Bridging the Gap: Early Education on Robot and AI Ethics through the Robot Theater Platform in an Informal Learning Environment

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ABSTRACT

With the rapid advancement of robotics and AI, educating the next generation on ethical coexistence with these technologies is crucial. Our research explored the potential of a child-robot theater afterschool program in introducing and discussing robot and AI ethics with elementary school children. Conducted with 30 participants from a socioeconomically underprivileged school, the program blended STEM (Science, Technology, Engineering & Mathematics) with the arts, focusing on ethical issues in robotics and AI. Using interactive scenarios and a theatrical performance, the program aimed to enhance children's understanding of major ethical issues in robotics and AI, such as bias, transparency, privacy, usage, and responsibility. Preliminary findings indicate the program's success in engaging children in meaningful ethical discussions, demonstrating the potential of innovative, interactive educational methods in early education. This study contributes significantly to integrating ethical robotics and AI in early learning, preparing young minds for a technologically advanced and socially responsible future.

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CCS CONCEPTS

•Social and professional topics~Professional topics~Computing education~Informal education •Social and professional topics~Professional topics ~Computing profession~Codes of ethics

KEYWORDS

Robot Theater; Robot and AI Ethics, Early education

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1 INTRODUCTION

As artificial intelligence (AI) and robots are becoming increasingly prevalent in everyday life, preparing the next generation for a world where they can coexist with these entities safely is becoming increasingly important. Despite the significance of this

Table 1. Overview of the Child-Robot Theater Program

Week	Module	Content	Activities	Robots and AI Tools Used	Ethical Topic
1	Introduction	The role of robotics and AI in human society, robot types and functions	Introduction to robots	Humanoid robots: NAO, Moxie, Milo Non-humanoid robots: Aibo, Quincy	N/A
2-3	Acting	Anthropomorphism (physical characteristics of robots), robot speech, emotions and facial expressions	Programming robot dialogue and facial expressions	Humanoid robots: NAO, Moxie, Milo Non-humanoid robots: Aibo, Quincy	Accessibility, bias and fairness
4-5	Dancing	Physics (weight and balance), physicality robot limitations, autonomous and non-autonomous movements	Programming robot movements	Humanoid robots: NAO, Pepper, Moxie, Milo Non-humanoid robots: Aibo, Quincy	Access to technology, bias and fairness, responsibility
6-7	Music & Sound	Music composition (AI, synthesizers, and interactive), robot voice (pitch, tone, and range), AI generated voice, haptic sonification	Programming robot speech, music composition with robots and AI tools	Humanoid robots: NAO, Pepper, Moxie, Milo Non-humanoid robots: Aibo, Quincy Tools: Makey-Makey, AI Duet, Semi-Conductor	Technology reliance, transparency, responsibility, privacy
8	Drawing	Robot and AI generated art	Creating art with robots and AI tools	Humanoid robots: NAO, Moxie, Milo Non-humanoid robots: Aibo, Quincy AI Tools: Sketch RNN, Image Creator	Abuse to technology, bias and fairness, robot and AI uses
9	Theatrical Performance	Embodying robot and AI ethics scenario	Participate in final performance	Humanoid robots: NAO, Pepper, Milo Non-humanoid robots: Aibo	Abuse to technology, bias and fairness

issue, there has been limited research directed toward preparing the next generation to seamlessly coexist with robots and AI in their daily lives, particularly in their social and ethical implications [4, 11]. Existing robot and AI educational tools, such as Cognimates, Machine Learning for Kids, or RAISE AI Playground, are more targeted toward middle and high school students and often do not cover the ethical aspects behind the tools [9, 14, 15].

Initiating conversations about robot and AI ethics with children is essential for fostering responsible and informed digital literacy [16, 19]. By engaging in these discussions early on, children can develop an increased awareness of the ethical considerations around technology use. This awareness will enable them to develop the skills needed to make ethical, informed decisions, navigate potential challenges, and contribute positively to the evolving technological landscape in the future [1]. Ethical considerations in AI are complex and multifaceted, encompassing issues such as privacy, bias, transparency, and the impact of automation on employment and jobs [13]. Despite the proliferation of research on robot and AI ethics, there have not been systematic efforts to translate such scholarship into a K-12 classroom.

