Familiarizing Children with Artificial Intelligence

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Recently, children's Artificial Intelligence (AI) literacy has gained interest due to AI penetrating our daily lives more widely. This paper illustrates findings from an empirical study with the purpose of familiarizing two classes of 11-12-year-old children (N=37) with central concepts related to AI, using existing material with modifications. During the sessions, children experimented with creative and hands-on Machine Learning activities, encouraging reflection around AI and the role of technology in everyday life. Children were asked about their views of AI first, and after that the concept was explained to them. Findings of the study suggest that some children's opinion about AI was changed after they were engaged in the learning activities. Observations also suggest that children seemed to learn more easily through hands-on activities and by listening to stories.

CCS CONCEPTS • Social and professional topics~Professional topics~Computing education~Computing literacy • Social and professional topics~Professional topics~Computing education~K-12 education • Computing methodologies~Artificial intelligence • Computing methodologies~Machine learning

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1 INTRODUCTION

The society is digitalizing at a fast pace, and it is acknowledged that we will be living our future with AI powered systems. Due to this, people's technological literacy and ability to shape technology are recognized as even more crucial than before, as Williams et al. state: "In an increasingly AI-powered society, it is important to consider citizen's AI literacy – how much do people really understand AI?" [36: 10]. The rapid growth of AI across a wide

range of sectors [19] [30] has also increased the need of a workforce with strong computational skills, specifically with knowledge and ability to work with AI [19], and AI literacy has been identified as a central competence in the current world [24]. Children are already interacting with various types of intelligent systems at home and in schools [33]. This includes various types of robots [28], conversational agents such as Siri and Alexa [9] [29] and recommendation systems on social media and other popular sites such as YouTube [26]. However, not all of these interactions are harmless [26]. Therefore, it is imperative to develop AI literacy in children to counter harm and build a nuanced understanding of the impact and effects of technology such as AI/ML.

In their technology-rich future, children need skills and competencies to deal with technology [14] – to be able to understand technology, to approach it critically and to start shaping it, if not even driving its development as protagonists [15]. Further, as Do-it-yourself (DIY) tools and kits become increasingly intelligent, such as Google's AIY voice and video kits, and permeate into to the Maker spaces, we need to explore simple yet innovative ways to educate children about AI. Researchers, practitioners, educators, and other experts are involved in this goal of developing children's AI literacy and competence, and to demystify the black box thinking and nature of AI/ML. A shining example of this are the books and materials developed by Linda Liukas, including the Hello Ruby book series [21] that explains complicated computer science concepts for young children with simple real-world examples and hands-on activities, with guides and materials for teachers to incorporate in their everyday lessons. Several other programs have been developed in recent years with the goal of AI education at the K-12 level [30]. Both short- and long-term working with children have been tried out, like introducing children to AI at a science museum in 30 min. [5], or introducing children to the basic AI concepts through a science museum exhibition [6].

To explore simple ways to educate children about AI we conducted a study with schoolchildren at City of [anonymized], in Finland. We explored what children think about AI, how aware of this concept they are, and how they understand it after it is explained to them. As our research questions, we ask: How to familiarize children with AI in school context? What seems to work and what kind of challenges can be encountered?

2 METHODOLOGY

We conducted two 45 min. sessions with two classes of 11-12-year-olds (the 5th grade), altogether 4 sessions. In Class 1 (18 children), we got consent for the research from the parents of 6 girls and 4 boys (out of 11 girls and 7 boys) and in Class 2 (19 children) for 2 girls and 4 boys (out of 13 girls and 6 boys). The sessions were integrated with children's daily teaching where 45 minutes is a typical school lesson time in Finland with children of this age. In practice, this means maximum of 30 minutes active working time with children. All children participated in all activities regardless of consent, and were seated separately to collect material only from children with consent. As we did not have much time available to work with children, we searched for simple and easily understandable material, and ended up using Linda Liukas' material as she explains computational concepts through a story. She is a programmer, storyteller, illustrator, and writes books for children, and her way of teaching computing concepts was interesting and easy compared to the other online material. Only readily available equipment in the classroom was used i.e., laptops, cubes, activity worksheets printed on paper. No extra material other than the prints was brought to the classroom.

