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Students' Normative Perspectives on Classroom Robots

Sofia SERHOLT [a,1], Wolmet BARENDREGT [a,b], Dennis KÜSTER [c], Aidan JONES [d], Patrícia ALVES-OLIVEIRA [e,f], and Ana PAIVA [e]

[a] *Department of Applied IT, University of Gothenburg, Gothenburg, Sweden*
[b] *The Linnaeus Centre for Research on Learning, Interaction and Mediated Communication in Contemporary Society (LinCS), University of Gothenburg, Gothenburg, Sweden*
[c] *Department of Psychology and Methods, Jacobs University Bremen, Bremen, Germany*
[d] *Electronic, Electrical and Computer Engineering, University of Birmingham, Birmingham, UK*
[e] *INESC-ID and Instituto Superior Técnico, Universidade de Lisboa, Porto Salvo, Portugal*
[f] *Instituto Universitário de Lisboa (ISCTE-IUL), CIS-IUL, Porto Salvo, Portugal*

Abstract. As robots are becoming increasingly common in society and education, it is expected that autonomous and socially adaptive classroom robots may eventually be given responsible roles in primary education. In this paper, we present the results of a questionnaire study carried out with students enrolled in compulsory education in three European countries. The study aimed to explore students' normative perspectives on classroom robots pertaining to roles and responsibilities, student-robot relationships, and perceptive and emotional capabilities in robots. The results suggest that, although students are generally positive toward the existence of classroom robots, certain aspects are deemed more acceptable than others.

Keywords. normative perspectives, children, students, classroom robots

1. Introduction

Robots are becoming increasingly prevalent in today's society, not least within education. This is partly indicated by research projects [1-3] and laboratories [4] devoted to exploring children's interactions with robots and potential opportunities for learning; and partly by robot initiatives conducted at specific educational institutions. Robots are becoming more autonomous in that they "can sense [their] environment, plan based on that environment, and act upon that environment with the intent of reaching some task-specific goal (either given to or created by the robot) without external control" [5]. Yet, increased autonomy of robots is not limited to physical abilities, but also affects the social sphere [6-8]. Following these developments, it can be expected that autonomous and socially adaptive *classroom robots* will soon begin to feature more prominently in

[1] Corresponding Author: Sofia Serholt, Department of Applied IT, University of Gothenburg, E-mail: sofia.serholt@ait.gu.se, tel.: +46 737108076

primary education. However, this is not likely to be a straightforward process. For example, a Eurobarometer conducted in 2012 on public attitudes towards robots revealed that although EU citizens were generally positive towards the use of robots in society, only 3% believed that robots should be used for educational purposes, while 34% thought that robots in education should be banned altogether [9].

Drawing inspiration from a Responsible Research and Innovation (RRI) perspective, we argue that it is important to pay special consideration to the views of stakeholders so that they can take an active part in shaping the future of robotic developments [10, 11]. While the Eurobarometer results capture our attention, we need to move forward and attempt to disentangle what functions of classroom robots stakeholders consider more or less desirable. Although sensitivity towards target users' needs has been emphasized in the past concerning the acceptable *design* of robots [12-14], our work focuses on the *normative* perspectives of stakeholders, i.e., what robots should and should not *be* or be able to *do* in schools, complemented by questions about robots' expected abilities or stakeholders' willingness to engage in different kinds of interactions with robots in the future. Thus, we will first consider what robots *can do* now or in the future, and thereafter ask stakeholders about those functions specifically. While we have explored this with teachers in our previous work [15], we now seek to study the case of classroom robots through a questionnaire study with students enrolled in compulsory education in three European countries.

2. Related Work

Previous research has indicated that robots can foster students' learning while creating an enjoyable experience [16, 17], and various possibilities and applications of robots are fervently discussed and tested in educational institutions [8, 18-21]. By drawing on Papert's constructionist ideas [22], robots are used as hands-on tools to facilitate students' Science, Technology, Engineering and Math (STEM) skills by allowing them to program [23] or assemble robots from scratch [24]. Other educational applications of robots are more geared towards interaction, whether this be through tele-presence robots that can mediate students' interactions with human teachers [25], or via direct interaction with robots as, e.g., tutors [26], learning companions [27], or tutees [28]. A practical distinction between these fields, we argue, lies in the autonomy of the robot. In the hands-on and tele-presence cases, the robot is directly manipulated by the student or the teacher, respectively, whereas in the other applications (e.g., a tutoring robot) the robot is more autonomous in carrying out actions without input from an operator [20].

