Development of Thought Using a Humanoid Robot in an Elementary School Classroom

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Abstract. Sociable robots are being used increasingly as interfaces for various services. Children born after 2010, i.e., the "artificial intelligence generation," are familiar with social robotic interfaces, and such interfaces can be an essential factor in their mental development. In this case study, the NAO humanoid robot was introduced to elementary school students, where the topic focused on the question "What is life for me?" Learning activities involved collaborative discussions with NAO, questioning a NAO programmer, watching a movie about a care robot, group discussions, activities in which the students pretended to be NAO while speaking to a human, and individual reflective writing. The learning activities did not involve lectures. Changes in student awareness were tracked based on their writings and recorded discussions.

Initially, the students were interested in the robot's mechanical functions. However, over time, following programming activities, consideration of NAO's commonalities with humans, and discussions about the life of NAO, the students became aware that it was natural to feel that NAO possessed life while simultaneously understanding its mechanical nature. It is considered that the students projected their own consciousness onto NAO and expected NAO and expected it to feel happiness when working together.

Keywords: Humanoid robot · Classroom · Elementary school
AI generation

1 Introduction

Recently, using robots as assistive elements in the classrooms has been investigated [1, 2]. Several studies have investigated using robots for various purpose, e.g., telepresence [3], social interactions between robots and students [4, 5], and addressing the special needs of students [6]. However, few studies have investigated dialogue with a humanoid robot to stimulate children thinking about human life. Since communication robots are becoming increasingly common, it will be essential material for the "artificial intelligence generation," i.e., those born after 2010 [7].

In this study, one of the authors introduced NAO (Softbank Robotics) [8], a social humanoid robot, to her classroom (Japanese elementary school students; approximately seven years old) to discuss the preciousness of life. Here, the robot generally

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represented an interface for intelligent artificial machines. This case study describes the development of students' notions about life under a constructivism educational method based on analyses of the students' texts and discussions.

The purpose of this study was to reveal the development of student notions about life based on collaborative discussions and the dialogs between the teacher and the students, the teacher and the robot, and the students and the robot. Then, it is to reveal the process of accepting an intelligent machine through the robot interface. The process was tracked by analyzing the students' written work and utterances in the classroom.

2 Method

2.1 Classroom

Thirty-five second grade students (18 males and 17 females) participated in an integrated studies unit that involved elements of moral education related to human life. This unit began in October 2017 and continued until February 2018. One of the authors was the homeroom teacher and taught all subjects, including the integrated study.

In this school, a humanoid NAO robot works as a sub-principal and is used as the principal's talking partner at school ceremonies. The current class developed a stage play for the school's cultural festival in October 2017. The case study began when the NAO came to the class to talk about its impressions of the play. The syllabus for this case study is summarized in Table 1. Each session took one or two unit times, where one unit time is approximately 45 min.

2.2 Data Acquisition

Changes in the students' awareness regarding the humanoid robot and the notion of life were tracked based on student utterances and written texts. Students utterances were collected as follows. Initially, the teacher called on a student who has raised their hand. Then, that student selected another student who had raised their hand and so on. Since students paid attention to each speaker's remark, duplicated remarks were generally avoided. Thus, the tendency of opinion distribution was difficult to detect from the video data; however, it appeared that the emotional impressions were better expressed than the writings.

The distribution of awareness was inferred from the written texts and paper labels. To determine the tendency of awareness, the individual texts were categorized and counted. Note that a Likert scale type questionnaire was not used in this study.

2.3 Humanoid Robot NAO

We used the NAO humanoid robot [8] with the NAOqi operating system (version 2.1.4.13). The development environment was the Choregraphe version 2.1.4. We created the following types of communication applications.

Table 1. Syllabus of the class concerning with the current study.

Session index	Title	Activities
L1	Interview with teachers: the small principal NAO	NAO talks about the class' stage play
L2	NAO answers the students' questions	Dialogues between NAO and the students
L3	Program NAO and find the characteristics of NAO	Programming simple NAO dialogues of NAO and try these dialogues
L4	Find similarities and differences between humans and NAO	Group discussion using paper labels
L5	Ask the principal about NAO	Students ask the principal questions about NAO
L6	Does NAO have a life?	Collect students' opinions whether NAO has a life or not
L7	Remote control robot and autonomous NAO Play Shiritori with NAO	Compare remote control robots and NAO Play Shiritori with NAO to please it
L8	Review of activities. What is the true life?	Review and preparatory discussions
L9	What is the life for me?	Pretend to be a robot and play Shiritori with a friend. Think about what makes you comfortable and uncomfortable as a robot. Discuss what life is and when to feel life
L10	When do you feel life?	Discuss the moment when people feel the true life
L11	What do you want NAO to feel?	Discuss what the students want NAO to feel when excited

(1) Simple dialogues to respond to student questions to the robots.