Given this complexity, our research aims to evaluate the efficacy of the child-robot theater afterschool program in achieving the following objectives: Can a child-robot theater program effectively 1) introduce the topic of robot and AI ethics, 2) facilitate discussions on complex ethical topics, and 3) increase general awareness of robot and AI ethics among children?

2 METHODS

2.1 Participants

Thirty students from a socioeconomically underprivileged elementary school in a rural area of the United States participated in our study with written assent and parents' consent. Other children were allowed to join the program without participating in research activities. Attendance was not mandatory, allowing students to come and go based on their individual schedules. An average of 14 children attended per session across the nine sessions. The participants comprised 14 male and 16 female students, with ages ranging from 5.42 to 11.92 years (M = 8.04, SD = 1.79).

2.2 Program Overview

The child-robot theater afterschool program was initially designed to enhance students' learning by integrating novel topics, such as STEM with robotics, with a more familiar realm, such as arts [2, 3, 8]. In this specific iteration of the child-robot theater program, a significant emphasis was placed on incorporating robot and AI ethics themes into the curriculum. Implemented as an afterschool extracurricular activity for elementary school students, these sessions were structured to include 30-40 minutes of guided activities and an additional 20-30 minutes dedicated to free play with robots. Figure 1 shows the various robots utilized in the program and Figure 2 shows the afterschool program setting, including a child interacting with a robot during free play.

The curriculum was organized into four two-week modules, each focusing on a different aspect of robot or AI behavior within the context of an artistic domain. Table 1 details the different modules, ethical topics, and the specific robots and AI tools utilized in each module.

2.3 Robot and AI Ethics Integration

Due to the lack of established information and metrics for evaluating the perception of robot and AI ethics in elementary school students, we conducted a review leading to the identification of diverse micro- and macro-ethical topics related to robots and AI, coupled with corresponding measures previously tailored for assessing adult perspectives on robots and AI [5, 10, 12]. The adapted measures were integrated into the pre- and post-program interview questionnaires and interspersed throughout the program. Additional questions pertaining to the participants' perceptions of robot capabilities and trust in robots were also asked participants' perceptions of robot capabilities and trust in robots and AI were also asked.

To further facilitate ethical discussions, researchers developed short video scenarios featuring robots in ethical dilemmas, drawing inspiration from the previously mentioned micro- and macro-ethical topics identified in the literature review. These

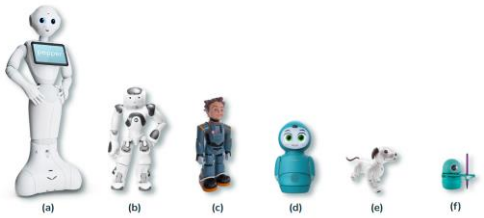

Figure 1. Robots used in the robot-theater program. (a) Pepper, (b) NAO, (c) Milo, (d) Moxie, (e) Aibo, (f) Quincy

videos were incorporated in the second week of each module, directly tying into the respective module's topic to ensure an easy transition in understanding. At the end of each video, researchers engaged students in discussions by posing questions about the ethical topic presented, fostering a dynamic and participatory learning environment.

One video addressed bias and fairness, featuring a human professor discriminating against a blind robot student, NAO. Following the presentation of the video, the researcher initiated a discussion beginning with more straightforward content-related questions such as, "What happened in the video?" and "How do you think the NAO robot felt?" The researcher then transitioned to the ethical theme of the video. Encouraging participants to reverse roles in their minds, the researcher asked, "Let us think about this the other way around. Imagine NAO as the teacher and the human as the student. Does your opinion change? If so, why or why not?" This scenario provided an engaging and straightforward introduction that biases can exist not only in people but also within technology.

The program concludes with a final theatrical performance, focusing on an ethical issue of bias, fairness, and mistreatment of technology. The script centered around a scenario in which a new robot student faces bullying from both robot and human peers. Participants chose their roles in this scenario with robot actors. The overarching goal was to deliver a dynamic and hands-on experience, enabling students not only to physically interact with the technology but also to embody and grapple with the ethical considerations.