Observations together with *field notes* and collecting *documentation generated by the children* were the main methods for data collection. Observations focused on whether the children were interested in learning these concepts, whether they understood the concepts, whether they were actively participating in the sessions and in discussing the topic with each other, and whether they had any questions. After the final session, *a semi-structured*

interview was conducted *with the teacher* to get his opinion and feedback about the sessions, children's learning, and the study itself. The documentation data was collected through activity worksheets that the children filled in during the sessions. The worksheets are from Linda Liukas's online materials which includes Task 25 on Machine learning and AI (https://www.helloruby.com/loveletters), lesson plan for book 1 (Lesson 1: Ruby's algorithm, http://www.helloruby.com/teach), and make your robot (http://www.helloruby.com/play/54). They include questions about computing concepts and activities regarding AI, ML, and training data. We asked children also 'what three things comes to your mind when you hear the word AI?' in the beginning and after sessions.

In the thematic analysis, data was critically analysed i.e., field notes regarding observations were read frequently, activity worksheets were read repeatedly, and audio file of teacher's interview was listened carefully. Responses of the children regarding whether they understood the concepts or not were counted through the activity worksheets. The different kinds of data were combined and organized in different ways to generate answers to the research questions. Findings were discussed among authors to reach shared understanding.

3 FINDINGS

In **the first session**, we aimed for raising children's interest in the topic and taught them some basic concepts needed to understand AI and ML (Table 1). An online tool 'Teachable machine' was used for ML. Other tools were rejected due to limited access to the features, complexity of activities, and difficulty regarding its explanation to the children in limited time.

Table 1: Study plan for the learning activities in the first session

Learning goal	Practical approach
	Background
Raising children's interest and attention, explaining abstract concepts through engaging examples based on a story	The researcher read aloud a story about Ruby from the book "Hello Ruby: Adventures in coding" (page 1 – 23) [21]
	Learning basic concepts
Learning what computational thinking is: it is what humans do not computers; it refers to logical thinking, the ability to recognize a pattern, think with algorithms, decomposition, and abstraction of a problem.	To make this concept easily understandable for children, the four components of computational thinking were explained through story-based examples and real-life experiences.
Learning what algorithm is: a set of clear, short, and detailed instructions to solve a problem	First, the researcher told a story-based example from the Hello Ruby book: Ruby was asked to clean up the toys. So, she only picked up toys and left the pens and papers on the floor because pens and papers are not toys. Also, her dad asked her to dress up. She puts on her dress but keeps her pajamas on, because she was not explicitly explained to change out of her polka-dot pajamas. Then, the researcher acted as the computer and the children acted as programmers. The children guided the researcher to pick up a book that was on a table, a couple of meters away from where the researcher was sitting.
Learning what pattern recognition is: recognizing the common pattern among various things	First, the researcher told a story-based example from the Hello Ruby book: One of the gems was placed in a high place. So, Ruby builds a ladder to get the gem. She gathers two long wooden sticks and a few small sticks. She placed the two long sticks vertically (let's say 10-15 inches apart) parallel to each other and then placed a small stick onto the long

Learning goal	Practical approach
	sticks horizontally and tied it up. She did the same with the rest of the small sticks, placing them parallel to the first small stick and then tied them up. She repeats the steps until she has tied all small sticks. The researcher further explained through real-life experience i.e., students were asked about the common cupcakes' ingredients, which are flour, sugar, egg, flavor.
Learning what decomposition is: division of a big task into small tasks	The researcher told a story-based example from the Hello Ruby book: task given by Ruby's father i.e., find five gems. Ruby divides the big task into small tasks which are: 1) Make the plan and look for clues 2) Leave out unnecessary details, 3) Set off for the adventure.
Learning what abstraction is: focusing on key factors and leaving out unnecessary details	First, the researcher told a story-based example from the Hello Ruby book: Ruby thinks about *how to find all five gems? What happens if she gets lost? And how does she know what to bring with her?* However, in the end, she stops thinking about these useless things and leaves for the journey while taking the shortest route keeping the map and rope with her. The researcher further explained through real-life experience i.e., Google map shows buildings, roads, and buses but does not show the number of rocks on the ground. To reach the destination one does not need to know the number of rocks on the ground.

In **the second session**, we continued with teaching what AI and ML are, and what training data is (Table 2).