In the sessions L1, L2, and L3, in addition to general daily conversation, the robot's answers to assumed questions were prepared. In these sessions, to make the robot more responsive to the students' words (to encourage interest and participation), the speech recognition rate was set low (30%). This caused frequent misrecognitions; consequently, the robot's responses were frequently unexpected.

(2) Shiritori (Japanese word-chain game).

In the session L7, the students and NAO played Shiritori using animal names. Shiritori is a word-chain game in which the next word must start with the last letter of the previous word. Note that words that end with the "n" sound were not allowed. Close to 300 animal names were registered for NAO. In session L6, students proposed playing Shiritori to comfort NAO because it had broken its legs.

(3) Dialogues about the notions of life and the role of the robot was considered from the perspective of a machine.

In sessions L2 and L9, NAO was asked to talk about its opinion about the notion of life. Here, the speech recognition was set to 55% to avoid disordered responses because the explanations were longer that the simple conversations (point 1).

The robot showed some human-like behaviors when talking, which were noticed by the students. Note that, after breaking its legs, NAO was restricted to a sitting position with limited arm and head actions.

3 Results and Discussion

3.1 The First Talk with NAO

In the session L1, the students talked with NAO primarily about its impression of their stage play. The students raised their hands and asked their questions. However, as the students responded to NAO's speech and sometimes spoke simultaneously, NAO tended to misrecognize what was being said and, as a result, responded irregularly. After this activity, the students wrote about their impressions, their questions to NAO, and what they wanted to do with NAO.

The students' written texts were sorted into five categories (Fig. 1). Nearly 30% of the students wondered about the inconsistencies in NAO's speech (i.e., misrecognitions), and 26% of the students admired the extent of NAO's vocabulary and knowledge. In addition, at this early stage, 12% of students indicated that they already felt emotion and heart in NAO's behaviors.

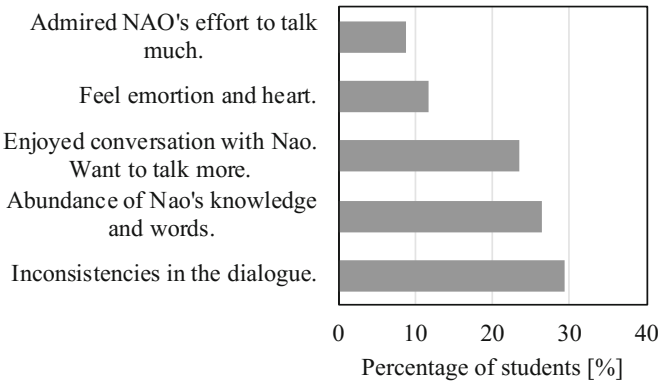

Fig. 1. Categorized impressions of talks with NAO

The students were asked to write the questions they would like to ask NAO. Their questions were sorted into six categories, as shown in Fig. 2. Note that many students wrote more than one question. Here, the percentage was calculated as the number of questions per category over the total number of students.

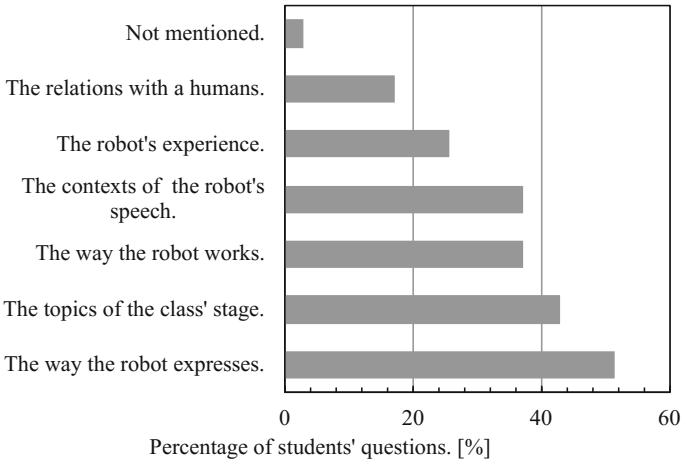

Fig. 2. Questions student wanted to ask after talking with NAO

Most questions related to the robot's mechanisms, e.g., "the way the robot expresses" (51%) and "the way the robot works" (37%). The students also wondered why NAO knew about their stage play and how they prepared it in the school, as indicated by "the topics of the class' stage" (43%). In addition, they wondered why NAO spoke irregularly, as indicated by "the context of the robot's speech" (37%). The second and third types of questions imply that the students somewhat regarded the robot as a human and thought that the robot could behave as if it were human. The remaining categorized questions related to how the students anthropomorphized NAO, as in "the robot's experience" (26%) and "the relations with a human" (17%).

