

Teaching AI and Robotics to Children in a Mexican town

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Figure 1: (a) Instructor demonstrating coding activities to children with open-source educational robot, (b) instructor playing bingo game with AI and Robotic-based cards, (c) instructors presenting AI and Robotics fundamentals to children, (d) children interacting in group activities, and (e) showcase activity where instructor(s) helped a group of four children to present their projects.

ABSTRACT

In this paper, we present a pilot study aiming to investigate the challenges of teaching AI and Robotics to children in low- and middle-income countries. Challenges such as the little to none experts and the limited resources in a Mexican town to teach AI and Robotics were addressed with the creation of inclusive learning activities with Montessori method and open-source educational robots. For the pilot study, we invited 14 participants of which 10 were able to attend, 6 male and 4 female of (age in years: mean=8 and std= ± 1.61) and four instructors of different teaching experience levels to young audiences. We reported results of a four-lesson curriculum that is both inclusive and engaging. We showed the impact on the increase of general agreement of participants on the understanding of what engineers and scientists do in their jobs, with engineering attitudes surveys and Likert scale charts from the first and the last lesson. We concluded that this pilot study helped children coming from low- to mid-income families to learn fundamental concepts of AI and Robotics and aware them of the

potential of AI and Robotics applications which might rule their adult lives. Future work might lead (a) to have better understanding on the financial and logistical challenges to organise a workshop with a major number of participants for reliable and representative data and (b) to improve pretest-posttest survey design and its statistical analysis. The resources to reproduce this work are available at <https://github.com/air4children/dei-hri2023>.

CCS CONCEPTS

- Human-centered computing → Empirical studies in HCI; Accessibility systems and tools;
- Applied computing → Interactive learning environments;
- Social and professional topics → Children;
- Computing methodologies → Cognitive robotics.

KEYWORDS

Child-centred AI, Educational Robotics, Child-robot interaction

ACM Reference Format:

Antonio Badillo-Perez, Donato Badillo-Perez, Alex Barco, Rocio Montenegro, and Miguel Xochicale. 2023. Teaching AI and Robotics to Children in a Mexican town . In *HRI '23: ACM/IEEE International Conference on Human-Robot Interaction, March 13–16, 2023 Stockholm, SE*. ACM, New York, NY, USA, 6 pages. <https://doi.org/XXXXXX.XXXXXXXX>

1 INTRODUCTION

Teaching Artificial Intelligence (AI) and Robotics to young learners has been made good progress in the last decade [3, 5]. Educational progress has been possible due to the great investment in AI and

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HRI '23, March 13–16, 2023, Stockholm, SE

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ACM ISBN 978-1-4503-XXXX-X/18/06...\$15.00
<https://doi.org/XXXXXX.XXXXXXXX>

Robotics in countries such as U.S.A, Germany, Denmark, and Sweden, making those countries and their communities to define core values in AI and Robotics [5]. These raise the question on how to adapt such core values from the most to the least privileged environments [11]. Recently, it has been few progress on using open-source educational robots and the creation of child-centred programs to teach AI and Robotics in low- and middle-income countries [2, 13]. However, there are various challenges on teaching AI and Robotics to young learners. For instance, the barrier of teaching programming skills to those who are still learning writing and reading skills to which visual and auditory programs using sensor, action and logic blocks helped to address such challenges [12, 17]. Other challenge is the little to none experts to teach AI and Robotics and its limited educational material in low- and middle-income countries [2, 18]. Hence, the aim of this work is to investigate further challenges of teaching AI and Robotics to young audiences in a Mexican town where little no experts can teach such subjects with limited resources.

In this paper, we present challenges of teaching AI and Robotics to Children in a Mexican town. In section 3, we present the study design and curriculum design with four lessons. In section 4, we present results and surveys from a pilot experiment. We then conclude the paper and add future work in section 5.

