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Can Mindfulness Help Primary Education Students to Learn How to Program With an Emotional Learning Companion?

ELIZABETH K. MORALES-URRUTIA[1], JOSÉ MIGUEL OCAÑA[2], DIANA PÉREZ-MARÍN[3], AND CELESTE PIZARRO[4]

[1]Universidad Técnica de Ambato, 180103 Ambato, Ecuador
[2]Ejército Ecuatoriano, 180156 Ambato, Ecuador
[3]Ciencias de la Computación, Arquitectura de Computadores, Lenguajes y Sistemas Informáticos y Estadística e Investigación Operativa, Universidad Rey Juan Carlos, 28933 Madrid, Spain
[4]Matemática Aplicada, Ciencia e Ingeniería de los Materiales y Tecnología Electrónica, Universidad Rey Juan Carlos, 28933 Madrid, Spain

Corresponding author: Diana Pérez-Marín (diana.perez@urjc.es)

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ABSTRACT Teaching programming to children has attracted significant research in recent decades. In our previous work, we co-designed the learning companion called Alcody with children between 10-12 years old who had some previous programming knowledge. Alcody is based on Papert's constructionism theory, interacting with the students in pseudocode and providing recommendations as emotional support. Students using Alcody could significantly increase their scores in a programming test as well as seeming to be happy using the system. However, the relationship between the increase in scores and satisfaction and motivation levels was not explored. Moreover, since the COVID-19 pandemic, children have seemed too distracted and stressed to keep focusing on learning programming. This is why this paper introduces, for the first time in the literature, the use of mindfulness (the quality of being aware of the present moment) to help children focus before their programming sessions. The hypothesis is that by integrating mindfulness into the teaching of programming to children with an emotional learning companion, such as Alcody, the learning of programming concepts and students' attitudes to learning can be improved. To test the hypothesis, an experiment was carried out with 137 students between 10-12 years old during the 2020 summer, split into a control group (without mindfulness) and a test group (with mindfulness). The 69 students in the test group achieved a significantly higher improvement in their post-test programming scores, and significantly higher satisfaction and motivation levels than the students in the control group. Moreover, students in the test group reported that they liked the experience of practicing mindfulness and that they felt it helped them to focus. It is therefore concluded that integrating mindfulness practices into the teaching of programming to children can be beneficial to increase their scores, satisfaction, and motivation levels.

INDEX TERMS Mindfulness, emotional learning companion, learning programming, primary education.

I. INTRODUCTION

Teaching programming to children has many benefits, both for children who want to become Computer Engineers and for children who want any other profession. This is because by learning how to program, children are able to understand the world in which they live [1] and improve their cognitive skills [2]–[5].

However, teaching programming is not easy [6]. It has attracted a great deal of research since the 1980s with the pioneering work started by Papert's LOGO language based on the constructionism theory [7]. According to the Papert's constructionism, learning is better if the student can build some element (''the object to think with''). Students need to program to learn how to program, because learning will not happen just by listening or reading about programming. Moreover, the idea is that students should reach their own solution, as there is not a unique correct solution. For that, students should be guided to a correct solution [6].

Natural Language Interaction can be used to help students reach their solution [8]. Talking and writing make us think, and by thinking children can improve their programming

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knowledge and skills. As Papert said: "We learn better by doing…but we learn better still if we combine doing with talking and thinking about what we have done." "Life is not about 'having the right answer' – it is about getting things to work." [9].

Another possibility for teaching programming, and helping students create their programs is to use visual programming environments with multimedia languages such as Scratch [10]. Scratch is also based on Paperts' constructionism theory [11] and is currently one of the most used approaches to teach programming to children worldwide. There are many others [12] such as using robots [13] or unplugged approaches (without using technology) whose results are still under study [14].

However, there is still little evidence on how to design successful coding experiences for children according to their age, attitude and needs [11]. In our previous work [15], an emotional learning companion called Alcody co-designed with children between 10-12 years old was presented to explore the possibility of applying Papert's constructionism ideas of helping children to reach their own solution by programming in an environment adapted to their age, attitude and needs.

Learning can also be seen as the expression of personal feelings [16]. There is a relationship between the feelings of the children and how they can code. Therefore, emotions should be taken into account when teaching programming [17].

In the words of Papert, "You can't learn bread-and-butter (basic) skills if you come to them with fear and the anticipation of hating them." [7]. A learning companion should be able to support students' emotions to provide a pleasant environment that improves the learning experience.

Research has also been intense in the mindfulness field [18]. Mindfulness can be defined as a state of "non-judgmental, moment-to-moment awareness" [19], and has been studied across varied disciplines. Previous mindfulness research has explored its potential to regulate stress and improve cognitive, emotional, and interpersonal functioning [20].

In the current pandemic situation due to COVID-19, students could be more distracted and stressed and it could affect to their ability to learn. Mindfulness could be seen as a possible support to help learners to focus on the present moment and to remove distractions.

In this work, a step further is explored; can mindfulness practice be integrated into the teaching of programming for children? Would it be beneficial to increase their learning scores, motivation and satisfaction levels? What do the students think about practicing mindfulness?

An experiment with the same 137 children who had used Alcody during the 2019/2020 academic year to learn programming was carried out during the 2020 summer months. A control-test pre-post test research design was followed. All the students took a pre-test at the beginning of the summer. During the months of July and August, they connected online, one hour per week, to study loops with Alcody. Half of them were randomly assigned to the control group (no mindfulness) and the other half was randomly assigned to the test group (with ten minutes of mindfulness practice at the beginning of each session).

The results show not only that mindfulness can be integrated into the teaching of programming to children, but that students significantly increased their scores and reached higher satisfaction and motivation levels than children who did not practice mindfulness.

The paper is organized into seven sections: Section II presents related work; Section III describes the Alcody environment and learning companion; Section IV focuses on the experiment carried out; Section V presents the results; Section VI presents the discussion and threats to validity; and, Section VII ends the paper with the main conclusions and lines of future work.

II. RELATED WORK

A. TEACHING PROGRAMMING IN PRIMARY EDUCATION

Teaching programming to Primary Education students is not new. It was started by Papert in the 1980s with the constructionism approach [7]. The core ideas were that to learn how to program it was necessary to think with objects. The language used was LOGO and the object to think with was a turtle.

However, the complexity of finding teachers able to teach programming to children and the creation of many friendly computer programs shifted the focus from teaching how to create programs to teaching how to use programs since the 1990s until recent years.

The digital world in which children live makes some researchers think that just using computer programs, without understanding how they work, is not enough [1]. Moreover, an important milestone was the manifestation of the so-called "computational thinking" for students, who want or do not want to become computer engineers, but who will be able to solve their daily problems using computer resources [21]. Currently, teaching programming in Primary Education is seen as complex but a necessary and beneficial tool to develop other cognitive skills as well as logical thinking [22].

Many approaches are being explored to overcome the complexity of teaching programming to children. Pedagogic theories such as Papert's constructionism and, in general, learning by doing [23] can support the didactics of programming in the school tool. Ausubel's Meaningful Learning Theory [24] can also be helpful in considering that new knowledge should be built upon previous knowledge. Any significant learning comes from the link between previous concepts and new concepts. Given that for programming, many concepts must be learned such as sequencing, variables, input/output, conditionals and loops, the order in which these concepts are taught is important. Moreover, teachers should check that previous concepts have been learned before advancing to more difficult programming concepts.

Pérez-Marín *et al.* [1] combined the use of metaphors and the multimedia language Scratch [10] to ease students into the learning of programming with significant results.

Scratch is one of the most commonly used graphical drag-and-drop approaches to create programming like connecting puzzle pieces based on constructionism and learning by doing theories.

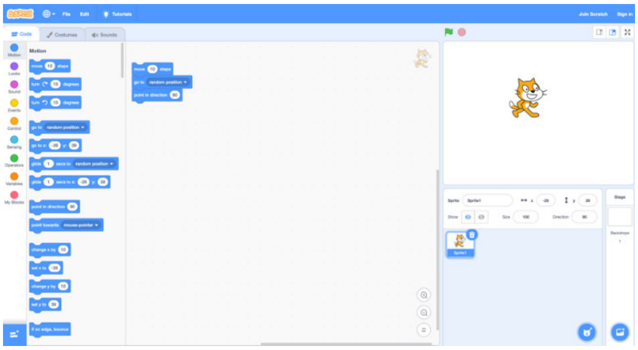

FIGURE 1. Sample Scratch snapshot.[1]

In Scratch, children are encouraged to create their own games with sounds, graphics and effects. See Figure 1 for a sample snapshot. Scratch is free to download or use online. As can be seen, on the left there are several instructions as puzzle pieces that children can drag and drop into the center to create their programs with objects such as the cat and see the results of the execution of the instructions. For instance, to move the cat several steps or make the cat say "Hello."