2.4 Measurements

At the beginning and end of the program, children completed pre- and post-program interview questions to report their perceptions of robot capabilities, trust in robots, as well as the aforementioned perceptions of robot and AI ethical topics. The questions varied in structure, running from Likert-scale items to questions that encouraged more open-ended responses, prompting participants to explain their rationale behind specific answers. In addition to quantitative data, qualitative data were gathered through audio and video recordings.

The preliminary findings from our research suggest that the child-robot theater afterschool program effectively engaged children in discussions on robots and AI ethics. While the complete analysis is pending, some intriguing and insightful excerpts from interview questionnaires and qualitative data are provided below.

Figure 2. A researcher introduced the sound and music module to students (left); a researcher demonstrated Pepper's dance to a student (right).

3 PRELIMINARY RESULTS

3.1 Fairness and Bias

Eighteen participants completed interview questionnaires related to fairness and bias. Two-thirds of students (N = 12) expressed that robots and AI should help all people equally. However, some students (N = 5) mentioned that robots and AI should only help some people. When asked to elaborate, children stated that robots and AI should help "people who need them, like people with autism," while others stated that robots and AI should help only people who "understand [robots]" or "make robots." One student mentioned that robots and AI should help no one. Notably, when discussing the ethics video featuring NAO, the blind robot student, children emphasized the importance of inclusivity even if the roles were reversed. Children stated, "we should not use robots to exclude anybody."

3.2 Transparency

Eighteen participants completed interview questionnaires related to transparency. In response to "Should AI/robots explain why they make certain choices?" more than half of the students (N = 11) stated that robots and AI should explain their choices "only when you ask them." Some students (N = 6) had divided opinions: three students advocated for the viewpoint that robots and AI should "always" explain their choices, while the remaining three students asserted the opposite, advocating for "never" providing explanations. One student stated robots and AI should provide explanations "only when things go wrong."

3.3 Privacy

Seventeen participants completed interview questionnaires related to privacy. Students were allowed to choose multiple answers. When asked, "Which of the things companies that made AI/robots should be able to use? (your name, your address, your picture, your speech, your search history like the YouTube videos you watch)," students' responses varied. Most students mentioned being comfortable with companies knowing their name and picture (N = 15 and 9), and fewer students were comfortable with companies knowing their address, speech, and search history (N = 4, 6, and 6). One expressed, "No way! I don't want them to know what I watch." However, some students seemed to understand that this information was already known by algorithms within

YouTube. During a discussion, one stated, "Sometimes [YouTube] keeps showing me videos from the same people I watch."

Some of these concerns extended to the notion of trusting a robot with a secret, with responses reflecting the children's nuanced understanding of robot and AI capabilities. While some attributed a social presence to robots, acknowledging them as friends, stating "[the robot] loves me." Others remained skeptical, stating, "No, because the robot could tell everybody. Anybody could ask the robot about [someone's] secrets." Another student said they can "kind of [trust robots and AI], but you have to program to make sure they are not going to tell anyone [your secret]."

3.4 Robot and AI Uses

Seventeen participants completed interview questionnaires related to robot and AI uses. Students were allowed to choose multiple answers. More than half of the students suggested that robots and AI could be used to help others, do their chores, and learn (N = 13, 11, and 13). However, three students mentioned that they can use robots and AI to cheat in school. Another student mentioned that people "can use [robots and AI] for everything."

3.5 Responsibility

Sixteen participants completed interview questionnaires on who would be responsible for robots and AI in case of mishaps. Students were allowed to choose multiple answers. Students' responses varied greatly on whether the robot or AI developer, company, user, government, or robot/AI itself should be responsible (N = 8, 6, 7, 4, and 5) without a clear consensus. However, when presented with a framework of technology reliance in a video scenario, a student stated, "It's [the user's] fault because they're the ones being addicted to it and ignoring everyone 24/7."