2.1. Robot Roles and Responsibilities

Depending on the specific application, different implications follow from introducing robots into classrooms. More autonomous robots could potentially be given roles and responsibilities that are traditionally assigned to human teachers. Aside from tutoring or being tutored by students during lessons, robots could also assess students' learning performances, and possibly assign grades to their schoolwork. Although teachers tend to be highly skeptical about robots' capabilities to assess students' skills such as writing [15], research conducted by the Australian Curriculum, Assessment and Reporting Authority revealed that computer-generated automatic assessments of student essays

"were statistically and substantively equivalent to those provided through human scoring" [29].

As possibilities of robots are increasingly explored, debates are fueled in popular media concerning whether robots will *replace* human teachers in delivering educational content to students in the future [30-33]. While visions of substantially reducing the workload of teachers with robots have not aimed at replacing them, the rapid advancement of robots shows potential for partially substituting human teaching with robots, e.g., in the case of language learning [34]. Possibilities aside, we seek to study whether (and to what extent) students think that robots should assume more responsible roles in education.

From a human perspective, autonomy and responsibility also entail moral accountability. As robots are increasingly designed to take on more "sophisticated humanoid forms", Kahn et al. [35] argue that it becomes increasingly likely that people will consider robots morally accountable for their own actions. A different view is that developers should be responsible for robots' potential mistakes or wrongdoings like any other product, but it has been argued that it is unreasonable to expect developers to be held accountable for negative situations or consequences of using particular robots when they "learn" and function autonomously [36, 37]. This creates a responsibility ascription problem [37, 38], and we aim to explore whether students think that robots should be held responsible for possible wrongdoings.

2.2. Children's Relationships with Robots

Robots are often intentionally designed to evoke children's relationship formation with them [7, 12]. For example, Kanda, Sato, Saiwaki and Ishiguro [8] implemented strategic social behaviors in their classroom robot seeking to encourage more long-term interactions, and several studies have revealed tendencies in children to perceive robots as friends [27, 39-41]. Turkle [42] has observed that social robots evoke feelings of attachment in people, and argues that social robots are becoming relational artifacts. This demonstrates a shift from technology as a mediating artifact between humans, to technology as the target or object of social interaction [43]. Yet, it is not clear whether these developments are desirable or just an unintended design consequence.

2.3. Perceptive and Emotional Capabilities

According to Bloom [44], personalization and adaptive tutoring are important for effective education. Personalization has been shown to be important for human-robot interaction as well [27, 45, 46]. In their literature review on long-term human-robot interaction, Leite, Martinho and Paiva [47] have indicated the importance of robots being equipped with empathy, memory and adaptation in order to foster more long-term interactions. In the case of classroom robots, this usually entails temporary, anonymous storage of data about students which can account for previous interactions and provide learner models of students [7, 48]. While there is no uniform technical approach to gathering such data, it could include capturing of facial expressions, speech, video or other physiological data such as skin conductance [12]. To avoid moving too far in undesirable directions, we seek to ask students whether such practices are acceptable or not.

3. Method

The present questionnaire study aimed to explore students' perspectives on potential characteristics, tasks and roles assumed by classroom robots. We invited school classes of students to participate in the study. The study was organized as part of a series of workshops on robots in Sweden (SE), Portugal (PT) and the United Kingdom (UK), wherein students were asked to share their ideas concerning what a classroom robot should and should not *be* or *do* respectively. Parental consent was obtained prior to the study, and students' verbal consent was obtained at the time of the study. Students were also given the opportunity to opt out at any time while still being able to participate in the workshop itself. The questionnaires were then distributed at the end of the workshop.

3.1. Participants

A total of 175 (74 female; 100 male; 1 unknown) students aged 11-18 (M = 13.53; SD = 1.83) filled out the questionnaire during the study. As entire school classes were invited to participate, ages among participants were not evenly distributed among the countries. In the UK, students were aged 11-12; in SE 11-12 or 15-16; and in PT 13-14 or 17-18. 42% of the participants lived in SE, 35% in PT, and 23% in the UK.

