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Computational Thinking Initiation. An experience with robots in Primary Education

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Abstract: Computational Thinking (CT) is an increasingly interesting educational trend, since it is currently thought that the next generation will need to master this skill in order to succeed in modern life. At the same time, research indicates that motivation is a key element that affects the effectiveness of educational processes. Consequently, educators should take into account this fact when designing teaching sequences. In this paper, we present a robotics-based instruction for third-grade students aimed at introducing computational thinking ideas. The experience was carried out with 63 students. An assessment of different indicators concerning learning outcomes, such as mental rotation or computation thinking gains, was performed. In particular, from a motivational perspective, a test developed by Keller (1983; 1987; 2010) was employed in order to assess four dimensions: attention, relevance, confidence and satisfaction. Results show the participants' high motivation after working with robot computational ideas. These results may eventually support the use of educational robotics in order to promote students' development of computational thinking in primary schools.

Keywords: *Computational Thinking; Educational Robotics; Motivation; Primary Education; Instructional learning.*

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Introduction

The World We Live In

Currently the world revolves around technology. Every day, millions of people send millions of messages through communication apps, emails, etc. In addition, we use all kinds of software to perform everyday tasks such as buying and selling things, controlling our accounts, playing, traveling, etc. This means that we organize our lives through computer technology. It is clear that technology can be found everywhere in our society, and that it impacts almost every aspect of our daily lives. For

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this to be possible, it has been necessary to develop specific hardware and software to improve and introduce technology in all possible situations.

Faced with this situation, people need a minimum amount of knowledge and skills in order to adapt to the changing environment around us, something which Manovich (2013) describes as a software-driven world, and these skills are included in computational thinking (CT). Citizens should be prepared, since in the future it is possible that technological tools will be the only tools for work and socialization (Beran, Ramirez-Serrano, Kuzyk, Fior, & Nugent, 2011; Díaz, Queiruga, Tzancoff, Fava, & Harari, 2015) and, consequently, citizens will be obliged to know how to use them (Nath & Som, 2017). Therefore, schools, as a reflection of society and as the teaching centers for future citizens, have the obligation to use and integrate technology in the classroom. Based on the above, there are several proposals on how to integrate digital literacy coding in the K-12 education curricula (Angeli et al., 2016; Balanskat & Engelhardt, 2015; Barr & Stephenson, 2011; Bocconi et al., 2016; Brennan & Resnick, 2012; Llorens, García-Peñalvo, Molero, & Vendrell, 2017). These proposals offer very different approaches to the learning of CT in K-12 education, For example, while some of them integrates literacy coding and CT as cross-disciplinary elements in curricula (see, e.g., Angeli et al., 2016), others recommends a specific subject or area focused on coding languages (see, e.g., Brennan & Resnick, 2012).

Although programming is obviously useful to develop CT, CT encompasses more elements and is more complex that just using programming languages (Resnick et al., 2009). CT is a type of thinking that can be employed in an array of tasks in our daily lives. For instance, Henderson (2009) claims that "writing instructions, choreographing a dance using graphical software, cooking from a recipe, following instructions to construct a table, or using an electronic instrument are all examples of everyday computational thinking" (p. 100). However, some areas, such as CT, are more prone to require the use of CT. Indeed, Swaid (2015) showed the direct relationship between CT and STEM subject. STEM areas seem to be the most powerful for acquiring this type of thinking in students, where mathematics is the common component in all of these areas. In addition, code-literacy skills are understood to be an important part of STEM disciplines (Weintrop et al., 2016). However, there are researchers who present CT as interdisciplinary content in education, because, in the end, CT is a way of reasoning that includes different aspects of intelligence and knowledge. This allows the use of CT continuously in our daily life (Balladares, Avilés, & Pérez, 2016; Hemmendinger, 2010; Valverde-Berrocoso, Fernández-Sánchez, & Garrido-Arroyo, 2015; Wing, 2006, 2010) .

Finally, the introduction of technology in the classroom must be relevant in education, so that it increases the effectiveness of student learning, or prepares students for the future in a better way. Therefore, this paper focuses on the motivation of learners. Motivation is one of the most powerful elements in the learning process, because high levels of motivation bring about an increase in practice (Cabero, Fernandez, & Marín, 2017), and practice is necessary for learning (Poulos, Ponnusamy, Dong, & Fanselow, 2010). In addition, many studies with an educational instruction design have investigated, in depth, the effects of motivation (Huang, Huang, Diefes-Dux, & Imbrie, 2006), and how to apply strategies to improve motivation in these designs (Loorbach, Peters, Karreman, & Steehouder, 2015).

