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

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A B S T R A C T

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

Table 1
Previous studies of SAR's acceptance.

References	Robot	Model	Interaction	Results	Application	Subjects/age	Sample size
de Ruyter and Aarts (2004) and Saini et al. (2005)	iCat, its virtual agent	Social behaviors questionnaire (SBQ) User satisfaction questionnaire (USQ). The unified theory of acceptance and the use of technology (UTAUT)	Dialog, facial expression of emotions	Positive bias in users perception, enhance user acceptance for the home dialog system	Mediator between user and home technology	Eldery	82
Heerink et al. (2006)	iCAT		Conversation, face expression of emotions	Good acceptance; depends on social qualities of the robot; gender differences	Interaction in a small groups of 8 people each, conversation, instruction, provide information about weather	Elderly	40
Heerink et al. (2008) and Zaad and Allouch (2008)			UTAUT	Social presence influences on acceptance and enjoyment; enjoyment does not depended of easiness of use; intention of use influence on acceptance	Interaction in a small groups of 8 and 4 people each; conversation; two experiments: more social with touch screen, less social without touch screen	65–89	70
Heerink et al. (2009a,b)						65–94	30
2010 (assessing acceptance) Heerink et al. (2010a)						65–96	40 + 88 + 30 + 30
2010 virtual reality Heerink et al. (2010b)						65–96	40
Looije et al. (2006) and Bickmore and Schulman (2007)	iCat, its virtual agent	Unified Theory of Acceptance and Use of Technology (UTAUT)-questionnaire Tanaka et al. (2006)	Dialog, facial expression	Embodied accepted as robotics animal	Guidelines/assistance to diabetics	22–29 students	6
You et al. (2006)	RoboSapien	Original Questionnaire	Multiple kinds of interaction in the class environment	Positive acceptance	Teaching assistant	11 yrs old	100
Bickmore and Schulman (2007)	Virtual agent Louise	PANAS	Conversation	Cympathy and desire for long-term interaction	Companion	18–30	16 (students)
Wada and Shibata (2007)	Seal robot: Paro	Corticosteroids Test, the density of the each social network of the subjects Heerink et al. (2006)	Dialog, body expression of emotions	Enlarged social network, reduced stress	Three types of behavior: proactive, reactive, And physiological	67–89, suffered from dementia	12
Weiss et al. (2008)	ACE	UTAUT	Conversation, face expression of emotions	Positive social acceptance	Field study, conversation with passing by pedestrians	18–75	48
Zaad and Allouch (2008)	No robots	UCAM based on TAM	Users that had experience with some robot should describe their impression	Partial acceptance was reported, the users desired for more control over the robot	Elderly assistant	Eldery	38
Ezer et al. (2009)	No robot	Technology acceptance model	Users were asked to imagine a robot in their home	Robots are accepted as performance directed machines, less as social devices	No interaction, users opinions were based on users previous knowledge	65–86 (117) 18–25 (160)	
Kuo et al. (2009)	"Charles" is based on the Peoplebot from Mobile Robots	Attitudes Towards Healthcare Robots scale (ATHR), Robot Attitudes Scale (RAS)	Instruction mode	Significant gender effect (male had more positive attitude toward the robot); Age was not found as significant effect; Desire for more interactiveness	Measured their blood Pressure	57–80	57
Klamer and Allouch (2010)	Zoomorphic robots Nabaztag	Interview with original Questionnaire	Conversation	Social factor was found by significant factor for acceptance	To motivate users to follow physical activity plan	50, 60, 65	3
Díaz et al. (2011)	NAO, Pleo	Questionnaire for asses satisfaction and perception about robots	Game-like	Differences in acceptance	Game	11–12 yrs old	49

(continued on next page)

Table 1 (*continued*)

References	Robot	Model	Interaction	Results	Application	Subjects/age	Sample size
Heerink (2011)	Video the RoboCare robot	UTAUT	Conversation	Negative correlation between age and intention to use; negative correlation between education level and acceptance of robot as a social entity	Assistance in daily activities, fitness adviser	65–92	66
Mubin et al. (2010)	iCat	SASSI and Game Experience Questionnaires	Conversation, expression of emotions	Children enjoyed interacting with the robot	Play-made , educational game	9–12	116
de Graaf and Allouch (in press)	NAO	Questionnaire	Conversation	Positive acceptance, gender influence	Not defined	18–28	60
Panek et al. (2012)	NAO	Open discussion	Conversation, slide projection	Better acceptance with projector	Elderly assistant and trainer	55–81	6
Tay et al. (2013)	Not listed	TAM	Conversation, gesture	Gender stereotypes influenced HRI	Security	20–25	40
Kim, Jung et al., 2013	NAO	Questionnaire	Lecture	Acceptance depends on familiarity	Lecturer	Undergraduate students	27

Table 2
Model overview.