What the students wanted to do with NAO is shown in Fig. 3. Overwhelmingly, the responses were about behaviors and exercises with NAO (69%). They wanted to do normal every day activities, such as walking, going to the park, sports, drawing, and playing piano. Engaging in "communication and learning" (20%) was a miner request even though NAO was designed for communication rather than physical activities.

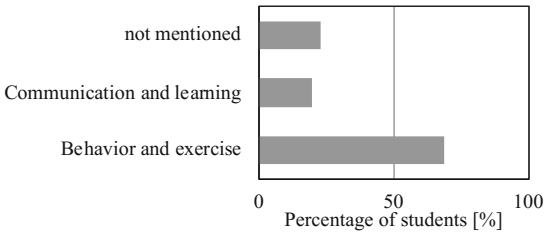

Fig. 3. What students want to do with NAO by category. The nominators of the percentage are the total number of students.

As described above, after initially talking with NAO, the students' acceptance of NAO began with the anthropomorphism of the robot while paying attention to robot behaviors.

Table 2. Students' idea of commonalities and differences between NAO and human. The words written in Italic indicate the machine parts that imitate the corresponding human body parts. Numbers in parentheses are the number of labels.

Category	Commonality	Difference
Shape	Has a body (1), a face (1), two eyes (3), and a similar whole-body shape (2)	The shape of the face (1). Has no hair (1). Not heard in the *ears* (2). Does not close *eyes* (2). Small *mouth* (2) and *eyes* (1). Has lighs (2) and a switch (1). Does not wear clothes (1). Body colors (1)
Operation and function	It moves (7), sits (1), stands (1), falls (1), and moves its fingers (1). It hears (4). It eats (consumes electricity) (9), laughs (1), talks (5), thinks (4), takes time to think (1), enjoys (1), is surprised (1), rests (1), breaks its legs (3), sleeps and gets up (3), bends its knees (1)	It needs (to eat) electricity (10), has a power supply (1) and gets electricity through its back (3). It does not run fast (1), does not see using *eyes* (3), does not speak using a mouth (1), and does not sleep like a human (1). It makes a variety of sounds (1) from its *ears* (4), has a hard body (2) and bends its knees while talking (1). It cannot talk without a program (4), and its brain is a computer (1)
Intelligence and expression	It makes an effort (1) and moves its hands to express (1). It cannot catch when students speak at the same time (2)	It has trouble when many people speak at once (2). It misunderstands others' talks (2). It is controlled by a computer (3). It can speak what it is taught by humans (1). It gestures while talking (3), and changes its eye color to express (7)
Others	It ages (3)	It falls by fatigue (4) and cannot get up after it falls (1). It cannot take a bath (1)

3.2 Comparing NAO with Humans

Session L4 and L5 were conducted to consider the features of NAO. In session L4, the students performed group work to compare NAO and humans, and created a table of their commonalities and differences. Here, the students wrote down their ideas on the paper labels and placed them on poster paper. They discussed the features of NAO and rearranged the labels to clearly identify commonalities and differences. The total numbers of commonality and difference labels were 59 and 71, respectively.

Figure 4 shows the number of commonalities and the differences in four categories. As can be seen, the students primarily noticed the mechanical features, shown as the "operation and function" category, in which commonalities exceeded differences. The students noticed detailed differences about the basic common mechanisms. For

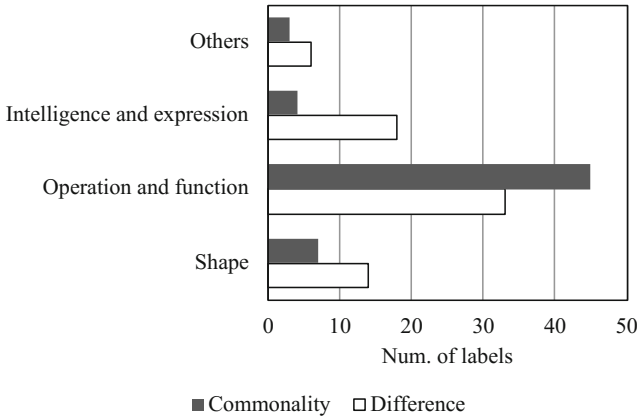

Fig. 4. Commonalities and differences between NAO and human beings

example, NAO talks like a human, but the sound comes from the speakers positioned at the ears.