3.2. Procedure

Given the difficulties in imagining futuristic technologies [49-51], it has been suggested that research participants should be provided with detailed descriptions of features and functions of robots before partaking in a study [52]. Therefore, we gave students a brief presentation about the nature of the study in the presence of an Aldebaran Nao T14 torso robot, which could perform a number of social behaviors such as talking and dancing. Then, a 5-min video about current developments in social robotics was shown. The video illustrated how external sensors and software programs can be used in order to interpret children's affective states. It also presented several robots (both tele-presence and autonomous humanoids) currently in use in primary education in various countries. The video ended with two short segments of some futuristic possibilities of robots depicted in two science fiction movies (*I, Robot* and *Robot and Frank*) in order to raise ethical issues to their attention and inspire participants to think beyond their current experiences with technology. Drawing on the ContraVision approach [51], the videos were intentionally edited so that *I, Robot* was deemed to be perceived in a more negative light, and *Robot and Frank* in a more positive light. The ordering of these two segments was counterbalanced. Following the video, participants were requested to read through a short fictive vignette in the form of a comic book about a 12-year-old student's interaction with a classroom robot that could interpret and adapt to emotional states.

After the introduction, participants were assigned to groups of 3 to 4 students in which they were to discuss desirable and undesirable features in a classroom robot[2]. Following the discussions, participants were requested to place themselves in a secluded spot to fill out the individual questionnaires.

[2] The qualitative results from these discussions have previously been analyzed and submitted to a journal. As the article is currently undergoing blinded review, the reference cannot be provided here.

3.3. Questionnaire

The questionnaire was designed to include a set of different criteria on ethical issues, robot features, and areas of concern. Inspiration for the questionnaire items was initially drawn from two separate sources: the Negative Attitudes Towards Robots Scale (NARS) [53], and a collection of normative issues surrounding emerging technologies compiled in a deliverable by the EU-project ETICA [54]. Thereafter, analysis of previous work on classroom robots served as a lens in developing questions particularly relevant for the educational context (see Section 2).

Children's surveys should be tailored according to the social and cognitive development of the target age group [55]. The language should be simple and direct, and ambiguity should be avoided. Also, children are more likely than adults to respond in socially desirable ways, so prescribing values or posing questions in certain ways may easily sway them. It is furthermore not advisable to present too many response options. In some cases, five point scales may be valid for older children, whereas with younger children, response options should be limited to a maximum of three [55]. As such, we chose to refrain from the more conventional use of five point scales in favor of merely "*yes*", "*no*", or "*I don't know/I don't want to answer*". Considering that our study comprised students ages 11-18, we chose to make the questionnaire more adapted for the younger students, and maintained this design for all participants.

The questions were initially written in English and thereafter translated to Swedish and Portuguese by a native speaker. The translated questions were then cross-checked with an additional native speaker to ensure that they corresponded well with the original formulations. The questionnaire items in English are presented in Table 1.

Table 1. Items on the questionnaire

	Questions 1-14
1.	Do you think that robots with human characteristics should be present in schools?
2.	Do you think that robots should show feelings?
3.	Would you be able to talk to a robot?
4.	Could you ask a robot for help with your schoolwork?
5.	Could you become friends with a robot?
6.	Would you be able to talk to a robot in front of your schoolmates?
7.	Would you want a robot to grade your schoolwork?
8.	Would you be able to trust a robot?
9.	Do you think that children in preschool should have robot teachers/assistants?
10.	Do you think robots should decide things in society?
11.	Would you like a robot to record the things you do and say?
12.	Would you like a robot to be able to analyse your feelings based on e.g. your facial expression and pulse?
13.	Do you think robots should be held responsible if they do something wrong?
14.	Do you think robots should replace teachers in school?

4. Results

In contrast to adults' expressed aversions to robots in education [9], the analysis of our study revealed that 76.2% of the students had overall positive attitudes toward the presence of robots with human characteristics in education (Q1), and 87.8% were

positive about asking a robot for help with their schoolwork (Q4). These questions were posed in a general manner, and as such, do not indicate what kinds of robots the students had in mind when responding. Thus, in the following subsections, results will be presented in accordance with the different areas of inquiry identified in the related work, namely robots' roles and responsibilities in general and pertaining to education, students' (envisioned) relationships with robots, and finally, students' perspectives on perceptive and emotional capabilities of robots.

4.1. Robot Roles and Responsibilities

We aimed to understand students' views on robots grading students' schoolwork (Q7), featuring as teachers or assistants with young children (Q9), or being able to replace human teachers (Q14). While these questions were specifically targeting roles and responsibilities within the educational context, we asked how this relates to responsibility (Q13) and autonomy (Q10) for robots on a more general level. Figure 1 details the response frequencies to these questions, revealing that the considered educational responsibilities were deemed inappropriate by the majority of students. However, robots' grading students' schoolwork generated more uncertain or positive responses when compared to robots replacing teachers or featuring in pre-school. Taken together, these findings suggest that the participants could imagine allocating certain tasks to a robot under the premise that this would not interfere with the role of the human teacher. On the more general questions, while 58% of the participants thought that robots should be held responsible for potential wrongdoings, 86% did not think that robots should be able to make decisions in society.

