Robot tutors

Smakman, Matthijs; Konijn, Elly A.

published in
Robotics in Education
2020

DOI (link to publisher)
10.1007/978-3-030-26945-6_34

document version
Publisher's PDF, also known as Version of record

Robot Tutors: Welcome or Ethically Questionable?

Matthijs Smakman[1,2(✉)] and Elly A. Konijn[1]

[1] Department of Communication Science, Media Psychology Program, VU University Amsterdam, Amsterdam, The Netherlands
matthijs.smakman@hu.nl, elly.konijn@vu.nl
[2] Institute for ICT, HU University of Applied Sciences Utrecht, Utrecht, The Netherlands

Abstract. Robot tutors provide new opportunities for education. However, they also introduce moral challenges. This study reports a systematic literature review ($N = 256$) aimed at identifying the moral considerations related to robots in education. While our findings suggest that robot tutors hold great potential for improving education, there are multiple values of both (special needs) children and teachers that are impacted (positively and negatively) by its introduction. Positive values related to robot tutors are: psychological welfare and happiness, efficiency, freedom from bias and usability. However, there are also concerns that robot tutors may negatively impact these same values. Other concerns relate to the values of friendship and attachment, human contact, deception and trust, privacy, security, safety and accountability. All these values relate to children and teachers. The moral values of other stakeholder groups, such as parents, are overlooked in the existing literature. The results suggest that, while there is a potential for applying robot tutors in a morally justified way, there are imported stakeholder groups that need to be consulted to also take their moral values into consideration by implementing tutor robots in an educational setting.

Keywords: Social robots · Moral values · Ethics · Robot tutors · Robot-assisted (language) learning · Child-robot interaction

1 Introduction

New technology provides important tools for modern education and can provide unique learning experiences to students, thereby improving their achievements. One such technology is the educational robot. The EduRobot Taxonomy classifies three types of educational robots, being: (1) Build Bots, (2) Use Bots and (3) Social Bots [1]. Build Bots are used for teaching students new subjects by letting them build and program robots, such as with LEGO Mindstorms. The second type (Use Bots), consist of robots that can be used immediately, that is, students don't need to build the robot. The third type (Social Bots), are for interacting with the robot as a social entity. The robot then appears to be perceived by children as a peer rather than a tool and – according to the children – the humanoid robots even seem to establish a kind of friendship-relation with them [2]. The Social Bots classification corresponds with the role of an educational robot as a *learning collaborator* described by Miller et al. [3]. This, often humanlike robot with social features, in the role of

M. Merdan et al. (Eds.): RiE 2019, AISC 1023, pp. 376–386, 2020.
https://doi.org/10.1007/978-3-030-26945-6_34

a learning collaborator is what this paper defines as a "robot tutor", which is a common understanding of the definition in robotic literature [4].

Although the robot tutor is said to provide great opportunities [4], it also introduces moral challenges. Potential risks related to applying robot tutors in an educational context are voiced through different channels, however, no systematic overview exists to date. Several studies on moral conceptions regarding this topic emphasise the need for moral considerations and guidelines [4–9]. In this paper, we present a systematic literature review aimed at identifying the opportunities and concerns for (moral) values regarding tutor robots.

In the following, we outlay our methodological approach to identify moral values, following the Value Sensitive Design methodology [10], which is often used to integrate moral values into technology. Then, we detail the selection procedure of the literature search and categorise the moral values based on the concerns and opportunities identified in applying robots in education.

1.1 Moral Conceptions Regarding Robot Tutors

Moral conceptions are "the basic notions of the right, the good, and moral worth" [11]. Moral conceptions define the relative (moral) values of activities and experiences, and they specify an appropriate ordering [11]. This paper uses a common definition of a value, being: "a value refers to what a person or group of people consider important in life" [10].

