not satisfied with the proposed schedule.

The answers about bibliography and multimedia resources allow us to conclude that trainees were satisfied with the resources provided by the course.

There was a great satisfaction towards the teacher's work and the pedagogical support given during the course, but in one question, "It encouraged my participation", answers were distributed between the positive and negative levels of the scale.

We can verify that most of the items presented satisfactory results, and, compared to the categories analysed previously, this category of interpersonal relationships presents results more dispersed by the negative and positive levels of the scale. This is an aspect that should be considered in the future too.

It was observed an evolution of the trainees' knowledge, and the respondents referred that the course corresponded and exceeded even their initial expectations.

It should be noted that all the trainees who answered the questionnaire would recommend this course to other people, which corroborates their satisfaction regarding to their participation in the same.

As strong points, the trainees emphasized the support and competence of the technical-pedagogical team, and the quality of the content and resources. As weak points, they mentioned the tight schedule for the activities and said they needed more time for each activity, especially for the final project.

6.3 Continuous improvement

With the completion of the course and the participation and opinion of the trainees we realized that there are changes that have to be made and things to be improved. Since we are already preparing the next edition we will include some of these changes right away, namely:

- Presentation of content: in this respect it is our objective to present the content more clearly, so that there is no difficulty in interpreting and finding it. We also intend to make formatting adjustments, both in terms of the size and / or colour of the fonts used and the level of graphics presented throughout the course.
- Support material: At this point, we intend to give trainees a wider range of references so that they can consult more authors and papers and make a better understanding of the content and materials presented.
- Activities: Our goal for the activities presented is to redesign some of them and adjust the number of activities according to the course schedule reducing it a bit. This is because, from the experience of the first edition, it was concluded that there were too many activities and some were too broad or high demanding.
- Images and/or videos: In order to stimulate learners and synthesize content, it is our goal to improve and construct some new images (for example include more screenshots) and to integrate explanatory videos to illustrate some tasks into places that justify it.

7. Conclusions

In this paper we described a course that we have developed at the Project of Distance Education of the University of Coimbra to learn CT concepts and Scratch specially designed for elementary school teachers. Although we had already some experience in designing and running distance education courses at the University of Coimbra, this was the first edition of the course and our first experience in teaching CT and Scratch at distance. This experience was important because it came to reinforce our idea that every teacher should be able to improve his/her CT knowledge. Also that is possible to effectively learn and teach CT and Scratch at distance with quality as both trainees and teachers recognized. Although the course allowed the trainees to develop useful products that they can use in their own classrooms, we must point that the learning has not occurred with the same depth for all the trainees, as the score obtained using Dr. Scratch in the final projects and our own perception reveal. Another conclusion is that some changes and improvements should be made in the course and because another edition is planned to start soon we will introduce them straight away. It is also our intention to do more studies with the subsequent editions of the course and to keep refining it.

References

Ahamed, S., Brylow, D. & Early, J. (2010). CT for the Sciences. Proceedings of the 41st ACM technical symposium on Computer science education (pp. 42-46). Milwaukee, WI, USA.

Barr, D., Harrison, J. & Conery, L. (2011). CT: A Digital Age Skill for Everyone. Learning and Leading with Technology, 20-23.

Barr, V. & Stepheson, C. (2011). Bringing CT to K-12: What is Involved and what is the Role of the Computer Science Education Community? Inroads, 2(1), 48-54.

Barrows, H. S. & Tamblyn, R. M. (1980). Problem-Based Learning: An Approach to Medical Education. New York: Springer.

Batey, D. (2012). The Measurement of Creativity: From Definitional Consensus to the Introduction of a New Heuristic Framework. CREATIVITY RESEARCH JOURNAL, 24(1), 55–65.

Brennan, K. & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. Proceedings of the 2012 annual meeting of the American Educational Research Association (pp. 1-25). Vancouver, Canada.

CS Unplugged (2017). Retrieved from http://csunplugged.org/.

Curzon, P., Peckham, J., Settle, A. & Roberts, E. (2009). Computational Thinking (CT): On Weaving It Proceedings of the 14th annual ACM SIGCSE conference on Innovation and technology in computer science education (pp. 201-202). Paris, France.

EduScratch (2017). Projeto EduScratch. Retrieved from http://eduscratch.dge.mec.pt/.

Ennis, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), Teaching thinking skills: Theory and practice (pp. 9-26). New York: W. H. Freeman & Company.

Fartura, S. (2007). Aprendizagem baseada em problemas orientada para o pensamento crítico (Master thesis). Aveiro: University of Aveiro.

García-Peñalvo, F. J. (2016a). A brief introduction to TACCLE 3 - Coding European Project. In F. J. García-Peñalvo & J. A. Mendes (Eds.), 2016 International Symposium on Computers in Education (SIIE 16). USA: IEEE.

García-Peñalvo, F. J. (2016b). What Computational Thinking Is. Journal of Information Technology Research, 9(3), 5-8.

Google (2017). Computational Thinking Concepts Guide. Retrieved from http://computationalthinking.pbworks.com/w/file/fetch/108605812/ComputationalThinkingConceptsGuide.pdf.

Guzdial, M. (2008). Education, Paving the Way for CT. Communications of the ACM, 51(8), 25-27.

Hughes, J. (2016). Best apps for teaching programming. Retrieved from http://www.taccle3.eu/english/2016/05/10/best-apps-for-teaching-programming/.

IniProg (2017). Projeto Iniciação à Programação no 1.º Ciclo do Ensino Básico. Retrieved from http://erte.dge.mec.pt/iniciacao-programacao-no-1o-ciclo-do-ensino-basico.