Code	Construct	Definition	Questionnaire
ANX	Anxiety	Evoking anxious or emotional reactions when using the system	1. I should use the robot, I would be afraid to make mistakes with it 2. If I should use the robot, I would be afraid to break something 3. I find the robot scary 4. I find the robot intimidating
ATT	Attitude	Positive or negative feelings about the appliance of the technology	5. I think it's a good idea to use the robot 6. The robot would make my life more interesting 7. It's good to make use of the robot
FC	Facilitating conditions	Objective factors in the environment that facilitate using the system	8. I have everything I need to make good use of the robot. 9. I know enough of the robot to make good use of it
ITU	Intention to use	The outspoken intention to use the system over a longer period in time	10. I think I'll use the robot in the near future 11. I am certain to use the robot in the near future 12. I'm planning to use the robot in the near future
PAD	Perceived adaptability	The perceived ability of the system to be adaptive to the changing needs of the user	13. I think the robot can be adaptive to what I need 14. I think the robot will only do what I need at that particular moment 15. I think the robot will help me when I consider it to be necessary
PENJ	Perceived enjoyment	Feelings of joy or pleasure associated by the user with the use of the system	16. I enjoy the robot talking to me 17. I enjoy doing things with the robot 18. I find the robot enjoyable 19. I find the robot fascinating 20. I find the robot boring
PS	Perceived sociability	The perceived ability of the system to perform sociable behavior	21. I consider the robot a pleasant conversational partner 22. I find the robot pleasant to interact with 23. I feel the robot understands me. 24. I think the robot is nice
PU	Perceived usefulness	The degree to which a person believes that using the system would enhance his or her daily activities	25. I think the robot is useful to me 26. It would be convenient for me to have the robot 27. I think the robot can help me with many things
SI	Social influence	The user's perception of how people who are important to him think about him using the system	28. I think the staff would like me using the robot 29. I think it would give a good impression if I should use the robot.
SP	Social presence	The experience of sensing a social entity when interacting with the system	30. When interacting with the robot I felt like I'm talking to a real person 31. It sometimes felt as if the robot was really looking at me 32. I can imagine the robot to be a living creature 33. I often think the robot is not a real person. 34. Sometimes the robot seems to have real feelings
Trust	Trust	The belief that the system performs with personal integrity and reliability	35. I would trust the robot if it gave me advice. 36. I would follow the advice the robot gives me

statements. The questions are listed randomly. One to five points provided to the participants so that they can rank the questions. The range moves from "strongly disagreed" (one point) to "strongly agreed" (two points). When a statement is characterized as negative (like item three), stronger agreement leads to a lower score. The "Perceived Ease of Use" was omitted from the initial questionnaire due to the low importance for the setup of this study. The UTAUT model has been widely used for the evaluation of SAR acceptance in many previous studies (Heerink, 2011; Heerink et al., 2008, 2009a, 2010a; Mubin et al., 2010; Tay et al., 2013; Zaad & Allouch, 2008) and has been found to be reliable.

Original model is based on the following hypothesis:

H1. Intention to Use is determined by Perceived Usefulness, Perceived Enjoyment, Social Influence and, and Trust.

H2. Perceived Usefulness is influenced by Perceived Adaptability and Anxiety.

H3. Perceived Enjoyment is influenced by Social Presence and Perceived Sociability.

H4. Perceived Sociability is influenced by Trust.

H5. Social Presence is influenced by Perceived Sociability.

The duration of use was not included due to the fixed duration of the study.

The hypotheses listed above were those to be tested.

3. Methods

3.1. Experiment setup

The experiment was performed during a professional workshop on educational robotics for preschool and elementary school teachers. The attendees were exposed to a NAO robot located in the lobby. The robot was the only interactive tool; there were other informational materials (e.g. posters) nearby. The robot approached people passing by who were in the lobby looking at posters and interacted with those who responded. Then, all of the workshop attendees were asked to answer the UTAUT questionnaire. The completed questionnaires were collected before the lecture session started in order to avoid the influence of the subsequent activities on the findings.