In Scratch there are instruction blocks for motion, looks (input/output instructions are grouped here), sound, events, control (conditionals, loops instructions are grouped here), sensing, operators, variables and the possibility of creating new instruction blocks.

Each category is associated with a color to make it easy for the child to find it on the left. There are parameters in some of them that can be typed into the indicated gap.

Scratch is highlighted as one of the most commonly used pieces of software. However, there are many other approaches such as using robots [13] and even unplugged approaches without devices [14]. Given that the focus of this paper is on the software approach, another four apps are reviewed because of their relevance on Google's Play Store or Apple's App Store: Kodable, Cargobot, LightbotJr and Easy Logic.

Kodable is also free software to teach programming to children from 5 years old (see Figure 2). As with Scratch, it is based on a drag-and-drop approach. It has several difficulty levels and contents to practice sequences, loops, variables, conditionals, algorithms, problem solving, as well as games to develop logical thinking.

Cargobot is an iPad app to teach programming like a game (see Figure 3). It uses the Codea language to give instructions to a robot so that it makes certains actions and passes several levels. It is also based on using puzzles. The main features of Cargobot are its beautiful graphics and puzzles to be solved by children.

[1]https://scratch.mit.edu/projects/editor/?tutorial=getStarted

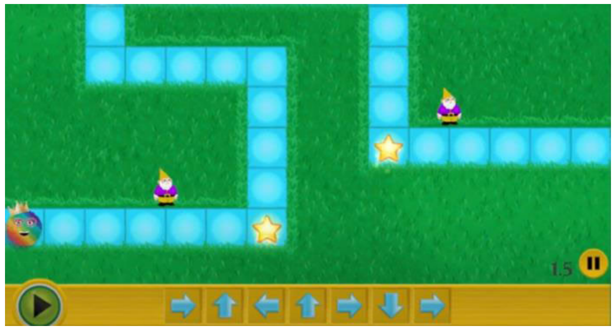

FIGURE 2. Sample Kodable snapshot.[2]

FIGURE 3. Sample Cargobot snapshot.[3]

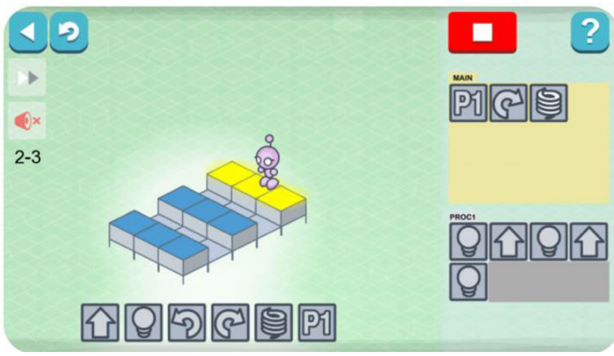

FIGURE 4. Sample LightbotJr snapshot.[4]

LightbotJr is an app to teach programming by asking children to tell the robot how to turn on the light in a room (see Figure 4). Using LightbotJr children learn about sequences, procedures, conditionals and loops.

EasyLogic [25] is software to teach programming with an affective tutoring system based on block techniques (see Figure 5). EasyLogic uses Google's Blockly interface[5] and responds to the emotional state of the students. The emotions that are taken into account by EasyLogic are boredom, engagement and frustration. The system evaluates when the student requires assistance, and helps them create their own algorithms and execute them using Javascript. EasyLogic is the software most relative to the proposal in this paper

[2]https://www.kodable.com/
[3]https://twolivesleft.com/CargoBot/
[4]http://lightbot.com/

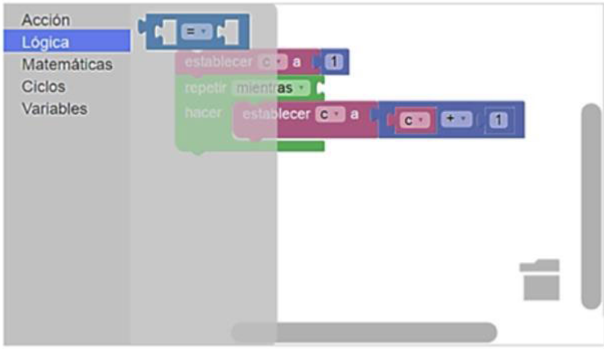

FIGURE 5. **Sample EasyLogic snapshot (source: [25]).**

as it relates teaching programming with affective states. Moreover, EasyLogic also offers tutorials, contextual help and courses on sequences, conditionals and loops. The preliminary results of an experiment with 10 students were satisfactory.

B. LEARNING COMPANIONS

A learning companion can be defined as an interactive system that possesses a certain level of intelligence and autonomy, as well as social skills, to maintain a long-term relationship with students [26]. The companion can communicate with students using voice, text, graphics, animations and any other multimedia element.

Learning companions can be classified according to several criteria such as their appearance, role, goal and context. They can appear as human beings, animals, robots, or even teachers. Depending on the role and goal, the companion could be just an emotional support for the student without providing knowledge or requesting knowledge; or, it is also possible for the companion to learn from the student following the "learning by teaching" approach [27].

Some examples are without computer devices and integrated into software. A sample without a computer device with an animal form could be Cognitoys such as Dino (see Figure 6) that uses IBM's Watson technology to answer children's questions. An example with a robot form could be the Wisconsin HCI learning companion robot for reading (see Figure 7). It was developed for children between 11-12 years old to accompany them while reading so that they are not alone when reading to promote an interest in reading [28]. In recent years, Augmented Reality has been incorporated so that children read with the robot as digital information can enrich what children read in the physical book.

Previous research has showed evidence that children using learning companions are more focused on their tasks than children using educational computer programs without learning companions [29]. Private tutoring with a learning companion has proved to be more efficient than only learning in classroom with more students as they had different learning

[5] https://developers.google.com/blockly

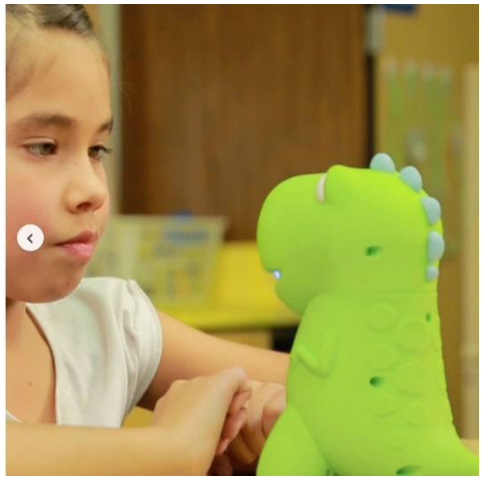

FIGURE 6. **Sample learning companion in an animal form.[6]**

FIGURE 7. **Wisconsin HCI robot for reading.[7]**

rhythms and the teacher could not adapt the interaction to the needs of each individual student [30].

In recent decades, Affective Tutoring Systems have also been created to detect the emotional state of students with or without a learning companion. Emotions have an impact on cognitive processes [31]. Empathy has also been researched for learning companions to motivate students to study with good results [32].

C. MINDFULNESS

Mindfulness can be defined as a state of "nonjudgmental, moment-to-moment awareness" [19]. It has its roots in the Buddhist philosophy and practices of letting go of the random ideas that distract people. The goal is to focus and have total attention on the present task with multiple benefits such as greater concentration and mental clarity, a reduction in distractions and rambling, a reduction in impulsivity, more effective management of stress and emotions, greater creativity

[6] https://computerhoy.com/noticias/life/green-dino-cognitoys-juguete-inteligencia-artificial-24511

[7] https://hci.cs.wisc.edu/project/a-learning-companion-robot-for-reading/

and empathy with others, and a greater enjoyment of the present moment [33], [34].

In recent decades, the practice of mindfulness has no longer been restricted to Buddhist temples as there has an emergence of the concept in broader social contexts or organizations such as schools, where it can benefit wellbeing for learning [35], [36]. In particular, many schools in Spain (private and public) have already incorporated mindfulness practices to help students focus and relax from the age of four [37].

O'Donnell [38] suggested that the widespread interest in mindfulness could be found in the common states of distraction, anxiety and lack of connection found in current society. In general, mindfulness offers a way to overcome the chaos and stress; and, in particular, for learners it has been used with satisfactory results.

An experiment with 83 students between 11-13 years old followed a mindfulness program by listening to audio recordings for 10 consecutive weeks (1 hour per week) to reduce aggressiveness in the classroom. The results found that mindfulness could be used as a tool to reduce aggressiveness in the classroom [39]. Mindfulness with audio recordings and 10-minute breathing exercises has also been proved useful to improve mental health through adaptive responses during emotional processing for children [40]. There is also solid evidence of a beneficial relationship between mindfulness and creativity [41].

