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Storytelling by a kindergarten social assistive robot: A tool for constructive learning in preschool education

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ABSTRACT

Kindergarten Social Assistive Robotics (KindSAR) is a novel technology that offers kindergarten staff an innovative tool for achieving educational aims through social interaction. Children in a preschool setting have previously been shown to benefit from playing educational games with the KindSAR robot. The experiment presented here was designed to examine how KindSAR can be used to engage preschool children in constructive learning. The basic principle of constructivist education is that learning occurs when the learner is actively involved in a process of knowledge construction. In this study, storytelling was used as a paradigm of a constructive educational activity. An interactive robot served as a teacher assistant by telling prerecorded stories to small groups of children while incorporating song and motor activities in the process. Our results show that the children enjoyed interacting with the robot and accepted its authority. This study demonstrates the feasibility and expected benefits of incorporating KindSAR in preschool education.

1. Introduction

1.1. Robots and education

Robotics technology has recently become a fashionable tool for supporting the educational process at the middle and high school levels. Benitti (2012), in a summary of recent research on incorporation of robotics in the educational process, point outs that most of the work in this area describes the use of robots as a platform for the teaching of subjects that are themselves closely related to the robotics field, such as robot construction (including mechatronics and electronics) and programming. The robotic tools in such cases have been employed to engage students in motivated learning in the fields of physics and mathematics. In addition, they have helped to develop or improve problem solving, logic, and scientific inquiry. Ages of the research participants varied between 6 and 16. Most of the experiments involving robotics activities were not integrated into classroom activities, but took place in an after-school or summer camp program. Moreover, the robotics mostly were applied as an extracurricular activity, always involved a “group of tutors”. Prominent among the robotic tools used for educational activities were Lego robots, with variations in the models used (NXT, RCX, and Evobot).

The author also mentions studies in which robots does not used as a platform for the science teaching, but as an active teacher’s/therapist’s assistant in the development of social communication skills in individuals with autism. This area of robotics is called Social Assistive Robotics (SAR).

1.2. Social assistive robotics

Assistive robotics makes use of a broad class of robots whose function is to assist users in their daily activities, mainly out of preschool education. SAR (Feil-Seifer & Matarić, 2005) utilizes robots that assist users primarily through social rather than physical interaction, and typically address critical areas in medical care by automating the supervisory, coaching, motivational, and companionship aspects of

Abbreviations: KindSAR, kindergarten social assistive robotics; SAR, social assistive robotics; EC, eye contact; IL, interaction level; P, performance level.

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interactions with vulnerable individuals. Up to now the main populations in whom SAR has been applied are the elderly, patients with dementia and cognitive/motor disorders (Heerink, Krse, Evers, & Wielinga, 2008; Klamer, Allouch, & Heylen, 2011), and children with autism (Goodrich, Colton, Brinton, & Fujiki, 2011; Thota, Kearney, Boirum, Bojedla, & Lee, 2011; Villano et al., 2011). Unlike treatments based on computer technology, e.g., video instruction (Shukla-Mehta, Miller, & Callahan, 2009), or on virtual peers through the internet (Tartaro & Cassell, 2008), SAR creates opportunities not only to learn from a non-threatening, three-dimensional inanimate object, but also to learn through interaction, thus encouraging autonomous social behavior. From a technological point of view, SAR is an advanced field of robotics that merges challenging state-of-the-art research on machine-learning algorithms, artificial intelligence, and real-time control issues (Feil-Seifer & Matarić, 2011; Lee, Kieser, Bobick, & Thomaz, 2011; Shim & Thomaz, 2011).

In the field of child care, several studies have demonstrated positive effects of SAR on typically developing children and on children with social disorders (e.g., Kozima, Nakagawa, & Yano, 2004; Tanaka, Movellan, Fortenberry, & Aisaka, 2006). iRobi, a humanoid teaching-assistant robot, has been tested in elementary school (Han, Jo, Park, & Kim, 2005; Han & Kim, 2009; Kanda, Hirano, Eaton, & Ishiguro, 2004; Shin & Kim, 2007; You, Shen, Chang, Liu, & Chen, 2006). This wheeled robot conducts educational activities (such as storytelling and English language learning) mainly through embedded computer-based games. AIBO, a robotic pet, was introduced by Yamamoto, Tetsui, Naganuma, and Kimura (2006) into class work for 4–6-year-olds.