Thus far, there is no systematic literature review on the moral conceptions regarding tutor robots. The existing systematic reviews on robots in education, such as [4] and [12], do not address the moral conceptions. There are some systematic literature reviews on moral conceptions regarding general upcoming technologies which incidentally also mention robots in a classroom, such as [13]. However, a systematic literature review specifically addressing moral considerations regarding the implementation of robot tutors in an educational context is missing. Until now, researchers have used general reviews on technology and values as a basis to study moral conceptions regarding robot tutors, such as [9], in their study on the moral conceptions of teachers regarding tutor robots. A review by Sharkey [14] focused specifically on moral conceptions and robot tutors. However, the non-systematic nature of Sharkey's review makes it hard to evaluate. Given the nature of education and children being a vulnerable group, it is important to critically examine new technology intended to be used in education. Risks or pitfalls related to implementing robot tutors are still unknown and previous studies on moral conceptions regarding this topic stress the need for a systematic review on the academic literature regarding moral considerations that may provide a basis for desirable guidelines [4–9].

2 Methodology

Our methodological approach to identify the moral conceptions regarding tutor robots is based on the Value Sensitive Design methodology. Value Sensitive Design is a theoretically grounded methodology that accounts for values, from a multi stakeholder perspective, when designing and integrating new technology in a social context [10]. It

provides a methodology to discover and conceptualise values related to that technology by identifying the concerns and opportunities at stake in the particular system from a multi stakeholder perspective [15]. The first step is to identify the stakeholders who will be affected by the technology. Second, for each stakeholder the concerns (disadvantages, downsides, drawbacks and risks) and opportunities caused by implementing a robot tutor are described. These opportunities and concerns are then linked to moral values, thereby identifying the moral values related to the implementation of robot tutors in education.

The first step of our systematic literature review was to identify relevant databases. A comprehensive search for relevant databases was conducted, resulting in databases from various academic fields, being: *IEEE Digital Library, SpringerLink, JSTOR, Science direct, ACM, NARCIS, EBSCO, Web of Science* and *Scopus*. Second, an initial search string was formed to identify synonyms for tutor robots.

To determine the initial search string, the keywords identifying robot tutors from a previous, initial review concerning robot tutors, were used [16]. This resulted in multiple search terms for tutor robots and various synonyms for concerns and opportunities. In several search rounds, we refined the search criteria such that most relevant references were selected, and irrelevant ones excluded. This resulted in our final search string as follows: ("robot tutor" OR "tutor robot" OR "robotic tutor" OR "teacher robot" OR "robot teacher" OR "robotic teacher" OR "education* robot") AND ("harm" OR "benefit" OR "positive effect" OR "negative effect").

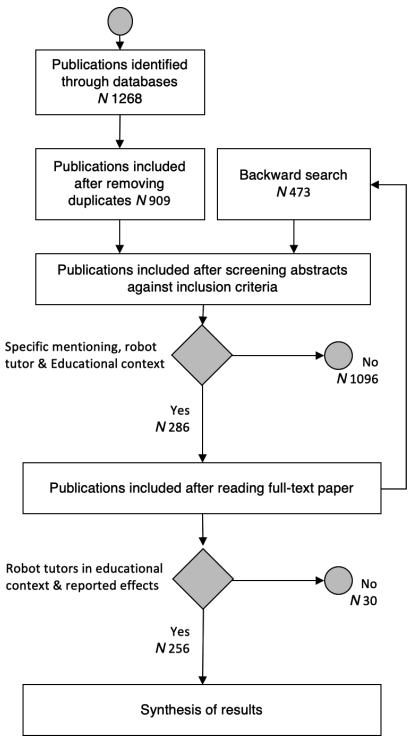

Fig. 1. Selection procedure

2.1 Selection Procedure

The first step in the selection procedure (shown in Fig. 1) was to exclude duplicates, resulting in 909 unique studies. Second, we checked if the abstracts did match our inclusion criteria, which were: (1) the context should be educational, and (2) the abstract should include a specific mentioning of a tutor robot. We also excluded publications that were not written in English. To identify the educational context, terms were included such as teacher, pupil, school, education, tutor, peer, assignment, learning, course, curriculum, kindergarten, and learning topics such as chess and language. Exclusion criteria for the educational context were: hospital, elderly, industry, robots learning from (human) teachers and reinforced learning. To identify various types of the robot tutor, inclusion terms were: learning collaborator,

learning companion, learning peer, teaching assistant and physical agent. Exclusion criteria regarding the topic robot tutors were: as a programming project (e.g., Lego Mindstorms), as a learning focus, virtual agent, distance education, software robots, virtual reality, augmented reality, telerobot, therapy tool, constructivism, and robotic education. To focus on robot tutors, we excluded the constructionism literature because this focuses mostly on Build Bots and Use Bots. After this phase, we conducted a backward reference search which resulted in 473 possibly relevant studies. The abstracts of these studies were matched to the inclusion criteria, making the total of studies selected for full-text analysis 286. In the last step, 30 studies were excluded based on the missing educational context or missing full-text, resulting in a final list of 256 studies (available at the Open Science Framework [17]) which were included in the synthesis of the results.