3.2. Subjects

All 36 workshop attendees either actively interacted with the robot or observed such an interaction; in this way, the observers were interacting with the robot by proxy (Fig. 1). Eighteen of them completed the questionnaire. Of these 18, 6 were male and 12 were female. They ranged in age from 28 to 74, with a mean age of 47 ± 13 years. All the subjects were preschool and elementary school teachers with no previous experience of interaction with SAR. Of the 18 who completed the questionnaire, seven of them actively interacted with the robot while the rest of them observed the session (http://www.ariel.ac.il/research/tesrl/-miscellaneous/jerusalem-workshop-2012).

3.3. Procedure

The robot stood on a table with a small ball and a bottle of water nearby. It looked around and approached passing attendees by saying "Hi!" and waving its hand. If a participant responded, the robot asked the attendee to give him a ball, indicating that it (robot) could not do it by itself. After the robot was given the ball, the robot dropped the ball on purpose, so that the ball rolled away. The robot then said, "Do me a favor, I cannot run after it." The attendee had to go after the ball, retrieve it, bring it back, and give it to the robot again. After getting the ball back, the robot thanked the attendee in an informal manner and said: "I am too tired to run after that ball. Could you give me a bottle of water to drink?" When the attendee gave the bottle to it, the robot laughed and asked, "Are you serious? Don't you see that I am a robot? Robots do not drink!" Then the robot sat down to rest and, after a small break, repeated the procedure.

Fig. 1. The interaction between the NAO robot and the subjects.

The purpose of the procedure was to persuade the attendees to interact with the robot, to motivate them to fulfill robot's every request, even if it was an absurd request. The interaction procedure was designed to be humorous. These traits were displayed by the robot's use of informal language and the expression of exhilarated emotions through body motion, gestures, and blinking.

3.4. Experimental platform

Our previous results (Belokopytov & Fridin, 2012; Fridin, 2014a,b Fridin & Yaakobi, 2011; Fridin et al., 2011; Keren et al., 2012) showed that children aged 4–7 had positive interactions with the robot Nao (Aldebaran Robotics, France), which was used as a platform in our study. This indicates that the robot can be used teaching purposes in preschool and elementary school.

Nao (Gouaillier et al., 2009) is a small, 58 cm tall, robot that looks like a toy. It is perceived as a smart, non-threatening educational tool (Nalin, Bergamini, Giusti, Baroni, & Sanna, 2011) with whom preschool-aged children positively interact. The robot speaks in a female voice (commonly associated with kindergarten staff), expresses emotions (through verbal and non-verbal communication), and uses proper vocabulary. The robot has 25 Degrees of Freedom, which allows it to perform variety of movements. It is widely used in SAR (e.g. Kim, Park, & Sundar, 2013), particularly in acceptance studies (de Graaf & Allouch, 2013; Díaz et al., 2011; Kim, Jung et al., 2013; Panek, Edelmayer, Mayer, Beck, & Rauhala, 2012).

The system that we created allows the robot to be remotely controlled with a client server application (NaoServiceClient). From this, commands can be sent to the Nao webserver installed in the robot's computer. The client application is installed on an Android tablet. The robot performed the procedure all-alone. Only the fact that the ball/bottle was in robot's palm was indicated by a technician through remote control. The participants were not informed that a technician was involved.

The experimental procedure described above was originally designed by a developmental psychologist and specialist in human–robot interaction (Fig. 2, "Design Template"). The design of the robot's behavior, including movements, speech, emotional expressions, and program flow, were coded by a programmer using the Python programming language and the Nao system's graphical programming language (Fig. 2, "Programming language"). Prior to the procedure, particular robot's behavior was uploading from a PC to the robot through LAN-wire connection.

3.5. Data analyses

The scores of the questionnaire were processed as follows (Heerink et al., 2009a):

- Calculating the scores for each construct by averaging the scores on the items.
- Establishing Cronbach's Alpha for the items of each construct. A solid construct would have an Alpha of at least 0.7.
- Analyzing basic descriptive statistics: minimum and maximum scores, mean and standard deviation, to get a first impression of the scores.
- The hypotheses were tested by analyzing correlations (strictly explorative) or linear regressions to determine the reliability of constructs (alpha of at least 0.7).