Why Assess Motivation?

CT gives us a new role in our interaction with computational agents, changing this from one of being digital consumers to being software and hardware creators and developers (Resnick et al., 2009; Zapata-Ros, 2015). This new role should be taught not only, as Alan Perlis points out, at university level (Guzdial, 2008), but also from elementary educational levels. For this reason, educational policies are working on introducing CT into their curricula (INTEF, 2018; Manches & Plowman, 2017; Micheuz, 2008; Shute, Sun, & Asbell-Clarke, 2017; Swaid, 2015; The Royal Society, 2012; van Diepen, Perrenet, & Zwaneveld, 2011), encouraging researchers and teachers at different educational levels to introduce CT into the classroom, producing different ways of introduction CT into curricula (see, for example: Angeli et al., 2016; Balanskat & Engelhardt, 2015; Bocconi et al., 2016; Brennan & Resnick, 2012).

One of the most important factors in educational contexts is student motivation. Motivation is identified as a complex element that stimulates and has an influence on learning behaviors (Gage & Berliner, 1998; Huang et al., 2006). It has been shown that there is a direct relationship between motivation and practice, since higher levels of motivation lead to more practice (Cabero et al., 2017).

The concept of motivation is complex and has been defined from different perspectives. In our study, we understand motivation as the “students’ willingness to participate in class activities and their reasons for doing so” (Brophy, 1998, cited in Cheng & Yeh, 2009, p. 597). In educational settings, the ARCS Model, developed by Keller (1987, 2010), has been employed myriad of times to test the effect of instructional materials (Loorbach et al., 2015). Additionally, a recent meta-analysis emphasized that the use of the ARCS model was predominant in areas such as STEM and Technology, and that this model has been employed with K-12 students (Li & Keller, 2018).

The ARCS model is determined by the interaction of four dimensions: attention, relevance, confidence and satisfaction. Attention, relevance and confidence are goals that people should have in order to be motivated to learn (Keller, 2010). In the first of these dimensions, motivation towards learning happens when the student perceives a gap in his/ her current knowledge, which leads them to pay attention. This leads to the second dimension, which is generated when it is perceived that learning is useful for their interests, in other words it is relevant. The third dimension occurs if they consider that they will be successful in carrying out the task, or knowledge learning, which affects their confidence. Finally, all of these dimension converge in satisfaction, at which point positive results are anticipated for the task to be carried out (Keller, 2008). The fact of maintaining adequate levels of satisfaction means the students will maintain motivation (Rodgers & Withrow-Thorton, 2005). To determine the motivational performance of the instructional design used, Keller (2010) designed the

Instructional Materials Motivation Survey (IMMS) instrument. This instrument is relevant in the general scientific scene, and in our study in particular, because it has been validated with high reliability and used in numerous studies in which the use of technology as a motivational factor is analyzed (Bolliger, Supanakorn, & Boggs, 2010; Li & Keller, 2018; Rodgers & Withrow-Thorton, 2005; Wenhao Huang, Diefes-Dux, Imbrie, Daku, & Kallimani, 2004).

What Is Computational Thinking?

CT as a concept first appeared in 2006 following the definition of Wing (2006) who expressed it as a process that "involves solving problems, designing systems, and understanding human behavior" (p.33). Nevertheless, CT is a type of thinking based on the idea of “procedural thinking” situated in the constructionism theory of Papert (1983), therefore, CT basis are not so new. The first definition established by Wing caused a confrontation with some researchers such as Glass (2006), who stated that the description of CT was so close to the meaning of problem solving that CT did not exist. As a consequence, (Wing, 2008, 2010) reformulated the definition of CT including its form and utility. This new definition described the concept as "the thought processes involved in formulating problems and their solutions, so that the solutions are represented in a form that can be effectively carried out by an information-processing agent" (Cuny, Snyder, & Wing, 2010, cited in Wing, 2010, p.1). We can conclude that CT is human thought, focused on solving problems from a computational viewpoint. It is a procedure that combines humans’ inherent and computational skills in order to solve problems, resulting in a synergic process between humans and computational agents. It is important to understand that CT is not programming, but programming is part of CT (Resnick et al., 2009).