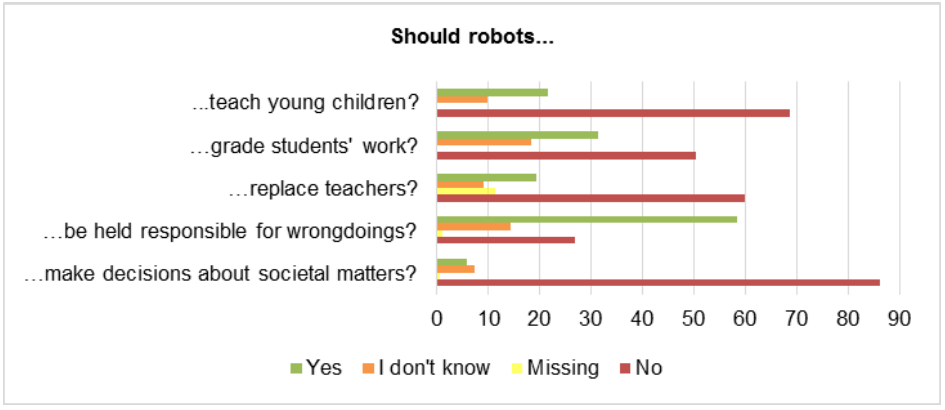

Figure 1. Response frequencies on Q7, Q9, Q14, Q13 & Q10 expressed as % of whole sample ($N = 175$)

4.2. Envisioning a Relationship

We also asked how students felt about engaging in social relationships/interactions with robots. This might be very different from simply requesting help concerning schoolwork from a robot as this could be similar to the use of other digital technologies in education that students might be growing increasingly accustomed to (e.g. searching for

information online or playing educational computer games). We therefore explored if and how students envisioned themselves relating to a robot, pertaining specifically to speaking to a robot either by themselves (Q3) or in the presence of their peers (Q6), becoming friends with a robot (Q5), or affording trust to a robot (Q8). Figure 2 presents these response frequencies, which show that students were positive towards the idea of talking to a robot (Q3), yet not as positive towards the idea of talking to a robot in front of peers. Moreover, developing friendships with robots appeared to be more difficult to envision, as only about half of the participants responded affirmatively. Trusting a robot was seen as even more unlikely, although there were quite a few missing responses here, suggesting that this was a problematic question to answer or situation to imagine.

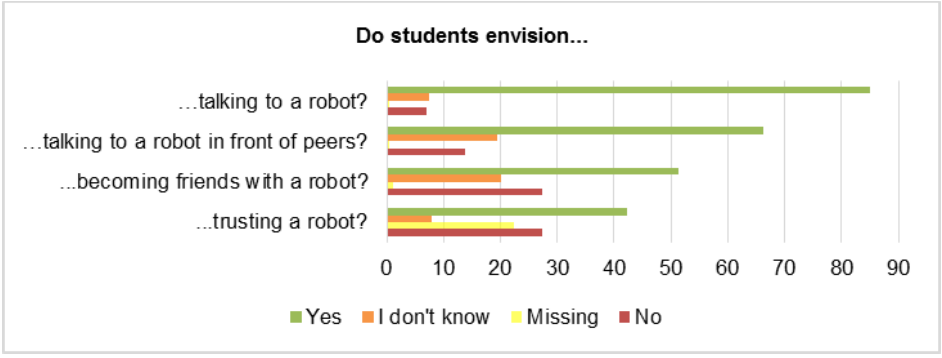

Figure 2. Response frequencies on Q3, Q5, Q6 & Q8 expressed as % of whole sample ($N = 175$)

4.3. Perceptive and Emotional Characteristics

Finally, we sought to explore whether the students thought robots should be able to express (Q2) or understand their emotions (Q12), and record what they do and say (Q11). Figure 3 displays the response frequencies for these questions, indicating that expressing and understanding emotions were both deemed more acceptable than recording students.

