Educational Robot European Cross-Cultural Design

Anna-Maria Velentza[1,2](✉), Stavros Ioannidis[1], Nefeli Georgakopoulou[2,3], Mohammad Shidujaman[4,5], and Nikolaos Fachantidis[1,2]

[1] School of Educational and Social Policies, University of Macedonia, Thessaloniki, Greece
nfachantidis@uom.edu.gr

[2] LIRES Robotics Lab, University of Macedonia, Thessaloniki, Greece

[3] INREV Laboratory, Paris 8 University, Paris, France

[4] Academy of Arts and Design, Tsinghua University, Beijing, China

[5] Bangladesh Robotics Foundation, Dhaka, Bangladesh

Abstract. Educational robots have been used successfully in a variety of teaching applications and have been proven beneficial in teaching STEM studies. Although educational robots are already been using, it is important to identify the robot's characteristics -appearance, functionality, voice- that is closer to the users' needs. Our target is to use participatory design procedures to identify the users' attitudes and needs to construct an educational robot based on them. In this paper, we introduce the STIMEY Robot, which created through these procedures after a cross European study where five different countries participated. The robot evaluated in real classroom environment with students aged between 13 and 18 years old, who had a STEM les-son with the aid of the robot. Our results clearly suggest that students agreed with the robot's interactive skills and ability to provide feedback and also they statistically significantly changed their attitudes towards its usability after having a lesson with it.

Keywords: Educational robots · Cross-culture · Participatory design · Robot design · Real class evaluation · STEM

1 Introduction

Social robots are getting more involved in our everyday lives because of their ability to express verbal and nonverbal cues, conversation abilities, and emotional bonds that can be built in humans after human-robot interaction activities [1]. Those robots' characteristics have proven beneficial for their use in the educational field. One of the main challenges is to match their social behavior, style, appearance, and interaction with the educational demands and the actual users' needs. Social robots when teaching a lesson in typical education students, seem to accomplish similar tutoring skills with human teachers, especially when they perform controlled tasks and manage to enhance students' cognitive and affected outcomes [2]. There is also evidences that children- social robots' interaction can increase children's' communication and language performance [3]. More

M. Kurosu (Ed.): HCII 2021, LNCS 12763, pp. 341–353, 2021.
https://doi.org/10.1007/978-3-030-78465-2_26

specifically, social robots seem to be helpful in STEM studies. For example, the Cozmo robot can deliver exercises and engaging materials to students between 14 and 17 years old and they significantly improved their knowledge in mathematics [4]. Educational robots boost teamwork and problem-solving activities and thus, those engaged in STEM education are successful in a variety of learning scenarios [5].

Despite their usability and effectiveness through different learning activities, there is moral consideration regarding the use of social robots in education. Those considerations may vary across different educational cultures. Focus groups with Dutch Educational Policymakers Considerations revealed 15 theoretical values that vary from 'the robots' capability to lower teachers' workload' to 'matters about the escalating influence of commercial enterprises on the educational system' [6]. The different educational cultures are a view of the currency of general cultural differences between different countries, especially from different continents. There are cultural differences in people from Asian, American, African, European populations regarding their attitudes toward robots, their acceptance, and their usability [7]. On the other hand, countries in the same continents such as Europe, seem to have similar attitudes towards robots, despite some minor differences regarding the level of acceptance of robots in their every-day life [8].

Before being able to design efficient educational robots, there are still some answers about the users' attitudes towards robots' characteristics that are certainly missing. The stakeholders whose opinions we should take into consideration are primary the students but also the teachers and the parents. Also, before constructing an educational robot we should merge their learning and educational needs with their social and cultural habits.

There are four critical stages in the design procedure of a social robot· taking into consideration previous studies, the robot's impact on the target group's behavior, the stakeholders' attitudes towards robots, and their feedback and reaction regarding the robot's final appearance [9]. Augmented Reality (AR) and Virtual Reality (VR) technologies is an interactive way of engaging stakeholders in multiple human-robot interaction scenarios [10]. Although there are also other interactive design activities such as drawing or showing images of existing robots or robotics parts [11], the stakeholders need to collaborate with robots within the targeted operational environment [12].