Why Robots?

Robotics is part of every sector of our lives in an increasingly broad and sophisticated way. We are constantly interacting with robots, assigning them tasks that facilitate our own work in the different fields in which we operate. Therefore, learning about the different uses of robots is interesting and useful.

In the educational context, the latest NMC / CoSN Horizon Report, in its K-12 version (Freeman, Becker, Cummins, Davis, & Hall Giesinger, 2017), presents educational robotics as one of the most important advances in technology in the short term, due to the enormous diversity of possibilities it offers. Its interest in the classroom has been progressively increasing over recent years, in parallel to a process of conceptual transformation and application that has evolved from a traditional version, which involved the development of technical knowledge from the construction and programming of robots (Barker & Ansorge, 2007), towards more innovative learning paradigms (Gaudiello & Zibetti, 2016) in which the robot becomes a tool, at the service of teachers and students, to develop skills and promote the acquisition of content and competences of practically all curricular areas (Mubin, Stevens, Shahid, Mahmud, & Dong, 2013).

In this sense, even acknowledging the scarcity of studies which analyze the integration of robotics in the classroom (Benitti, 2012; Toh, Causo, Tzuo, Chen, & Yeo, 2016), educational robotics seems to be beneficial in terms of motivation (Chin, Hong, & Chen, 2014; Karim, Lemaignan, & Mondada, 2016), problem solving (Lindh & Holgersson, 2007), participation (Toh et al., 2016), teamwork (Varney, Janoudi, Aslam, & Graham, 2012), and cooperative learning (Denis & Hubert, 2001), among others. Likewise, the generalization of increasingly cheaper new robots, and the progressive introduction of computational thinking in the classroom, through visual programming by blocks (Román-González, 2016), allow students to participate in interactive and attractive highly-experienced learning experiences (Chang, Lee, Wang, & Chen, 2010).

Methodology

Research Goal

The current paper aims to evaluate whether the use of educational robotics in a multidisciplinary context of map-reading tasks influences third-grade student motivation. Although motivation has been largely studied before, the present study analyses it in a novel context with regard to previous literature. First, the instructional approach used in the study analysis the motivational effect of educational robotics in a multidisciplinary approach within two subjects, Mathematics and Social Sciences. Second, the instruction was designed to be developed in the same amount of time that is usually devoted to this kind of instructions in Year 3. Finally, all the tasks employed in the instruction were oriented to promote students' acquisition of CT.

Participants

Participants were selected from three third-grade classrooms at a primary school in Spain. Students were organized into two different groups (experimental and control). The study was carried out during the first term of the academic year, so all the participants were seven or eight years old at the time. The experimental and control group consisted of 27 students (12 girls and 15 boys) and 26 students (15 girls and 11 boys), respectively. The classroom teachers reported that none of the groups had previous experience either working with robots or in programming activities before the study.

Instruments

In order to assess the students' mental rotation ability, an adapted instrument of the Map Test for Children (Peter, Glück, & Beiglböck, 2010) was used. This instrument is designed for pre- and elementary school students to evaluate basic components of the use of maps. This instrument consists of 16 items which show two map views, in which there is a series of buildings whose layout on the map changes. For each item, the buildings were numbered in the overhead map view, but not in the 3D view. In the 3D view there was a single building marked with a colored dot. The task consisted of identifying the building marked with the dot in the 3D view in the overhead map view. Students had 30 seconds to complete each item. In this study, we only focused on the 8 items that required the students to use mental rotation skills.

Another instrument used was an adaptation of the Computational Thinking test (Román-González, Pérez-González, & Jiménez-Fernández, 2017; Román-González, 2016) which evaluates different elements of CT. In particular, we were interested in measuring the students' proficiency regarding sequences and loops, so the instrument consisted of 12 items. All the items from the both previous tests were evaluated in a binary manner, as correct or incorrect. Consequently, each student was assigned a score calculated as the number of correct responses.

However, concerning student motivation, we employed the Instructional Materials Motivation Survey (IMMS) instrument (Keller, 2010). This instrument has been designed to evaluate the motivational effect that the use of educational materials can promote. The instrument consisted of 36 items using a 5-point Likert scale, from 1-totally disagree to 5-totally agree, and addressed the four motivational dimensions: attention, relevance, confidence, and satisfaction (Keller, 1987, 2010).