2.2 Data Analysis

This review covers various scientific fields such as *Pedagogy, Education, Philosophy, Human-Computer Interaction, Robotics, Psychology*, and *Communication science*. Therefore, the 256 publications selected for full-text coding were diverse in their goal and methodology. The full-text data analysis was conducted in three cycles of coding, following Strauss and Corbin's process of (1) open coding, (2) axial coding, and (3) selective coding [18]. Applying these three cycles, we segmented the publications based on their main goal for comparison purposes and as such identified the categorisation of these studies. We identified five categories: (1) Conceptual studies, (2) Design studies, (3) Effect studies, (4) Exploratory cases, and (5) Perception studies. This categorisation does not only provide a framework for comparison purposes but also provides a systematic overview of the available studies till 2018 related to tutor robots.

For each individual category of these studies, through our full-text data analysis, we identified the concerns and opportunities discussed within each paper and linked their effects to a specific or multiple stakeholder group(s). The key stakeholders in education research are: the government, parents, staff, students, supervisory board, business, supplying schools, recipient schools, and other educational institutions [19].

3 Results and Discussion

The results of our systematic review are here presented in terms of the concerns and opportunities related to the introduction of a robot tutor from a stakeholder perspective as discussed in the papers under review. The identified concerns and opportunities, and the number of studies which reported on these concerns and opportunities per category (see Sect 2.2), are summarized in Table 1. Due to space limitations, the results are presented in this concise format to be further discussed in the next section. In general, we found that all concerns and opportunities discussed in the identified studies were related to children and teachers as stakeholders. Potential effects on other stakeholder groups were not discussed, therefore the remainder of this section will be structured

around these two stakeholders, shown in Table 1 as Ch for Children and T for Teachers.

Table 1. Opportunities (O) and Concerns (C) per category for children (Ch) and teachers (T)

Opportunities and concerns			Categories (see Sect. 2.2)					
O/C	Ch/T	*Description*	*Conceptual studies, N = 39*	*Exploratory cases, N = 87*	*Perception studies, N = 26*	*Design studies, N = 31*	*Effect studies, N = 73*	*Sum of H/B*
O	Ch/T	Motivation and enjoyment	10	43	5	8	24	90
O	Ch	Reduced anxiety	1	9	2	1	1	14
O	Ch	Personalised learning	12	7	7	14	6	46
O	Ch/T	New opportunities for education, new social interactions, or beyond the classroom learning	11	21	13	6	9	60
O	T	Reduced workload	6	9	4	0	0	19
C	T	Cost of the robot	2	4	5	1	1	13
C	Ch	Privacy and security	2	0	3	3	0	8
C	Ch	Social implications, e.g. friendship, trust, respect, and deception	8	1	3	1	1	14
C	Ch/T	Discomfort, e.g. Uncanny Valley effect and stress	1	6	3	1	5	16
C	T	Technology is too complicated or low technology adaptation	1	4	3	0	0	8
C	Ch	Loss of motivation	4	6	1	1	3	15
C	Ch	Loss of human contact	2	2	5	0	0	9
C	T	Control and accountability issues	3	0	2	1	0	6
C	Ch/T	Disruption	0	2	2	1	3	8
C	T	Increase of workload	1	0	1	0	0	2
C	T	Technology is inadequate, ineffective or wrong expectations	6	18	7	4	6	41

The goal of this systematic literature review was to identify and categorise the concerns and opportunities linked to implementing robot tutors in an educational context as reported in the extant literature. Thereby, discovering the moral values affected by its introduction from a multi-stakeholder perspective. Following the steps of the Value Sensitive Design methodology, we evaluated and linked the effects of the concerns and opportunities onto moral values regarding new technology, design and robotics reported in earlier studies [9, 14, 20, 21]. Based on these studies [9, 14, 20, 21], we identified thirty-seven moral values. Of these possible values, fourteen were

relevant to be related to the concerns and opportunities identified through our review. Some values were combined to form a clustered topic in merging them together, such as 'Psychological welfare & Happiness' and 'Friendship & Attachment' because these appear closely related. Thus, these fourteen values (summarized, clustered, and numbered in Table 2) are potentially undermined (i.e., negatively related) or positively related to the introduction of robot tutors and will each be discussed in the next section.