In our study, under the Horizon 2020 funded project STIMEY [13] we conducted a cross- European user- centered design procedure in order to identify the ideal characteristics that an educational robots should have. For this purpose, we took into consideration the robot's appearance, usability, hardware, and software features. We collaborated with the stakeholders -teachers, students, parents- and based on them, we designed a robot prototype based on their needs and test it in a real school classroom environment. Our most important findings are that a) stakeholders from different European countries -Germany, Belarus, Greece, Finland, and Spain are having similar needs and ideas about the ideal educational robot and b) after testing the robot prototype in Greek schools we found out that the robot prototype was positively evaluated. c) Students aged between 13 and 18 years old, after having a lesson with the STIMEY robot teaching assistant, statistically significantly re-evaluated their opinion regarding the usefulness of a robot in the classroom in comparison with their opinion before having a lesson with it. The stakeholder who participated in the robot's design procedure were from both north and south European countries and thus the STIMEY robot prototype seems to be a representative educational robot for European stakeholders' needs. To the best of the authors' knowledge, there are no other studies actively involving the educational stakeholders in the development process of educational robots in a cross European study, while the stakeholders' opinions, as expressed in our experiments, are by themselves, valuable contributions for the development of efficient educational robots.

2 Related Work

Appearance and functionality are the more common robot characteristics that researchers typically focus on since they are the key factors that affect the human- robot interaction and can determine the time humans will spend with a robot performing a specific task [14]. Experience is a key factor for accepting technology and robots [15]. Moreover, humans prefer to collaborate with robots with characteristics that fit into their norms regarding the performed task, such as serious personality traits for serious activities and cheerful personality traits for cheerful activities [16, 17]. Li et al., performed multi- culture research between Korean, Chinese, and German populations regarding their attitudes about a robot's appearance and performed tasks. Results showed cultural differences in participants' engagement and likeability. Moreover, participants during the interview procedure, expected the robot appearance to match with the task that the robot was supposed to perform but that did not confirm during the subjective rating procedure [18].

The social educational robot Wolly is an example of a robot that designed through participatory designed procedures and constructed and implemented (software and hardware) based on the target group needs [19]. Bertel et al., suggested a semi-structured participatory design procedure for the children's' involvement in the designed procedure [20].

A user-centered design procedure in a sample of 116 university students indicated that they preferred to collaborate with a robot with both machinery and humanoid appearance and basic facial characteristics. Additionally, they suggested that an educational robot should provide user-centered support based on the students' learning needs [21, 22]. Velentza et al., shown that university students, pre-service teachers had statistically significant different opinions about the ideal characteristics that a robot- tutor should have before and after having a course with it [23]. Similarly, with [21], students before interacting with a social robot preferred to collaborate with a robot with machinery characteristics while after the interaction, they both preferred machinery and humanoid characteristics [23]. On the other hand, although younger adults are more familiar with robots than the previous generations, when a group of students instructed to draw a robot, the most frequent drawing stemmed from books' illustrations [24].

3 Present Study

Based on the research results described in the last section, it is very clear that it is important to investigate the impact of educational stakeholders' opinions about the ideal characteristics that a robot teaching assistant should have to efficiently interact with students and collaborate with teachers. It is also important to identify those characteristics after constructing a robot-prototype based on their needs and evaluate it in action in a real classroom environment, as suggested by [25], and not only by approaching the stakeholders' beliefs theoretically or via VR and AR technologies.

The current study, thus, explores whether there is any difference in the educational stakeholders -students, teachers, parents, school principals- attitudes and opinions regarding a teaching assistant educational robot based on their culture. All the participants were from European countries. Based on their needs and beliefs, the STIMEY consortium designed and constructed a robot prototype. After constructing the prototype, we tested and evaluated it in real school classrooms in order to identify:

1) What are the participants' positions, and attitudes towards STEM and STIMEY science before having a lesson with the STIMEY robot?
2) What is the effect of their demographic profile?
3) Did the lesson with the STIMEY robot reinforce students' positions, and attitudes towards STEM science and STIMEY?