Procedures

The intervention was geared toward introducing primary students to CT activities while addressing, at the same time, contents from Mathematics and Social Sciences curricula. In particular, the intervention was focused on map-reading tasks, a topic which is usually worked on in both subjects in the third grade, but usually without appropriate coordination. The design of activities from the intervention had to necessarily take into account: (a) the students' prior CT proficiency, and (b) the duration of the intervention. Regarding the former, although a pre-test was employed to confirm this fact, the prior level of CT was expected to be very low since the students had not completed programming activities before, nor was there any evidence of any activity somehow related to CT. In relation to the duration, it must be said that a specific objective when designing the intervention was not to exceed the time that teachers usually devote to working on map-reading tasks at this educational level. Often research papers show interesting pedagogical proposals that, however, teachers feel do not fit within curricula constraints. For this reason, we tried to design a teaching sequence which was easy to implement in a real classroom. A survey with over 100 teachers indicated that these types of task are usually covered over a two-hour period.

Therefore, taking into account these constraints, we opted for including only CT concept in the intervention. In particular, among the different CT concepts (Brennan & Resnick, 2012), we focused on *sequences*. Since the teaching sequence was the first time the students would get any programming experience, we chose the most basic concept and, additionally, we measured the complexity of the programs that students had to write in order to check that they were appropriate for beginners. With this in mind, we used the app *Dr. Scratch* (Moreno-León, Robles, & Román-González, 2015). *Dr. Scratch* is a web-app which assesses the complexity of programs written in *Scratch.* Given the fact that the code generated when programming *Ozobot* is not compatible with *Dr. Scratch*, we translated the programs from *Ozobot* to *Scratch*. After testing them in *Dr. Scratch*, a low level of complexity was observed in all cases. Indeed, the programs were rated with a complexity of 3 on a scale of 21 (see Figure 1). The results supported our view that these tasks might be appropriate for introducing students to programming and CT.