2 CHALLENGES OF TEACHING AI AND ROBOTICS TO CHILDREN

2.1 Teaching bias in AI

Smith et al. pointed out the current challenges of when and how to teach computing ethics to students [16]. Learning ethics in introductory courses help students to think ethically about their computation topics [8]. Payne et al. have shown great progress on making pilots and beta test teaching ethical AI to young audiences [14]. For instance, on summer 2021 a pilot to teach ethical AI to young audiences were organised with 28 kids at the Media Lab with a cost of \$150 for the week, leading to a beta test with 250 students in autumn 2021. Such pilots considered question related to the everyday life of children, such as "What's is the best algorithm to make a peanut-butter sandwich?: is it the algorithm that makes the tastiest sandwich? , is it the prettiest sandwich?, is it the quickest and easiest to make? or the easiest to clean up?". Hence the challenge is to contextualise such questions in a Mexican town where children may know little to none about AI, Robotics and ethics (bias).

2.2 Inclusive learning of AI and Robotics with Montessori method

Montessori method is focused in child-centred development where the role of Montessori teachers is to help children individually or in small groups engaging in self-directed activities [1]. The adoption of technological topics (AI and Robotics) into Montessori methods has been experimented and studied in the last 10 years [7]. However, there are other skills that are also required to create inclusive learning of new technologies. For example, "collaborative skills" and "understating concepts" are two main factors to design inclusive AI literary for children in low, medium and high socioeconomic

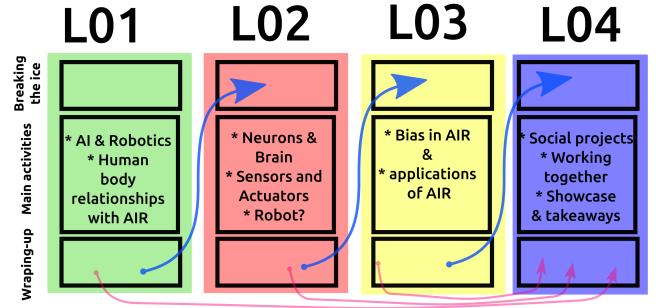


Figure 2: Curriculum design with four lessons of 1 hour and a half (L01, L02, L03 and L04). The arrows illustrate the connection between the the last and the first part of each lesson as way to summarise the progress of each lesson (blue arrows) and connections with their full curriculum (red arrows).

backgrounds [5]. Also, there is evidence on the impact of collaboration and engagement activities on how coding games and robots to enhance computational thinking [15]. Hence, the challenge is how to adapt Montessori method to not only create conditions to develop physical and social requirements but collaborative and literacy skills through hands-on activities.

3 PILOT STUDY: STUDY DESIGN AND CURRICULUM DESIGN

3.1 Participants

In this pilot study, we invited 14 participants between the age of 6 to 9 years old. During the pilot workshop, only 10 participants (6 male and 4 female) of (age in years: mean=8 and std= ± 1.61) were able to join the workshops as remained ones were unable to attend due to personal circumstances. We also invited four instructors with various experiences levels in teaching subjects to young audiences (two between 5 to 10 years and two with less than 2 years) and one person to lead the logistics of the event.

3.2 Lessons

Aiming to create inclusive teaching practices for students, we considered a study design based on procedures, instruments, data collection and analysis [6]. Considering the limited human and material resources, we decided to teach four lessons instead of the original ten lessons for the pilot study of this curriculum.

Figure 2 illustrates the curriculum design for the pilot experiment. During the first lesson, we introduced basics concept of human senses and how AI relates to identifying cats and dogs. We were able to use more dynamic activities with protoboards and simple electric circuits so that children can easily learn fundamentals on how a robot works (Figure 1d). For the second lesson, we presented examples on how AI learn to recognize animals or humans with a tangram activity and gave them a mini introduction to the code that they will use for the robot. In the third lesson, we adopted a bingo game with key terms from the previous lessons (Figure 1b). We introduced what is algorithm with an activity of cooking quesadillas where students learnt that everyone can have a different

answer given the same instruction. We also organised activities on action/reaction with different sensors, how sensors work, how to program sensors and examples with the protoboards and circuits. During the fourth lesson, we closed the course, starting with an activity in the garden where students program their teammates and practice to give instructions to a robot in order to get the wanted result. Then we show them some real life applications of AI and robotics and we grouped participants in three teams so they could program their robots and design their logo (Figure 1e).