Table 2. Values related to the implementation of robot tutors

Positively related (+)	Negatively related (−)
(1) Psychological welfare & (2) Happiness	(1) Psychological welfare, (2) Happiness
(3) Efficiency	(3) Efficiency
(4) Freedom from bias	(4) Freedom from bias
(5) Usability	(5) Usability
	(6) Deception & (7) Trust
	(8) Friendship & (9) Attachment
	(10) Human contact
	(11) Privacy, (12) Security, (13) Safety and (14) Accountability

3.1 Values Attributed to the Introduction of Robot Tutors

Based on the opportunities reported, five positive values are created by the introduction of robot tutors: psychological welfare, happiness, efficiency, freedom from bias, and usability. However, all five values are also potentially negatively influenced by the robot tutor, making the total list of values that are potentially undermined by the robot tutor fourteen. In the following, we will describe the findings for each of these values in general without going into specific details due to space limitations. The detailed data-analysis, which can be retrieved from the Open Science Framework (https://osf.io/97uza), provides an overview of the 256 studies included in our systematic review.

Psychological Welfare & Happiness. Many studies report on opportunities and concerns that affect the values psychological welfare and happiness, for both children and teachers (e.g. [22–25]). These values refer to affective states such as mental health, comfort and peace. The robot's ability to comfort children, for example making children with ASD feel more at ease, directly relates to this value. The ability to create an enjoyable and fun educational context can also be linked to these values. However, concerns are reported in [26–28] that children sometimes fear robot tutors because of their appearance or sudden movements. Furthermore, the robot could lead to feelings of anxiety when children become too emotionally attached.

For teachers, the robot can take over dull or repetitive tasks which could lead to a potential increase in job satisfaction. Nevertheless, teachers are also reported to fear a loss of jobs by the introduction of robot tutors. However, the current state of

technology is severely inadequate for a sophisticated level of natural and autonomous interaction with children.

Efficiency. Multiple studies report on opportunities and concerns that will affect the value of efficiency, referring to the relationship between the gains and means of resources and can affect both children and teachers (e.g. [29–31]). Some results suggest that robots can be a more effective tool compared to a computer-based tutoring system. However, since robot tutors are a novel technology and the empirical studies are often based on short interactions, the efficiency regarding specific learning topics needs further evaluation. It is further reported that the current robot tutors hardly meet the requirements posed by professionals [31]. Voice recognition and speech are just two of the technical components that need to be optimised. Furthermore, the robot's ability to efficiently, and appropriately, respond to social context is still lacking, which causes breakdowns in the interaction. Studies report that these shortcomings could lead to the robot being a costly and ineffective tool, causing a decline in efficiency in the learning process, for both child and teacher. However, its ability to support teachers in multiple activities, such as building e-portfolios and record data during assessments is seen as possibly enhancing this efficiency.

Freedom from Bias. Results of our review further showed that the introduction of robots may free possible unfair treatment of children due to biases, or one's perception thereof. A robot responds unbiased and in the same way to all children, without prejudice. Furthermore, the robot's capability to adapt to childrens' needs could lead to the removal of possible pre-existing social biases of teachers.

As designers and robot builders try to integrate human constructs into robot tutors, it's also possible for technical biases to occur. Studies report that programming bias-free self-learning systems, such as robots that can adapt to children's needs (i.e., personalisation), is one of the key challenges in Artificial Intelligence. Taking into account the nascency of the required technology for a robot tutor, designers should consider how biases could be excluded from educational robots to ensure each child gets a bias-free experience, and the robot does not potentially favour certain children over others.