4. Results

Cronbach's Alpha was calculated to test the construct's reliability (an alpha of 0.7 and higher was acceptable). Table 3 shows that most of the constructs were reliable. The ones there were not were FC, SI, SP and Trust. ITU construct was extremely reliable.

Standard descriptive statistics showed diversity in the means of the scores of different constructs. The Attitude construct had a maximal score of 4.29 had while Social Presence construct had a minimal score of 2.57 The scores varied by construct (see Table 3) from 0.01 in Intention To Use (three questions) to 0.816 in Trust (two questions).

The correlation between reliable constructs, as was estimated by Cronbach's Alpha, is presented in Table 4. It shows that there is a significant, strong relationship between Intention to Use and Perceived Usefulness. There is a small correlation between Intention to Use and Attitude. The table also shows weak correlations between Perceived Usefulness and Perceived Adaptability and Perceived Usefulness and Anxiety. There is a mild correlation between Perceived Enjoyment and Perceived Sociability.

Table 5 shows regression results: Intention to Use predicting Perceived Usefulness and Perceived Enjoyment predicting Perceived Sociability.

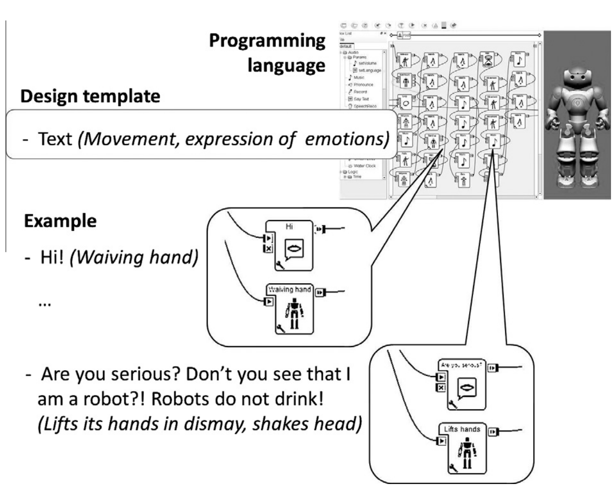

Fig. 2. Programming process of the robot NAO.

5. Discussion

This study showed that the sample of pre-school and elementary school teachers generally accept that a human-like robot can serve as an interactive tool in teaching process. It is reflected by the fact that all of the constructs (with the exception of Social Presence) averaged higher than 3.0. The scores concerning teachers' positive feelings about the robot (the Attitude construct) and the feelings of joy and pleasure associated with the use of the system (PENJ construct) were the highest. Similar to the results of previous studies (Table 1), the teachers consistently showed that robots do not evoke negative emotional reactions (according to the results from the Anxiety component).

The teachers reported that the robot seemed to be sufficiently adaptable to their needs (Perceived Adaptability). As was shown in previous studies (Ezer et al., 2009), robots are accepted as performance-directed machines, not as social devices. This perception of robots could lead to the user adapting the robot to his/her needs. At the setup used in this study, subjects revealed the teachers themselves to be adaptable by following the robot's orders, but they perceived that they could potentially adapt the robot to their needs. This can be explained by the well-adapted robot's behavior and tuned coordination between the subject's reactions and the robot's actions. As previously noted, the positive emotional environment of the interaction could lead to the perceived adaptability of the robot (Klamer & Allouch, 2010; Saini et al., 2005).

The procedure of the experiment included a casual, non-binding dialog between the subjects and the robot. During this conversation, the subject had the opportunity to not participate, to avoid the situation, or to lead it in a different direction. Any of these choices could have had a positive impact on the acceptance of the robot, as was previously noted (Zaad & Allouch, 2008).

Most of the tested constructs were found to be reliable. Those that were unreliable were the Facilitating (FC), Social Influence (SI), Social Presence (SP), and Trust constructs. These might be less important when looking at acceptance at the stage of interaction between teachers and the robot at the acquaintance level. For most of the subjects, it was the first time that they had experienced an interactive robotic system. The low reliability of the SP construct may be explained by the absence of a social model of interaction with the robot that has not yet been formed. The low reliability of the Facilitating Conditions (FC) construct may reflect the fact that a small number of questions (2 questions only) do not provide enough evidence to evaluate the influence of environmental factors on the teachers' acceptance of the robot. However, we believe that formal instruction and further experience will lead to a better understanding of this factor.

It could be supposed that a real classroom environment might influence the results. For example, the experience of interaction with a robot as teacher assistant could lead to correlation of PENG

Table 3
Cronbach's alpha and descriptive statistics of the tested constructs.