3.3 Surveys

Considering "Engineering Attitudes Survey" [4], we surveyed all participants with same survey, one for the first lesson and one for the last day of the lessons. Considering the reduction of time, fatigue and financial compensation, we consider a three-scale Likert chart [9], where each statement in our survey has three numbers where 1 is totally disagree; 2: not sure, and 3 totally agree . See original statements in Table 1 and Spanish translation of the statements in Fig 4. To analysis the results of the survey we consider the percentages of the responses of each statement from the first and the last lesson and illustrate the results using percentage response of Likert scale charts. Considering the small sample of participants and the no assumptions to data distributions, we choose the non-parametric Wilcoxon signed-rank test for statistical analysis for answers of pretest and posttest survey [10].

4 RESULTS

Four lessons of the designed curriculum were organised on Mondays and Wednesdays in a Mexican town during two weeks of November 2022. Instructors helped children in the pilot workshop by creating groups of three to four children. In the final lesson groups presented their project with their own robot and children with the help of the instructor explained the application of the robot (Figure 1).

We only considered 9 participants for the survey as 5 participants were neither in one of the days of the surveys or there were not able to be in person in such days. Figure 3 illustrates percentages or responses of 20 statements from 9 participants for 1 which is totally disagree; 2: not sure, and 3 totally agree. It can be noted that "S3: I would like a job where I could invent things.", "S11: I would like a job that lets me figure it out how things work" and ", and "S18: Engineers help make people's lives better." showed an increase of agreement. Whereas "S6: I would like to build and test machines that could help people to walk." and "S8: I would enjoy a job helping to protect the environment." created less disagreement. "S17: Scientist help make people's lives better." resulted in the highest average value whereas "S16: Engineers cause problems in the world." is the lowest average value. "S19: I think I know what scientists do for their jobs." and "S20: I think I know what engineers do for their jobs." showed both an increase on agreement between participants and decrease in disagreement.

A Wilcoxon T test was used to analyze the results of the survey before and after the survey to see if the engineering attitudes had a significant effect on pre and post survey of the workshop. The average survey before the test was lower ($\mu = 2.194500 \pm \sigma 0.558367$) compared to the posttest results ($\mu = 2.239500 \pm \sigma = 0.396796$). There

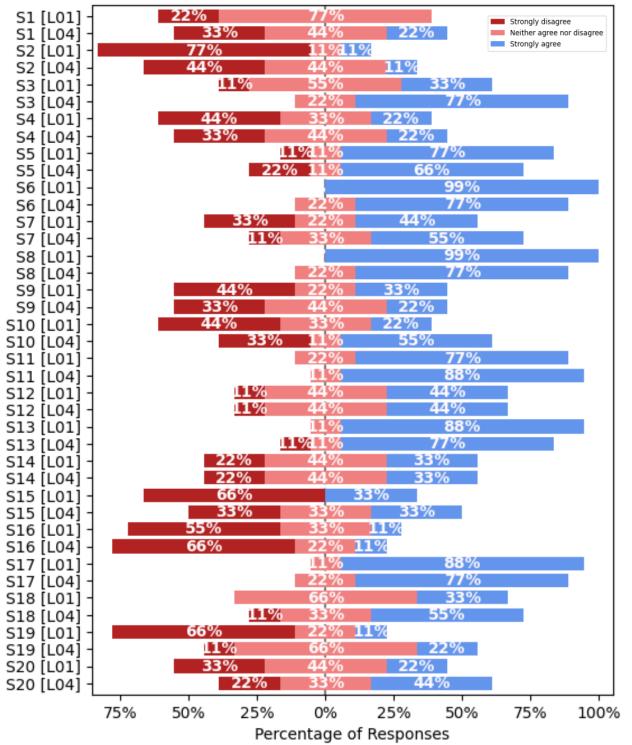


Figure 3: Percentages of responses of 9 participants from the survey with 20 statements (S1 to S20) of the first lesson (L01) and the fourth lesson (L04). See Appendices for further references on the statements of the survey.

was no statistically significant in the increase of attitudes towards engineering ($t=53.5$, $p = 0.45$). See Appendix section for reproducible Jupyter notebooks of statistical analysis and plots.

