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May I teach you? Students' behavior when lectured by robotic vs. human teachers

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ABSTRACT

Social robots have been and are currently being used in many projects, research initiatives and experiments, but we know relatively little about them compared to humans when performing a social task such as teaching. Using an experiment in which a robot and a human teacher were used for teaching computational concepts to a group of K-12 students, the main goal of this paper is not to analyze the scores obtained in the post-test performed, but to focus on the students' attitudes towards robots. In order to do this, a version of the NARS and RAS questionnaires, adapted for children, was used. The analysis of the results of these questionnaires considers differences between age groups and students lectured by a robot vs. a human teacher. We conclude that age is the main factor that affects students' attitudes towards robots, although we also found other differences between the robot and the human teacher group.

1. Introduction

Robots have been proposed as teaching assistants for children, but there is a lack of empirical evidence of the educational effectiveness in the use of robots (Salvini, Korsah, & Nourbakhsh, 2016). An experiment using the robot Baxter for teaching basic computational principles was performed at University of León. We compared acquired abilities in students with a control-group lectured in a traditional way by a human teacher. After a short lecture, students were evaluated and some interesting conclusions were obtained from that study. One of the most surprising ones was the fact that there was only one specific group in which older students did not get better scores than younger ones, i.e., where the educational progress was not followed. There were 210 students with ages ranging from 6 to 16, divided into three age-groups, and each of these groups was split in two; one received the lecture by the robot and the other by the human teacher. The only group that did not improve with respect to younger students' scores was the oldest group taught by the human teacher. Having observed students in both human and robot classes, we think that older students were not paying enough attention in the human-taught class. The reason could be that they were in a summer code camp where they were not expecting to be evaluated, so they were not paying much attention to “just another human teacher.” On the contrary, the same age group with Baxter as a teacher was having a new experience and were paying much more attention. This last group did get better scores than younger ones and, in fact, was the group with the best results.

The complete study regarding the scores obtained in this experiment as well as its analysis and discussion have been published in another work. In this paper, our first goal is not to analyze the results obtained, but to analyze the attitudes towards robots. We think students' attitudes can affect the results obtained, as mentioned before, and definitely have to be taken into account if it is planned to use robots in the long term, and not just for short experiments.

Our second goal is to study the factors that affect the perception

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of students towards robots. Previous research suggests that there are several issues that can affect the way that robots are perceived: for instance, individual personality or gender (Syrdal, Dautenhahn, Woods, Walters, & Koay, 2006). These authors have also developed experiments that take into account the impact of previous experience of individuals with computers and robots (Syrdal, Dautenhahn, Woods, Walters, & Koay, 2007).

However, other authors (Mutlu, Forlizzi, & Hodgins, 2006) have shown that pre-existing attitudes towards robots are difficult to extrapolate purely from demographics or from previous experiences with the use of technology.

Another issue that should be explored is the context in which the evaluation took place. While there are some studies that examine the impact of gender or previous experience with technology with regard to the attitudes towards robots (Nomura & Takagi, 2011), they have been developed in the context of robotic assistants. This work, however, is focused on how robots can be accepted as teachers, and it has been carried out in an educational context with students of different ages.

Given this context, it is necessary to use a common instrument to evaluate these differences. Nomura et al. defined NARS (Negative Attitudes towards Robots Scale) (Nomura, Suzuki, Kanda, & Kato, 2006b). With this instrument, it is possible to look for negative perceptions about robots in a different context. Nomura, Kanda, Suzuki, and Kato (2008) also studied the relationship between the NARS scale and the Robot Anxiety Scale (RAS) which we have also used in this paper. The analysis of the results obtained for these questionnaires will help us identify which factors may affect students' perception of robots.

The remainder of the paper is organized as follows: the second section describes the research context of this work, the third section describes in detail the experiment designed to evaluate the initial hypotheses; section four presents the statistical analysis of the data gathered, which are discussed in the fifth section. Finally, section six summarizes the conclusions obtained in this research, and the further work envisioned.

2. Research context

The present work is based on the utilization of a robot as a teacher in an educational context and the attitudes that students show towards it. Three important issues should be explored: the application of robotics in education; the evaluation of the perception towards robots; and how interaction is carried out with robots and the educational implications thereof.