For teachers, the use of mindfulness and contemplative approaches has also proved beneficial [42]. No previous studies on using mindfulness to teach programming to children have been found in the literature. However, a trend has been detected to mindfully code among programmers in pursuit of reduced stress levels and to be calm and able to focus on their tasks [43]. This is particularly relevant due to the COVID-19 pandemic that has increased the anxiety and stress levels of people all over the world.

III. ALCODY

In this section, Alcody is described as with our previous research [15]. A demonstration of Alcody can be used online at alcody.site with the username "diana" and the password "123." Section III.A provides the theoretical and practical reasons to use Alcody to test the benefits of mindfulness practice, Section III.B provides the theoretical famework, Section III.C describes the dialog management, Section III.D describes the emotional accompaniment, and Section III.E provides some previous results.

A. RATIONALE

Learning companions have proved to be efficient in teaching children adapting to their own rhythms as well as providing emotional support to motivate them to keep learning [29]–[32]. Learning companions can empathize with children as they have anthropomorphic features with a head, body and limbs. It is particularly relevant that the companion has a face to show emotions and to accompany the students, and a calm state to help students to study on-line at home in the current COVID-19 pandemic [15].

Moreover, Alcody seeks to help children to program through its pressence and messages by following a sympathetic strategy to guide users to a positive state with dialogue turns. It is necessary in the case of children with some Scratch previous knowledge, who want to keep learning how to program in their transition to more textual programing.

Up to our knowledge, no other emotional learning companion has been found to teach programming to children in their transition from block-based language programming to textual programming, which is why Alcody was chosen.

To sum up, efficiency (good results of using learning companions to teach before and during COVID-19), adaptability (different dialogue for each child), age (10-12 years old), previous knowledge (in the transition from block-based language programming to textual programming) and flexibility (being able to modify the source code of Alcody as we have created it) are the main reasons to use Alcody in this paper. All in all, other teaching digital tools could be combined with the mindfulness practice for younger students without previous programming knowledge (e.g. ScratchJr or Scratch), or for older students that could regard Alcody as childish (e.g. robots or more professional programming environments).

B. THEORETICAL FRAMEWORK

Under the constructivism umbrella [44], [45], the individual cognitive aspect of constructivism of Piaget's theory [46] can be higlighted because, to Piaget, knowledge can be seen as an experience that each child acquires through interaction with the world [47]. This is why, when teaching children in Alcody, it is important to consider their previous knowledge and their individual preferences and features and not just provide data but support the child to experience learning in a motivating and pleasant environment with the learning companion as shown in Figures 8 and 9.

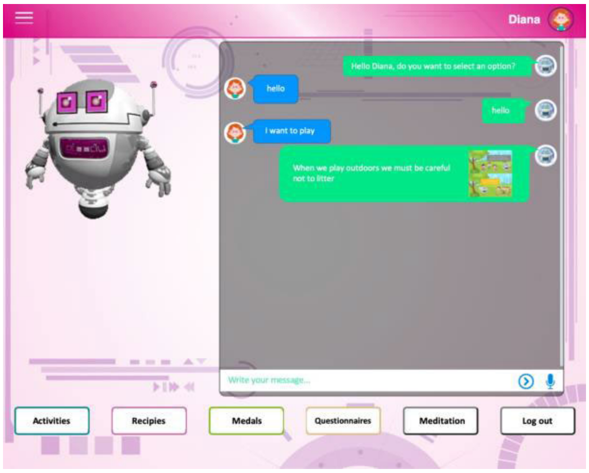

FIGURE 8. Sample Alcody interface.

According to Ekman, emotions can be defined as "a process, a particular kind of automatic appraisal influenced by our evolutionary and personal past, in which we sense that

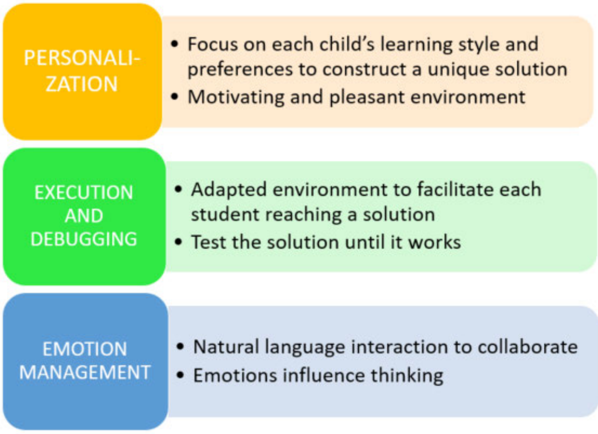

FIGURE 9. Connection between Alcody and constructionism (source:[15]).

something important to our welfare is occurring, and a set of psychological changes and emotional behaviors begins to deal with the situation." Emotions are taken into account, in Alcody, according to the Ekman's emotion theory [48] based on facial expressions (see Figure 10).

FIGURE 10. Basic Ekman's emotions in faces and avatars.[8]

There are other psychological theories about emotions but Ekman's theory is chosen as basis for Alcody because it is focused on "basic emotions" that must be accompanied by facial expressions and specific physiological responses. Surprise, sadness, fear, disgust, anger and joy have been integrated as basic emotions into Alcody with their animation and recommendations associated because they are a limited number of emotions, they have adaptative value, and, they can be combined to create complex emotions [48].

Moreover, according to Ekman's basic emotions involve an automatic assessment, are originated by universal triggers, are present in other primates, have a quick start, have a short duration, and, are associated with particular thoughts and experiences.

For Ekman, basic emotions have a universal communicator value. All members of our species interpret the expression similarly, regardless of context and sociocultural variables. Emotions inform our peers about the affective states that we feel, the antecedents that have triggered the emotion and the potential actions that can unleash.

Learning can also be seen as the expression of personal feelings [16]. There is a relationship between children feel and their ability to code. Highly motivated children can handle the cognitive load better and construct their artifacts better. Alcody was designed to support and manage students' basic emotions to provide a pleasant and motivating environment that leads the learning experience to success.

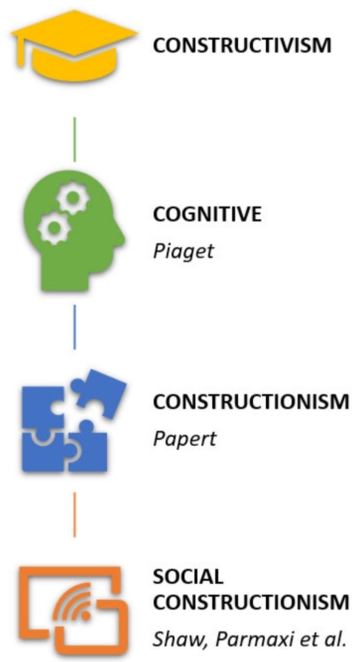

FIGURE 11. Theoretical framework of Alcody [15].

For instance, if students are sad because of the COVID-19 situation, Alcody can show them a sad face and provide them with a recommendation to feel better to reach an optimal state to keep learning how to program when they are no longer sad Papert *et al.* [7] extended the Piaget's cognitive constructivism by taking the context and media into account (see Figure 11). Context is important for Alcody, as when children are in their lessons (face-to-face or online) they can talk to each other about the programs they are creating, collaborate, show the teacher their progress and ask questions if they have doubts.

The idea is not to isolate children when using Alcody but to integrate its use into the classroom by mixing the benefits of social interaction with the computer to learn how to program as the mediating tool (even more necessary when face-to-face lessons are not possible and all interaction is through the computer).

In Papert's own words, constructionism can be defined as "Constructionism—the N word as opposed to the V word—shares constructivism's connotation of learning as 'building knowledge structures' irrespective of the circumstances of

[8]https://www.scoop.it/topic/paul-ekman-by-wolfgang-axel

learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe.'' [49].

Papert's constructionism is more pragmatic than Piaget's cognitive constructivism [16]. It is considered that students will learn to program by programming using computers and reaching their own solution. This is why personalization and adaptation options are so relevant in Alcody and students are allowed to test their programs until they work.

Social constructionism is an evolution of constructionism with an emphasis on the social setting whilst engaging the student in the artifact construction [50], [51]. By creating social meaningful artifacts such as games, children seem able to learn how to program as described in Section II.

Social constructionism is also valuable to enhance the social setting [52]. Children can become the producers of their programs in their cultural historical social context by interacting with other children and taking their emotions into account [17].

C. DIALOG MANAGEMENT

Alcody has been co-designed with children between 10 and 12 years old [53] following the MEDIE methodology [54]. According to the co-design, Alcody has a robot form with pastel colors. Alcody is usually calm as shown in Figure 10, ready to talk in the chat with children to teach them programming by asking them to create some program involving input/output, conditionals or loops. The interface and dialog with Alcody is currently only available in Spanish. Figures 12 and 13 have been translated for the benefit of non-Spanish readers.

