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Acceptance of socially assistive humanoid robot by preschool and elementary school teachers

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ABSTRACT

This study examined the first-time acceptance of (SAR) by preschool and primary school teachers. A modified Unified Theory of Acceptance and the Use of Technology model was applied using the questionnaires filled out by 18 teachers following interactions with a robot. The participants demonstrated positive reactions and acceptance accompanied by a variety of answers. The lack of consolidated views in the tested population of teachers and the need for an adaptation of the model are suggested. The future intensive research of teacher–acceptance of SAR will avoid the gap between technology and the end-user.

1. Introduction

1.1. Acceptance of technologies by teachers

The acceptance of innovative educational technology by teachers is a crucial issue, especially since technology-supported educational practices are becoming increasingly introduced and implemented in the teaching process (Alavi, 1994; Hiltz, 1994; Jonassen, Peck, & Wilson, 1999; McKendree, Stenning, Mayes, Lee, & Cox, 1998). Without the teacher's acceptance, educational technology cannot hope to deliver whatever value it may hold (Zhao, Hueyshan, & Mishra, 2001). Technology acceptance can be defined as, "a user's willingness to employ technology for the tasks it is designed to support" (Dillon & Morris, 1996).

Despite research that shows the capability of technology to facilitate teaching and learning, the use of technology in the classrooms remains insufficient and teachers do not use technology effectively enough (Bourgonjon et al., 2013; Hu, Clark, & Ma, 2003; Lim & Khine, 2006). Researchers have identified several factors that influence the adoption and integration of technology into teaching. These factors include: user characteristics, content characteristics, technological considerations, and organizational capacity (Balanskat, Blamire, & Kafal, 2006; Buabeng-Andoh, 2012; Clausen, 2007; Lim & Chai, 2008; Rogers, 2003; Stockdill & Morehouse, 1992; Tondeur, Valcke, & van Braak, 2008). On the other hand, the use of technologies in educational process is intensively studied and their high acceptance among the students have been proved (Cheng, Lou, Kuo, & Shih, 2013; Furió, González-Gancedo, Juan, Seguí, & Rando, 2013).

At the current level of technology development, the majority of research is focused on user characteristics. Of the research done on humans' interaction with and acceptance of robots in the classroom, only few studies have concentrated on the teacher's side; the majority of the studies have investigated student–robot interactions (see Buabeng-Andoh, 2012 for review).

1.2. Socially Assistive Robotics in education

SAR is the class of robotics that provides assistance to human users through social, rather than physical, interaction (Feil-Seifer & Matarić, 2011). SAR has been used in critical areas in medical care to automate supervision, coaching, motivation, and companionship aspects of interactions with vulnerable individuals. Currently, the main populations in which SAR has been tested and applied are the elderly (Heerink, Krose, Evers, & Wielinga, 2008; Heerink, Krose, Wielinga, & Evers, 2009a; Saini, De Ruyter, Markopoulos, & Van, 2005; Zaad & Allouch, 2008), patients with dementia (Tapus, Tapus, & Matarić, 2009) and cognitive/motor disorders (Wainer, Feil-Seifer, Shell, & Matarić, 2006), and children with autism (Goodrich, Colton, Brinton, & Fujiki, 2011; Thota, Kearney, Boirum, Bojedla, & Lee, 2011; Villano et al., 2011).

In the field of child care, several studies have shown the positive impact of SAR on typically developing children and children with social disorders (Kozima, Nakagawa, & Yano, 2004; Tanaka, Movellan, Fortenberry, & Aisaka, 2006). iRobi, a humanoid teaching-assistant robot, has been tested in elementary schools (Han, Jo, Park, & Kim, 2005; Han & Kim, 2009; Kanda, Hirano, Eaton, & Ishiguro, 2004; Shin & Kim, 2007; You, Shen, Chang, Liu, & Chen,

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2006). This wheeled robot conducts educational activities (English language learning, storytelling, and others) mainly through embedded computer-based games. Yamamoto, Tetsui, Naganuma, and Kimura (2006) introduced AIBO, a robotic pet, into kindergarten class work for 4–6 year-olds.

Few studies of the interaction of preschool age children with SAR have been conducted. These studies tested the interaction between the NAO robot in the natural environment of a kindergarten classroom with normally developed (Fridin, 2014a,b; Keren, Ben-David, & Fridin, 2012) and disabled (Belokopytov & Fridin, 2012; Fridin, Bar-Haim, & Belokopytov, 2011; Fridin & Yaakobi, 2011) children, ages 3–6. These studies showed that children enjoyed interacting with the embodied robot, followed its instructions, and were willing to accept the robot as both a playmate and instructor.

To our knowledge, research on the acceptance of SAR by preschool teachers has not been conducted or published.

1.3. SAR acceptance

The use of SAR within the acceptance paradigm is even more complicated and crucial, than the acceptance of other robotic technology. This is due to the increased value of the psychological, communicational, and emotional factors, in addition to the common ergonomics, safety, and previous experience factors that are found in the interactions with SAR robots (Heerink, 2011; Heerink, Kröse, Wielinga, & Evers, 2009b; Picard, 1997; Picard & Daily, 2005).