3.1 Hypothesis

Based on [8] we expect that although there are cultural differences between European countries and their educational standards, they will have similar attitudes toward the appearance and the usability of an educational robot. Moreover, we expect that students after having a lesson with the robot will improve their attitudes toward STEM and educational robots. Finally, we believe that the robot prototype will be positively evaluated after its use, especially because of the user-centered design procedure followed by the STIMEY Project partners.

4 Participatory Design

4.1 Participants

In the study participated a total number of 132 stakeholders, (Finland n = 27, Greece n = 24, Spain, n = 24, Germany n = 30, Belarus n = 27) and among them were students between 10 and 18 years old, teachers and school directors from primary, lower secondary and upper secondary education, parents and professionals engaged in STEM related careers. A gender balance among participants was ensured (female n = 73, male n = 59).

4.2 Procedure

The procedure followed the participatory design standards and the stakeholders worked in close collaboration with expert groups in order to analyze their attitudes, consider their needs, evaluate the benefits and deficiencies of a products' design before, during, and after its development and implementation. There were five stages during the procedure· preliminary research, design, development and implementation, pilots, final implementations. For the data collection, we held focus group sessions for each country participating in the STIMEY consortium, following the same protocol in all the cases [26].

Robot. In the beginning, during the co-design focus groups, participants indicated their ideas regarding the ideal robot's appearance and the robot's voice commands. Based on them, 103 items/ideas were grouped based on their conceptual similarity at six groups of requirements· a) Appearance of the robot (32), b) Functionality of voice commands (27), c) voice of the robot (19), d) personality of the robot (6), e) language of the voice commands (2), f) voice commands' risks (2). Each group of requirements presented to the stakeholders followed by a short description. One of the participants' priorities when discussing the robot's appearance characteristics was its small size (n = 26). Then to be human-like/humanoid (n = 14), able to be customized/modified by students (n = 14), not human-like/not humanoid (n = 12), robot-like/ machine-like (n = 11) and easy to carry/portable (n = 10). The most common participants' requirements for the robot's voice commands were to be adjustable (n = 12) and simple/easy to understand (n = 11). More detailed information regarding the stakeholders' association in the different steps of the procedure can be found in Christodoulou et al., [27] accompanied by preliminary evaluation results of the robot prototype STEM-oriented robot-assisted collaborative online teaching-learning task.

4.3 STIMEY Robot Prototype

From the 103 items referring to the robot, 78 were adopted in the design procedure (78%), while 22 did not for various reasons (24%), such as the contradiction of one requirement with another, high costs, or time-consuming integration, technology limitations or technical restrictions.

The STIMEY robot, depicted in Fig. 1 was designed to encourage students to involve more actively during the learning process through the STIMEY Platform based on a variety of principles:

1. The STIMEY robot was able to talk, reply to students' questions based on a set of pre-programmed behaviors, provide them with feedback, evaluate their answers in given knowledge acquisition questions, change facial expressions, move its hands and head, move backward and forward through wheels. In its back, it has an embedded mobile phone, serve as the robot's 'brain', giving information to the students.
2. The STIMEY robot will accompany the students as a partner and will communicate with them (speech/listening, gesture, etc.) as a friend. Based on its feature to act as a friend makes it capable to help students with a variety of learning tasks through the online platform. The robot is also able to enhance communication between students (using video, speech, and gestures).
3. The STIMEY robot will be upgraded (software and hardware) to show cognitive, emotional, and physical development. The evolution of the robot will be based on the student's progress, as shown by their electronic profile, portfolio, and creativity curve (STEM progress) which are scored in the STIMEY Platform. In this way, the capabilities of any STIMEY robot will represent its owners.

4. The STIMEY robot will have a small size, enough to be carried in a bag or placed on a table. It will have some human characteristics (e.g. face, arms, torso) and will be customized in terms of adding or extracting parts on the robot. At the same time, its appearance will also have some machinery features and its general design will follow a cartoonish style. The robot will also have different forms based on the stakeholder's requirements, as shown in Fig. 1, left picture, and various color options.

The robot will be like a student pal, and it may vary according to students' creativity. Even though the torso will not be constructed with iron materials, it will be fall resistant.