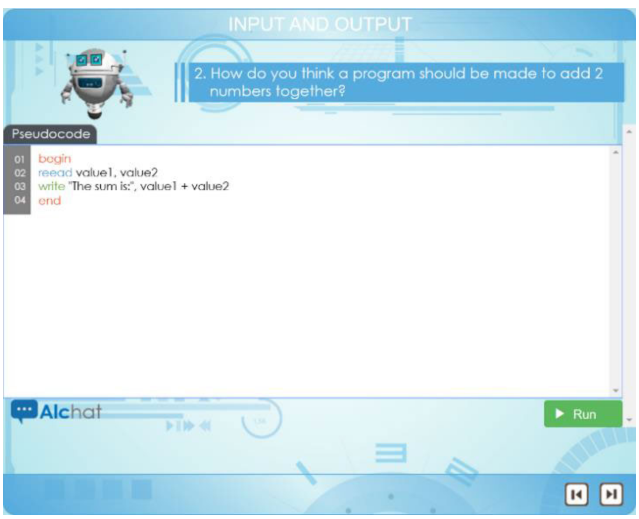

FIGURE 12. Sample Alcody p-code program (source: [15]).

As can be seen in Figure 12, Alcody is asking students to write a program to add two numbers together. Students must type the program using Alcody's p-code (see Table 1) and click ''Run.''

FIGURE 13. Sample help provided by Alcody's debugging possibilities (source: [15]).

TABLE 1. Alcody p-code (source: [15]).

Instruction	Explanation
begin	Marks the beginning of a program
end	Marks the end of a program
write "t" | var	Show something on screen (text between " " or the data from the name of the variables)
read *var*	Read a value from the keyboard and save it in variable *var*
if *cond* then *X* else *Y*	Marks the beginning of a condition with two branches (*X*, *Y*) depending on *cond*

Alcody compiles the program. It is not interpreted line by line so students have to think about the whole program and they get the result of the compilation. If the result is as expected, Alcody congratulates them and asks for another program that covers the programming curriculum concepts given by their teachers. If the result is not as expected, as shown in Figure 13, Alcody's debugger can help students by making them aware of their mistakes with informative feedback so that students can think and retype the program until they reach the correct solution [55].

Alcody has six tutorials about the programming concepts to teach students to understand them and how to program using Alcody's pseudocode. Tutorials are available during all sessions with Alcody so that students can use them as many times and as often as they need.

D. EMOTIONAL ACCOMPANIMENT

Alcody has been provided with management for six emotions (see Figure 14): surprise, sadness, fear, disgust, anger, and happiness. Whenever children instead of writing a program in the Alcody chat use an expression related to emotions such as ''I want to play'' or ''I am afraid,'' Alcody provides some recommendations to address their emotional state with the idea of reaching an optimal state to be able to think about the program required.

FIGURE 14. Emotions in Alcody.

At the beginning of each Alcody session, the companion asks the children how they are. They can then choose to start programming, play with the recipes and games if they are allowed, or receive some recommendation from Alcody if they say that they do not feel good.

Recommendations in Alcody have two images: the first one is related to the emotion detected in the children and, the second provides a message to help children overcome or cope with the situation. Alcody connects with the emotion of the children as shown in Figure 14 (with its face and body expression) to show empathy and later it goes back to its normal state. Children are again asked about their emotions at the end of the sessions with Alcody.

For instance, if it seems that a child is only thinking that they would like to be outdoors writing sentences like "I would like to be outdoors" or "I am bored," Alcody would detect it and the recommendation shown in Figure 15 would appear on screen.

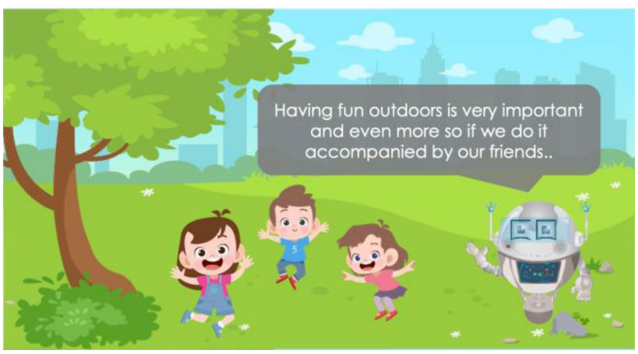

FIGURE 15. Sample recommendation provided by Alcody.

The happiness emotion is detected whenever children use expressions such as "I want to have fun," "I like school," "I am happy" or "I like to play." The disgust emotion is detected whenever children use words such as disgust, dislike, unpleasant, ugly classroom, ugly house, untidy, "I have complicated homework," difficult homework, horrible homework, "it bothers me," "it makes me angry," "doesn't love me" or "doesn't care." The anger emotion is detected whenever children use words such as "I push myself," "I hit," "I bounce," "I throw it," "I hit it," "I get mad," mad, or "I am upset." The fear emotion is detected when children use words such as "I'm sick," "I'm afraid of the doctor," "I don't want to go to the doctor," nightmares, "I has a nightmare," "I couldn't sleep," "I am scared at night," or monster. The surprise emotion is detected whenever children use words such as "how untidy," "this puzzles me," or "I do not understand." The sadness emotion is detected whenever children use words such as "I have nothing," "I want to cry," "I feel very bad," "I am poor," "I am exhausted," "I am tired," "I am not making any progress" or "I've got a bad grade."

In the new version of Alcody, children can also have access to a 5-minutes mindfulness audio recording before they start using the program. The goal of the audio recording is to help them relax and focus on the programming task during the session. The audio recording starts with the sound of a bell and continues with breathing exercises until the sound of a bell marks the end of the session.

E. PREVIOUS RESULTS

In [15], it was reported how Alcody was used by 137 students aged between 10 and 12 with previous programming knowledge in Scratch in their transition to learning textual programming for ten months. Students were able to significantly increase their learning scores in a pre-post test on writing programs covering the input/output concept from 0.88 in the pre-test up to an average score of 8.01 in the post-test, and the conditions concept from 0.98 in the pre-test up to 6.97 in the post-test using a 0 (minimum) up to 10 (maximum) scale.

Regarding satisfaction, 95% of the students indicated that they were satisfied. However, given that the satisfaction questionnaire was anonymous, it was not possible to relate the increase of learning scores with satisfaction levels.

It was not possible to study how to support students that may be suffering from the COVID-19 situation and, although they reported being happy using Alcody, it was observed that they had problems focusing when the lesson was not face-to-face and they were at home.

IV. METHOD

The study is a pre-post control-test group design. Following an adaptation of the guidelines to report experiments in Software Engineering written by [56], [57], this section is structured as follows: A. Goal, B. Participants and Context, C. Experimental Material, D. Tasks, E. Variables, F. Hypotheses, G. Experimental Instruments, H. Procedure, I. Analysis Procedure, and J. Validity and Reliability.

A. GOAL

The main goal of the study was to find out whether integrating a mindfulness approach to teach programming to children could be beneficial in increasing their learning, satisfaction and motivation levels. Three quantitative research question were formulated as follows:

RQ1. How can the practice of mindfulness in teaching programming to children with an emotional learning companion affect their learning gains?

RQ2. How is the practice of mindfulness related to the satisfaction perceived by the students when learning how to program with an emotional learning companion?

RQ3. How is the practice of mindfulness related to the motivation perceived by the students when learning how to program with an emotional learning companion?

Moreover, a fourth, more qualitative research question was formulated to take students' opinions into account.

RQ4. What do students think about the practice of mindfulness to focus on their programming lessons?

B. PARTICIPANTS AND CONTEXT

The experience was conducted during the 2020 summer with 137 students (aged between 10 and 12). Almost half the students were girls. All had already used Alcody during the 2019/2020 academic year to learn about sequencing, memory, input/output, and conditionals with a significant increase in their learning scores and a positive attitude to the system [15].

Due to the lockdown, all students continued to connect online from home using their computer. All children had a computer, the digital skills to use it, and an Internet connection.

As in the previous experiment, neither the children nor the teacher was paid for using Alcody nor given educational credits or higher scores as a reward. They were committed to their classes as using Alcody was integrated into their lesson activities.

Again, no permission was granted by the school to record the sessions. The consent was to allow children to use Alcody. Confidentiality was assured, as children did not give their name to Alcody at any time. However, assigning an independent variable to any personal information was permitted to code each student to find the relationships between the scores, satisfaction and motivation values.

Given that it was a Catholic school, children were used to starting their lessons with a prayer and giving thanks to God, and the school allowed us to play the mindfulness audio recording at the beginning of the lessons too. No children knew of mindfulness or had practiced mindfulness before the experiment.

Randomly assigning each student to either a control group (without mindfulness) or a test group (with mindfulness) was also permitted.

C. EXPERIMENTAL MATERIAL

All educational material was provided in the Alcody educational environment for both the tutorials and programming exercises. Alcody's curriculum was focused on the loops concept. The goal was to teach the meaning of loops in programming, and to develop students' skills in writing programs using the loops instructions in p-code.

