TRAINING THE COMPUTATIONAL THINKING WITH AUGMENTED REALITY

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ABSTRACT

To overcome the difficulties of teaching Computer Programming, felt by teachers and students, an increasingly bigger community of researchers in Computer Science is claiming for the importance of preparing students, since very early (primary school), to acquire Computational Thinking skills; in that way the interpretation and design of algorithms/programs will become much easier. However, the development of Computational Thinking requires the creation and use of appropriate Learning Resources. The pragmatics shows that a person only acquires a new way of thinking or a new way of behaving if he is trained with the appropriate devices. First of all, in the paper, we will discuss how an ontology can be used to specify what is involved in Computer Programming and how these concepts and Computational Thinking concepts are related. We believe that this formal description will guide the choice of convenient Learning Resources. In that context, we intend to investigate the impact of Augmented Reality on them. After the ontological approach, the paper will focus on the process of shaping Computational Thinking through Augmented Reality. We aim at creating AR-based Learning Resource in an attractive way to improve fundamental skills on young students.

KEYWORDS: Computational Thinking; Programming; Learning Resource; Augmented Reality; Teacher support Tools; Ontology.

1. INTRODUCTION

Nowadays we need to adopt new strategies that promote in the students the development of fundamental skills like reading, writing, arithmetic, or analytic capabilities. These skills are crucial for many activities that in general require Problem-Solving capabilities as it is the case of Computer-based tasks demanding for Computational Thinking (CT) ability. In that direction, CT shall be included as a fundamental skill in the primary and secondary school curricula. The aim of such a decision is to develop in the student's competencies for problem-solving that will be required to the 21st-century citizens. To train and induce in the student's CT a novel teaching/learning process must be devised using techniques derived from Mathematics, Gaming, and Computer Science. The abilities that characterize CT---like logic reasoning, abstraction, rigor in analysis and specification, strategic planning, etc.---are of uttermost relevance in Programming. Augmented Reality is defined by Azuma (Azuma 1997) as the overlapping of virtual information in the real world through technology. This information can be simple textual images or 3D objects that can perform interactions with such objects. AR provides greater motivation, gains learning, and delights the students who use it. In that context and motivated by the evidence that the main investment to educate people in Computational Thinking is the choice/creation of appropriate resources, we intend to investigate the impact of Augmented Reality (AR) on the education on CT. AR supports pedagogical approaches through constructivism learning by enabling educational experiments that complement the

activities of the real classroom. We believe that it is possible to explore AR as a technology that provides constructs to develop skills of uttermost importance for computer programming, not only as a mere technology operator, but also as a computationally literate individual. AR in education can be applied in the training of students' abilities, encouraging learning based on discoveries. Summing up, AR can be used to provide a rich contextual learning environment, adhering to constructivist principles, fostering opportunities for multiple learning styles, engaging learners in ways that are not possible in real-world without real consequences if mistakes are made during the training. These advantages will be used to created Learning Resources that should be available to promote CT in primary and secondary schools. We have as indicators the following questions to research: How can an ontology be used to describe CT; A formal description helps in choosing the LR; What are the impacts of AR Resources on CT; How to study the Impacts of Learning Resources in the development of Computational Thinking?

Consequently, the main objective of the research project here proposed is to improve motivation in teaching CP. To attain that objective, the following specific objectives must be achieved: Study broadly and deeply the area of AR in Education to characterize and classify the best possible those tools to know the systems that have been proposed and developed, what approaches have been used in their implementation, and so identify clearly what is solved and what deserves further research; Choose/create a generic architecture (among the existing ones or defining a new one) that can always be adopted to build an AR-based LR, Identify what components are stable and those that vary from a specific system to another one, in order to understand which information needs to be specified in each concrete case, aiming at the construction of those artifacts; Use the ontology *OntoCnE—Ontology for Computing-at-School (from the Portuguese Ontologia para Computação na Escola).* developed to describe CT; Validate with concrete case studies the approach proposed and the generator we intend to developed.

THE IMPORTANCE OF TEACHING COMPUTATIONAL THINKING

Computational Thinking is a way of thinking that uses various educational techniques that develop competencies in students required in the 21st century, to organize people's mind in order to efficiently solve problems (Wing 2006); explains that CT is the ability to formulate a problem and express its solution in such a way that the problem will be solved. In this way, CT helps expressing how to solve a problem by approaching the concepts of decomposition, abstraction and algorithmic design (sequence of elementary steps to obtain the solution). Computational Thinking is based on the concepts of Pattern Recognition, Abstraction, Problem Decomposition and Algorithms.

In 2006,(Wing 2006, 2011, 2014) proposed the foundations of Computational Thinking and showed how society is influenced by technology even more in education. According to the author, the most important and high-level thinking process is the process of abstraction, being used in the definition of patterns, generalizing from specific instances and parametrization. With adequate resources, it is possible to work with the identification of common characteristics between the problems and their solutions. We can also identify patterns among the sub-problems that have been abstracted, finding an efficient solution to the problems encountered. It is also possible to work with resources that help breakdown processes in smaller parts for easier resolution. Thus it is possible to prepare the thought so that it arrives at the moment of creation of the Algorithms in the strategy or clear instructions for the solution of the problem. Learning Resources (LR) are hard or soft devices that allow students to train previous knowledge or acquire new knowledge, stimulating their ability to comprehend, organize and synthesize educational content in a specific domain (Bušljeta 2013). As said above, we believe that we need to resort to LRs to train Computational Thinking; so LRs will play a very important role in this process. However, it is crucial to have adequate resources to transmit the different skills involved in Computational Thinking. The richer the resources, the better students will shape their minds, learning the desired competencies. The LRs that we intend to use are of two types: *virtual* (need electronic devices) and *unplugged* (do not need any kind of electronic devices). The ability of way of thinking can be developed by inserting disciplines in the curriculum using technology to promote computational literacy or disciplines that explore the concepts of Computational Thinking through games, robotics or even cross-sectional, all skills are related to better communication and problem-solving in all aspects of life. These artifacts are often available in the school environment in which they help improve the quality of teaching and the innovation of the teaching-learning process. This technology is effective for