Most of these studies focused on elderly people; others tested children's' acceptance of SAR; only a few experiments were conducted with adults, but not elderly participants. These studies are further detailed in Table 1. A large portion of the research investigated the acceptance of robots or their virtual agents as a conversational partner (Heerink, 2011; Heerink, Kröse, Evers, & Wielinga, 2010b; Heerink, Kröse, Wielinga, & Evers, 2010a; Heerink et al., 2009a; Kim, Jung, Lee, & Han, 2013; Tay, Park, Jung, Tan, & Wong, 2013; Zaad & Allouch, 2008). The users reported positively concerning both functional and social acceptance (Picard & Daily, 2005) of the robots and gave high ratings on trust and friendliness. Social presence during the experiment was cited as being crucial for both the functional and conversational acceptance of embodied agent technology (Zaad & Allouch, 2008). Several personal characteristics were found to be very influential in the acceptance of SAR. One of these characteristics was gender. Male participants appeared more eager to interact with the SAR than female participants (Heerink, Kröse, Wielinga, & Evers, 2006) and "had a more positive attitude toward the robots" (Kuo et al., 2009). However, this phenomenon might be generation-related (age) Heerink et al., 2006. There was a negative correlation between age and intention to use the robots (Heerink, 2011), but this effect was not detected by another study (Kuo et al., 2009). There was also a negative correlation between education level and the acceptance of the robot as a social entity (Heerink, 2011). In a large social network, the SAR reduced stress (Tay et al., 2013) and induced the desire for more interaction (Kuo et al., 2009). Conversely, elderly participants perceived the SAR more as a machine than as a social device (Ezer, Fisk, & Rogers, 2009) and desired for more control over the robot and more freedom to make their own decisions (Zaad & Allouch, 2008). The robot's personality was also found to be a significant factor that influenced the user's acceptance (Saini et al., 2005). For instance, an extroverted version of the robot was found to be more accepted by the user than its introverted version (Saini et al., 2005).

Other studies reported positive acceptance of SAR by secondary-school students (Díaz, Nuno, Saez-Pons, Pardo, & Angulo, 2011; Mubin et al., 2010; You et al., 2006) and college students (Graaf and Allouch, 2013; Kim, Jung et al., 2013; Looije, Cnossen, & Neerincx, 2006; Tay et al., 2013). The acceptance of the virtual agent tested with young adults (ages 18–30) successfully induced sympathy and a desire for a long-term relationship (Bickmore & Schulman, 2007).

No formal studies on SAR acceptance were performed with children of preschool and elementary school age. This was probably due to the difficulty applying the Technology Acceptance Model (Klamer & Allouch, 2010) and similar models with small children. Acceptance of SAR at these ages can be derived from the interaction studies. The results of all of these studies showed a positive interaction at different setups (Fridin et al., 2011; Han & Kim, 2009; Han et al., 2005; Kanda et al., 2004; Keren et al., 2012; Kozima et al., 2004; Shin & Kim, 2007; Tanaka et al., 2006; Yamamoto et al., 2006).

Another important aspect of the SARs' use during the educational process is the interaction with teachers. However, to our knowledge, no SAR acceptance study has yet been performed.

1.4. Objectives

The acceptance of robotic technology by teachers is not the same as by students. The acceptance by teachers has dual importance. On one hand, the teacher has the responsibility of ensuring the proper operation of the device, showing its additional value in the educational process, and providing wider view of the goals and importance of technology use (Buabeng-Andoh, 2012; You et al., 2006). On the other hand, a social robotic agent is a tool for and an assistant to the teacher, while, for a student, it can be a friend and playmate (Hyun, Park, Jang, & Yeon, 2010) or authority figure like a teacher (Hyun, Yoon, Kang, & Son, 2009).

The objectives of this study were to evaluate the acceptance of a humanoid, social assistive robot by preschool and elementary school teachers and to test the Unified Theory of Acceptance and Use of Technology model adopted by Heerink for SAR (Heerink et al., 2009a).

2. Research model and hypotheses

For the evaluation of acceptance, we used the Unified Theory of Acceptance and Use of Technology (UTAUT) model proposed by Venkatesh, Morris, Davis, and Davis (2003), evaluated by de Ruyter and Aarts (2004) and further improved by Heerink et al. (2009a). This model is based on the Technology Acceptance Model (TAM) Davis, 1989. TAM is a methodology that not only provides insight into the probability of the acceptance of a specific technology, but also into the influences underlying acceptance tendencies. In TAM, the perceived ease of using the technology and the perceived usefulness of the technology are the main factors that influence the user's intent to use the system, which is, in turn, the main predictor of the actual use of the system.

Venkatesh et al. (2003) offered an overview of TAM acceptance models and incorporated the most reliable constructs into the UTAUT model. In UTAUT, the perceived usefulness of the technology encompasses a broader range of ideas and was renamed Performance Expectancy. This term outlines the expectations that the user has about the performance of the system. Perceived ease of use was also more broadly defined and was renamed Effort Expectancy. This term describes the expectations the user has of the effort that is needed to use the system. Other factors that were created include Social Influence (SI) and Facilitating Conditions (FC).

In our study, we used the UTAUT model modification presented by Heerink et al. (2009a). This model uses a structured questionnaire (Table 2), in which each construct is represented by multiple