5 CONCLUSIONS AND FUTURE WORK

In this paper, we investigated the challenges of teaching AI and Robotics to young audiences with a pilot study in a Mexican town. We designed ten lessons but only were able to pilot four lessons due the limited material and human resources. We also surveyed participants using Engineering Attitudes Survey from [4], and showed the impact on the increase of general agreement of understanding what engineers and scientist do in their jobs using Likert scale charts. However, statistical analysis suggested no statistically significant in the increase of attitudes towards engineering which we think is related to our small sample. Also, during the survey we noted that children were not able to read long sentences and were confused about agreement and disagreement terminology in the Likert scale.

We conclude that children and parents had the willingness to join this pilot study by learning new experiences on collaborative and fun activities based on Montessori education and with low-cost educational robots. We also conclude that to be inclusive we would like to include anyone from a potential generation that might be ruled by AI. Hence, thanks to these activities we allowed these children coming from low- to mid-income families to learn and be

aware of the potential of AI which is crucial in this technological world.

However, the limited and self-funded budget for this project restricted us to prepare and organise a major number of lessons and reach more participants which hopefully will be addressed in future work. We will also improve our pretest-posttest survey design with a reliable and representative data and its statistical analysis.

ACKNOWLEDGMENTS

To Andrea Aguilar-Galindo, Gustavo Barbosa, Donato Badillo-Perez and Antonio Badillo-Perez for volunteering as instructors in the workshops. To Martha Pérez and Donato Badillo for their support in organising the pilot of the workshops in their teaching installations. To Rocio Montenegro for her contributions with the design of activities based on Montessori education. To Alex Barco for his feedback to improve the scientific impact of our collaborative work. To Mercedes Pérez Mendonza for her feedback on interactive activities. To Victor Alonso for his feedback on teaching AI to children. To Leticia Vázquez for her support with the translation of surveys and feedback to improve the workshops. To Elías Méndez Zapata and Abdel Rodriguez Cuapio from Tlaxcala Polytechnic University for their support with the invitation of students and feedback on the hardware design of the robot. To Xiaoxue Du from MIT Media Labs for her suggestions on the study design. To Angel Mandujano, Elva Corona and others who have supported AIR4children project to keep it moving forward.