4 DISCUSSION

The preliminary findings suggest that through the interactive, embodied, and constructionist medium of robot theater, children were receptive to discussions about robot and AI ethics and can give their nuanced perspectives on a range of ethical topics. The observed engagement during the program as well as the teacher and staff members' testimony suggest that this approach effectively captures children's interest while fostering meaningful discussions and critical thinking skills.

The child-robot theater program fundamentally offers an interactive learning experience where children are learning by engaging with robots and with their peers [6]. The active and embodied learning approach of the final theatrical performance is a key strength of the robot theater program. Allowing students to embody roles in an ethical scenario provides a unique opportunity for children to internalize ethical considerations and gain a first-hand understanding of complex issues [17]. This approach not only makes abstract concepts more tangible but also ensures that learning is contextual and engaging.

The child-robot theater also situates ethical discussions in a context that is both familiar and engaging to children, which mirrors Constructionists' cognitive apprenticeship approach [7]. In this program, children are not passive recipients of information, but they actively engage in critical thinking and ethical reasoning. By encouraging children to reflect on ethical scenarios, participating in the program can instill a sense of ethical awareness that can be carried into their interactions with technology in everyday life.

5 CONTRIBUTIONS, LIMITATIONS, AND FUTURE DIRECTIONS

This paper presents a novel exploration of early education on robot and AI ethics, addressing a critical yet underexplored domain. The multidisciplinary and interactive approach of child-robot theater significantly differs from conventional educational tools, specifically enhancing ethical awareness among young learners about technology use. The program's design fosters a child-centric and participatory learning environment, encouraging critical thinking and engaging discussions about ethical scenarios involving robots and AI. Moreover, using interactive and embodied learning methods, such as short video scenarios and theatrical performance, not only makes abstract concepts more tangible but also ensures that learning is contextual and engaging. The research offers valuable insights and potential influences on future educational tools delving into robot and AI ethics. By effectively engaging elementary school children in discussions on robot and AI ethics, this study takes a significant step toward preparing the young members of society for a future intertwined with these technologies.

While this research made novel contributions in providing a platform for integrating robot and AI ethics into early education, it is not without limitations. One limitation is the preliminary nature of our findings. The insights drawn are based on initial observations of qualitative data, offering an early glimpse, but a more thorough analysis will be followed to provide a holistic overview of the program's impact. Additionally, as this program was the first rendition that featured robot and AI ethics as its central topic, there are areas for improvement and expansion. The current program focused on a select set of ethical issues and scenarios, which, while important, do not encompass the entire spectrum of ethical considerations in robotics and AI. Future renditions of the program will aim to include a more extensive breadth and depth of ethical topics.

The robots were often portrayed in a manner that emphasized their anthropomorphic characteristics. We addressed anthropomorphism as a topic within our curriculum as it plays an important role in relationships with robots and developing trust. However, given it might lead children to consider robots as possessing unnecessarily high intelligence or similar human-like qualities, we acknowledge it requires a cautious approach.

Furthermore, including the perspectives of parents and teachers in future studies may also provide a more comprehensive understanding of the impact of children's learning of robot and AI ethics. Given these considerations, the child-robot theater program has opened a new avenue for engaging elementary school students with the ethical aspects of robots and AI.

REFERENCES

[1] S. Ali, B. H. Payne, R. Williams, H. W. Park, and C. Breazeal, "Constructionism, Ethics, and Creativity: Developing Primary and Middle School Artificial Intelligence Education".

[2] J. Barnes, M. S. FakhrHosseini, E. Vasey, Z. Duford, and M. Jeon, "Robot Theater with Children for STEAM Education," Proceedings of the Human Factors and Ergonomics Society Annual Meeting, Vol. 61, no. 1, pp. 875–879, Sep. 2017, doi: 10.1177/1541931213601511.

[3] J. Barnes, S. M. FakhrHosseini, E. Vasey, C. H. Park, and M. Jeon, "Child-Robot Theater: Engaging Elementary Students in Informal STEAM Education Using Robots," IEEE Pervasive Computing, Vol. 19, no. 1, pp. 22–31, Jan. 2020, doi: 10.1109/MPRV.2019.2940181.