Usability. In value sensitive design literature, the value of usability refers to making all relevant stakeholders successful users of technology and can be broken down into three challenges: (1) technological variety, (2) user diversity and (3) gaps in user knowledge [20]. Overlooking the results of the review, user diversity and gaps in user knowledge are reported in several studies (e.g. [32–34]) Results report that the robot tutor could be used by children of different age groups, skill levels, or children with disabilities, thereby positively impacting the value of usability. However, the potential gap between the knowledge of teachers to use robot tutors effectively should be attended to, to ensure that all teachers are capable of using the robots. Furthermore, in our opinion, interacting with robots early on in school could prepare children for a society in which robots could potentially play a big part, thereby making them able to access and use this technology in the future.

Deception and Trust. One of the design challenges for the robot tutor reported in the studies in our review, is to create trustworthy relationships with children. This would

lead to a more stable and improved interaction between child and robot [35]. However, this could undermine the values of trust and avoiding deception. Studies (e.g. [9, 14, 35]) report on concerns about children that might potentially be deceived by the robot tutor; children could imagine that the robot really cares about them. As children are reported to be willing to share secrets with a robot, the value of trust could be undermined when the child finds out the teacher can access the data of the robot.

Friendship and Attachment. A concern which was mainly raised by the conceptual studies (Table 1) is that when children perceive a robot tutor as their friend. This might have a negative impact on the concept of friendship and attachment, according to several studies (e.g. [2, 36]). However, none of the effect studies report negative consequences regarding children's perception of friendship.

Human Contact. The value of human contact could be undermined, studies report, because the social bond children experience with a robot may lead to them preferring the companionship of a robot over that of their human peers. According to several studies, this could potentially lead to the loss of human contact [14, 35]. Although none of the studies report on the robot being designed to replace human contact, concerns are expressed about eventually reducing human-to-human contact in schools when teachers are replaced by robots.

Privacy, Security, Safety, and Accountability. Results of our review show that the introduction of robot tutors may impact the values of privacy, security and safety, and accountability (e.g. [14, 35, 37]). The physical presence of the robot and its ability to record data has an impact on these values. Audio and visual files of children, recorded by the sensors of the robot, could be unobtrusively stored and accessed by unauthorised individuals, which is a concern of teachers [9]. Who should be authorised to access these records, however, is an important open question. We believe this is especially important when such data contains private information of children, such as secrets, which the child told the robot in confidence. In line, who should be accountable for the impact of tutor robots and where the responsibility should lie, is reported as a concern [14, 35, 37], especially since the technology is reported to be costly [38].

4 Future Research

This paper shows the importance to address various sensitive moral considerations for children and teachers when designing and implementing robot tutors. Further qualitative and quantitative research is needed into how different stakeholders perceive and prioritise the moral values to allow schools to make calculated, well-informed decisions when implementing robot tutors, and to help the robotic industry to integrate moral values in their tutor robot design. As the current scientific literature on robot tutors does not include the values of all stakeholders affected by the introduction of robot tutors, future research should also focus on identifying their values and norms in an empirical manner. Specifically, the values of parents should be taken into account, in addition to the teachers and children, as they are the representatives of children and experience the effects of robot tutoring first hand.