The mindfulness audio was recorded and provided by an expert instructor with the breathing exercises and the sound of the bell at the beginning and end.

Other materials could have been used to test the influence of mindfulness in teaching programming such as the programs reviewed in Section II with a different sample, for instance, children between 6-8 years old without previous programming knowledge. However, given the sample, for children who already knew Scratch and were in the transition from block-based programming languages to textual programming, no better alternative to the learning companion to teach programming to children integrating mindfulness was found in the literature.

D. TASKS

There was a one-hour lesson with Alcody per week. Students were allowed to read or listen to the loops tutorial if they had any doubts during the lesson. The first ten minutes were devoted to praying and thanking God and mindfulness practice for students in the test group, and praying and thanking God in the control group (no mindfulness). See Figure 16 for a sample mindfulness session with the test group.

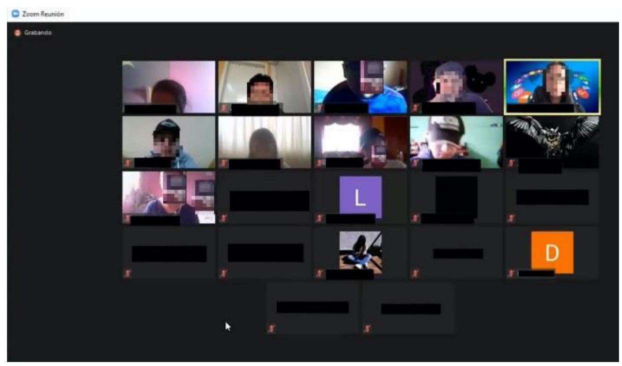

FIGURE 16. Sample online mindfulness practice before using Alcody in the test group.

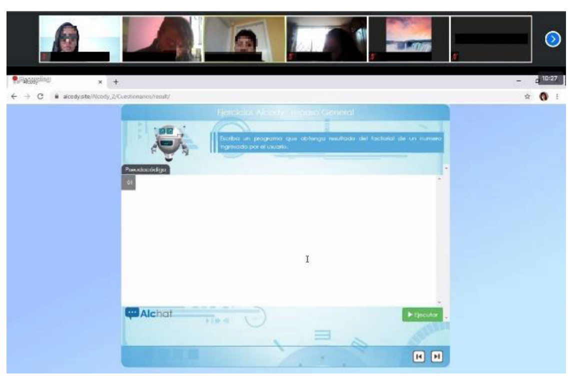

FIGURE 17. Sample lesson with Alcody.

The following fifty minutes were for all students to solve the exercises asked by the companion in the chat. Figure 17 shows a sample image of an online session with Alcody.

The photo was taken during a real session, which is why the interface is in Spanish as it is the original Alcody interface.

Table 2 shows the timing with the teaching activities asked of the children.

TABLE 2. Timing of the teaching with alcody.

Period	Concepts covered with Alcody
June 2020	Tutorials to remember Alcody's p-code and previous concepts. Post-test of previous concepts and pre-test for loops
June-August 2020	Loops concept
End of August 2020	Post-test for loops

The Zoom videoconference software was used one hour per week following the school timetable for the lessons. Students in the control group were in their virtual room only with the teacher without mixing with the students in the test group. Similarly, students in the test group connected with the teacher in a different room at a different time without mixing with the control group. The test group connected on Tuesdays at 11:20am and on Wednesdays at 9:45am. The control group connected on Fridays at 9:45am and Thursdays at 11:20am. Children could only connect to the Zoom room at those times and with their teacher and members of their group. They were not allowed to access any other room at a different time in Zoom and no face-to-face lessons were possible due to the COVID-19 pandemic.

The same teacher taught the control and test group during all the lessons. The teacher always checked that students connected in their group. Belonging to the control or test group was permanent throughout the experiment and all students connected through the sessions.

The only difference in the students' tasks between the control and test groups was the use of mindfulness. They had to complete the same activities to cover the loops concept.

E. VARIABLES

The dependent variables of the pre-post test single group experiment were related, firstly, to learning programming concepts, measured by scores obtained for the students in tests at the beginning and end of the experiment. These scores (Pretest, Posttest) were gathered with the tests described in Section V.G. Secondly, two dependent variables were related to the students' levels of satisfaction and motivation. They were ordinal variables scaled from 1 to 10. They were measured using an opinion questionnaire filled in by all students at the end of the experiment.

One factor, Group, is considered to be an independent variable, related to the use or not of mindfulness. Table 3 contains the list of dependent and independent variables.

F. HYPOTHESES

In this section, a main hypothesis under study is presented and the working statistical hypotheses used to answer it is described.

TABLE 3. Summary of variables, type (DV- dependent variable, IV – independent variable), name and description.

Aspect	Type	Variable	Name
Learning of programming concepts	DV	Pretest scores	Pretest
	DV	Posttest scores	Posttest
Psychological factors	DV	Level of Motivation	Motivation
	DV	Level of Satisfaction	Satisfaction
	IV	Use of mindfulness	Group

H: Integrating mindfulness into the teaching of programming to children with an emotional learning companion increases the learning of programming concepts and improves students' attitude to learning.

H encompasses three sub-hypotheses:

H_a: If children practice mindfulness before their programming learning sessions, they will achieve higher learning gains than children who do not practice mindfulness before their programming learning sessions.

In this case, two different aspects are involved in this hypothesis:

1) EFFECTS BETWEEN SUBJECTS

The objective is to know whether there is any significant difference between the pretests for the control and test groups. The same applies for the posttest (whether there is any difference between the posttests for the control and test groups). The null hypothesis for the pretests is therefore:

H_{0apre}: there were no significant differences in pretest scores between students who practiced and did not practice mindfulness.

In simple terms, the null hypothesis is that the two groups come from the same population.

Likewise, for the posttest, it is:

H_{0apost}: there were no significant differences in posttest scores between students who practiced and did not practice mindfulness.

2) EFFECTS WITHIN SUBJECTS

The objective now is to know if there is any significant difference between pretest and posttest scores in the control group, i.e., students who did not practice mindfulness and, also, if there was any significant difference between pretest and posttest scores in the test group, i.e., students who practiced mindfulness.

The null hypothesis for the test group is therefore:

H_{0atest}: there were no significant differences in pretest and posttest scores for students who practiced mindfulness.

Similarly, the null hypothesis for the control group is:

$H_{0acontrol}$: there were no significant differences in pretest and posttest scores for students who did not practice mindfulness.

Hb: If children practice mindfulness before their programming learning sessions, they will achieve higher satisfaction levels than children who do not practice mindfulness before their programming learning sessions.

As the variable Satisfaction was recorded after the experiment, it asks whether satisfaction levels were higher in the test group than in the control group. The null hypothesis is therefore:

H_{0bsat}: there were no significant differences in satisfaction levels between students who practiced and did not practice mindfulness.

Hc: If children practice mindfulness before their programming learning sessions they achieve higher motivation levels than children who do not practice mindfulness before their programming learning sessions.

It is similar to the previous hypothesis. As the variable Motivation was also recorded after the experiment, it asks whether motivation levels were higher in the test group than in the control group. The null and alternative hypotheses are therefore:

H_{0cmot}: there were no significant differences in motivation levels between students who practiced and did not practice mindfulness.

G. EXPERIMENTAL INSTRUMENTS

Three instruments were used in the experiment: a programming test, an opinion questionnaire for the control group and an opinion questionnaire for the test group. The programming test asked the following question focused on evaluating the students' loops programming skills:

Q1. Write a program to count from 1 to 5. *(loops concept)*

The question was evaluated from 0 (minimum score) to 2 (maximum score), awarding 0.5 points for each of the following four aspects to consider whether the loops program was correct:

1) The use of a counter variable.
2) The creation of a stop condition.
3) To correctly increment the counter variable.
4) The correct use of the syntax.

```
iniciar
para i=1 hasta 5
escribir i
siguiente i
finalizar
```

FIGURE 18. Rubric to evaluate Alcody's p-code for the loops test.

Figure 18 shows sample correct Alcody p-code to count from 1 to 5 using i as the counter variable, the stop condition ("hasta 5"), incrementing the counter variable with the instruction ("siguiente i") and the correct use of syntax.

The questionnaire for the control group consisted of two questions to gather information on how students perceived the experience of using Alcody without mindfulness. The questionnaire for the test group also had those two questions plus two additional questions on their opinion regarding the practice of mindfulness. Table 4 gathers the questions, their possible answers, and their related psychological factors

TABLE 4. Final opinion questionnaire.