Kalelioğlu, F., Gulbahar, Y. & Kukul, V. (2016). A Framework for Computational Thinking Based on a Systematic Research Review. Baltic Journal of Modern Computing, 4(3), 583-596.

Lee, I., Martin, F., Denner, J., Coulter, B., Allan, W., Erickson, J., Malyn-Smith, J. & Werner, L. (2011). CT for Youth in Practice. Inroads, 2(1), 32-37.

McLeod, S. (2015). Stages of Development. Retrieved from https://www.simplypsychology.org/piaget.html.

Moreno-León, J., Robles, G. & Román-González, M. (2015). Dr. Scratch: Automatic Analysis of Scratch Projects to Assess and Foster Computational Thinking. RED, Revista de Educación a distancia, 46.

Morreale, P., Joiner, D. & Chang, G. (2010). Connecting Undergraduate Programs to High School Students: Teacher Workshops on CT and Computer science. The Journal of Computing Sciences in Colleges, 25(6), 191-197.

Naughton, J. (2012, March 31). Why all our kids should be taught how to code. The Guardian.

Neto, C. (2001). A criança e o jogo: perspectivas de investigação. Faculdade de Motricidade Humana. Universidade Técnica de Lisboa. Retrieved from http://www.fmh.utl.pt/Cmotricidade/dm/textoscn/acriancaeojogo.pdf.

Ochse, R. (1990). Before the gates of excellence: The determinants of creative genius. New York: Cambridge University Press.

Ouahbi, I., Kaddari, F., Darhmaoui, H., Elachqar, A. & Lahmine, S. (2015). Learning Basic Programming Concepts by Creating Games with Scratch Programming Environment. Procedia - Social and Behavioral Sciences, 191, 1479-1482.

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York: Basic Books, Inc.

Pinto-Llorente, A. M., Casillas-Martín, S., Cabezas-González, M. & García-Peñalvo, F. J. (2017). Building, coding and programming 3D models via a visual programming environment. Quality & Quantity. doi:10.1007/s11135-017-0509-4

Plucker, J. A., Beghetto, R. A. & Dow. G. T. (2004) Why Isn't Creativity More Important to Educational Psychologists? Potentials, Pitfalls, and Future Directions in Creativity Research. Educational Psychologist, 39(2), 83-96. doi: 10.1207/s15326985ep3902_1

Resnick, M., Maloney, J., Monroy-Hernandéz, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosebaum, E., Silver, J., Silverman, B. & Kafai, Y. (2009). Scratch: Programming for All. Communications of the ACM, 52(11), 60-67.

Rosenthal, T. L. & Bandura, A. (1978). Psychological modeling: Theory and practice. In S. L. Garfield & A. E. Bcrgin (Eds.), Handbook of psychotherapy and behavior change (2nd ed., pp.621-658). New York: Wiley

Sáez-López, J. M., Román-González, M. & Vázquez-Cano, E. (2016). Visual programming languages integrated across the curriculum in elementary school: A two year case study using “Scratch” in five schools. Computers & Education, 97, 129-141.

Savin-Baden, M. & Major, C. (2004). Foundations of Problem-based Learning. New York, Society for Research into Higher Education & Open University Press: MacGraw-Hill Education.

Schunk, D. H. (1987). Peer models and children's behavioral change. Review of Educational Research, 57(2), 149-174.

Selby, C. & Woollard, J. (2013). CT: The Developing Definition. Retrieved from http://eprints.soton.ac.uk/356481/.

Settle, A., Franke, B., Hansen, R., Spaltro, F., Jurisson, C., Rennert-May, C. & Wildeman, B. (2012). Infusing CT into the Middle-and-High-School Curriculum. Proceedings of the 17th ACM annual conference on Innovation and technology in computer science education (pp. 22-27). Haifa, Israel.

Silva, D. (2015). Educação e ludicidade: um diálogo com a Pedagogia Waldorf. Educar em Revista, 56, 101-113.

Silva, J. T. (2009). Medindo as percepções de auto-eficácia no âmbito da aprendizagem e da carreira: Introdução da Secção Temática. Psychologica, 51, 5-11.

Sternberg, R. J. & Lubart, T. I. (1999). The Concept of Creativity: Prospects and Paradigms. In Sternberg, R. J. (Ed.), Handbook of creativity (pp. 3-14). New York: Cambridge University Press.

TACCLE 3 Consortium (2017). TACCLE 3: Coding Erasmus + Project website. Retrieved from http://www.taccle3.eu/.

Tenreiro-Vieira, C. & Vieira, R. M. (2001). Promover o pensamento crítico dos alunos: Propostas concretas de sala de aula. Porto: Porto Editora.

Tenreiro-Vieira, C. & Vieira, R. M. (2012). Co(relação) entre a literacia científica e o pensamento crítico no contexto da educação em Ciências com orientação CTS. Proceedings of III Seminário Ibero-americano Ciência-Tecnologia-Sociedade no Ensino das Ciências – VII Seminário Ibérico CTS no Ensino das Ciências. Madrid, Spain.

Wing, J. (2006). CT. Communications of the ACM, 49(3), 33-35.

Yadav, A., Zhou, N., Mayfield, C., Hambrush, S. & Korb, J. (2011). Introducing Computational Thinking in Education Courses. Proceedings of the 42nd ACM technical symposium on Computer science education (pp. 465-470). Dallas, TX, USA.

Zimmerman, B. J. (1977). Modeling. In H. Hom & P. Robinson (Eds.), Psychological processes in children's early education (pp. 37-70). New York: Academic Press.