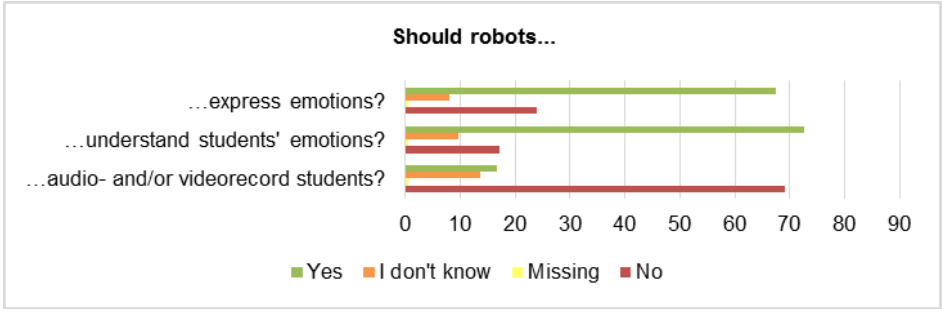

Figure 3. Response frequencies on Q2, Q12 & Q11 expressed as % of whole sample ($N = 175$)

4.4. Acceptance Continuum

To provide an overview and summarize the results of this study, Figure 4 presents the response frequencies of all items on the questionnaire. The questions have been modified for readability purposes, and are sorted from the highest to lowest percentage of "yes"-responses. For original questions, see Table 1.

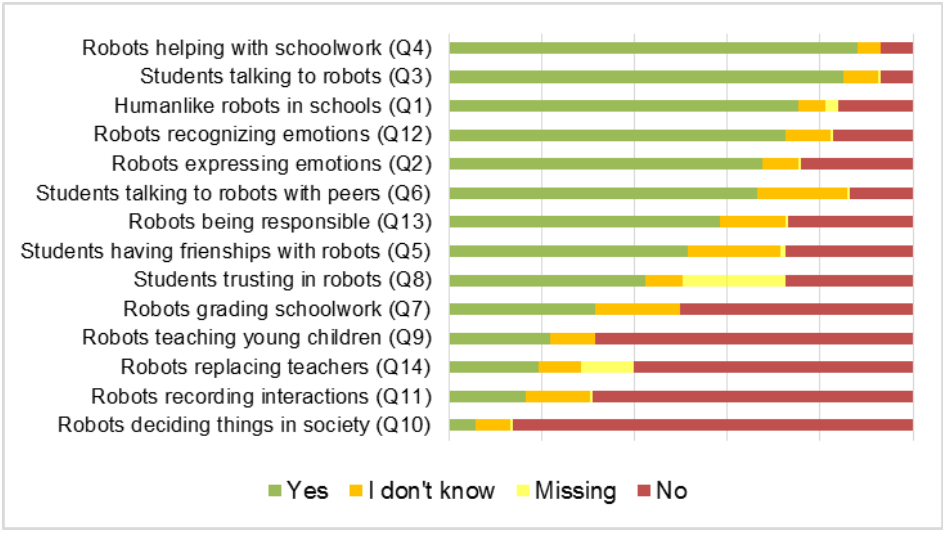

Figure 4. Questionnaire items on continuum ranging from most to least positive responses expressed as % of whole sample ($N = 175$)

5. Discussion

The results of the study revealed that students, unlike the adult respondents in [9], considered robots acceptable additions to classroom practices (i.e. a majority of students could envision robots featuring in schools, as well as asking them about school-related work). However, when going into detail about different robot roles and features which are or may become technically possible in the future, it is clear that some aspects of classroom robots were deemed more unacceptable than others. Working with young children, replacing teachers or grading students' schoolwork were all undesirable practices. Also, most students did not think that they would be able to trust a robot, nor did they express a desire for a robot to grade their schoolwork or make decisions on a more general level concerning matters in society. Nevertheless, the majority thought that robots should be held responsible for potential wrongdoings.

In contrast to Turkle's [42] description of robots as relational artifacts, our results suggest that the students perceived them as tools. The students could, e.g., envision speaking to a robot themselves, yet this did not necessarily imply that they would feel comfortable speaking to a robot in front of their peers or becoming friends with it, which is contradictive to how children have behaved when interacting with robots in previous studies [27, 39, 41, 56].

Furthermore, classroom robots are often equipped with capabilities pertaining to perceiving and processing the educational situation. This can include merely storing and processing visual or auditory input in order to better understand students' learning processes, but it can also relate to endowing robots with more humanlike traits such as artificial emotion expression or empathy [7, 12]. Our study showed that students considered both expressing and understanding emotions by robots as desirable characteristics, but actual recordings of students were deemed unacceptable. This might prove problematic for the field as recollections of previous interactions are necessary for a robot to be able to properly adapt to individual students [7, 47].