Voice Commands. The voice commands of the robot will be adjustable and easy to use, will be functional, easy to control and they will support learning. Moreover, the user will be able to monitor the voice commands (also with a text application). The voice commands will be given gradually to the robot and the user will have a certain level of freedom in selecting them.

Robot's voice: human-like, friendly and clear, kind and joyful.

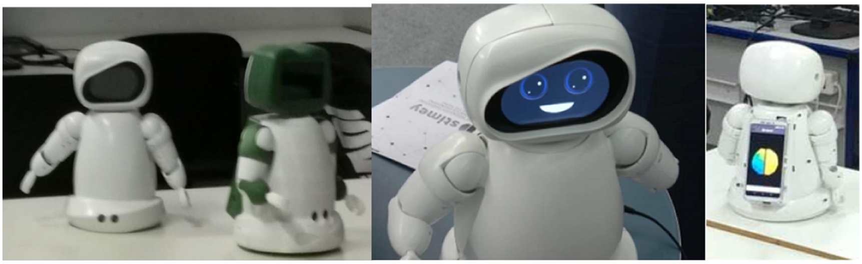

Fig. 1. The STIMEY Robot Prototype, left: two different versions of the robot, middle: happy facial expression, right: the robot's back with the embedded mobile phone device.

5 Evaluation- Experimental Design

5.1 Participants

The total number of participants was 92, 43 Boys 42 Girls, and seven who preferred not to mention their gender. 51 of them studied in junior high school, aged between 13 and 15 years old and 40 of them in senior high school aged between 16 and 18 years old. Only one student did not mention his/her age. They were all assigned to Greek schools and they all had normal or corrected to normal vision and hearing and their native language was the language of the lesson and the given questionnaires. They participated in the experiment after the principal of their school applied for participation through a project open invitation. The experiments lasted for one month and took place for every school classroom at the same hour in the morning in their school unit.

5.2 Design

In each school classroom, we conducted one lesson which lasted for two hours with the aid of the STIMEY Platform and Robot prototype. In this course, we first introduced the STIMEY platform and its capabilities to the students. The students then completed questionnaires related to their opinions regarding the hypothetical use of a robot during their courses. Then the lesson was implemented utilizing the STIMEY educational Platform, accompanied by the STIMEY Robot which was the tutor of the lesson in collaboration with a teacher with STEM studies expertise. Finally, after the end of the lesson, the students were asked to complete an online questionnaire regarding their Attitudes, Positions, and Behaviours towards STEM and STIMEY robot (STQ). The participants had as much time as they wanted to fill the questionnaire anonymously.

The given questionnaire, STQ was tailor-made, designed by the project partners based on the evaluation needs. There were three demographic, two close types, and 22 Likert scale questions (from 1–5, evaluated from totally agree to totally disagree with the questions' statement).

5.3 Procedure

In the beginning, all the students who participated in the lesson were informed about the STIMEY program and its actions, as well as about its online Platform and the STIMEY robot. Students were then asked to answer a 10 min pre-test questionnaire. The students then logged in to the STIMEY platform using their credentials. Before having the lesson with the robot, there was a familiarization phase where the students watched two videos (ten minutes duration) with the STIMEY Robot in action. After the end of the video, the robot stood in the middle of the class as shown in Fig. 2 and each student had access to one pc or tablet. The lesson that the robot taught to the students was about STEM and more specifically about the 'Dark Side of the Moon', explaining basic physics and astrophysics principles regarding the lighting conditions of the moon. The lesson was adapted based on their educational level. Our goal was to show as many robot's features and behaviors during the course about its appearance (i.e. different facial expressions) and usability (i.e. feedback, interconnectivity with the web- platform) before they evaluate it.

5.4 Data Analysis

Before the data analysis, we performed a Varimax factor analysis on the robot's characteristics and students- STIMEY robot interaction as well as a Cronbach's alpha reliability analysis on the dimensions of opinions, positions, and attitudes towards STEM sciences and the STIMEY robot.

For the analysis of the STQ, we calculated the Mean Value (*MV*) and Standard Deviation (*SD*) for each STQ question. To identify the effect of the students' demographical characteristics on their attitudes toward STEM studies and STIMEY robot, we applied a Kruskal Wallis test. Additionally, we conducted a paired-sample t-test to compare the differences in the students' attitudes before and after having a lesson with the robot.