References

1. Catlin, D., Kandlhofer, M., Holmquist, S., Csizmadia, A.P., Cabibihan, J.-J., Angel-Fernandez, J.: EduRobot taxonomy and papert's paradigm. In: Dagiene, V., Jasute, E. (eds.) Constructionism 2018 Constructionism, Computational Thinking and Educational Innovation: Conference Proceedings, Vilnius, Lithuania, p. 11 (2018)
2. Leite, I., Martinho, C., Paiva, A.: Social robots for long-term interaction: a survey. Int. J. Soc. Robot. **5**, 291–308 (2013). https://doi.org/10.1007/s12369-013-0178-y
3. Miller, D., Nourbakhsh, I., Siegwart, R.: Robots for education. In: Springer Handbook of Robotics, pp. 1283–1301 (2008). https://doi.org/10.1007/978-3-540-30301-5_56
4. Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., Tanaka, F.: Social robots for education: a review. Sci. Robot. **3**, 10 (2018). https://doi.org/10.1126/scirobotics.aat5954
5. Baxter, P., Ashurst, E., Kennedy, J., Senft, E., Lemaignan, S., Belpaeme, T.: The wider supportive role of social robots in the classroom for teachers. In: 1st International Workshop on Educational Robotics at the International Conference on Social Robotics, Paris, France, p. 6 (2015)
6. Heerink, M., Vanderborght, B., Broekens, J., Albó-Canals, J.: New friends: social robots in therapy and education. Int. J. Soc. Robot. **8**, 443–444 (2016). https://doi.org/10.1007/s12369-016-0374-7
7. Lin, P., Abney, K., Bekey, G.: Robot ethics: mapping the issues for a mechanized world. Artif. Intell. **175**, 942–949 (2011). https://doi.org/10.1016/j.artint.2010.11.026
8. Serholt, S., Barendregt, W., Leite, I., Hastie, H., Jones, A., Paiva, A., Vasalou, A., Castellano, G.: Teachers' views on the use of empathic robotic tutors in the classroom. In: The 23rd IEEE International Symposium on Robot and Human Interactive Communication, pp. 955–960. IEEE, Edinburgh (2014). https://doi.org/10.1109/ROMAN.2014.6926376
9. Serholt, S., Barendregt, W., Vasalou, A., Alves-Oliveira, P., Jones, A., Petisca, S., Paiva, A.: The case of classroom robots: teachers' deliberations on the ethical tensions. AI Soc. **32**, 613–631 (2017). https://doi.org/10.1007/s00146-016-0667-2
10. Friedman, B., Kahn, P.H., Borning, A., Huldtgren, A.: Value sensitive design and information systems. In: Doorn, N., Schuurbiers, D., van de Poel, I., Gorman, M.E. (eds.) Early Engagement and New Technologies: Opening up the Laboratory, pp. 55–95. Springer, Dordrecht (2013). https://doi.org/10.1007/978-94-007-7844-3_4
11. Rawls, J.: The independence of moral theory. In: Proceedings and Addresses of the American Philosophical Association, p. 5. American Philosophical Association (1974). https://doi.org/10.2307/3129858
12. van den Berghe, R., Verhagen, J., Oudgenoeg-Paz, O., van der Ven, S., Leseman, P.: Social robots for language learning: a review. Rev. Educ. Res. (2018). https://doi.org/10.3102/0034654318821286
13. Heersmink, R., Timmermans, J., van den Hoven, J., Wakunuma, K.: ETICA Project: D.2.2 Normative Issues Report (2014)
14. Sharkey, A.J.C.: Should we welcome robot teachers? Ethics Inf. Technol. **18**, 283–297 (2016). https://doi.org/10.1007/s10676-016-9387-z
15. Spiekermann, S.: Ethical IT Innovation: A Value-Based System Design Approach. Auerbach Publications (2015). https://doi.org/10.1201/b19060
16. Smakman, M.: Moral concerns regarding tutor robots, a systematic review. In: ATEE Winter Conference, Technology and Innovative Learning, Utrecht, The Netherlands (2018). https://doi.org/10.13140/RG.2.2.33565.00482
17. The data-analysis data. https://osf.io/97uza/