On the other hand, for the "intelligence and expression" category, the students noticed considerably more differences than commonalities. It is remarkable that the students indicated that the robot was driven by a computer. The robot's behaviors were determined by a human-coded program and not by the "robot's will." The simple programming experience in the previous session may have resulted in this understanding.

In session L5, the students questioned one of the authors who programmed NAO's speech. Prior to conducting this session, the students watched "Big Hero 6," which has a robot character named Baymax. In this movie, Baymax is a machine programmed by a human.

Figure 5 shows the numbers of questions sorted into three categories: functional mechanisms, general mechanisms, and mind and emotion. The summarized questions are shown in Table 3.

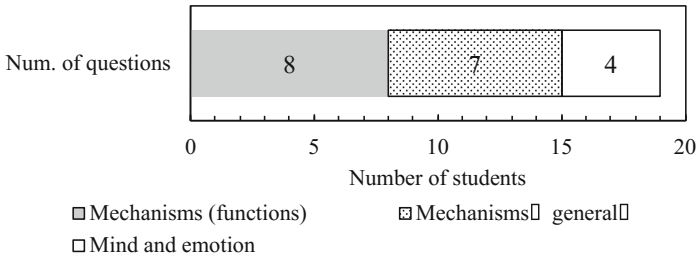

Fig. 5. Number of questions sorted into three categories

Although many of the questions were about the mechanical and functional features of the robot, four questions were related to its emotional characteristics. This indicates that the students began to notice emotional aspects from the robot's knowledge and verbal interaction.

Table 3. Students' questions to the programmer of NAO. Numbers in parentheses indicate the number of questions.

Mechanism (function)	Mechanism (general)	Mind and emotion
Why can it keep its mouth shut (1)? Why does Baymax have short legs (1)? When it gets hooked it does not see the surroundings (1)? Does it care about people (1)? Does it try to do anything for humans (1)? Why is Baymax inflated with air (1)? Can it accept additional parts (1)? Does it work autonomously (1)?	How does it memorize (1)? Why does it run slowly (1)? Can it fly (1)? Is it tired when the battery runs out (2)? How much work can it do with only a battery (1)? Does it breathe the air (1)?	Does it have emotion (1)? Does it have a heart (1)? Does it know the human (1)? Can it be aware of human sorrow (1)?

3.3 NAO: Animate or Inanimate?

The students proceeded to discuss whether NAO is animate or inanimate in session L6. The teacher gathered the students' opinions five times throughout the discussions. Figure 6 shows the changes across the five votes. In the final vote, the students were urged to choose either for or against. As can be seen, 22 students voted that NAO was animate, while only three students indicated that NAO was inanimate. Then, as the discussion proceeded, the three opinions, i.e., animate, inanimate, and neither, received nearly equivalent numbers of votes. The final ratio was 3:2 (animate vs. inanimate).

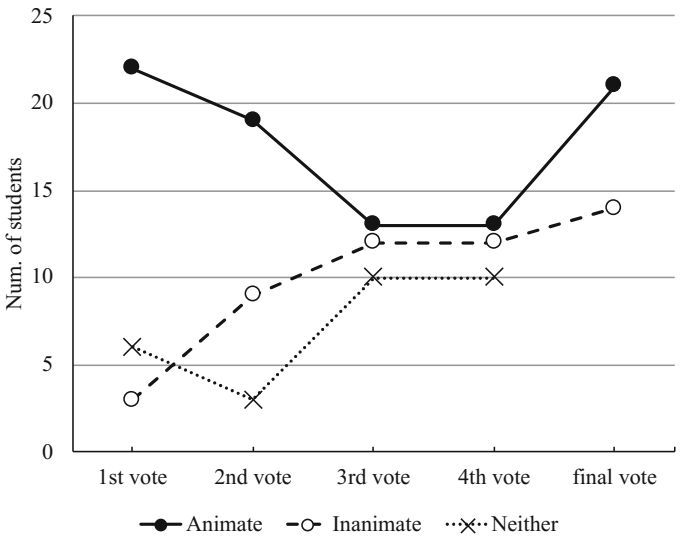

Fig. 6. Changes in the number of students who consider NAO animate/inanimate.