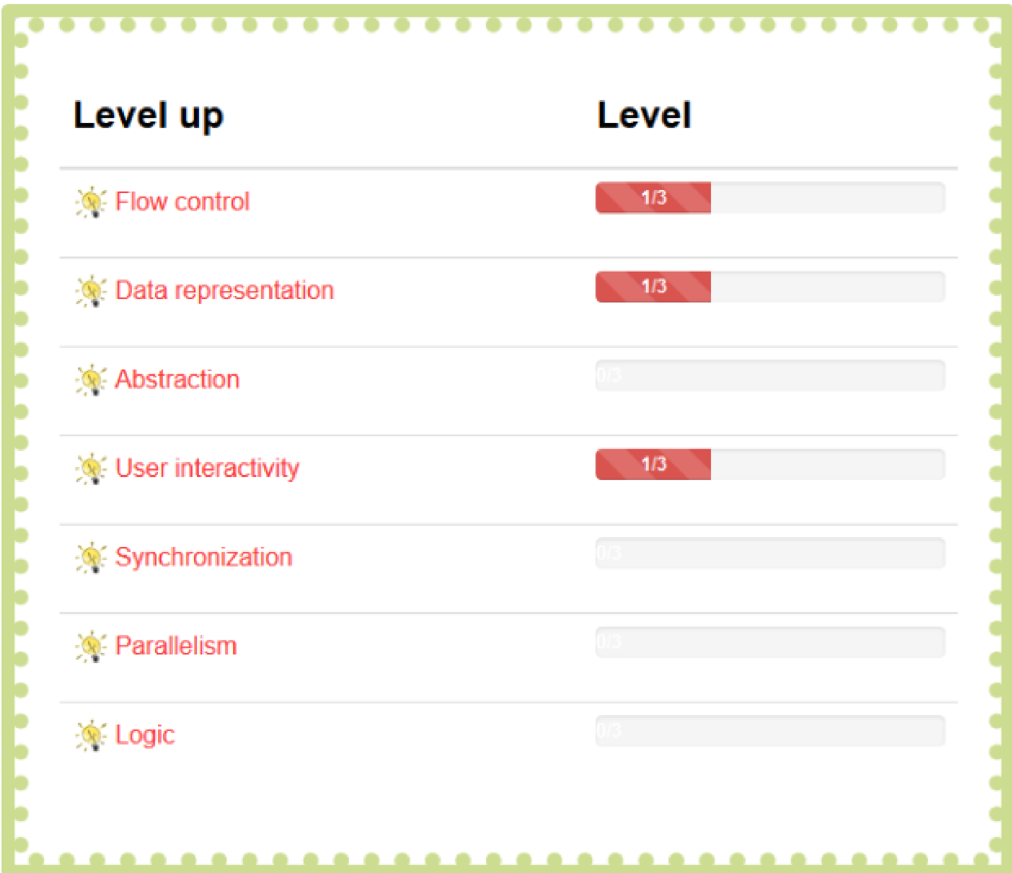

Figure 1. Assessment with *Dr. Scratch* of a program used in the study

Based on what has been previously mentioned, a quasi-experimental study was carried out. Both pre- and post-tests was employed to measure to what extent the students' CT and mental rotation level evolved depending on the type of intervention. However, this paper is exclusively focused on the effect of the intervention on the students' level of motivation.

One week after the pre-test, the intervention took place. The organization of the intervention in both control and experimental group was analogous. Consequently, students from the control group spent the same time on the same tasks as the students from the experimental group, as well as being provided with the same maps. Students from both conditions completed a first set of tasks working in small groups of four students, and later worked individually to solve a second set of tasks. The duration of the intervention in both cases was two hours. The control group worked in a pencil-and-paper environment, which is usual when solving map-reading tasks. In contrast, the intervention in the experimental group was based on the use of educational robotics. In particular, the educational robot used was the *Ozobot* robot.

Ozobot is a small robot, about 2.5 cm in height and diameter. One of the advantages of this robot is the ease of loading the program in the robot. In addition, the coding is carried out with an online block-based visual programming tool. These programming languages are especially suitable when introducing students to programming (Lye & Koh, 2014; Román-González et al., 2017; Román-González, 2016; Sáez-López, González, & Cano, 2016). The experimental group started with a brief explanation about how to program the *Ozobots*. This phase lasted 15-20 minutes. After this initial instruction, students from the experimental group were divided into groups of four, like the control group. Then, an A0-sized map of the city where the students lived was placed in the middle of the classroom. Additionally, each group was provided with two A3-sized maps. Then, all the groups in the experimental intervention were given a set of tasks. All the tasks were introductory activities that required the students to determine how to go from one location to another. The routes were relatively simple, because these first activities were designed in order to get the pupils of the experimental group familiar with the coding and loading of programs in *Ozobot*. Students from both groups were asked to write itineraries on paper, and for the experimental group was also to program the robots to complete the routes and check their solution. With this in mind, students from the experimental group were provided with tablets to access *Ozoblockly* (https://ozoblockly.com/), the block-based editor for coding and loading the programs into the robots (see Figure 2).