Fig. 2. Classroom set up during the robot's evaluation

5.5 Results

The Varimax factor analysis on the Likert scale questions revealed three dimensions regarding the students' interaction with the robot with Kaiser-Meyer-Olkin (KMO) 0.7, and four regarding their attitudes before and after the lesson as shown in Table 1. The first factor includes 6 questions with $\alpha = 0.8$ and named after the context of the questions as 'Student Feedback'. The second factor (5 questions), named 'Student-Robot Interaction', with $\alpha = 0.66$ and the third one 'Non-interaction'.

Table 1. Cronbach's alpha dimensional analysis.

Dimensions	Questions	Cronbach's alpha
Positive Opinion about STEM and STIMEY before the lesson	3	0,684
Positive Behavior about STEM and STIMEY before the lesson	2	0,621
Positive Opinion about STEM and STIMEY after the lesson	3	0,713
Positive Behavior about STEM and STIMEY after the lesson	2	0,724
Student's Feedback	6	0,807
Student-Robot Interaction	5	0,661
Non interaction	1	-

According to the students' evaluations, they agreed that the robot should give them positive feedback ($MV = 4.18$, $SD = 0.66$), and they have positive attitudes about its interactive abilities ($MV = 4{,}01$, $SD = 0{,}62$), positive opinions towards STEM studies and STIMEY robot after having a lesson with it (*MV* = 4,11, *SD* = 0,71) and also positive behavior (*MV* = 3,71, *SD* = 0,89). On the other hand, the students' behavior towards STEM studies and STIMEY robot before having a lesson with the robot is neither positive nor negative (*MV* = 3,51, *SD* = 0,91), similarly with their attitudes toward the robot's non-interaction (*MV* = 3,20, *SD* = 1,47), as shown in Fig. 3.

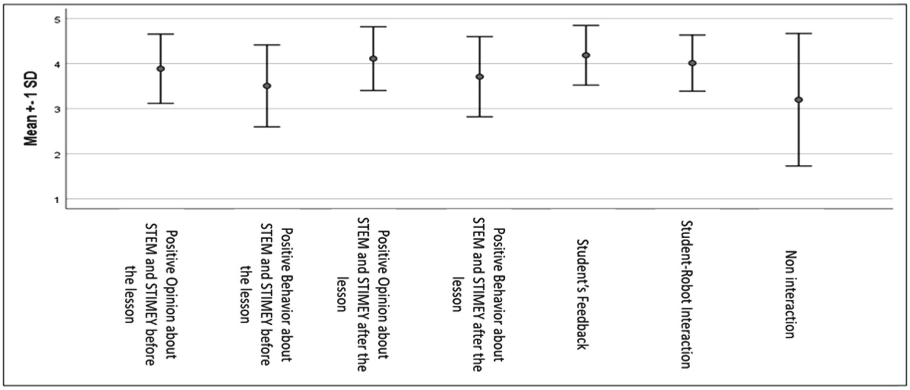

Fig. 3. MV and SD of the students' opinions, behaviour, attitudes towards STEM sciences and STIMEY Robot

The Kruskal Wallis measures indicated that there is a statistically significant difference regarding the students' gender and their attitudes toward STEM studies and STIMEY robot before having any lesson with it. More specifically, boys have more positive attitudes in comparison with others, girls and prefer not to say at H(2) = 8,69, p = 0,013 < 0,05. There were no statistically significant differences regarding students' age.

Most of the students, 32,97% (N = 30), indicated that Mathematics is the most difficult STEM course. Physics follows at 26,37% (N = 24) and then geography (10,99%, N = 10), biology, and the rest of them are split between chemistry, computer science, and engineering. It is worth mentioning that basic principles of computer science and engineering that are thought into school are theoretical without application and exercises.

Before having a lesson with the STIMEY robot, the students claimed that the use of the robot in the teaching procedure will make the most difficult STEM course (each student considered the one he/she declared at the beginning of the questionnaire) more pleasant (MV = 4.22, SD = 0.89), interesting (MV = 3.9, SD = 1.03) and more easily understandable (MV = 3.54, SD = 1.01). Moreover, they implied that the robot will help them focus more during the lesson on the difficult course (MV = 3.06, SD = 1.02) and that it will motivate them to follow an academic career in the future (MV = 3.38, SD = 1.11).