Table 2: Study plan for the learning activities in the second session

Learning goal	Practical approach
Learning what hardware and software are	The researcher explained that hardware is what we can touch e.g., mouse, keyboard, monitor, etc. Software is intangible, we cannot touch it; for example, an application on your computer to play songs or videos, a tool to open a picture on your computer, or a game that is installed on your computer.
Learning what is meant by artificial intelligence	The researcher explained AI as a group of computer software and hardware that works sensibly in a new situation. It can be a robot or a machine. It is also possible that machines that use voice recognition feature are using AI.
Learning what is meant by machine learning and training data	The researcher first explained that for the AI to behave sensibly a machine needs to learn by several examples and these several examples which are fed to the computer are known as training data. It can be pictures, text, video, or audio. Based on these examples, the computer builds a model and tests the new input based on that model and shows the result. Examples were given to the children: If we want the computer to recognize a cat in a picture, we need to provide several pictures of the cat to the computer. Then it builds a model, such as: a cat has ears, tail, four legs, and is small. Another example was about buildings: a building has windows, doors, walls, and roof. The concepts were further explained through an online web-application, Teachable Machine (https://teachablemachine.withgoogle.com/) for creating machine learning models. Children were asked to create two data classes that refer to various poses a human can take, and name them as they like. Then they were instructed to take several pictures of the same pose and add those to one class, and then several photos of another pose, different from the first one, and add those to the other class. Then, they trained the model by clicking on "Train Model" and then tested it. It was explained that the set of images of the pose which were fed to the application are called training data. When clicking on 'Train model', the application trains itself and builds a model based on the pictures. This is called ML.
Combining the previously learned concepts with the concept of a robot	Children filled in activity-worksheets which contained brainstorming tasks: design your own robot with name, length, feature and weight, and train it through examples to say greeting. After filling in all the papers regarding how they want their robot to look like and what features they want their robot to have, the students built a prototype of the robot using cubes.

Observations suggest that the concepts and activities of in Session 1 seemed to be easier for this age-group compared to the ones in Session 2. For instance, when the researcher finished explaining about algorithm, a girl

said *Because if we do not tell the computer that there is a chair in front of you and you have to stop and then turn from here, it will stumble around so we need to make it clear.* Moreover, the children easily understood questions listed in the activity-worksheets in Session 1 compared to Session 2. For instance, children were able to write algorithms using shortcuts without this being explained to them. The teacher also reflected on the activities of Session 1, saying that in a way, it was a bit too easy, even younger children could do it. The first session managed to explain the complex computing concepts to the children in an understandable manner: most students selected in their worksheets the option "I can do it" for the concept of computational thinking.

In the second session, the children were confused about ML and training data. One of the reasons can be that the story was skipped in the second session due to limited time. Before learning about AI children explained AI as *robot, coding* and *machine*. After being engaged in the learning activities the children explained AI as *thinking by itself, helping humans, phone, sciency stuff, robot, computers*. A student from Class 2 wrote *computers, voices and not real.* Children's facial expressions seemed to be confused even after the concept of AI was explained to them. To make it more understandable the concepts were explained again through an online activity. After the explanation, students had to answer the same question through the activity worksheets. This time some students described AI differently such as a girl said *Alexa*, another student while answering the questions, wanted verification *intelligent computer…?*, though some students still answered the same as before i.e. *robot*, *computer*. Only few children's perception was changed after being engaged in the learning activities. In the 16 worksheets from the second session only 7 students answered open-ended question about what AI is, and only 2 out of 7 students understood the concept as was expected from them. Moreover, concerning closed-ended questions, results from the worksheets suggest that less than half of the students understood AI. 4 students from Class 1 and 4 students from Class 2 felt that they understood the concept of ML, whereas 5 students from Class 1 did not fully understand the concept. For some of the children the concepts were not that difficult. As the teacher said: *I noticed some of them like the boy… he was understanding it quite quickly and get in on with it quite independently….* However, other children seemed merely to be playing, giving an impression of as they do not understand of what they are being taught.