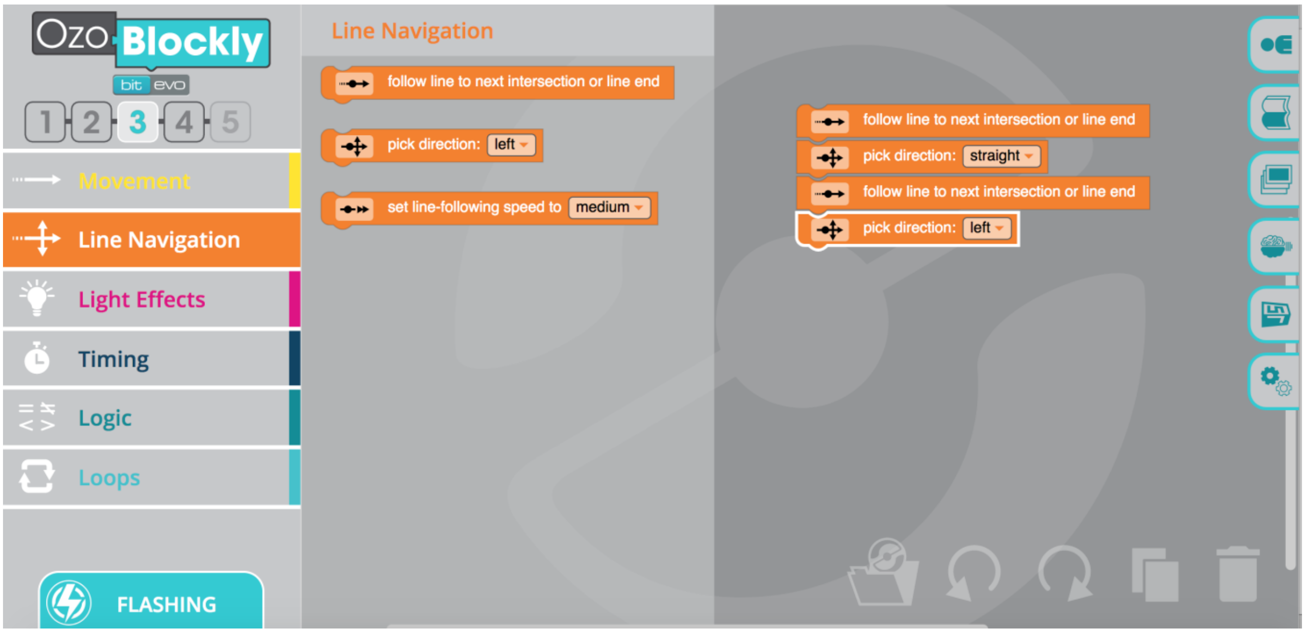

Figure 2. Screenshot from the Ozoblocky editor

After solving these group activities, students started an individual phase working alone. Each student was given a new set of tasks, similar to those solved previously but involving more complex itineraries. Again, the students were told to write their answers on paper, explaining clearly for each task how to get from the starting point to the destination. Students in the experimental group could use an *Ozobot* to program and check their solutions. To make this possible more *Ozobots* and tablets were available for each table.

One week after the intervention different post-tests were administered. Specifically, data from three variables were gathered: i) the students' mental rotation ability, ii) the students' CT level, and iii) the students' level of motivation.

Results

Data Analysis

The data analysis was mainly based on two independent variables: gender, and the group each student belonged to (control or experimental group). Moreover, the variables under analysis were total motivation, and each of the four sub-dimensions of the ARCS model (Attention, Relevance, Confidence, and Satisfaction). Data were analyzed by using the *IBM SPSS Statistics v.24* software. In addition, the effect sizes were calculated with Cohen's *d* (1988), using the Lenhard & Lenhard (2016) tool.

Findings

ANOVA tests were carried out to study the students' motivation according to their gender and group. No significant interaction between the experimental condition and gender were observed, F (1, 49) = 0.02, p = .901. Concerning the global score of motivation, there was a significant main effect of the group on student motivation, F (1, 49) = 13.07, p < 0.0001, d = 5.15. Students who completed the experimental intervention with *Ozobots* showed higher motivation scores than students who worked using pencil-and-paper (Table 1). In addition, there were also significant differences in student motivation depending on gender, F (1, 49) = 6.05, p = 0.018, d = 3.49. In particular, males manifested higher motivation levels than females (see Figure 3). The next sub-sections summarize the results for each of the motivational sub-dimension of the ARCS model.