The use of robotics in education is not new. It is one of the promising ways for developing highly demanded competencies such as computational and algorithmic thinking skills and programming. Moreover, it is believed to increase students' motivation towards a subject (García-Peñalvo, Reimann, Tuul, Rees, & Jormanainen, 2016).

The use of robotics in education has gained popularity specially thanks to low-cost and highly-accessible educational robotic kits (Sklar, Parsons, & Stone, 2004). Tangible devices make program execution explicit and concrete, and increase students' motivation because the latter can build and program their own robots and participate in competitions (Williams, 2003). Robotics can also enhance acquisition of Science, Technology, Engineering, and Mathematics (STEM)-based competencies (Cristoforis et al., 2013) and other type of competencies such as collaboration, imagination, and self-expression (Alimisis, 2013); and it is an especially useful tool when applying problem-based learning (Arlegui, Pina, & Moro, 2013), project-based learning (George & Leroux, 2001) or challenge-based learning approaches (Jou, Hung, & Lai, 2010). There are also initiatives such as The European Project TACCLE 3 - Coding (http://www.taccle3.eu/) that have generated a set of resources related to computational thinking and robots.

In this study, our research focuses on the use of a robot as a teacher, and the change of motivation and engagement in students in this situation. Our interest is more related to studies that explore motivation than to others that deal with specific learning models or with the acquisition of some competencies. We will focus on social robotics.

Social robotics research, as any other research field, tests the validity of its hypothesis even with groups that it was not intended for. One of the main issues arises when these robots are planned to be used in the long term. Research shows that up to one third of all assistive technologies are abandoned within one year of use (Gurley & Norcio, 2009). In order to avoid this scenario, it is necessary to propose a mechanism to understand user perception and attitudes about technologies, and especially about robotic platforms.

Various researchers have approached this topic in redent decades using questionnaires. Starting in 1989, general proposals such as the Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989) define a questionnaire for measuring target-user perceptions of technological systems. Parameters such as perceived usefulness, perceived ease of use, attitudes toward, behavioral intention to use, and actual use of a technological system, as well as interrelations between these categories are included in this instrument. Subsequent studies, such as the UTAUT model (Unified Theory of Acceptance and Use of Technology) (Venkatesh, Morris, Davis, & Davis, 2003) integrate most of the previous general approaches as TAM, TPB (Theory of planned behavior), MM (Motivational Model) or TRA (Theory of reasoned action). This model from can be considered the starting point for subsequent robotics frameworks, highlighting factors that directly affect the intention to use a robotic agent. The 31 items used in estimating the UTAUT questionnaire are classified into eight groups: performance expectancy, effort expectancy, attitudes toward using technology, social influence, facilitating conditions, self-efficacy, anxiety and behavioral intention to use the system.

With the intention of bounding these general perspectives, some proposals have been made focused on robotics. The Almere project (Heerink, Kröse, Evers, & Wielinga, 2010), which can be seen as an extension of the UTAUT proposal (Louie, McColl, & Nejat, 2014) shows a model of technology acceptance of social assistive robots focused on elderly users. In this case, the proposed questionnaire is composed of more than 40 questions grouped into 13 constructs.

Bartneck et al (Bartneck, Kulić, Croft, & Zoghbi, 2009). propose the Godspeed questionnaire to evaluate individual perception of robot anthropomorphism, animacy, likeability, and perceived intelligence. In addition, other approaches such as the USUS Evaluation Framework (Weiss, Bernhaupt, Lankes, & Tscheligi, 2009, pp. 11–26) for Human-Robot Interaction, address the research objectives of usability, social acceptance, user experience, and societal impact. However, the USUS approach does not provide its own questionnaire, instead it offers references associated with each research objective.

Almere and Godspeed can be seen as the comparison basis when measuring most of the factors that affect user behavior during interaction with a robot. Nevertheless, some researchers restricted their approaches to only evaluating some specific perception parameters in the human-robot interaction. The Negative Attitudes Toward Robots Scale (NARS) (Nomura, Kanda, Suzuki, & Kato, 2004) presents a more compact questionnaire, composed of three subscales, which measures the individuals' general attitudes

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