After having a lesson with the robot, the students claimed that the use of the robot in the teaching procedure will make the most difficult subject more pleasant (MV = 4.25, SD = 0.89), interesting (MV = 4.14, SD = 0.85), and more easily understandable (MV = 3.93, SD = 0.92). Moreover, they implied that the robot will help them focus more during the lesson on the difficult subject (MV = 3.75, SD = 0.95) and that it will motivate them to study from an academic perspective the more difficult subject in the future (MV = 3.67, SD = 1.05).

When comparing the two conditions, before and after having the lesson with the robot, students statistically significant improved their opinion that the robot will make the most difficult course more interesting, as shown by the t-test at $t(90) = -2,23$, $p = 0,029$ in comparison with their opinion before having the lesson. Similarly, after having the lesson, they believe that the participation of the robot will make the more difficult subject more easily understandable ($t(90) = -3,27$, $p = 0,002$) in comparison with their belief before having the lesson with it. Moreover, statistically significant more students, after the robot lesson, implied that it is possible to follow a STEM academic career in the future, ($t(90) = -2,50$, $p = 0,014$) compared with their intentions before having the lesson. Table 2 shows the students' evaluation regarding the robot's interactive skills and feedback after having a course with the robot.

Table 2. MV and *SD* of students' opinions regarding the robot's interactive behavior after having a lesson with it.

STIMEY robot's interactive skills	M.V	SD
After the end of the lesson, the STIMEY robot should give reward and positive feedback by using its facial expressions to the students based on their effort in the platform	4,37	0,77
During the lesson, STIMEY robot should ask questions to the students to provide them with additional information regarding the course	4,35	0,77
When the STIMEY robot provides additional information to the students, it should approach them and encourage them by using its facial expressions	4,34	0,88
When the STIMEY robot provides a quiz to the students, it should reward them for every correct answer by using body movements and facial expressions	4,21	0,86
When the lesson is over, STIMEY robot should verbally reward students about their effort (i.e. by saying 'congratulations')	4,14	0,86
When the STIMEY robot provides a quiz to the students, it should verbally reward them for every correct answer	4,13	0,96
When students post in the platform, STIMEY robot should verbally reward them by saying 'Well Done'	4,07	0,94
When the teacher prepares a lesson through the platform, STIMEY robot should send notifications to the students	4,00	0,93
When students post in the platform, STIMEY robot should not reward them verbally, but by using its body movements and facial expressions	3,91	1,02
When the STIMEY robot shows a video to the students, it should verbally comment on it (i.e. highlight the important parts of the video)	3,86	1,18

(*continued*)

Table 2. (*continued*)

STIMEY robot's interactive skills	M.V	SD
When the STIMEY robot shows a video to the students, it should look at them	3,45	1,14
When the STIMEY robot shows a video to the students, it should not show facial expressions such as surprize of close one eye, neither to intervene	3,20	1,47

Finally, students found that their favourite characteristic of the robot's appearance was its eyes (49,45%, N = 45), head (20,88%, N = 19), arms (14,29%, N = 13) and equally its torso and backpack at 7.69% (N = 7).

6 Discussion and Conclusions

Robots' characteristics such as their social behavior have been proven beneficial in educational and teaching tasks by strengthening student's cognitive and affective outcomes [2]. Educational robots also help students better understand and appreciate STEM studies [5]. It is important to identify the ideal robots' characteristics that enhance both students' learning outcomes and make them enjoy the lesson more, by taking into consideration among other factors, their culture. In the current study, we described the importance of designing and constructing educational robots based on the stakeholders' needs by conducting user-centred design procedures. The current robot design procedure took place during the HORIZON 2020 funded Project STIMEY. The educational stakeholders, students, teachers, school principals, parents, wherefrom five different European countries, giving a representative sample of the European population. They all had similar opinions regarding their attitudes about the ideal educational robot's appearance, voice, and functionality and we end up with six categories of recommendations. By following the majority of them (78%), we designed and constructed the STIMEY Robot prototype which was among others, portable, small-sized, a combination of humanoid, machinery, and cartoonish characteristics, able to change facial expressions, move parts of its body and give voice feedback and reward to the students.