teaching abstract and complex concepts because students can see the virtual elements immediately. AR also has student learning gains and improves motivation. This technology helps collaboration among students. The low cost is related to the simulations of environments or information in which a specific site would be necessary for teaching, for example, one can teach organic chemistry and observe the connections between the elements without the student's displacement to a laboratory. The information in the AR is apprised in real-time that provides an increase in the attention of the students. Thus the AR can be a powerful allied technology in the development of Computational Thinking in students exploring in different ways the decomposition, pattern recognition, abstraction and algorithm construction. The features present in the use of AR are: possible an education-oriented from the beginning has an educational target; Adaptive, Allows users to create, edit and visualize their own AR projects, doing it by themselves; and Interactive, Interactions help better concept understanding and gamifying the learning process. It helps students gain a better understanding of abstract concepts, fosters intellectual curiosity, creativity and teamwork. With the popularization of games and applications that use AR, there is also the adaptation for different platforms, including mobile platforms, in which the use of mobile phones to aid in education using AR is possible today.

We use OntoCnE ontology to describe Computational Thinking. This ontology is discussed with more details in the works of Araújo (Araújo et al. 2019). The work proposed by (Azevedo et al. 2019) describes Micas, as a tool that allows to store the resources and classifies them according to the OntoCnE, the tool can be accessed at - "*https://micas.epl.di.uminho.pt/*".

AUGMENTED REALITY AND LEARNING RESOURCES

The work of (Klopfenstein et al.) presented an AR system for mobile devices of Low cost, that uses a simple smartphone like an increased sensor to turn a fully unplugged coding set into an AR encoding experiment, use of new and innovative technologies, also reducing the requirements for the use of tools capable of being effective in teaching and learning coding skills. The game that the author developed based on letters, can be printed at home demonstrating simplicity and accessibility.

Already (Chung and Hsiao 2019) proposes a mobile system of incorporation of the AR designed for computational thinking exploring the concepts of debugging and the concept of abstraction of the students. The system allows interaction with the 3d models using hand movement, the research still in progress (2019) shows how it is possible to explore AR in Computational Thinking applying to High School demonstrating engagement among students by showing that the interface attracts attention quickly. The author's conclusions are that: Low-cost unplugged educational activities: simplicity and accessibility; Augmented sensor (mobile device) transforms the unplugged card game in an immersive experience. Compromise between innovative technologies and efforts in reducing requirements for Computational Thinking teaching.

Initially the use of AR in programming can be observed in the works of(Lee et al. 2004), the author presents a new approach for authoring tangible AR applications. This approach allows the user to carry out the authoring tasks within the AR application being built so that the development and testing of the application can be done concurrently throughout the development process. The results have shown that the users generally found it easier and faster to carry out authoring tasks using AR.

But the relationship between the development of Computational Thinking and programming learning with AR can also be seen currently in the works of (Jin et al. 2018; Krpan et al. 2018; Teng et al. 2018).

The work of (Krpan et al. 2018) uses Visual Programming Languages (VPLs), the idea to replace textual language constructs with visual representations or blocks resulted in the development of the visual programming languages (VPLs), but the visual blocks are then replaced with physical objects such as cards or cubes and are referred to as "tangible programming languages" (TPLs). The work of Jin (Jin et al. 2018) also deals with tangible programming with AR affirming that programming is an effective way to promote children Computational Thinking presenting a novel tangible programming tool using AR technology for young children helping children create their programs by arranging programming blocks and debug or execute the code with a mobile device. The students can learn fundamental programming concepts, such as parameters, loop logic, debug, etc; providing help children programming in an interesting and intuitive way. The similar work of (Deng et al. 2019) presents a propose too of a tangible programming tool designed to help children learn Depth First Search (DFS) algorithm with AR technology combining the visual environment presented in AR environment and tangible cards. The results of studies reveal that the huge

popularization of AR tools and these tools enable students to have better learning efficiency than the normal system. In addition, the AR system also made students have enhanced perceptions in terms of system usability, flow experience, and user perception, thus observing the great research niche related to AR and Computational Thinking through programming.

CONCLUSION

Coding is important, but not enough to learn Computer Programming; it is also necessary to learn how to analyze a problem, to strategically plan how to design a solution schema, test and assess outcomes to optimize solutions. To teach all those fundamental skills to become a Programmer, as argued along the paper, we believe that smart choices must be made to create adequate LRs. In that context, we propose the inclusion of AR technologies to improve such LRs. One of the objectives of the project here reported is the creation of a specialized framework to support the development of new artifacts incorporating AR. The automatization process will be guided by OntoCnE, an ontology for Computational Thinking, to provide a formal representation of the knowledge domain. That generator or framework will leverage the production and availability of the adequate effective resources. To sum up the discussion sustained in the present paper, we defend that it is necessary to develop digital technologies and digital media to build sensitive LR to be applied in the basic education curriculum to train students in the principles of Computational Thinking to allow them to solve correctly problems using the computer.

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