Question	Possible answer	Psychological factor
1. (all) On a scale from 0 (minimum) to 10 (maximum), what is your satisfaction level?	Number (0-10)	Satisfaction
2. (all) On a scale from 0 (minimum) to 10 (maximum), what is your motivation level?	Number (0-10)	Motivation
3 (test) Do you like to practice mindfulness?	Likert scale (1-5)	Opinion
4. (test) Do you think that mindfulness is useful in helping you focus?	Yes/No	Opinion

Questions 1 and 2 were the same for all the students as they asked about the satisfaction and motivation levels reached on a scale from 0 (minimum) to 10 (maximum) after having used Alcody to learn loops.

Students in the test group (with mindfulness) were also asked questions 3 and 4 about whether they felt that mindfulness had helped them focus more on their programming and their opinion regarding the use of mindfulness to learn programing with a learning companion.

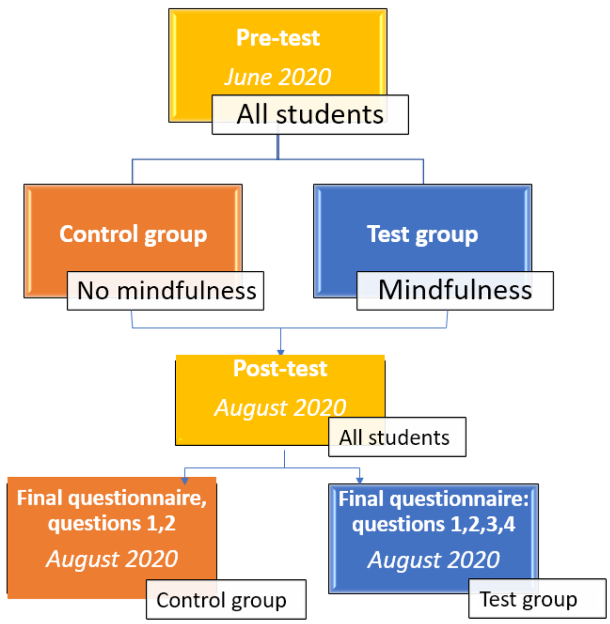

FIGURE 19. Diagram of the experiment procedure.

H. PROCEDURE

A pre-post test procedure was followed for two months (see Figure 19). The progress of the students' loops programming skills was measured by asking all students to complete a pre-test at the end of June 2020 and a post-test at the end of

August 2020. The pre- and post-test were the same programming test described in Section IV.G

At the end of August 2020, all students were also asked to fill in a final opinion questionnaire as described in Section IV.G. Students in the control group were asked by their teacher whether they knew what mindfulness was and if they had practiced it at some point during the summer to help them in their learning.

I. ANALYSIS PROCEDURE

To answer RQ1 and test Ha, two different procedures were involved depending on the type of effect.

First, the effect between subjects was studied. A possible model that would include this study is an ANCOVA model, where the pretest variable would act as a covariate, the postttest variable as a dependent variable, and the group variable as a factor. Unfortunately, although there is normality in the data, there is no equality of variances between the two populations.

Thus, after checking the independence between the samples for the control group and the test group (for both the pretest and posttest variables), an independent samples t-test was chosen to compare the control and test groups in pretest and posttest.

Specifically, the pretest null and alternative hypotheses are as follows:

$$\left.\begin{array}{l} H_{0apre}: \mu_c = \mu_t \\ H_{1apre}: \mu_c \neq \mu_t \end{array}\right]$$

where μ_c is the mean of the pretest in the control group and μ_t is the mean of the pretest in the test group.

A similar test was used for the posttest:

$$\left.\begin{array}{l} H_{0apost}: \mu_c = \mu_t \\ H_{1apost}: \mu_c \neq \mu_t \end{array}\right]$$

Note that if there was no significant difference between the control group and the test group in the pretest, it could be said that both groups were homogeneous at the beginning of the experiment, i.e., both the control group and the test group start under the same conditions. Thus, looking directly at the posttest score of both groups would be an indication of improvement in the score.

For the second part of the study developed in Ha, after checking the correlation between the two groups (pretest and posttest for the test score variable), the paired t-test was used.

Therefore, the null and alternative hypotheses for the test group are:

$$\left.\begin{array}{l} H_{0atest}: \mu_{pre} = \mu_{post} \\ H_{1atest}: \mu_{pre} = \mu_{post} \end{array}\right]$$

where μ_{pre} and μ_{post} are pretest and posttest means respectively.

Likewise, the null and alternative hypotheses for the control group are:

$$\left.\begin{array}{l} H_{0acontrol}: \mu_{pre} = \mu_{post} \\ H_{1acontrol}: \mu_{pre} = \mu_{post} \end{array}\right]$$

To answer RQ2 and test Hb, a nonparametric test was used due to the lack of normality and homoscedasticity in the samples. After checking for independence, the Mann-Whitney U test was used.

The null and alternative hypotheses are:

$$\left.\begin{array}{l} H_{0bsat}: P(x_i > y_i) = \frac{1}{2} \\ H_{1bsat}: P(x_i > y_i) \neq \frac{1}{2} \end{array}\right]$$

where x_i is an observation of the Satisfaction variable in the test group and y_i is an observation of the Satisfaction variable in the control group.

To answer RQ3 and test Hc, a similar study to the previous hypothesis was developed. The null and alternative hypotheses are:

$$\left.\begin{array}{l} H_{0cmot:P}(x_i > y_i) = \frac{1}{2} \\ H_{1cmot:P}(x_i > y_i) \neq \frac{1}{2} \end{array}\right]$$

where x_i is an observation of the Motivation variable in the test group and y_i is an observation of the Motivation variable in the control group.

To answer the qualitative RQ4 question, the free-text responses given by the students to the third question of the final opinion questionnaire were classified using the COUNTIF function in Excel.

J. VALIDITY AND RELIABILITY

This section summarizes the validity and reliability of the study. Statistical calculations were performed with the program IBM SPSS Statistics, Version 25.

First, the validity of the questionnaire was quantified using Aiken V [58] that can be used to summarize item content-relevance ratings obtained from a panel of expert judges. In this case, ten experts were asked about clarity, appropriateness and relevance for different items of the test, scoring from 0 to 4, with 0 being the lowest value. All items obtained an Aiken V value greater than 0.8, which is considered acceptable, see [59].

Inter-rater reliability for the three raters who used the rubric to code the scores was evaluated using Fleiss' kappa [60], attaining a value of 0.78 and considered substantial agreement.

The overall internal consistency of the questionnaire was evaluated using Cronbach's alpha, attaining 0.973 [61].

Finally, it is also necessary to validate the consistency of the hypotheses by answering these two questions:

1) Are the hypotheses described in Section IV.F adequate and sufficient to answer the research questions of the paper?

2) With the experiment described would it be possible to test the hypotheses described in Section IV.F?

Regarding question 1: to test Ha answers RQ1, to test Hb answers RQ3, and to test Hc answers RQ3. This can be said because there is previous literature as [62] who proved in her mindfulness training for children "Pay attention works!" that just half an hour per week (10 minutes each day) during eight weeks can improve students' skills to focus before school activities. Only RQ4 would not have an associate hypothesis given its qualitative nature. Therefore, it can be said that the hypotheses are adequate as they serve to answer the RQs of the paper, and that they are sufficient as they cover all RQs of the paper.

Regarding question 2: it is possible to test the hypotheses as it is possible to collect data from the students in pre-post test learning scores and questionnaires with information about their satisfaction and motivation levels. Moreover, an independent samples t-test can be chosen to compare the control and test learning scores in the pretest and posttest to test Ha, and a Mann-Whitney nonparametric test can be used to test Hb and Hc given the nature of the data as explained in Section IV.I. With the results gathered, the hypotheses can be tested and conclusions reached.

V. RESULTS

A. LEARNING GAINS

Related to RQ1, effects between subjects were studied. Firstly, a descriptive analysis of the data was performed to explore any possible improvement in the post-test score compared to the pre-test, in both the control group and the test group.

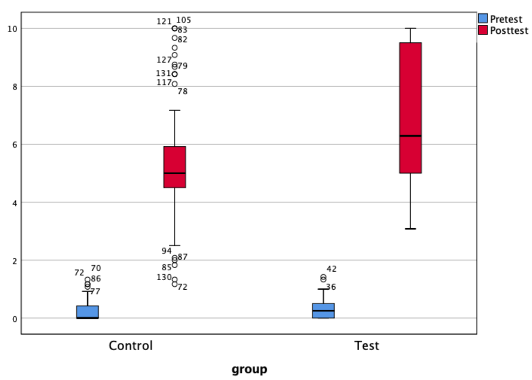

FIGURE 20. Pre- and post-test box plots for all concepts.