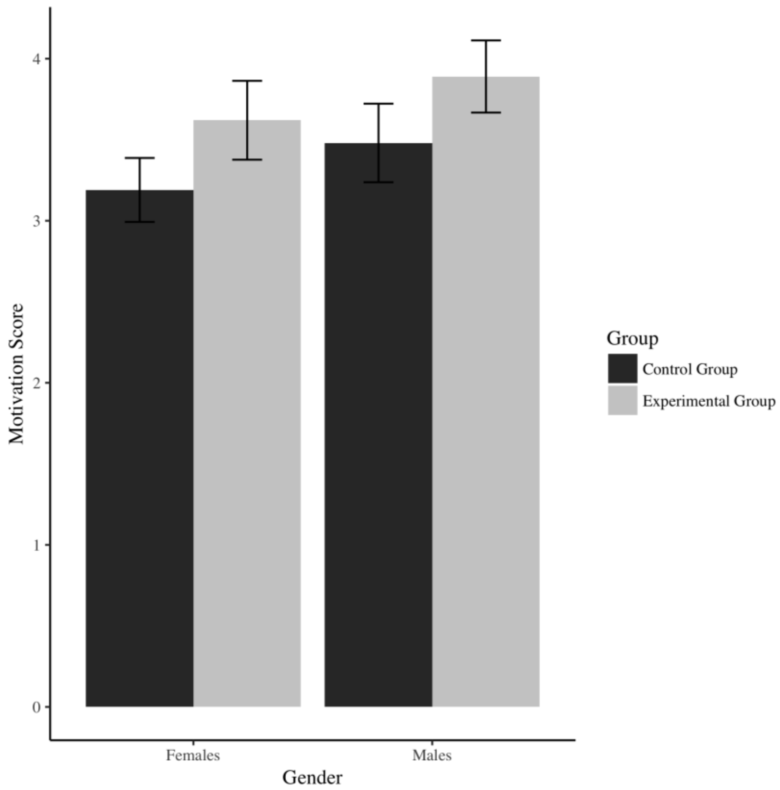

Figure 3. Student motivation score according to gender and group

Attention Dimension

There was no significant relationship between the group and gender on student attention *F* (1, 49) = 0.49, *p* = .487. Nevertheless, A significant main effect of the intervention group on attention was detected, *F* (1, 49) = 9.316, *p* = .004, *d* = 4.33. The means show that the intervention group obtained better results in the attention dimension than the control group (see Table 1). Although the means for male students seems higher than for females, there is no significant effect of gender on attention, *F* (1, 49) = 2.39, *p* = .129, *d* = 2.19.

Relevance Dimension

No significant interaction effect occurred between gender and experimental condition on the motivational dimension of relevance (*F* (1, 49) = 0.01, *p* = .907). A significant main effect of the type of the intervention on relevance was observed, *F* (1, 49) = 8.37, *p* = 0.006, *d* = 4.08. The means indicates that the experimental group showed higher levels in the relevance dimension than the control group (see Table 1). However, there was no significant effect of gender on the relevance component, F (1, 49) = 0.10, p = 0.757, d = 0.43. Thus, the scores on the relevance dimension were similar for boys and girls (Table 1).

Confidence Dimension

No interaction between gender and group on this dimension was detected, F (1, 49) = 0.01, p = .918. There was a non-significant main effect of the experimental condition on student confidence (F (1, 49) = 3.73, p = 0.059, d = 2.73. The average score for the experimental group was higher than the control group (see Table 1). On the other hand, there was a significant effect of gender on student confidence, F (1, 49) = 7.62, p = 0.008, d = 3.91. Boys showed a higher score on the confidence dimension than girls (Table 1).

Satisfaction Dimension

As in the rest of dimensions, there was no interaction effect between the experimental group and gender on student satisfaction, F (1, 49) = 0.47, p = .498. Again, a significant effect was observed based on the type of intervention on student satisfaction, F (1, 49) = 4.35, p = .042, d = 2.96. The average score for students who completed the intervention working with educational robotics was greater in comparison to the scores of students from the control group (Table 1). Moreover, a significant main effect of gender on satisfaction was also detected, F (1, 49) = 6.27, p = .016, d = 3.54. Thus, higher rates of satisfaction occurred for male students in comparison with females (Table 1).

Table 1.

Means and Standard Deviations by Factor of Dependent Variables

Dependent Variable	Control Group			Experimental Group		
	Females	Males	Total	Females	Males	Total
Total motivation	3.19 (0.11)	3.49 (0.13)	3.34 (0.08)	3.62 (0.12)	3.89 (0.11)	3.75 (0.08)
Attention	3.17 (0.15)	3.53 (0.17)	3.35 (0.11)	3.77 (0.17)	3.91 (0.15)	3.84 (0.11)
Relevance	3.10 (0.14)	3.16 (0.17)	3.13 (0.11)	3.56 (0.16)	3.59 (0.14)	3.57 (0.11)
Confidence	3.10 (0.14)	3.50 (0.16)	3.30 (0.11)	3.37 (0.16)	3.80 (0.14)	3.58 (0.10)
Satisfaction	3.49 (0.19)	3.86 (0.21)	3.68 (0.15)	3.78 (0.21)	4.43 (0.19)	4.11 (0.14)

Discussion

Educational robotics has aroused great interest in the educational community, and there are a large number of proposal to introduce it at all educational levels, from early childhood education (Sáez-López & Cózar-Gutiérrez, 2016, 2017) to university studies (Kim, 2015). Related to this, a huge amount of research has be carried out in order to determine the potential of educational robotics in the learning process (Benitti, 2012; Toh et al., 2016). The current study has focused on analyzing how the use of an educational robot, *Ozobot*, affects third-grade students' motivation when solving map-reading tasks. These types of tasks are usual at this level, since they are associated with learning standards from two subjects: Mathematics and Social Sciences.