In the present study, we consider the robot's evaluation in Greek schools, by 92 students aged between 13 and 18 years old who had a two hours STEM lesson instructed by the STIMEY Robot. Results showed that students after having a lesson with the robot had positive attitudes and behaviors towards its interactive skills and ability to give feedback. Moreover, after having a lesson with the robot, students statistically significantly improve their beliefs regarding the robot's ability to make even the most difficult course more interesting ($p = .029$) and more easily understandable ($p = .002$). Furthermore, students believe that it is possible to follow a future carrier in STEM studies, in comparison with their beliefs before having a lesson with the robot ($p = .014$).

As future work, we plan to evaluate the robot with students and stakeholders in more European countries and for others abroad in Europe to find out if we can generalize our principles regarding the educational robot characteristics.

References

1. Onyeulo, E.B., Gandhi, V.: What makes a social robot good at interacting with humans? Information **11**(1), Art. no. 1 (2020). https://doi.org/10.3390/info11010043
2. Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., Tanaka, F.: Social robots for education: a review. Sci. Robot. **3**(21) (2018). https://doi.org/10.1126/scirobotics.aat5954
3. Neumann, M.M.: Social robots and young children's early language and literacy learning. Early Childhood Educ. J. **48**(2), 157–170 (2019). https://doi.org/10.1007/s10643-019-00997-7
4. Ahmad, M.I., Khordi-moodi, M., Lohan, K.S.: Social robot for STEM education. In: Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction, New York, NY, USA, pp. 90–92, March 2020. https://doi.org/10.1145/3371382.3378291
5. Benitti, F.B.V., Spolaôr, N.: How have robots supported STEM teaching? In: Khine, M.S. (ed.) Robotics in STEM Education, pp. 103–129. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-57786-9_5
6. Smakman, M., Berket, J., Konijn, E.A.: The impact of social robots in education: moral considerations of dutch educational policymakers. In: 2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), August 2020, pp. 647–652 https://doi.org/10.1109/RO-MAN47096.2020.9223582.
7. Nomura, T.: Cultural differences in social acceptance of robots. In: 2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN), pp. 534–538, August 2017. https://doi.org/10.1109/ROMAN.2017.8172354
8. Gnambs, T., Appel, M.: Are robots becoming unpopular? changes in attitudes towards autonomous robotic systems in Europe. Comput. Hum. Behav. **93**, 53–61 (2019). https://doi.org/10.1016/j.chb.2018.11.045
9. A framework for organizing the tools and techniques of participatory design|Proceedings of the 11th Biennial Participatory Design Conference. https://dl.acm.org/doi/abs/10.1145/1900441.1900476?casa_token=3HZNgr5FT1QAAAAA:9mHWxUIh_7fQkLbi4qE4Fn-hNlI5StbwQu4H3K9igIzZjyQ4AnSLsE6fGy4IgO3hSDpJd3WEJNgAccessed 19 Mar 2020
10. Jalowski, M., Fritzsche, A., Möslein, K.M.: Applications for persuasive technologies in participatory design processes. In: Oinas-Kukkonen, H., Win, K.T., Karapanos, E., Karppinen, P., Kyza, E. (eds.) PERSUASIVE 2019. LNCS, vol. 11433, pp. 74–86. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-17287-9_7
11. Rose, E.J., Björling, E.A.: Designing for engagement: using participatory design to develop a social robot to measure teen stress. In: Proceedings of the 35th ACM International Conference on the Design of Communication, Halifax, Nova Scotia, Canada, pp. 1–10, August 2017. https://doi.org/10.1145/3121113.3121212
12. Salter, T., Werry, I., Michaud, F.: Going into the wild in child–robot interaction studies: issues in social robotic development. Intell. Serv. Robot. **1**(2), 93–108 (2008). https://doi.org/10.1007/s11370-007-0009-9
13. 'STIMEY'. https://www.stimey.eu/home. Accessed 27 Apr 2020
14. Faccio, M., Minto, R., Rosati, G., Bottin, M.: The influence of the product characteristics on human-robot collaboration: a model for the performance of collaborative robotic assembly. Int. J. Adv. Manuf. Technol. **106**(5–6), 2317–2331 (2019). https://doi.org/10.1007/s00170-019-04670-6
15. Heerink, M.: Exploring the influence of age, gender, education and computer experience on robot acceptance by older adults. In: 2011 6th ACM/IEEE International Conference on Human-Robot Interaction (HRI), pp. 147–148, March 2011. https://doi.org/10.1145/1957656.1957704