Figure 20 shows the grouped box plots for the different variables studied, both pretest and posttest, for the control group and the test group. They show the homogeneity in the pretests for both groups, with mean and median at 0.24 and 0.00 respectively in the control group, and 0.30 and 0.25 in the test group. The standard deviation is very similar at 0.37 in the control group and 0.34 in the test group. All of them have different atypical data marked with circles. In addition, both groups show a gain in the posttest score, with a greater dispersion compared to the pretest score in both cases (2.09 and 2.30 for the control and test groups respectively). In the test group, higher values are generally presented, with the mean at 6.99 and the median at 6.29, with the control group being 5.36 and 5.00. Numerous outliers are shown in the posttest of the control group, both below the upper and lower range. In the case of the test group, however, there are no outliers. The values in Table 5 complement the previous comments.

TABLE 5. Descriptive analysis of the sample.

	Control		Test	
	Pre	Post	Pre	Post
N	69	69	68	68
$\bar{x}$	0.24	5.36	0.30	6.99
MED	0.00	5.00	0.25	6.29
SD	0.37	2.09	0.34	2.30

These insights taken from the descriptive analysis will be analyzed in detail using the statistical tests shown below.

After checking normality in the samples, it was verified that there was no significant correlation between them in the control and test groups for Pretest and Posttest. The independent samples t-test was used and the results obtained shown in Table 6.

TABLE 6. Results of the Independent Samples t-test between the control and test groups in Pretest and Posttest.

	t	df	Sig.	d
PRETEST (CONTROL-TEST)	1.09	135	0.278	-
POSTTEST (CONTROL-TEST)	4.33	133.44	0.000	0.75

As evidenced in Table 6, there is no significant difference ($p = 0.278$) between the scores of the control group and the test group. It can therefore be said that the experiment started from a pretest with homogeneous populations in both groups (control and test). Thus, comparing the posttest scores is representative of student learning, since both groups started from the same point.

Regarding the posttest, there is a significant difference ($p = 0.000$) between the scores of the control and test groups. The effect size of the t-test is calculated using Cohen's d [63]. The effect size, 0.75, corresponds to a large effect, with a percent change of 30% (large increase).

TABLE 7. Results of the Paired t-test between pre-test and post-test in the control and test groups.

	t	df	p-value	d
CONTROL (PRE-POST)	20.08	68	0.000	3.44
TEST (PRE-POST)	23.93	67	0.000	4.1

For the second analysis, effects within subjects related to RQ2, a paired t-test was carried out to compare the scores for pre and posttest in the control and test groups. Table 7 reflects the significant increase in the score between the pre and posttest for both the control and test groups, with $p < 0.01$. This increase was quantified using d. There is a huge effect ($d = 3.44$) in the control group. In test group there is also a huge effect, with a value higher than the control group ($d = 4.1$)

1) SATISFACTION

Related to RQ3, the possible relationship between the use of mindfulness and the degree of satisfaction of the students was studied.

As a first approximation, a bar chart for each pair of variables is shown. Figure 21 shows higher levels of satisfaction for the test group than the control group.

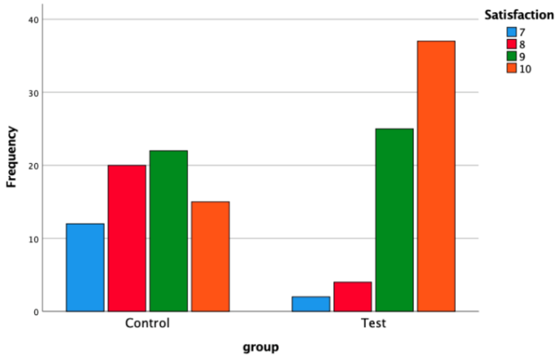

FIGURE 21. Bar chart for Group and Satisfaction variables.

After this first insight, a more in-depth study, through correlation calculations was carried out. Given that the variables studied, (Satisfaction in control group and Satisfaction in test group) are both ordinal variables, the non-parametric correlations between them were first calculated. Kendall's Tau-b was used to evaluate the correlation between variables. Table 8 shows that there was no significant correlation between them.

TABLE 8. Non-Parametric correlations for Satisfaction in the control and test groups.

	Value	Sign.
Kendall's Tau-b	0.17	0.1

TABLE 9. Mann-Whitney U test for satisfaction, using the variable group as the i.v.

	Mann-Whitney U	Z	p-value	Effect-Size (r)
Satisfaction	1241.50	5.02	0.000	0.41

Therefore, it was decided to analyze the differences between Satisfaction in the control and test groups with a non-parametric test for independent samples. The Mann-Whitney U test was chosen to compare differences between two independent groups. Table 9 shows the output for this test, as well as the value of effect size r in the case of significant differences between groups, calculated, again, following recommendations about the effect size of the non-parametric test, i.e., $r = \frac{Z}{\sqrt{N}}$, with N being the total number of observations on which Z is based. Satisfaction values of the test group were significantly higher than the control group. The effect size of 0.41 corresponds to a large effect.

2) MOTIVATION

Finally, and related to RQ3 too, the possible relationship between the use of mindfulness and the degree of motivation of the students was studied.

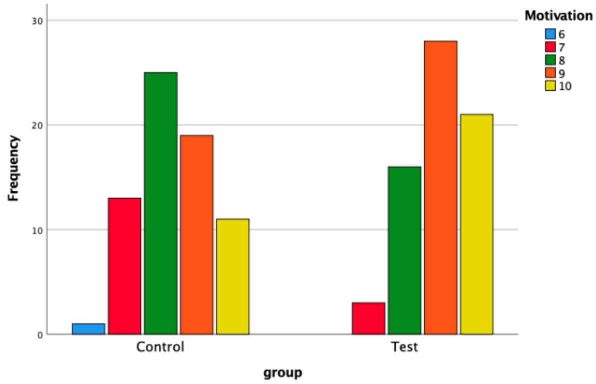

FIGURE 22. Bar chart for Group and Motivation variables.

Again, as a first look, a bar chart for each pair of variables is shown. Figure 22 shows higher levels of motivation for the test group than the control group.

Kendall's Tau-b was used to evaluate a possible correlation between the variable Motivation in the control group and the test group. Table 10 shows that there was no significant correlation between them.

TABLE 10. Non-Parametric correlations for Motivation in the control and test groups.

	Value	Sign.
Kendall's Tau-b	0.02	0.874

Therefore, it was decided to analyze the differences between Motivation in control and test groups, using the Mann-Whitney U test (see Table 11).

TABLE 11. Mann-Whitney U test for motivation, using the variable group as the i.v.

	U Mann-Whitney	Z	p-value	Effect-Size (r)
Motivation	1554.00	3.56	0.000	0.29

Table 11 shows the output for this test, as well as the value of effect size r in the case of significant differences between groups. This test shows significant differences between the two groups, with $r = 0.29$, corresponding to an intermediate effect.

B. OPINION ABOUT MINDFULNESS

The opinion of the students in the test group (who practiced mindfulness before learning to program with Alcody) were recorded in questions 3 and 4 at the end of the experiment as described in Section V.

Figure 23 shows the 69 answers to question 3 "Do you like to practice mindfulness?" on the Likert scale: 1 - I hate it

FIGURE 23. Results of question 3.

(0 answers); 2 - I do not like it (1 answer); 3 - It is indifferent to me (4 answers); 4 - I like it (8 answers); 5 - I love it (55 answers).

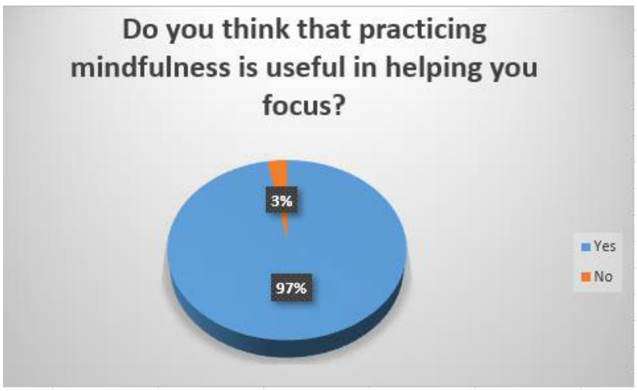

FIGURE 24. Results of question 4.

Figure 24 shows the 69 answers to question 4 "Do you think that practicing mindfulness is useful in helping you focus?" as Yes (66 answers) and No (3 answers).

VI. DISCUSSION

A. EVALUATION OF RESULTS AND IMPLICATIONS

To the best of our knowledge, this is the first time in the literature that children have practiced mindfulness before their programming learning sessions.

Three quantitative research questions were formulated regarding the impact of mindfulness on students learning programming, their satisfaction and motivation levels as well as one qualitative research question regarding students' opinion on practicing mindfulness to learn programming.