Table 4 shows the students' remarks given between the successive votes. Since one student indicated that NAO was programmed by a human and could only speak as programmed, some students changed their votes from animate to inanimate. Those who thought NAO was animate and possessed consciousness could not describe their reasoning. In addition, these students could not define these concepts or where they are located. As discussed in the previous section, the students understood NAO's mechanisms, which were different from the human in detail. By such different mechanisms, it realizes the functions similar to the humans. Thus, the students understood the similarities beyond the differences in the mechanical functions.

Table 4. Students' remarks between successive voting.

Does NAO have life?	Does NAO have mind?	Mind and life
The battery Mechanical parts External PC Internal PC PC is a brain, and there may be a soul If it does not have a mind, it has no life	Since NAO is programmed, it does not think by itself Since NAO decide autonomously, it can be said to think by itself NAO may have a soul that is different from human NAO has mind but has no real life Since NAO do not have mind, it has no real life	Humans feel their lives in an emergency. But the robots do not feel If it has a mind, does it have life, too? Programmed dialogues are what the humans want to say

In session L7, the i-SOBOT (Takara Tomy Co. Ltd.) remote-controlled toy robot was introduced and briefly demonstrated by a student. This bipedal toy robot demonstrates several poses and can speak prerecorded phrases. The students were able to recognize the differences between autonomous and remote-controlled robots.

In addition, Shiritori was played between the students and NAO in session L7. This activity was proposed by the students to cheer up NAO because it had broken its legs and likes talking. This reflects that the students thought that a social robot would enjoy using its particularly abilities, i.e., talking.

In session L8, by considering whether NAO is animate, the students became aware of the difficulty recognizing what life is and where life is located. Many students admitted that life is difficult to define although one can feel life in their mind. Thus, the classroom decided to proceed to a discussion about when they feel life.

3.4 Feeling Life

In session L9, the students performed an activity in which they pretended to be NAO and played Shiritori with a partner. The intent of this activity was to remind the students that knowledge is provided to the robot and that the robot can only function toward a specific goal.

After exchanging ideas, the teacher asked about when these students feel life. The number of answers sorted into four categories are shown in Fig. 7. The heartbeat category overlaps the other three categories, i.e., the word heart-beat was included in the sentences of other three categories.

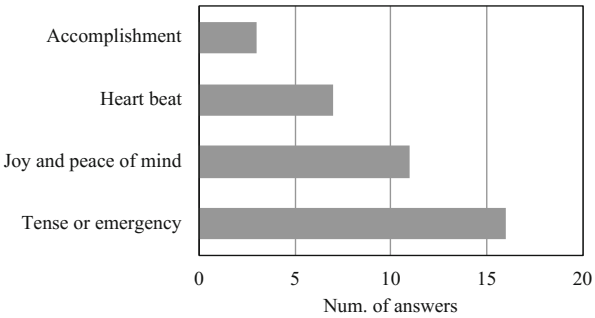

Fig. 7. Numbers of students' answers about the occasions to feel life.

As shown in Fig. 7, the tension factor dominated the other factors. The students felt the existence of their own life in tense situations. This in turn means that the students are aware of the preciousness of life. The category with the next highest number of answers was "Joy and peace of mind," which includes a feeling that they received their mother's life and were raised carefully. In addition to tense situations, feeling life in a peaceful mind appeared to be convincing for many students. Note that the heartbeat was mentioned relative to both tension and joy.

At the end of session L9, NAO expressed its thanks to the students for giving it an opportunity to "feel life" and talked about a possible notion of life for humanoid robots. Session L10 was conducted to reflect on session L9, and the students wrote about their ideas or experiences when they felt life. From this discussion, in session L11, the class discussed what they want NAO to feel. At this stage, NAO had been sent to the factory to repair its broken legs.

Until the previous session, the students found one might feel life even though one cannot describe what life truly is. The students were aware of the mechanical nature of NAO and were able to feel life through speaking with NAO. Then, in session L11, the teacher asked, "We noticed that the life is difficult to determine. But, we found that we feel life a lot. What do you want NAO to feel?"