[4] J. Borenstein and A. Howard, "Emerging challenges in AI and the need for AI ethics education," AI Ethics, Vol. 1, no. 1, pp. 61–65, Feb. 2021, doi: 10.1007/s43681-020-00002-7.

[5] C. S. Chai, X. Wang, and C. Xu, "An Extended Theory of Planned Behavior for the Modelling of Chinese Secondary School Students' Intention to Learn Artificial Intelligence," Mathematics, Vol. 8, no. 11, Art. no. 11, Nov. 2020, doi: 10.3390/math8112089.

[6] K.-Y. Chin, Z.-W. Hong, and Y.-L. Chen, "Impact of Using an Educational Robot-Based Learning System on Students' Motivation in Elementary Education," IEEE Trans. Learning Technol., Vol. 7, no. 4, pp. 333–345, Oct. 2014, doi: 10.1109/TLT.2014.2346756.

[7] A. Collins, J. S. Brown, and S. E. Newman, "Cognitive Apprenticeship: Teaching the Craft of Reading, Writing and Mathematics," Thinking: The Journal of Philosophy for Children, Vol. 8, no. 1, pp. 2–10, Mar. 1988, doi: 10.5840/thinking19888129.

[8] J. Dong et al., "A Child-Robot Musical Theater Afterschool Program for Promoting STEAM Education: A Case Study and Guidelines," International Journal of Human–Computer Interaction, Vol. 0, no. 0, pp. 1–17, 2023, doi: 10.1080/10447318.2023.2189814.

[9] S. Druga, "Cognimates." 2018.

[10] Y. Ikkatai, T. Hartwig, N. Takanashi, and H. M. Yokoyama, "Octagon Measurement: Public Attitudes toward AI Ethics," International Journal of Human–Computer Interaction, Vol. 38, no. 17, pp. 1589–1606, Oct. 2022, doi: 10.1080/10447318.2021.2009669.

[11] J. Irwin, A. Dharamshi, and N. Zon, "Children's Privacy in the Age of Artificial Intelligence," Canadian Standards Association, [Online]. Available: https://www.csagroup.org/wp-content/uploads/CSA-Group-Research-Children_s-Privacy-in-the-Age-of-Artificial-Intelligence.pdf

[12] Y. Jang, S. Choi, and H. Kim, "Development and validation of an instrument to measure undergraduate students' attitudes toward the ethics of artificial intelligence (AT-EAI) and analysis of its difference by gender and experience of AI education," Educ Inf Technol, Vol. 27, no. 8, pp. 11635–11667, Sep. 2022, doi: 10.1007/s10639-022-11086-5.

[13] A. Jobin, M. Ienca, and E. Vayena, "The global landscape of AI ethics guidelines," Nat Mach Intell, vol. 1, no. 9, Art. no. 9, Sep. 2019, doi: 10.1038/s42256-019-0088-2.

[14] D. Lane, "Machine Learning for Kids." 2018.

[15] MIT Media Lab, "RAISE AI Playground." 2020.

[16] D. T. K. Ng, J. K. L. Leung, S. K. W. Chu, and M. S. Qiao, "Conceptualizing AI literacy: An exploratory review," Computers and Education: Artificial Intelligence, vol. 2, p. 100041, Jan. 2021, doi: 10.1016/j.caeai.2021.100041.

[17] S. Papert and I. Harel, Constructionism. in Constructionism. Westport, CT, US: Ablex Publishing, 1991, pp. xi, 518.

[18] J. Su and W. Yang, "AI literacy curriculum and its relation to children's perceptions of robots and attitudes towards engineering and science: An intervention study in early childhood education," Journal of Computer Assisted Learning, Vol. n/a, no. n/a, doi: 10.1111/jcal.12867.

[19] A. Jobin, M. Ienca, and E. Vayena, "The global landscape of AI ethics guidelines," Nat Mach Intell, Vol. 1, no. 9, Art. no. 9, Sep. 2019, doi: 10.1038/s42256-019-0088-2