From the teaching methods perspective, story-telling and hands-on experience seemed to play a significant role in making the children engaged in the activities and enjoy them. In the first session, the children felt they understood the concepts when the examples were based on the story. In the second session, the online activity regarding ML helped them in learning. The teacher pointed out in the interview: *the activities and questions done in session 2 engaged the children in thinking more which is good for them. Especially, in the online activity and (quadrant) questions were interesting and good considering their age-group.* Many children from both classes asked the name of the storybook, indicating they were interested in it and enjoyed listening to it. In the second session, a child from Class 2 told the researcher that he had read the whole storybook and liked it very much. A few children shared personal stories which showed their interest as well as how keen they were to learn more about the computing concepts. At the end of the session, many children also asked: *Will you come again? We will be waiting*. This suggests they enjoyed activities and wanted to have more. In Session 2, children seemed to be curious as well, interested and enjoying the online ML activity. Some children expressed their excitement through phrases i.e., *Cool* and *Awesome.*

Considering both sessions, one can say that children learned a lot within the short timeframe. Due to limited time, some concepts and activities were skipped, such as programming was only briefly explained to the children. The study could have easily included 6-8 sessions for the children to fully grasp all the concepts. Even the teacher said: *Overall, I think (…) we could have had more time. Like there was always a bit of rush and maybe this… could be*

even more like a… 6-week project rather than just 2-days. So, in that way the activities that you did could have been like a good introduction… but I think that some of the children or many of them might even (…) go further with it.

4 CONCLUDING DISCUSSION

We contribute to the field of children's AI literacy by demonstrating an easy to understand way of bringing AI to the classrooms, especially for novice researchers who aim to research in this area as well as educators who want to work with the topic with their learners. Our aim was to understand how to familiarize children with AI with a quick and simple manner in school context. We want to highlight storytelling, hands-on experience, and tasks with tangible objects: they engaged the children in the learning activities. Regarding *storytelling*, understanding of the concepts seemed to be easier for the children when learned through a story, which children listened attentively. Even if the value of storytelling has been recognized in previous research e.g. [12] [11] [23] and has been seen as valuable for facilitating the design process as well as for children's learning, it has not yet been celebrated much in the context of AI literacies and AI education. [1] however, discusses the value of design fiction in engaging children in ML learning activities, in line with the findings of our study. Design fiction narratives, future oriented and imaginary, for sure provide an exciting means for children to engage in ML learning activities and to reflect on such technologies in their future lives, while we argue that the stories by Linda Liukas [21] offer another example that engages children and should be considered as valuable in the quest of educating children about such complex topics as AI and ML. Generally, however, it seems to be challenging for the children to grasp the concepts of AI and ML, especially during a limited timeframe. We think that is no wonder as even adults do have difficulties with those: the literature indicates it is challenging to introduce AI and ML even to adult designers and that we are holding a variety assumptions, fears and hopes for it [3] [7] [38]. Observations and the teacher interview also suggest the children were very engaged with the *hands-on exercise* and with *working with tangible objects*. Our study corroborates existing literature on the significance of tangible objects and hands-on learning activities in learning about AI and related concepts, in our case with 11-12-year-olds: previous studies have got positive results using Lego Duplo blocks with 4-6-year-olds for when learning AI concepts, a hands-on collaborative tool to teach basic ML concepts for 15-17-year-olds [37], or tangible cards for learning programming with 8-9-year-olds [8].

Our challenges were largely related to lack of time in the context of school, where we wanted to fit in with the school schedules and infrastructures to find ways for schoolchildren to learn about AI, aiming at high ecological validity of the results. Our findings suggest however that the short timeframe we had in our use was too limited in this study to learn such complex concepts. Explanation of the activities on the worksheets also took more time than expected. This is an important observation for the context of school: pre-arrangements and settling in can take a lot of time, not always taken into account in the design of the learning activities by the researchers. In contrast, other studies that had more time available for teaching had better results.

As for the future studies, literature regarding familiarization of AI concepts to the children is still needed. Parents' and teachers' AI literacy plays an important role in teaching AI to the children and bringing it to schools. Proper age for children to start to learn AI should be considered as well. Our 11-12-year-olds struggled with the more demanding concepts but managed well with the more simple ones. We call for further research with different age groups, and also with different amount of available time for teaching, to increase our understanding on how these central concepts should be taught to children. Deployment of AI curriculum at schools could help children to understand AI [2], and [31] has presented an idea of an AI curriculum. What could the steps for bringing AI in schools to be is an important question for future research, as well as how to integrate this kind of curriculum in the

existing studies of children – there are already huge demands for children's learning the schools need to try to fulfill and when something is added in the curriculum, it often means that something else then needs to be left out. One possibility is to teach the concepts gradually, in this kind of small sessions very now and then. It is likely that if similar type of study was conducted again with the same group of children it would yield increased learning as the children are already aware of the activities and concepts they need to learn or explore. Teachers views to how to the integration could be made is an important topic for the future research as well.