Statistical analysis shows that there are significant differences in student motivation based on two factors: gender, and the experimental condition, that is the use (or not) of educational robotics during the teaching sequence. In particular, the results indicate that students who designed and coded programs to make *Ozobots* follow an itinerary on a map showed a higher level of motivation than those students who wrote down the solutions on paper; the usual method when map-reading tasks are addressed in classrooms. These results are aligned with research which points out that educational robotics usually promote better levels of motivation in all dimensions related to motivation (Chin et al, 2014). Similar results have been reported for different ages (Chang et al., 2010; Chin et al., 2014; Highfield, 2010; Ruiz-del-Solar & Avilés, 2004). In addition, different studies claim that there is digital divide in technology due to gender (Cooper, 2006; Martínez-Cantos, 2017; Wong, Castro-Alonso, Ayres, & Paas, 2015). Indeed, this study demonstrates a higher level of motivation for male students in comparison with female students. Despite this fact, our results clearly show that, even starting from an unequal initial level of motivation for males and females, there is a significant improvement for both the boys and girls who worked with *educational robotics*. Therefore, it seems that educational robotics increases the motivation of students, regardless of their sex.

In the study we employed the ARCS model to measure different dimensions of motivation. Taking into account the four dimensions (attention, relevance, confidence, and satisfaction), significant differences with large effect sizes were observed for attention, relevance, and satisfaction. This is especially relevant, since attention and relevance are regarded as determinant factors for learning (Keller, 2010). In addition, the effect on the satisfaction dimension may have interesting pedagogical consequences, since student satisfaction is usually associated with the degree of subsequent practice that the student will perform (Cabero et al., 2017; Keller, 2010; Rodgers & Withrow-Thorton, 2005).

Concerning the effect of educational robotics, the only dimension where statistical differences were not observed was confidence. Although the effect size is large, and greater means were found in the experimental group, it is possible experimental instructions could have had little effect in in students' confidence in comparison to other dimensions. In this sense, Moller y Russell (2008) presented similar results in their work, that can be explained since confidence is a belief that does not correspond with real success (Keller, 1987). In fact, Keller and Suzuki (1988, cited by in Huett, Moller, Young, Bray, & Huett, 2008) exposed that confidence consisted of different sub dimensions, the most important of which are: perceived competence, perceived control and expectancy for success. An improvement in these sub dimensions could take place with a longer intervention, since it would be easier to make students feel competent, in control and successful (Huett et al., 2008).

In summary, it is possible to conclude that introducing CT with robots may generate high results related to student motivation within a multidisciplinary approach to curricula contents in Grade 3. In addition, these results show that the use of educational robotics means that students pay more attention, as pointed out by Chang et al. (2010), and that attitudes toward the tasks are positive (Chin et al., 2014). Therefore, taking into account that practice improves learning (Poulos et al., 2010) and that practice is greater when motivation is higher (Cabero et al., 2017), it seems evident that the use of robots is effective for learning, as pointed out by Eguchi (2016).

Another relevant factor to be considered is the fact that the intervention length was two hours. Hence, we can also conclude that the inclusion of CT with educational robotics is highly motivating in the short term. Although this may be seen as very positive, since the use of robots has shown to have a relevant impact on student motivation in only two hours, some questions arise that need to be addressed in the future. In particular, future studies should analyze whether this effect is sustainable over the medium and long term. Moreover, in recent years different studies have reported that the integration of technology in educational contexts increases student motivation and learning outcomes (Cabero et al., 2017). Future studies may address whether improvements in motivational aspects due to the use of educational robotics when introducing CT result in improvements in learning.

Limitations

Although in this case the intervention was intentionally designed with a short duration, future studies are necessary to analyse the impact of educational robotics in the long term. Studies with longer instructions may offer evidence of whether students' confidence can increase due to the use of educational robotics in classrooms, or to what extent improvements in motivational outcomes are lasting when students get used to working with educational robotics. In addition, since this issue is beyond the goals of this paper, the relationship between motivation and learning outcomes is not addressed here. Other works might evaluate if improvements in motivational variables are eventually associated with better results in learning outcomes.

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