5.1. Limitations and Future Work

A limitation to this study could be the way in which participants were introduced to the topic which may have affected their responses. Although we tried to present both positive and negative possibilities of using robots, it is likely that participants' responses were affected by something that they read, viewed, or discussed during the workshops. While we assume that the workshops provided more balanced and comprehensive background information compared to research such as the Eurobarometer, we did not include a control condition for this factor in our design. It would therefore be interesting to conduct a similar questionnaire study where participants are not given any representation of robots beforehand. Also, like previous research [57], it would be interesting to systematically compare age-related or cultural differences of students' perspectives on robots, but due to the uneven distribution of age groups across the three countries, this was not feasible to do in this particular study. Thus, a follow-up study could include a larger sample where these factors are controlled. Finally, it is possible that the questionnaire items were not always entirely clear to all participants, evidenced by missing responses to individual items. Future work should thus re-examine and potentially rephrase individual items in order to avoid ambiguity.

6. Conclusion

Our results suggest that students in this age group (11-18) perceive certain educational roles of robots very positively, such as robots helping them with schoolwork. However, at the same time, students may be very skeptical about certain more controversial roles and functions of classroom robots. Certainly, the vast majority does not want to see teachers being replaced by robots, nor does there appear to be much favor towards the notion that robots might eventually be involved in other roles in society where they would make decisions with impact on humans. In between these end points of the discussion, we observe a lot of variance and gradation of responses in general. Overall, our findings thus appear to largely mirror the general emergent normative discussion about what robots should and should not be allowed to do in the future of education. Our data further highlights tensions that can be seen between highly desirable abilities of robots, such as being able to help, understand, and appropriately respond to the user's feelings and expressions – vs. the question of how this might be achieved without at least temporarily recording interactions or other kinds of user data. Finally, and somewhat surprisingly, many students appear to answer in an affirmative manner to the question whether robots should be "held responsible" if they do something wrong – i.e., our study shows indirect evidence for an implicit assumption that future robots indeed *can* be

assumed to be morally responsible and accountable. Taken together, we can see a very colorful picture emerging on the basis of this questionnaire data, including some pointers towards the main hopes and fears of young people imagining the potential future roles of robots in education.

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References

[1] EMOTE: Embodied Perceptive Tutors for Empathy-based Learning, http://www.emote-project.eu, Accessed 2016-08-04.
[2] EASEL: Expressive Agents for Symbiotic Education and Learning, http://easel.upf.edu/, Accessed 2016-08-04.
[3] L2TOR: Second Language Tutoring using Social Robots, http://www.l2tor.eu/, Accessed 2016-8-4.
[4] Personal Robots Group. MIT Media Lab, http://robotic.media.mit.edu/, Accessed 2016-08-04.
[5] J.M. Beer, A.D. Fisk, W.A. Rogers, Toward a Framework for Levels of Robot Autonomy in Human-Robot Interaction, *Journal of Human-Robot Interaction* **3** (2014), 74-99.
[6] G. Castellano, *et al.*, Towards Empathic Virtual and Robotic Tutors. In H.C. Lane, K. Yacef, J. Mostow, P. Pavlik, (Eds.), *Artificial Intelligence in Education*, (pp. 733-736). Springer Berlin Heidelberg, 2013.
[7] T. Belpaeme, *et al.*, Multimodal Child-Robot Interaction: Building Social Bonds, *Journal of Human-Robot Interaction* **1** (2012), 33-53.
[8] T. Kanda, R. Sato, N. Saiwaki, H. Ishiguro, A Two-Month Field Trial in an Elementary School for Long-Term Human-Robot Interaction, *IEEE Transactions on Robotics* **23** (2007), 962-971.
[9] European Commission, *Public Attitudes Towards Robots. Special Eurobarometer 382*, 2012.
[10] G. Eden, M. Jirotka, B. Stahl, Responsible research and innovation: Critical reflection into the potential social consequences of ICT. In *Proceedings of the IEEE 7th International Conference on Research Challenges in Information Science (RCIS)*, (pp. 1-12), 2013.
[11] R. Schomberg, From the ethics of technology towards an ethics of knowledge policy: implications for robotics, *AI & SOCIETY* **22** (2007), 331-348.
[12] A. Jones, *et al.*, Empathic Robotic Tutors for Personalised Learning: A Multidisciplinary Approach. In *Proceedings of the International Conference on Social Robotics*, (pp. 285-295), 2015.
[13] S. Šabanović, Robots in Society, Society in Robots, *International Journal of Social Robotics* **2** (2010), 439-450.
[14] T. Belpaeme, *et al.*, Child-Robot Interaction: Perspectives and Challenges. In G. Herrmann, M. Pearson, A. Lenz, P. Bremner, A. Spiers, U. Leonards, (Eds.), *Social Robotics*, (pp. 452-459). Springer International Publishing, 2013.
[15] S. Serholt, *et al.*, The case of classroom robots: teachers' deliberations on the ethical tensions, *AI & SOCIETY* (2016), 1-19.
[16] J. Kennedy, P. Baxter, T. Belpaeme, Comparing Robot Embodiments in a Guided Discovery Learning Interaction with Children, *International Journal of Social Robotics* **7** (2015), 293-308