REFERENCES

- [1] Haifa Aljabreen. 2020. Montessori, Waldorf, and Reggio Emilia: A Comparative Analysis of Alternative Models of Early Childhood Education. *International Journal of Early Childhood* 52, 3 (01 Dec 2020), 337–353. <https://doi.org/10.1007/s13158-020-00277-1>
- [2] Antonio Badillo-Perez, Badillo-Perez Donato, Coyotzi-Molina Diego, Cruz Dago, Montenegro Rocio, Vazquez Leticia, and Xochicale Miguel. 2022. Piloting Diversity and Inclusion Workshops in Artificial Intelligence and Robotics for Children. arXiv:2203.03204 [cs.RO]. <https://github.com/air4children/hri2022>
- [3] Marina U. Bers, Carina González-González, and Mº Belén Armas-Torres. 2019. Coding as a playground: Promoting positive learning experiences in childhood classrooms. *Computers and Education* 138 (2019), 130–145. <https://doi.org/10.1016/j.compedu.2019.04.013>
- [4] Christine Cunningham and Cathy Lachapelle. 2010. The impact of Engineering (EiE) on students' attitudes toward engineering and science. In *2010 Annual Conference & Exposition*. 15–1237.
- [5] Stefania Druga, Sarah T. Vu, Eesh Likhith, and Tammy Qiu. 2019. Inclusive AI literacy for kids around the world. *ACM International Conference Proceeding Series* (2019), 104–111. <https://doi.org/10.1145/3311890.3311904>
- [6] Xiaoxue Du. 2022. Explore the Use of Artificial Intelligence to Co-Design Inclusive Teaching Practices. (2022).
- [7] Mollie Elkin, Amanda Sullivan, and Marina Bers. 2014. Implementing a Robotics Curriculum in an Early Childhood Montessori Classroom. *Journal of Information Technology Education: Innovations in Practice* 13 (01 2014), 153–169. <https://doi.org/10.28945/2094>
- [8] Casey Fiesler, Mikhaili Friske, Natalie Garrett, Felix Muzny, Jessie J. Smith, and Jason Zietz. 2021. Integrating Ethics into Introductory Programming Classes. In *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education* (Virtual Event, USA) (SIGCSE '21). Association for Computing Machinery, New York, NY, USA, 1027–1033. <https://doi.org/10.1145/3408877.3432510>
- [9] Andrew T. Jebb, Vincent Ng, and Louis Tay. 2021. A Review of Key Likert Scale Development Advances: 1995–2019. *Frontiers in Psychology* 12 (2021). <https://doi.org/10.3389/fpsyg.2021.637547>
- [10] Eric Jones, Travis Oliphant, Pearu Peterson, et al. 2001–. SciPy: Open source scientific tools for Python. <http://www.scipy.org/>
- [11] Pratyusha Kalluri. [n. d.]. Don't ask if artificial intelligence is good or fair, ask how it shifts power. <https://www.nature.com/articles/d41586-020-02003-2>. Accessed: 2022-01-20.
- [12] Duri Long and Brian Magerko. 2020. What is AI Literacy? Competencies and Design Considerations. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) (CHI '20). Association for Computing Machinery, New York, NY, USA, 1–16. <https://doi.org/10.1145/3313831.3376727>
- [13] Rocio Montenegro, Elva Corona, Donato Badillo-Perez, Angel Mandujano, Leticia Vazquez, Dago Cruz, and Miguel Xochicale. 2021. AIR4Children: Artificial Intelligence and Robotics for Children. arXiv:2103.07637 [cs.RO]. <https://github.com/air4children/hri2021>
- [14] Blakeley Payne H. [n. d.]. An Ethics of Artificial Intelligence Curriculum for Middle School Students. https://ec.europa.eu/futurium/en/system/files/ged/mit_ai_ethics_curriculum.pdf. Accessed: 2022-01-20.
- [15] Kshitij Sharma, Sofia Papavlasopoulou, and Michail Giannakos. 2019. Coding games and robots to enhance computational thinking: How collaboration and engagement moderate children's attitudes? *International Journal of Child-Computer Interaction* 21 (2019), 65–76. <https://doi.org/10.1016/j.ijcci.2019.04.004>
- [16] Jessie J Smith, Blakeley H Payne, Shamika Klassen, Dylan Thomas Doyle, and Casey Fiesler. 2022. Incorporating ethics in computing courses: Perspectives from educators. *arXiv preprint arXiv:2212.06220* (2022).
- [17] Peta Wyeth. 2008. How Young Children Learn to Program With Sensor, Action, and Logic Blocks. *Journal of the Learning Sciences* 17, 4 (2008), 517–550. <https://doi.org/10.1080/10508400802395069> arXiv:<https://doi.org/10.1080/10508400802395069>
- [18] Weipeng Yang, Haoran Luo, and Jiahong Su. 2022. Towards inclusiveness and sustainability of robot programming in early childhood: Child engagement, learning outcomes and teacher perception. *British Journal of Educational Technology* 53, 6 (2022), 1486–1510. <https://doi.org/10.1111/bjet.13266> arXiv:<https://berajournals.onlinelibrary.wiley.com/doi/pdf/10.1111/bjet.13266>

