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A first proposal of Pedagogic Conversational Agents to develop Computational Thinking in children

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ABSTRACT

Pedagogic Conversational Agents are interactive systems that teach by talking to the students. They have been used in several domains to develop competences such as storytelling or negotiation from University to Pre-Primary Education. However, in the literature, no cases of using agents for teaching programming to develop computational thinking in children have been found. In the last decades, there is a growing interest in developing computational thinking in children. According to some authors, if children develop computational thinking, they will be able to solve not only computer problems but their daily life problems in a better way. It is under research which educational technologies and methodologies can be more adequate depending on the context to achieve this goal. In this paper, it is proposed, for the first time, the use of Pedagogic Conversational Agents to develop computational thinking in children. Given the complexity of designing this new type of agent, and as it has been done in previous occasions when trying to design a new agent, the MEDIE methodology will be followed to eventually integrate the agent into the classrooms.

CCS CONCEPTS

• Computing education Computational thinking • Software creation and management Designing software

KEYWORDS

Pedagogic Conversational Agents; Computational Thinking; Pre-Primary Education; Primary Education

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1 INTRODUCTION

In the last decades, educational systems have evolved with the goal of promoting the well-rounded education of the students through a learning based on both arts and science education. Computational Thinking (CT) is promoted to facilitate the analysis and ideas relationship [1].

Computational Thinking (CT) was defined, for the first time, by Papert, and initiated by Wing [2], which stated "computational thinking means to solve problems, design systems and understand human behaviour according to computer science concepts". Furthermore, Wing adds that the skills that are developed are useful to everyone, not just to computer scientists [2]. On the other hand, there are authors that generalise computational thinking to everybody in the digital society as a basic competence that we all should have [3]. Everybody with computational thinking can solve problems, not only computer science problems, but all problems in an intelligent and imaginative way.

To develop computational thinking, there is the hypothesis that computational thinking can be developed in a more efficient way in the childhood [1,4]. In the school context, it has been translated as using Scratch, Alice, or LEGO so that students can program creating their own interactive media and sharing them with other students [6].

It is still under research which educational technologies and methodologies can be more adequate depending on the context to develop computational in the school. In this paper, it is proposed, for the first time, the use of Pedagogic Conversational Agents (PCAs) to teach programming to develop computational thinking in children. PCAs can be defined as interactive systems that allow students to learn in an interactive way by talking to the students [7]. When PCAs have been used at school, some authors have reported statistical significant learning gains [8]. These results have been achieved by students under 12 years old, particularly between 9 and 12 years old. More studies with students of other ages are needed to confirm the results achieved [8].

Other reported benefits of using PCAs at school are the following: Persona effect [9], according to which just the presence of the agent in the interface focuses the attention of the students; the Proteus effect [10], according to which the students will work to look like their agent; and, the Protégé effect [11], following the learning by teaching methodology.

Given that no previous cases of using agents to teach programming children to develop their computational thinking have been reported in the literature, it is necessary to have some guide to design that type of agent. In previous occasions, when it is necessary to design and integrate a new agent, the MEDIE methodology has been found useful [12]. Thus, in this paper, the MEDIE methodology will be used to design a new agent called iProg to teach programming to children between 6-12 years old.

iProg should have the possibility of creating scenes, choosing characters, objects and personalize the actions through a logic procedure. iProg should also apply the cooking metaphor that compares cooking with programming [13] with the iProg chef module. The hypothesis is that the children will develop the computational thinking while playing with iProg and learning programming.

This paper is organised in five Sections: Section 2 reviews the research context with the main contributions of the literature; Section 3 focuses on the proposal it has been made a description of the agent; and, finally Section 4 ends with conclusions of this preliminary work and its future work.

2 RESEARCH CONTEXT

2.1 Computational thinking

Computational thinking (CT) was introduced, for the first time, by Papert [4], who used this term to describe programming environments to solve problems with algorithms and acquire digital competence [4,14]. Later, CT is generalised so that it can be used to solve problems, both of computer science nature, and non-computer science nature [2, 15].

The goal is not to replace creative, critical thinking or other competences, but to potentiate those other competences at the time that it is added this skill of using computers and algorithms to solve any problem [15-19]. Many governments are making a special emphasis in children comprehension of the digital language instead they will be mere computer software users [20]. To achieve that, some resources can already be found in the literature [21, 22]. Inclusion of coding and CT approaches into the official curricula are considered as important initiatives [2, 23-24].

Learning how to program can make changes in the way that people think [4, 25]. The reason can be found the analytical component of CT, which is quite similar to mathematical thinking (i.e. problem solving), engineering thinking (processes design and evaluation), and scientific thinking (systematic analysis). In computational thinking, non-rote or non-mechanical skills are fundamental. [2]

CT can be useful not only for Computer Science students or professionals, but for everybody [2]. It is particularly relevant to start with the development of computational thinking as soon as possible. It has been proved that

even 4 years-old children can understand programming concepts, build simple robots and move them so that they can interact with the environment [26, 27].

2.2 Pedagogic Conversational Agents

Pedagogic Conversational Agents (PCAs) are intelligent virtual systems that teach some domain or train some competence in an interactive way by talking to the students [7].

PCAs can adopt different shapes, showing reactivity, autonomy, sociability, and the skill to take decisions to achieve their goals [28]. Agents can collaborate, compete, negotiate, or interact in different ways with the environment [29-30].

