

Robots and Socio-cognitive Conflict Enhance Wayfinding in Children

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Abstract. This research aims to verify the effectiveness of robots (MecWilly, a humanoid robot and Blue-Bot, a non-humanoid robot) as learning-partners in children that act within their Zone of Proximal Development through the Socio-cognitive Conflict, compared to children acting with human learning-partners. The study aims to evaluate how a specific activity (define a route from beginning to the end) enhances the wayfinding skill in a group of 156 five years old children.

Keywords. Socio-cognitive Conflict, Robot, Children, Wayfinding.

1. Introduction

Studies about robotics use have significantly increased. The main theories regarding learning through the use of robotic artifacts are related to constructivism [13] and social constructivism [11], including assumptions from the theory of the zone of proximal development [19] and assumptions from the social learning theory [1].

Constructivism states that the human being is not a passive learner but builds his own knowledge through active experience with reality [13]. Particularly relevant is the theory of social constructivism, which states that individuals create meanings through interactions with other people and with the environment, which is why learning is considered a social process [11]. In situations in which robots assume the role of learning partners (or tutors), the concept of zone of proximal development is particularly relevant

The theory states that the child can reach his or her full potential interacting with a more experienced partner. Although, the social learning theory [1] emphasizes the relevance of social relations in the learning process, highlighting the children's capability of acquiring new knowledge and assimilating new behaviours by observing the actions of others. Finally, as claimed by Piaget [14, 20], learning may be initiated by cognitive conflict. According to the theories of social constructivism, this conflict originates in social interaction. Doise and Mugny [4] showed that inexperienced children benefit from the partner's point of view (such as in the theories of Vigotsky) but they also claim that expert children get benefits from pairs, allowing them to increase their performance capabilities.

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For these reasons, in the present study it is assumed that a robot-partner may engage the child in a real situation of socio-cognitive conflict, in order to enhance the child's ability.

2. The Use of Robots in Child Education

The employment of robots involves many human domains. It was found that robots are not only used in disability support, in ability development or to learn about robotics itself, but also in other fields such as the learning of a second language [12] or enhancing spatial skills [10;16].

Mubin and colleagues [13] refer to the specific use of robotics in education and identify two main categories concerning learning contents: robotics and computer education and non-technical education. The first domain category deals with learning about robotics itself or the functioning of technology (i.e. how to assemble or to program a specific robot). Meanwhile, in the second category learning regards non-technical information, because the robot acts as an intermediate tool to enhance specific abilities [9].

Some aspects, such as the type of robot used, or its purpose, depend on the setting and on the person who will interact with it. If the goal is merely a request to show a behavior or a sequence of movements, it is recommended to use basic and low-cost robots. Robots like Asimo [15] and MecWilly [12] result very useful to enhance abilities or acquiring non-technical knowledge such as music, spatial orientation and language

The educational context also defines the robot role, since it can be a passive tool to be manipulated and programmed, a co-learner or a partner.

3. The Role of Wayfinding and Spatial Orientation in Children

In the present study it will be analyzed the enhancement of a specific spatial orientation ability: the wayfinding competence, that is defined as the process of defining and following the path or route between an origin and a destination [6].

Some researchers [7; 18] questioned the idea that these knowledge systems are created from scratch. According to these authors such schemas do not appear in specific stages of development but they would always be available in the child. Indeed, investigation showed that in verbal interference task the advantage of adults compared to kids disappears in simple tasks of wayfinding [8]. This claims that children have no advantages because of their new mental schemas, but thanks to the use of language they can benefit from a different processing system and spatial information [22].

Other studies show that 2 year old children are able to use landmark and geometric information in order to locate objects previously seen and then hidden [22]. The same authors also claim that children under 3 years can link the spatial information to the left-right concept, clearly in a non-verbal manner, underling in this way the precociousness of an early spatial behaviour. Moreover, Cheng and Newcombe [2] verify that 2 to 3 years old children that are spatially disorientated by researcher can orientate themselves using exclusively the structure of the environment. On the other side, 3-4 year old children use other types of information to get orientation, such as colors of objects [3]. Furthermore, 5 to 6 year old children use physical maps to move in experimental locations [17].

3.1. Research Hypothesis

This research aims to verify the effectiveness of robots as learning-partners in pre-school children that act within their Zone of Proximal Development, compared to children acting with human learning-partners. The robots used are two: the humanoid robot MecWilly (fig.1) and the non-humanoid robot Blue-Bot (fig. 2).