[17] D. Leyzberg, S. Spaulding, M. Toneva, B. Scassellati, The Physical Presence of a Robot Tutor Increases Cognitive Learning Gains. In *Proceedings of the 34th Annual Conference of the Cognitive Science Society*), 2012.
[18] J. Han, Emerging Technologies: Robot Assisted Language Learning, *Language Learning & Technology* **16** (2012), 1-9.
[19] J.R. Movellan, F. Tanaka, B. Fortenberry, K. Aisaka, The RUBI/QRIO Project: Origins, Principles, and First Steps. In *Proceedings of the 4th International Conference on Development and Learning*, (pp. 80-86), 2005.
[20] O. Mubin, C.J. Stevens, S. Shahid, A.A. Mahmud, J.-J. Dong, A review of the applicability of robots in education, *Technology for Education and Learning* (2013), 1-7.
[21] F.B.V. Benitti, Exploring the educational potential of robotics in schools: A systematic review, *Computers & Education* **58** (2012), 978-988.
[22] S. Papert, *Mindstorms: children, computers, and powerful ideas*, Basic Books, Inc., 1980.
[23] G. Nugent, B.S. Barker, N. Grandgenett, The Impact of Educational Robotics on Student STEM Learning, Attitudes, and Workplace Skills. *Robots in K-12 Education: A New Technology for Learning*, (pp. 186-203). IGI Global, 2012.
[24] C. Vandevelde, F. Wyffels, C. Ciocci, B. Vanderborght, J. Saldien, Design and evaluation of a DIY construction system for educational robot kits, *International Journal of Technology and Design Education* (2015), 1-20.
[25] S. Yun, *et al.*, Engkey: Tele-education Robot. In B. Mutlu, C. Bartneck, J. Ham, V. Evers, T. Kanda, (Eds.), *Social Robotics: Proceedings of the 3rd International Conference on Social Robotics (ICSR), Amsterdam, The Netherlands*, (pp. 142-152). Springer Berlin Heidelberg, Berlin, Heidelberg, 2011.
[26] L. Hall, *et al.*, (2016). *Map Reading with an Empathic Robot Tutor*. Paper presented at the HRI 2016: International Conference on Human-Robot Interaction (Extended abstracts), Christchurch, New Zealand.
[27] T. Kanda, T. Hirano, D. Eaton, H. Ishiguro, Interactive Robots as Social Partners and Peer Tutors for Children: A Field Trial, *Human-Computer Interaction* **19** (2004), 61-84.
[28] S. Lemaignan, *et al.*, Learning by Teaching a Robot: The Case of Handwriting, *Robotics and Automation Magazine* (2016).
[29] ACARA NASOP Research Team, *An Evaluation of Automated Scoring of Naplan Persuasive Writing*, 2015. Retrieved from http://www.nap.edu.au/verve/_resources/20151130_ACARA_research_paper_on_online_automated_scoring.pdf
[30] R. Lloyd, *Robots Could Replace Teachers*, *Live Science* (2009). Retrieved from http://www.livescience.com/5576-robots-replace-teachers.html
[31] S. Sharwood, *Australian test finds robot essay assessors on par with human teachers*, *The Register* (2015). Retrieved from http://www.theregister.co.uk/2015/12/01/software_essay_marking_equal_to_human_essay_marking/
[32] J. Espinoza, *Robo-teacher is coming but don't expect to be inspired*, *The Telegraph* (2015). Retrieved from http://www.telegraph.co.uk/education/educationnews/11642622/Robo-teacher-is-coming-but-dont-expect-to-be-inspired.html
[33] J. Dunn, K. Dunn, *Technology Will Not Replace Teachers*, (2014). Retrieved from http://www.huffingtonpost.com/jeff-dunn/teachers-technology_b_4130200.html
[34] A.N. Meltzoff, P.K. Kuhl, J. Movellan, T.J. Sejnowski, Foundations for a New Science of Learning, *Science* **325** (2009), 284-288.
[35] P.H. Kahn, *et al.*, What is a human? Toward psychological benchmarks in the field of human–robot interaction, *Interaction Studies* **8** (2007), 363–390.
[36] S.P. Gill, Socio-ethics of interaction with intelligent interactive technologies, *AI & SOCIETY* **22** (2008), 283-300.
[37] A. Matthias, The responsibility gap: Ascribing responsibility for the actions of learning automata, *Ethics and Information Technology* **6** (2004), 175-183.
[38] D. Marino, G. Tamburrini, Learning robots and human responsibility, *International Review of Information Ethics* **6** (2006), 46-51.
[39] M. Fior, S. Nugent, T.N. Beran, A. Ramirez-Serrano, R. Kuzyk, Children's Relationships with Robots: Robot is Child's New Friend, *Journal of Physical Agents* **4** (2010), 9-17.
[40] E. Hyun, H. Yoon, S. Son, Relationships between user experiences and children's perceptions of the education robot. In *Proceedings of the 5th ACM/IEEE international conference on Human-robot interaction*, (pp. 199-200), 2010.
[41] F. Tanaka, A. Cicourel, J.R. Movellan, Socialization between toddlers and robots at an early childhood education center, *Proceedings of the National Academy of Sciences* **104** (2007), 17954-17958.
[42] S. Turkle, *A Nascent Robotics Culture: New Complicities for Companionship*, AAAI Technical Report Series, 2006. Retrieved from http://web.mit.edu/~sturkle/www/nascentroboticsculture.pdf