16. Goetz, J., Kiesler, S., Powers, A.: Matching robot appearance and behavior to tasks to improve human-robot cooperation. In: The 12th IEEE International Workshop on Robot and Human Interactive Communication, 2003. Proceedings. ROMAN 2003, pp. 55–60, November 2003. https://doi.org/10.1109/ROMAN.2003.1251796
17. Velentza, A.-M., Heinke, D., Wyatt, J.: Museum robot guides or conventional audio guides? an experimental study. Adv. Robot. **34**(24), 1571–1580 (2020). https://doi.org/10.1080/01691864.2020.1854113
18. Li, D., Rau, P.L.P., Li, Y.: A cross-cultural study: effect of robot appearance and task. Int. J. Soc. Robot. **2**(2), 175–186 (2010). https://doi.org/10.1007/s12369-010-0056-9
19. Gena, C., Mattutino, C., Perosino, G., Trainito, M., Vaudano, C., Cellie, D.: Design and development of a social, educational and affective robot. In: 2020 IEEE Conference on Evolving and Adaptive Intelligent Systems (EAIS), May 2020, pp. 1–8. https://doi.org/10.1109/EAIS48028.2020.9122778.
20. Bertel, L.B., Rasmussen, D.M., Christiansen, E.: Robots for real: developing a participatory design framework for implementing educational robots in real-world learning environments. In: Kotzé, P., Marsden, G., Lindgaard, G., Wesson, J., Winckler, M. (eds.) INTERACT 2013. LNCS, vol. 8118, pp. 437–444. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-40480-1_29
21. Reich-Stiebert, N., Eyssel, F., Hohnemann, C.: Exploring university students' preferences for educational robot design by means of a user-centered design approach. Int. J. Soc. Robot. **12**(1), 227–237 (2019). https://doi.org/10.1007/s12369-019-00554-7
22. Reich-Stiebert, N., Eyssel, F.: Robots in the classroom: what teachers think about teaching and learning with education robots. In: Agah, A., Cabibihan, J.-J., Howard, A.M., Salichs, M.A., He, H. (eds.) ICSR 2016. LNCS (LNAI), vol. 9979, pp. 671–680. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-47437-3_66
23. Velentza, A.-M., Pliasa, S., Fachantidis, N.: Future Teachers choose ideal characteristics for robot peer-tutor in real class environment. In: presented at the International Conference on Technology and Innovation in Learning, Teaching and Education, TECHEDU2020 (2020)
24. Höflich, J.R., El Bayed, A.: Perception, acceptance, and the social construction of robots—exploratory studies. In: Vincent, J., Taipale, S., Sapio, B., Lugano, G., Fortunati, L. (eds.) Social Robots from a Human Perspective, pp. 39–51. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-15672-9_4
25. Darriba Frederiks, A., Octavia, J.R., Vandevelde, C., Saldien, J.: Towards participatory design of social robots. In: Lamas, D., Loizides, F., Nacke, L., Petrie, H., Winckler, M., Zaphiris, P. (eds.) INTERACT 2019. LNCS, vol. 11747, pp. 527–535. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-29384-0_32
26. Pnevmatikos, D., Christodoulou, P., Fachantidis, N.: Designing a socially assistive robot for education through a participatory design approach: Guiding principles for the developers. Int. J. Soc. Robot.
27. Christodoulou, P., Reid, A.A.M., Pnevmatikos, D., del Rio, C.R., Fachantidis, N.: Students participate and evaluate the design and development of a social robot. In: 2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), pp. 739–744, August 2020. https://doi.org/10.1109/RO-MAN47096.2020.9223490