Figure 1: MecWilly the Humanoid Robot



Figure 2: Blue-Bot the non-Humanoid Robot

Moreover, the study aims to analyze whether two different experimental conditions enhance the wayfinding skills in a group of 156 five years old children. The first condition is called Child Socio-Cognitive Conflict (Child SCC), in which two children interact to reach a joint solution to give the correct instruction to the robot to perform the task. The second condition is called Robot Socio-Cognitive Conflict (Robot SCC), in which a child alone interacts with the robot to perform the same task. Children of all groups were individually evaluated in a pre-test detection and in a post-test detection. Further, a control group performed the same task of the previous conditions only after the post-test. Considering the presence of two robots (Mecwilly and Blue-Bot) it was hypothesized that there would be significant improvement from the pre-test to the post-test phase in the time and in the number of moves it took to perform the task in both experimental conditions (MecWilly Child SCC, MecWilly Robot SCC, Blue-Bot Child SCC, Blue-Bot Robot SCC), except the control group. According to Doise and colleagues [5], socio-cognitive conflict supports learning when children are actually comparing the resolution of the task. If a child performs the task without taking into account the information and the opinion of his partner, there will be no negotiations and result in real socio-cognitive conflict, thus the enhancement will be less effective. Starting from this premise, the differences in improvements in children will be compared in two different groups (considering also the control group): a Negotiation group (MecWilly Child SCC, SCC MecWilly Robot, Blue-Bot Child SCC) where there is an actual negotiation and a Non-Negotiation group (Blue-Bot Robot SCC), where interaction and negotiation are not present.

3.2. Method

The study involves 156 five year old children (80 females and 76 males) attending preschool. All activities were held in the preschool attended by the children. The conditions with the humanoid robot MecWilly used a 6X6 chessboard drawn on the floor (3x3 meters), while the condition using the Blue-Bot robot called for a smaller version of the same chessboard (90x90 centimeters) placed on the table. Some squares of the chessboard contained recycling bins. The children (either alone or in pairs) guide MecWilly and Blue-Bot via voice commands (forward, backward, right, left). The goal is to throw the plastic into the specific recycling bin.

3.3. Results

Following the first purpose of the research a repeated measures T-test was run. The results revealed that the groups MecWilly Child SCC ($T=3.73$), MecWilly Robot SCC ($T=2.99$) and Blue-Bot Child SCC ($T=3.27$) are characterized by similar and highly significant improvements in moves. Also, MecWilly Child SCC ($T=10.95$), MecWilly Robot SCC ($T=8.14$) and Blue-Bot Child SCC ($T=6.09$) improve in the time it took to perform the task. Opposingly, the Blue-Bot Robot SCC group exhibited a non-significant improvement in moves (0.07 moves less compared to the post-test), as well as the control group (0.54 moves less compared to the post-test). However, both groups showed a similar and highly significant improvement in the time to perform the task. Finally, to test the differences in improvements in the Negotiation group (MecWilly Child SCC, SCC MecWilly Robot, Blue-Bot Child SCC) and in the Non-Negotiation group (Blue-Bot Robot SCC) pre-test and the post-tests performances were compared. The ANOVA test showed non-significant differences between the Negotiation group and the Non-Negotiation groups in the pre-test, both in terms of moves ($F = 0.00$) and in the time to perform the task ($F = 2.33$). Conversely, the post-test shows significant differences. Indeed, the participants of the Negotiation group have used an average of 2.21 moves less to complete the task ($F = 14.71$) in the post-test. Similar results were found in the time to perform the task, at post-test, the Negotiation group takes less than 24.8 seconds compared to the Non-Negotiation group to complete the task ($F= 6.97$). The Negotiation group improved 40.14 seconds more than the Non-Negotiation Group ($F = 23.10$).

4. Discussion

In the present research it was verified that all experimental groups achieved significant improvements in the amount of time and the number of moves it took to perform the task, with the exception of Blue-Bot Robot SCC group and the Control Group. The results of the Blue-Bot robot SCC group and the control group lead to two important implications. First, taking the measurement test twice after a specific period of time (the control group situation) leads to solve the task in less time but do not solve it with less moves. In addition, the child activities alone with Blue-Bot (Blue-Bot robots SCC) showed no improvement since the activity. The improvement of the task execution time is a result of the repetition of the measurement test. Blue-Bot by itself is not a good partner for learning. Also, the experimental task done by two children together (Child SCC group), with MecWilly or Blue-Bot, brings benefits in terms of learning. The benefits are due to the socio-cognitive conflict condition that is generated between the two children. Children who do the experimental task with MecWilly (MecWilly Robot SCC group) achieved comparable improvements to children pursuing the task in pairs. Considering these results, it is possible to infer that MecWilly is an effective learning partner as a human partner [12]. Contrarily, considering the non-humanoid robot Blue-Bot, the results reveal that the experimental condition of the robot with the Non-Negotiation group (Blue-Bot Robot SCC) does not provide a real socio-cognitive conflict. Indeed, the activity of the individual child does not make improvements over the simple repetition of the task. In this regard it is important to point out that Doise and colleagues [5] showed that the socio-cognitive conflict should benefit learning when there is a negotiation of points of view. For these reason, MecWilly, while dispensing only dubitative questions (not having therefore a real point of view), succeeds in recreating the child's own cognitive stimulation given by negotiation between children. This conclusion is supported by the same results obtained by the MecWilly Robot SCC group (which is part of the Negotiation group) and Child SCC group.

5. Conclusions

This study has verified how a humanoid robot can be an effective learning partner enhancing wayfinding abilities in pre-school children, generating a socio-cognitive conflict situation as if there were two human partners. In particular, it has been found that the socio-cognitive conflict plays a key role in learning, making MecWilly a better learning partner than Blue-Bot.

Future research should investigate the bases launched by this study using other types of interactive robots and proposing the task to children of different ages, as well as investigating what other skills (e.g. solve logical and mathematical tasks) could be enhanced by using a robot as a learning partner.

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