Construct	Number of questions per construct	Alpha	Min	Max	Mean	Variance
ANX	4	0.806	3.56	4.33	3.96	0.106
ATT	3	0.844	4.11	4.61	4.29	0.075
FC	2	0.685	2.89	3.22	3.06	0.056
ITU	3	0.939	3.67	3.72	3.70	0.001
PAD	3	0.766	3.00	4.17	3.54	0.347
PENJ	5	0.807	3.89	4.22	4.08	0.024
PS	4	0.791	2.39	4.06	3.18	0.519
PU	3	0.783	3.78	3.89	3.83	0.003
SI	2	0.507	3.61	3.72	3.67	0.006
SP	5	0.685	2.22	3.32	2.57	0.160
Trust	2	0.301	2.56	3.83	3.19	0.816

Table 4
Correlations between reliable constructs.

The model hypothesis	Independent variables	Dependent variable	Pearson correlation	P
H1	ATT	ITU	0.269	0.049
	PENJ		0.015	0.913
	PU		0.528	<0.001
H3	ANX	PU	0.274	0.023
	PAD		0.272	0.023
H5	PS	PENJ	0.396	<0.001

Table 5
Hypotheses and regression scores.

The model hypothesis	Independent variables	Depended variables	Beta	t	P	R^2
H1	ATT	ITU	0.160	1.290	0.203	0.3
	PENJ		0.027	0.219	0.828	
	PU		0.498	4.090	<0.001	
H3	ANX	PU	0.234	1.765	0.084	0.1
	PAD		0.232	1.748	0.086	
H5	PS	PENJ	0.396	3.610	0.001	0.15

(Perceived enjoyment) with ITU (intention to use). In the current setup the robot joked and pranked with the participants. In a classroom a robot should be serious most of the time. It would lead to the reliable Trust construct. On the other hand, the current robot's behavior of a joker probably increased the self-confidence of the subjects and reduced the anxiety (reflected by ANX construct).

In order to observe the strong interactions between the components of the UTAU model (Heerink et al., 2009a), more prolonged experience with the robot is needed. Such interactions could not be expected at the acquaintance level of interaction of teachers' as found in this study. However, most of interactions were found to be significant (Fig. 3). Similar to the results found by previous studies (Hu et al., 2003), we found that Perceived Usefulness has a strong influence on Intention to Use. In other words, the desire to use robotic teacher assistants by preschool and elementary school teachers is determined mostly by theirs beliefs that the robotics assistant will enhance and facilitate the educational process.

As could be expected (Hu et al., 2003), we found that a meaningful relation exists between Perceived Sociability and Perceived Enjoyment.

The authors assume that the fact that some participants interacted directly with the robot and the other just observed has a minimal influence on the obtained results. The nearby observers were emotionally involved in the interaction session and expressed no less emotional reaction (Fig. 1).

The results of this study have practical implications for teacher educators, because it increases our understanding of how SAR-based learning could be introduced in teacher training programs, especially in early adoption phases. As was noted previously, it appears that teachers need information first and foremost before practical issues should be considered (Bourgonjon et al., 2013). SAR researchers should address in which specific cases and under which particular circumstances educational robot can increase the quality and effectiveness of the teacher profession (Fridin, 2014a). The focus on the quality of education guides teachers to accept SAR technology as a merit for their practice.

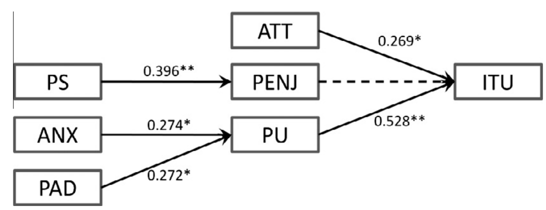

Fig. 3. Construct interrelations confirmed by regression analysis.

6. Limitations and future research

Future studies should overcome the limitations of this study: mainly, the small number of teachers who participated. A greater number in the experimental group could lead to the collection of more reliable and significant data. A larger sample size in future studies would reveal better explanation to the robot–teacher interaction and will allow application of more general statistical models, e.g. Structural Equation Modeling (Susanty, Miradipta, & Jie, 2013).