[43] E. van Oost, D. Reed, Towards a Sociological Understanding of Robots as Companions. In M. Lamers, F. Verbeek, (Eds.), *Human-Robot Personal Relationships*, (pp. 11-18). Springer Berlin Heidelberg, 2011.
[44] B.S. Bloom, The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring, *Educational Researcher* **13** (1984), 4-16.
[45] D. Leyzberg, S. Spaulding, B. Scassellati, (2014). *Personalizing robot tutors to individuals' learning differences*. Paper presented at the 2014 ACM/IEEE international conference on Human-robot interaction, Bielefeld, Germany.
[46] M.K. Lee*, et al.*, Personalization in HRI: A longitudinal field experiment. In *Proceedings of the 7th ACM/IEEE International Conference on Human-Robot Interaction*), 2012.
[47] I. Leite, C. Martinho, A. Paiva, Social Robots for Long-Term Interaction: A Survey, *International Journal of Social Robotics* **5** (2013), 291-308.
[48] K. Porayska-Pomsta, M. Mavrikis, S. D'Mello, C. Conati, R. Baker, Knowledge Elicitation Methods for Affect Modelling in Education, *International Journal of Artificial Intelligence in Education* **22** (2013), 107-140.
[49] L. Little, T. Storer, P. Briggs, I. Duncan, E-voting in an ambient world: Trust, privacy and social implications, *Social Science Computer Review* **26** (2008), 44-59.
[50] B.C. Stahl, N. McBride, K. Wakunuma, C. Flick, The empathic care robot: A prototype of responsible research and innovation, *Technological Forecasting & Social Change* (2013), 1-12.
[51] C. Mancini*, et al.*, (2010). *Contravision: exploring users' reactions to futuristic technology*. Paper presented at the SIGCHI Conference on Human Factors in Computing Systems, Atlanta, Georgia, USA.
[52] N. Reich-Stiebert, F. Eyssel, Learning with Educational Companion Robots? Toward Attitudes on Education Robots, Predictors of Attitudes, and Application Potentials for Education Robots, *International Journal of Social Robotics* **7** (2015), 875-888.
[53] T. Nomura, T. Kanda, T. Suzuki, Experimental investigation into influence of negative attitudes toward robots on human–robot interaction, *AI & SOCIETY* **20** (2006), 138-150.
[54] R. Heersmink, J. van den Hoven, J. Timmermans, *ETICA Project: D.2.2 Normative Issues Report*, 2014. Retrieved from http://www.etica-project.eu/deliverable-files
[55] E.D. de Leeuw, *Improving Data Quality when Surveying Children and Adolescents: Cognitive and Social Development and its Role in Questionnaire Construction and Pretesting*, 2011. Retrieved from http://www.aka.fi/globalassets/awanhat/documents/tiedostot/lapset/presentations-of-the-annual-seminar-10-12-may-2011/surveying-children-and-adolescents_de-leeuw.pdf
[56] E. Hyun, H. Park, S. Jang, H. Yeon, The Usability of a Robot as an Educational Assistant in a Kindergarten and Young Children's Perceptions of their Relationship with the Robot, *Korean Journal of Child Studies* **31** (2010), 267-282.
[57] A.M. Rosenthal-von der Pütten, N. Krämer, Individuals' evaluations of and attitudes towards potentially uncanny robots, *International Journal of Social Robotics* **7** (2015), 799-824.