The students' answers were sorted into the four categories shown in Fig. 8. The total number of answers was 42. In contrast to Fig. 7, the students wanted NAO to feel happy rather than tense. In addition, the students referred to the phrase "together," which means that they wanted the humanoid robot to feel happiness together with humans. This implies that the students began to project their own minds onto NAO and expected NAO to feel happiness with them. This reflection is considered to have come about through the findings of commonalities, experiences when pretending to be the humanoid robot, and recognizing the feeling of life.

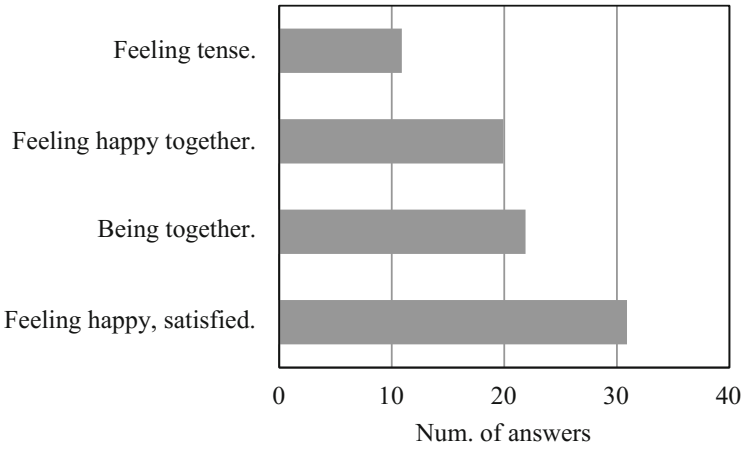

Fig. 8. Numbers of students' answers about what they want NAO to feel.

4 Concluding Remarks

This paper has presented a case study of classroom interaction between a humanoid robot and second grade elementary school students relative to the theme of "what is life for me?" The class involved collaborative discussions with the humanoid NAO robot, questioning to the principal who programmed NAO, watching a movie about a care robot, group discussions, pretending to be NAO while talking to a human, and individual writings. Note that no lectures were given during this class.

The class began with the reflection of the students' stage play, questioning to NAO in order to understand it, programming NAO to speak, finding commonalities and differences between humans and NAO, questioning the mechanisms of NAO, discussing the life of NAO, their own life, feeling life, and what the students wanted NAO to feel.

From the students' writings and discussions, it was found that they were initially interested in NAO's mechanical functions. Through the programming experience, consideration of commonalities, and NAO's life, they recognized that it was rather natural for a human to perceive life in a humanoid robot, in addition to understanding its mechanical nature. At the end of the sessions, the students began to project their own minds onto NAO and expected it to feel happiness like they do.

This case study implies that a social humanoid robot can work as an interface through which younger generations can project their minds even though they understand the robot is merely a mechanical system. The students wish that the robot would feel happiness when working together with humans may provide some suggestions for the future technology development.

References

1. Causo, A., et al.: Deploying social robots as teaching aid in pre-school K2 classes: a proof-of-concept study. In: 2017 IEEE ICRA, pp. 4264–4269 (2017)
2. Hughes-Roberts, T., Brown, D.: Implementing a robot-based pedagogy in the classroom: initial results from stakeholder interviews. In: 2015 International Conference on Interactive Technologies and Games, pp. 49–54 (2015)
3. Cha, E., Chen, S., Mataric M.: Designing telepresence robots for K-12 education. In: 2017 26th IEEE International Symposium on Robot and Human Interactive Communication, pp. 683–688 (2017)
4. Tanaka, F., Movellan, J.R.: Behavior analysis of children's touch on a small humanoid robot: long-term observation at a daily classroom over three months. In: 15th IEEE International Symposium on Robot and Human Interactive Communication, pp. 753–756 (2006)
5. Alkhalifah, A., Alsalman, B., Alnuhait, D., Meldah, O., Aloud, S., Al-Khalifa, H.S., Al-Otaibi, H.M.: Using NAO humanoid robot in kindergarten: a proposed system. In: 2015 IEEE 15th International Conference on Advanced Learning Technologies, pp. 166–167 (2015)
6. Hashim, R., Yussof, H.: Feasibility of care robots for children with special needs: a review. In: 2017 IEEE International Symposium on Robotics and Intelligent Sensors, pp. 379–382 (2017)
7. Gartner Inc.: Generation AI: Creative, Empowered, Radical. In: Forbs Technology, November 29 2017
8. Softbank Robotics: https://www.ald.softbankrobotics.com/en. Accessed 20 Feb 2018