Regarding RQ1. How can the practice of mindfulness in teaching programming to children with an emotional learning companion affect their learning gains? To test Ha, if children practicing mindfulness before their programming learning sessions will achieve higher learning gains than children who do not practice mindfulness before their programming learning sessions, an independent samples t-test was chosen to compare the control and test groups in pretest and posttest. The results in Section VI.A revealed a significant increase in the post test scores of the test group (higher than the control group). These results are related to findings of similar studies in which mindfulness was also used to help children study at school [35]–[37], [42]. It was in different domains and ages but, in all cases, mindfulness was proved beneficial for children as a way of reducing their stress and helping them focus [38], and in general, improving their mental health [40], [63]. As a practical implication, teachers in Primary Education trying to teach programming with a learning companion such as Alcody could allow 10 minutes of mindfulness practice before the lesson to achieve higher learning gains.

Regarding **RQ2. How is the practice of mindfulness related to the satisfaction perceived by the students when learning how to program with an emotional learning companion?** To test Hb, if children practicing mindfulness before their programming learning sessions will achieve higher satisfaction levels than children who do not practice mindfulness before their programming learning sessions, a Mann-Whitney U test of the data gathered in the questionnaire revealed a significant increase in the post test scores of the test group (higher than the control group). In particular, the satisfaction values recorded for the test group were significantly higher than the control group with a 0.41 effect size, which corresponds to a large effect.

Previous studies on the impact of mindfulness have also revealed an improvement of job satisfaction for adults [65], and in general, life satisfaction for healthy people [66] and people with some illness [67]. This study contributes to the literature by providing results indicating an improvement of students' satisfaction also in the context of teaching programming to Primary Education students. As a practical implication, Primary Education teachers could have an additional reason to introduce mindfulness before teaching programming to their students as they will increase not only the students' learning gains but also their satisfaction levels.

Regarding RQ3. How is the practice of mindfulness related to the motivation perceived by the students when learning how to program with an emotional learning companion? To test Hc, if children practicing mindfulness before their programming learning sessions will achieve higher motivation levels than children who do not practice mindfulness before their programming learning sessions, a Mann-Whitney U test of the data gathered in the questionnaire revealed a significant increase in the post test scores of the test group (higher than the control group). The test (see Table 10) showed significant differences between groups, with $r = 0.29$ indicating an intermediate effect.

This result is interesting because most papers in the literature on mindfulness focus on the opposite relationship: how motivation improves attention [68]–[70]. This paper explored how being focused on the task helps to become more motivated. It could also be related to the other mindfulness principle of not judging anything as good or bad, but just accepting everything as it is. It could improve motivation as children do not judge tasks as bad but as tasks to complete with their full attention at that exact moment [62], [71]. As a practical implication for Primary Education teachers of programming, introducing mindfulness before their lessons means they could not only improve the learning scores and satisfaction levels, but also the motivation levels.

Regarding **RQ4. What do students think about the practice of mindfulness to focus on their programming lessons?** The results in Section VI.D revealed that children liked the practice of mindfulness and that they thought it helped them focus. This is particularly relevant because, due to the COVID-19 pandemic, they had to connect online during the summer from home. It is a strange situation as children are used to being in class with their classmates and teacher. It is similar to the strange situation of teleworking that many people are currently doing and who, by practicing mindfulness, have perceived themselves as being more focused and reported feeling better [72]. As a practical implication for teachers in general during the COVID-19 pandemic, mindfulness could be a support to help students focus before their lessons.

B. THREATS TO VALIDITY

The study presented some threats to validity [73]:

- **Construct validity**: The instrumentation based on questionnaires to measure cognitive-emotional processes could be a threat to validity. In this study, this threat was minimized by limiting the answers to the questionnaires to categories like yes/no or a 1-5 Likert scale. Moreover, the combination of quantitative and qualitative data when dealing with emotional aspects in research helps to provide more valid data [74].
- **External validity**: the situation of the COVID-19 pandemic has affected all our lives as well as the lives of the students in the experiment and that should be taken into account. Moreover, although students in the test and control group were never mixed as they connected online with their teacher, the control group was formed with two groups of the school and the test group was formed with another two groups of the school as usually happens in research in education in real classrooms.
- **Internal validity**: Thanks to the pre-post test research design, some of the threats due to internal validity are removed as differential rates of mortality and selection bias [75], [76]. However, there are some internal threats to validity such as possible different digital skills and resources that students have at home, as they were not connected all together in the classroom. That all students had the same teacher could also have an impact, but in learning how to program with Alcody the teacher is only for questions regarding problems with the computer or to show progress as the key element of the teaching is in Alcody so this factor is not so relevant here. That some students could have parents that help them with the mindfulness practice while other students could have more skeptical parents that do not support or help their children so much with either mindfulness or learning programming may also affect motivation. Similarly, parents who rewarded their children more or less could have some impact on students' satisfaction. It is very difficult to separate those factors as the experiment was with children during the summer at home, and in general, as happens in any experiment outside the lab [77]. However, it can be shown that there was no contamination between the control and test group. Students in the control group did not mix with the students in the test group. The only difference between both groups was the use of mindfulness. No children (neither in the control nor in the test group) had any previous knowledge of mindfulness. At the end of August, after the post-test of the control group, the teacher asked the students whether they had used mindfulness to help them focus to study, and all students in the control group answered that they did not have any knowledge of mindfulness to help them focus on their learning. It could also be seen as a threat that students had previously used Alcody. However, it should not have a great impact on the results of this paper, as both students in the test and control groups had used Alcody.
- **Conclusions validity:** this is related with sources of random error and the appropriate use of statistics and statistical tests [78]. In this paper, all possible validity checks have been provided. However, a possible remaining threat could be the use of a rubric with a finite and discrete number of values.

VII. CONCLUSION AND FUTURE WORK

The use of mindfulness in education, in this case, for first time in teaching programming to children, has proven to be beneficial to students' learning, satisfaction and motivation. In an experiment with 137 students aged between 10 and 12 years old using the learning companion Alcody for two months. Although all students significantly increased their scores (as happened in previous studies with Alcody) the 69 students in the test group who practiced mindfulness before their programming sessions achieved a significantly higher improvement in their post-test programming scores, and significantly higher satisfaction and motivation levels than students in the control group who did not practice mindfulness. Moreover, students in the test group reported that they liked the experience of practicing mindfulness and that they felt it helped them to focus.

This study is not without its limitations. Some are: (1) lack of randomization when assigning students to the control and test groups. Due to the restrictions of the schools, it was decided to randomize the entire classes and assign all the students of the same class to the control or test groups, (2) the study was carried out only once in a single school, so it would be desirable to carry it out with more students in different schools, (3) there is no previous specific literature on this subject. This work could constitute the spearhead of future research.

As for future work, the intention is to overcome the limitations found, explore the relationship between mindfulness, anxiety, scores, satisfaction, motivation and frustration when children are learning to program with an emotional companion or even when they are starting to program using block-based language programs such as Scratch. We are also working to integrate mindfulness tips during all programming sessions (not only at the beginning). The goal is to test, during an academic year, how students who receive mindfulness tips deal with programs that do not compile or produce a different result to that expected compared to students who do not receive mindfulness tips.

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ELIZABETH K. MORALES-URRUTIA is currently a Computer Teacher and a Teaches Software of design with the Faculty of Design and Architecture, Technical University of Ambato. She has been a Master in Teaching and Curriculum and Technologies for teaching management and practice. She has also been teaching for 14 years. She has written a book about learning Libre in Office in Kichwa. Her research interests include related to programming teaching and learning processes and information technology in education.

JOSÉ MIGUEL OCAÑA is currently pursuing the Ph.D. degree in information and communication technologies with the Rey Juan Carlos University of Spain.

He has worked as a Teacher with the University of the Armed Forces for four years and occasionally with the Technical University of Ambato. Since 2018, he is been a part of the Universitas XXI Research Group, Rey Juan Carlos University. He is also a Computer Administrator with the Ecuadorian Army, for 17 years, and a Master in information technology. At the moment, he has published several scientific articles of impact and has participated in national and international conferences. His research interest includes human–computer interaction.

DIANA PÉREZ-MARÍN received the Ph.D. degree in computer science and telecommunication from European, in 2007.

She worked as a Lecturer and a Researcher with the Universidad Autónoma de Madrid for ten years. She has been a Lecturer and a Researcher with the Universidad Rey Juan Carlos, Madrid, Spain, for ten years, where she is currently an Assistant Professor with the Computer Science Department. She is a member of the Laboratory of Information Technologies in Education (LITE). Her research interests include human–computer interaction, computer assisted education, and computer science education. She has published more than 100 articles in nationals and internationals journals and conferences. She was a recipient of several awards.

CELESTE PIZARRO received the Ph.D. degree in computer science and mathematical modeling from Universidad Rey Juan Carlos, Madrid, Spain, in 2006, and dual the M.Sc. degrees in mathematics and statistics from the Universidad de Extremadura, Badajoz, Spain, in 2000 and 2001, respectively. She is currently Assistant Professor in applied mathematics with Universidad Rey Juan Carlos, where she is also an Assistant Professor with the Department of Statistics and Operations Research. Her research interests include different mathematical programming fields (stochastic, integer, and linear) and their applications.