It is also highlighted the possibility of interacting with the students in natural language. The research in Natural Language Processing is still not mature enough to allow a full natural language dialogue between the student and the agent in any domain. Nevertheless, it allows a mixed dialogue focused on a limited domain [31].

PCAs can assume the role of teacher, student or companying. When the agent acts as a teacher, the student learns the topics or is trained in the competences (see Figure 1). When the agent acts as a student, the agent learns from the student (it could be the case that there is another agent in the system acting with the teacher role, see Figure 2). When the agent acts as a companion, it provides emotional help, with gestures or messages such as "You are doing well!" (see Figure 3).

For a more detailed review on PCAs, see [12].

Figure 1. Sample interface of a PCA acting as teacher

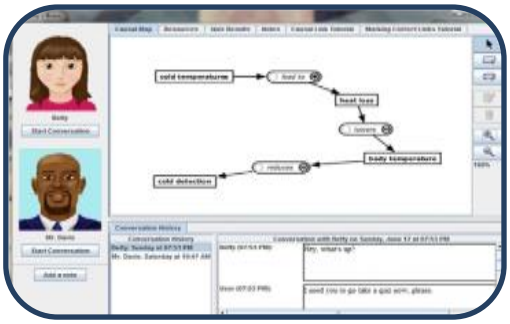

Figure 2. Sample interface of a PCA acting as student

Figure 3. Sample interface of a PCA acting as companion

3 PROPOSAL

In this paper, it is proposed the use of PCAs to develop computational thinking in children. The MEDIE methodology [12] will be followed to design and create such agent for children.

According to MEDIE, the first step is to communicate with the teaching team. This is the reason why the first step to create the agent has been to talk to programming teachers. They requested us a colourful agent with robot shape for 6-12 years old children. A first prototype in Spanish can be seen in Figure 4.

Figure 4. A first Spanish prototype of iProg

As can be seen, iProg has two scenarios as requested by the teachers: iProg storytelling and iProg chef.

iProg storytelling allows the children to create scenes, choose characters, objects and personalize the actions of the characters by using the iProg language programming. A first Spanish prototype of iProg storytelling can be seen in Figure 5. The goal is that children while interacting with iProg can create a story at the time that they are playing and programming.

iProg chef allows to apply the cooking-programming metaphor [13] that compares cooking with programming, and algorithms with recipes that should be followed step by step. A first Spanish prototype of iProg chef can be seen in Figure 6. The goal is that children while interacting with iProg can cook a recipe at the time that they are playing and programming.

To make clear how the PCA would be used the following learning paths are provided. In the case of iProg storytelling, the agent will first ask for a goal of the story, and later the agent will register the objects that the child chooses, and how they are used to fulfil the story goal. In the case of iProg chef, the agent will ask for a recipe to cook, and the child will execute step by step as in an algorithm the steps together with iProg to get the meal ready.

In both scenarios, it is taken into account how children have an initial mental structure based on before (initial analysis of the elements and actions to perform), during (the programming), and after (the result of the programming and how it has affected the elements of the story in iProg storytelling or the meal in iProg chef).

iProg will be used in several schools in Madrid to gather results of the experiences performed. Following MEDIE, after communication with the teaching team, the prototypes should be validated both by teachers and students. It requires going to the schools to know the students' opinions, and to reach a digital interactive version of the prototype with enough detail to allow children to start programming.

Another feature of iProg is that it will take into account the psychological aspects and emotions of the students. The face will show different gestures, and the lips will be animated to have voice. The goal is to provide a more real experience to the students, and to engage them more in the task, at the same time, that iProg develops computational thinking; it pretends to also help developing creative and emotional intelligence in the children.

For instance, if a psychological test at the beginning determines that a child likes everything in sequence, iProg chef will be provided, while if the test determines that the children likes to have a more global view, iProg storytelling will be provided. Nevertheless, to provide a whole training to the students, despite one of the scenarios will be the most prominent, the other scenario will be presented as well.

Multiple intelligences will be taken into account [32]. It is intended that iProg deal with the most prominent intelligence of each child, i.e. using more sounds for more musical children, or gestures for children who have that skill more developed. Nevertheless, as before, the goal is to develop all intelligences although there are some more prominent.

Figure 5. A first Spanish prototype of iProg storytelling

Figure 6. A first Spanish prototype of iProg chef

4 CONCLUSIONS

In this paper, it has been proposed for the first time the use of Pedagogic Conversational Agents to develop computation thinking in Primary Education children.

Pedagogic Conversational Agents have reported benefits in other domains, and levels from University to Pre-Primary Education. They have also been used to teach programming in the University, but it is the first time that they are proposed to teach programming to children and, at the same time, increasing the creativity of the students and taking into account their emotions

and multiple intelligences to develop computational thinking.

Once, the teachers have validated the iProg stories, and the iProg chef scenarios shown in this paper, the next step is to show them to children. It is our intention to involve children from the very beginning in the design of the agent to cover their expectations and needs as well as the teachers.

There are some similar experiments in this field. Tarkan et al [33] in their study show the importance of pair programming (Wiimote and Nunchuck), and a storytelling approach to programming. In this paper, it is intended to develop in children a sequential and structured reasoning linking the emotional part of children, through a graphical interface and storytelling approach.

Following an iterative and incremental process, the first basic programming concepts to be taught will be input/output, and once validated by teachers and students; more complex concepts as conditionals and loops.

Another research line is to compare the effectiveness and how impact on the emotions and creativity of the students the use of iProg versus Scratch following a Blended Learning methodology, once iProg has been integrated into the classrooms as indicated by MEDIE.

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