18. Corbin, J.M., Strauss, A.: Grounded theory research: procedures, canons, and evaluative criteria. Qual. Sociol. **13**, 3–21 (1990). https://doi.org/10.1007/BF00988593
19. Konermann, J., Janssen, H., Vennegoor, G.: Naar een actief en open stakeholdersbeleid in het voortgezet onderwijs: stakeholders in kaart brengen, mobiliseren en managen, 's-Hertogenbosch (2010)
20. Friedman, B., Kahn, P.H., Jr.: Human values, ethics, and design. In: The Human-Computer Interaction Handbook, pp. 1177–1201. L. Erlbaum Associates Inc., Hillsdale (2003)
21. Van Den Hoven, J.: Responsible Innovation. Presented at the Third International Conference on Responsible Innovation, 22 May, The Hague, The Netherlands (2014)
22. Shih, C.-F., Chang, C.-W., Chen, G.-D.: Robot as a storytelling partner in the english classroom - preliminary discussion. In: Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007), pp. 678–682. IEEE, Niigata (2007). https://doi.org/10.1109/ICALT.2007.219
23. Sumioka, H., Yoshikawa, Y., Wada, Y., Ishiguro, H.: Teachers' impressions on robots for therapeutic applications. In: Otake, M., Kurahashi, S., Ota, Y., Satoh, K., Bekki, D. (eds.) New Frontiers in Artificial Intelligence, pp. 462–469. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-50953-2_33
24. Brown, L., Kerwin, R., Howard, A.M.: Applying behavioral strategies for student engagement using a robotic educational agent. In: 2013 IEEE International Conference on Systems, Man, and Cybernetics, pp. 4360–4365. IEEE, Manchester (2013). https://doi.org/10.1109/SMC.2013.744
25. Alemi, M., Meghdari, A., Haeri, N.S.: Young EFL learners' attitude towards RALL: an observational study focusing on motivation, anxiety, and interaction. In: Kheddar, A., Yoshida, E., Ge, S.S., Suzuki, K., Cabibihan, J.-J., Eyssel, F., He, H. (eds.) Social Robotics, pp. 252–261. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-70022-9_25
26. Fridin, M.: Kindergarten social assistive robot: first meeting and ethical issues. Comput. Hum. Behav. **30**, 262–272 (2014). https://doi.org/10.1016/j.chb.2013.09.005
27. Mutlu, B., Forlizzi, J., Hodgins, J.: A storytelling robot: modeling and evaluation of human-like gaze behavior. In: 2006 6th IEEE-RAS International Conference on Humanoid Robots, pp. 518–523. IEEE, University of Genova, Genova, Italy (2006). https://doi.org/10.1109/ICHR.2006.321322
28. Ko, W.H., Ji, S.H., Lee, S.M., Nam, K.-T.: Design of a personalized r-learning system for children. In: 2010 IEEE/RSJ International Conference on Intelligent Robots and Systems, p. 6. IEEE, Taipei (2010). https://doi.org/10.1109/IROS.2010.5649668
29. Wei, C.-W., Hung, I.-C., Lee, L., Chen, N.-S.: A joyful classroom learning system with robot learning companion for children to learn mathematics multiplication. Turk. Online J. Educ. Technol. **10**, 11–23 (2011)
30. Han, J.: Robot-aided learning and r-learning services. In: Human-Robot Interaction. Intech Open Access Publisher (2010)
31. Huijnen, C.A.G.J., Lexis, M.A.S., Jansens, R., de Witte, L.P.: Mapping robots to therapy and educational objectives for children with autism spectrum disorder. J. Autism Dev. Disord. **46**, 2100–2114 (2016). https://doi.org/10.1007/s10803-016-2740-6
32. Reich-Stiebert, N., Eyssel, F.: Robots in the classroom: what teachers think about teaching and learning with education robots. In: Social Robotics, pp. 671–680. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-47437-3_66
33. Ahmad, M.I., Mubin, O., Orlando, J.: Understanding behaviours and roles for social and adaptive robots in education: teacher's perspective. In: Proceedings of the Fourth International Conference on Human Agent Interaction, pp. 297–304. ACM Press, Biopolis (2016). https://doi.org/10.1145/2974804.2974829

34. Kennedy, J., Lemaignan, S., Belpaeme, T.: The cautious attitude of teachers towards social robots in schools. In: Robots 4 Learning Workshop at IEEE RO-MAN 2016, p. 6 (2016)
35. Pandey, A.K., Gelin, R.: Humanoid robots in education: a short review. In: Goswami, A., Vadakkepat, P. (eds.) Humanoid Robotics: A Reference, pp. 1–16. Springer, Dordrecht (2017). https://doi.org/10.1007/978-94-007-7194-9_113-1
36. Zawieska, K., Sprońska, A.: Anthropomorphic robots and human meaning makers in education. In: Alimisis, D., Moro, M., Menegatti, E. (eds.) Edurobotics 2016 2016. AISC, vol. 560, pp. 251–255. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-55553-9_24
37. Salvini, P., Korsah, A., Nourbakhsh, I.: Yet Another Robot Application? [From the Guest Editors]. IEEE Robot. Autom. Mag. **23**, 12–105 (2016). https://doi.org/10.1109/MRA.2016.2550958
38. Han, J., Jo, M., Park, S., Kim, S.: The educational use of home robots for children. In: ROMAN 2005. 2005 IEEE International Workshop on Robot and Human Interactive Communication, pp. 378–383. IEEE, Nashville (2005). https://doi.org/10.1109/ROMAN.2005.1513808