SAR technology is still in its infancy, but assistive robotic platforms hold promise for extrapolation to hospitals and other venues for training and therapeutic programs that monitor, encourage, and assist their users. Tapus, Matarić, and Scassellati (2007) describe the broad scope of socially assistive robotics and propose a list of milestones and the grand challenges of this field.

1.3. Existing storytelling systems

Storytelling is essential for children's development of language expression, logical thinking, imagination, and creativity (Wright, 1995). Most of the existing systems of storytelling adopt emerging technologies that enhance children's enjoyment and encourage their engagement in developmental interactive stories (Table 1). In these systems children compose their stories; the system captures their voices and movement, and an embodied robot then acts out the story. These systems have been applied for purposes of rehabilitation (Plaisant et al., 2000), learning English (Lu, Changgogo, & Chen, 2007; Wu, Chang, Liu, & Chen, 2008), or simply to enhance children's creativity. Other researchers have shown how the same idea can be applied with a virtual robot (Table 1), or with an application for the teaching of programming (Kelleher, Pausch, & Kiesler, 2007), or for collaborative story composition (Wang et al., 2009).

Only a few researchers have proposed incorporating augmented reality into storytelling systems. Montemayor, Druin, Chipman, Farber, & Guha (2004), for example, created a physical interactive environment to enrich the storytelling system.

We are aware of only one storytelling system that was created to support teachers in the learning process (Shih, Chang, & Chen, 2007). That system was used to assist the educational staff to teach English.

The above systems have been applied in elementary and high school education (Table 1), but never in a preschool setting. Moreover, there is no available information on how a storytelling system can be utilized to assist teachers in the educational process or how to support constructive learning.

Table 1
Existing storytelling systems.

Task	Reference	Age of subjects	Sample size	Equipment	Applications
Children teach the robot to tell a story	Hsieh, Su, Chen, Chen, and Lin (2010)	NA	NA	Furry robotic bear, Web camera, notebook	Story composition
	Plaisant et al. (2000)	CP, 5 yr old ADSD, NA	2	Notebook, furry robot, variety of body sensors	Story composition for rehabilitation
	Lu et al. (2007)	10	34	Humanoid robot	Learn English
	Wu et al. (2008)	NA	NA	NA	Learn English
	Vaucelle and Jehan (2002)	5	NA	Dolltalk toy	Story composition + enhancement of children's creativity
	Ananny and Cassell (2001)	6–7	22	TellTale toy, looks like a caterpillar, consists of 6 individual pieces	Story composition activities
	Mutlu et al. (2006)	20	19–33	ASIMO robot (Honda)	Investigation of emulating human-like gaze behavior by robot
Children teach the virtual agent to tell a story	Wang et al. (2009)	6	NA	Virtual agent	Collaborative story composition (create roles and share stories)
	Sadik (2008)	6–15	35–45 students × 8 classes	Microsoft Photo Story on Notebook	Investigate the story composition process
	Kelleher et al. {2007}	Middle school students	88	Virtual agent	Introduce girls to computer programming
Children teach the robot to tell a story, using augmented reality	Ryokai and Cassell (1999)	5–8	36	StoryMat: a soft cloth quilt with appliquéd figures on it	Collaborative fantasy play and storytelling
	Montemayor et al. (2004)	4–6	11	Physical interactive environment	Story composition
	Sugimoto (2011)	9–12	24	Handheld projector, tortoise robot	Story composition
Robot acts as a teacher assistance	Shih et al. (2007)	High school students	20	RoboSapien	Learn English

ADS, autistic disorder syndrome; CP, cerebral palsy; NA, not available.