Today, there is still "a need for a grounded theoretical teacher-oriented model to describe and explain the adoption of digital game-based learning" (Bourgonjon et al., 2013), although the research of acceptance of computer games has been performed for longer than that of acceptance of robots. It was found by existing models individual differences, e.g., gender, teaching experience, teacher's beliefs about the usefulness of games etc., may influence acceptance of educational computer games (reviewed in Bourgonjon et al. (2013)). However, "because of the cross-sectional nature" of the computer games acceptance research, "future research – preferably based on a longitudinal approach or qualitative research on teachers with game-based learning experience – is necessary in order to make conclusions about the stability of the beliefs under study" (Bourgonjon et al., 2013).

The presented here study is the first attempt to investigate teachers' acceptance of a social assistive robot. Substantial future research is needed to evaluate individual differences and to check the stability of the beliefs under the study, similar to the studies on computer games acceptance.

For all of the subjects, it was their first experience with an interactive robotics system, thus this possible influence (Kim, Jung et al., 2013) was excluded.

Of course, more valuable users' data and dynamic changes of acceptance could be collected if the robot was available for a longer period, required the teachers to perform various tasks, and was available in different setups. In the current study, the teachers were opposed to interacting with the robot while amongst their colleagues. This kind of setup proved to be effective for the initial stage of contact with interactive robotics systems (Shiomi, Kanda, Ishiguro, & Hagita, 2006; Weiss et al., 2008). On the other hand, in a real school environment, the robot would serve as teacher's assistant; working together with a teacher as opposed to with the class. This setup differences should be considered for future research.

The UTAU model (Heerink et al., 2009a) used in this study was developed for a nonspecific population. The adaptation of the model to teachers, their specific social environment, and other factors, would increase the types of data collected as well as the significance of the findings. Other factors not tested in this study could influence acceptance and should be tested in the future. For example, the influence of personal, institutional, and technological factors on the acceptance of technology by teachers has been review by Buabeng-Andoh (Buabeng-Andoh, 2012). The influences of some of them (i.e. gender differences (Heerink et al., 2006; Tay et al., 2013), age impact (Heerink, 2011), educational level (Heerink, 2011), and cultural specificity (Kaplan, 2004) on the acceptance of robot have been tested on a personal level, but not on school or technological levels. Also, the influence of the robot's personality on the user's acceptance (Saini et al., 2005) should be considered.

There was some discrepancy between the robot's behavior (joker, game player) and the questionnaire, which evaluated the acceptance of the robot as a teaching assistant. The setup was designed in this way, because the purpose of the mentioned workshop was to introduce SAR technology to teachers. Therefore, the setup and the robot's behavior were designed for this purpose. Another acceptance study will be needed at the further stage of the implementation of SAR technology in an educational process, in a classroom environment.

7. Conclusions

SAR has great potential in teaching realm. The successful adaptation and integration of SAR in preschool and elementary school classrooms depends on the teachers' acceptance of it. The first attempt to examine the acceptance of this new technology by teachers as well as their underlying acceptance tendencies has been presented in this paper. Previous studies on human–SAR interaction discuss different aspects of acceptance but lacked a methodological approach to measure acceptance (Friedman, Kahn, & Hagman, 2003; Fujita, 2004; Kidd, Taggart, & Turkle, 2006; Wada, Shibata, Saito, & Tanie, 2005).

The positive reactions and acceptance demonstrated by the participants of our study was accompanied by their varied responses gathered from the questionnaire. We suggest that such these reactions reflect that the views of teachers concerning SAR and its use in the classroom have not yet been consolidated. Also, the evaluation of the applied model of acceptance could be adapted to the particular professional experience and working environment of preschool and elementary school teachers.

The opinions about and acceptance of SAR by teachers may significantly contribute to the development of this technology. We suggest that, in the future, intensive research of teachers' acceptance of SAR will diminish the gap between the technology and end-user (i.e. the teachers). Since the feeling of free-will is of great importance in the acceptance of SAR (Zaad & Allouch, 2008), the rich repertoire of educational games, which allow a teacher to feel in control of the technology, should be developed. Moreover, the public's general opinion on SAR could have a massive impact on teachers' SAR acceptance (Heerink et al., 2008).

The experiment was held among the workshop participants and not among randomly chosen teachers. The participants who were included in the study were interested in the interaction with SAR and it may cause a subject bias problem. Nevertheless, the participants of the workshop represented early-adapters of SAR technology. The integration of SAR technology in education will lean on such teachers. Therefore, the study on acceptance in this population is crucial.

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