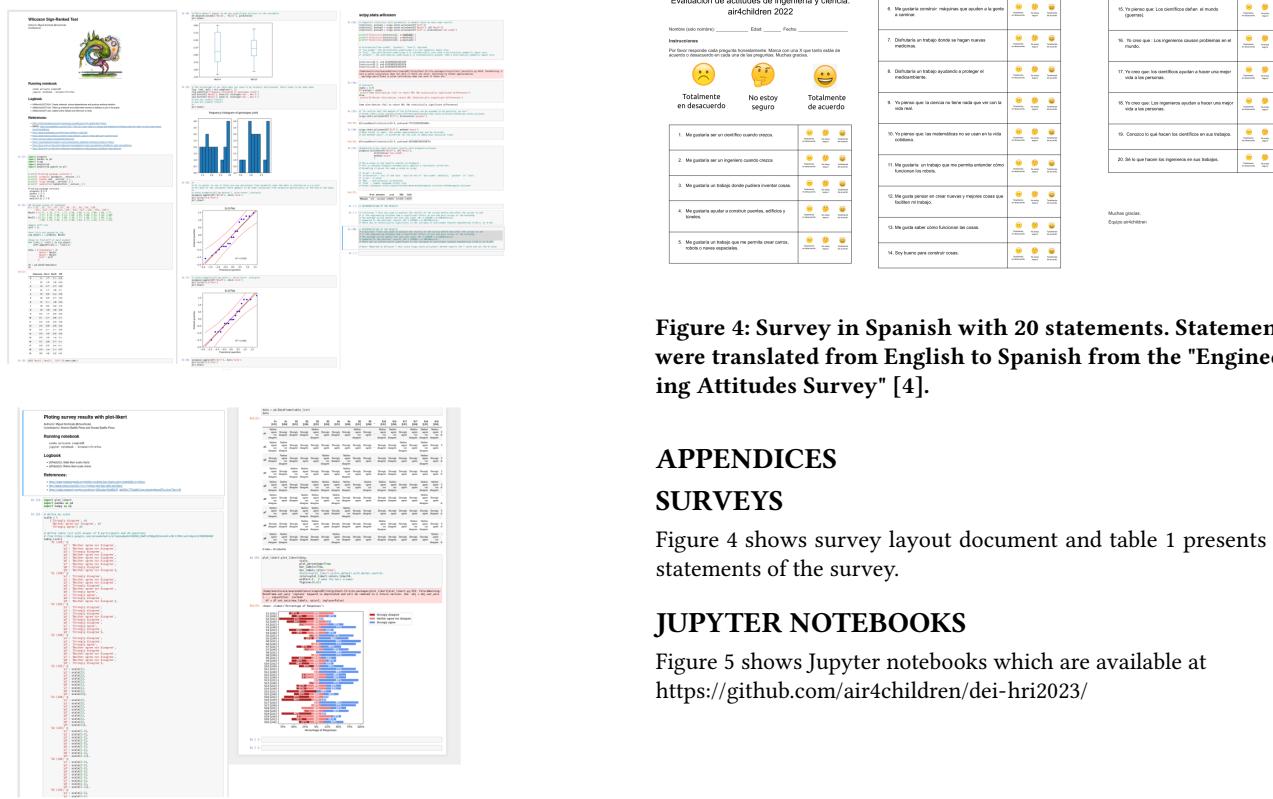


Figure 5: Jupyter notebooks are available at <https://github.com/air4children/dei-hri2023/>

Figure 4: Survey in Spanish with 20 statements. Statements were translated from English to Spanish from the "Engineering Attitudes Survey" [4].

APPENDICES

SURVEYS

Figure 4 shows survey layout document and table 1 presents 20 statements of the survey.

JUPYTER NOTEBOOKS

Figure 5 shows Jupyter notebooks which are available at <https://github.com/air4children/dei-hri2023/>

Table 1: Statements in the survey from "Engineering Attitudes Survey" [4].

Number	Statements
S1	I would enjoy being a scientist when I grow up
S2	I would enjoy being an engineer when I grow up.
S3	I would like a job where I could invent things.
S4	I would like to help to plan bridges, skyscrapers, and tunnels.
S5	I would like a job that lets me design a cars.
S6	I would like to build and test machines that could help people to walk.
S7	I would enjoy a job helping to make new medicines.
S8	I would enjoy a job helping to protect the environment.
S9	Science has nothing to do with real life.
S10	Math has nothing to do with real life.
S11	I would like a job that lets me figure it out how things work.
S12	I like thinking of new and better ways of doing things.
S13	I like knowing how things work.
S14	I am good at putting things together.
S15	Scientist cause problems in the world.
S16	Engineers cause problems in the world.
S17	Scientist help make people's lives better.
S18	Engineers help make people's lives better.
S19	I think I know what scientists do for their jobs.
S20	I think I know what engineers do for their jobs.