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REFERENCES

[1] Aki Tamashiro, M., Van Mechelen, M., Schaper, M. M., & Sejer Iversen, O. (2021, June). Introducing Teenagers to Machine Learning through Design Fiction: An Exploratory Case Study. In Interaction Design and Children (pp. 471-475).

[2] Ali, S., Payne, B. H., Williams, R., Park, H. W., & Breazeal, C. (2019). Constructionism, Ethics, and Creativity: Developing Primary and Middle School Artificial Intelligence Education, Proceedings of IJCAI, 1-4.

[3] Bratteteig, T., & Verne, G. (2018, August). Does AI make PD obsolete? exploring challenges from artificial intelligence to participatory design. In Proceedings of the 15th Participatory Design Conference: Short Papers, Situated Actions, Workshops and Tutorial-Volume 2 (pp. 1-5)

[5] Candello, H., Pichiliani, M., Pinhanez, C., & Wessel, M. (2019). 30 Minutes to Introduce AI to Kids, Association for the Advancement of Artificial Intelligence, 1-3.

[6] Candello, H., Pichiliani, M., Pinhanez, C., Vidon, S., & Wessel, M. (2020, June). Co-designing a conversational interactive exhibit for children. In Proceedings of the 2020 ACM Interaction Design and Children Conference: Extended Abstracts (pp. 326-331).

[7] Cave, S., & Dihal, K. (2019). Hopes and fears for intelligent machines in fiction and reality. Nature Machine Intelligence, 1(2), 74-78.

[8] Deng, X., Wang, D., Jin, Q., & Sun, F. (2019). ARCat: A Tangible Programming Tool for DFS Algorithm Teaching. Proceedings of the 18th ACM International Conference on Interaction Design and Children. 533-537. doi: 10.1145/3311927.3325308.

[9] Druga, S., Williams, R., Breazeal, C., & Resnick, M. (2017, June). "Hey Google is it ok if I eat you?" Initial explorations in child-agent interaction. In Proceedings of the 2017 conference on interaction design and children (pp. 595-600).

[11] Garzotto, F. (2014). Interactive storytelling for children: a survey. International Journal of Arts and Technology, 7(1), 5-16.

[12] Gökçe Elif Baykal, Maarten Van Mechelen, Tilbe Göksun, and Asım Evren Yantaç. 2018. Designing with and for Preschoolers: A Method to Observe Tangible Interactions with Spatial Manipulatives. In Proceedings of the Conference on Creativity and Making in Education (FabLearn Europe'18). Association for Computing Machinery, New York, NY, USA, 45–54.

[14] Iivari, N., & Kinnula, M. (2018). Empowering children through design and making: towards protagonist role adoption. Proceedings of the 15th Participatory Design Conference. 1-12.

[15] Iversen, O. S., Smith, R. C., & Dindler, C. (2017). Child as protagonist: Expanding the role of children in participatory design. Proceedings of the 2017 Conference on Interaction Design and Children. 27-37.

[19] Lee, I., Ali, S., Zhang, H., DiPaola, D., & Breazeal, C. (2021, March). Developing Middle School Students' AI Literacy. In Proceedings of the 52nd ACM Technical Symposium on Computer Science Education (pp. 191-197).

[21] Liukas, L. (2015). Hello Ruby: adventures in coding (Vol. 1). Macmillan.

[23] Moraveji, N., Li, J., Ding, J., O'Kelley, P., & Woolf, S. (2007, April). Comicboarding: using comics as proxies for participatory design with children. In Proceedings of the SIGCHI conference on Human factors in computing systems (pp. 1371-1374).

[24] Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. Computers and Education: Artificial Intelligence, 2, 100041.

[26] Papadamou, K., Papasavva, A., Zannettou, S., Blackburn, J., Kourtellis, N., Leontiadis, I., ... & Sirivianos, M. (2020, May). Disturbed Youtube for kids: Characterizing and detecting inappropriate videos targeting young children. In Proceedings of the international AAAI conference on web and social media (Vol. 14, pp. 522-533).

[28] Shamsuddin, S., Yussof, H., Ismail, L. I., Mohamed, S., Hanapiah, F. A., & Zahari, N. I. (2012). Humanoid robot NAO interacting with autistic children of moderately impaired intelligence to augment communication skills. Procedia Engineering, 41, 1533-1538.

[29] Spitale, M., Silleresi, S., Cosentino, G., Panzeri, F., & Garzotto, F. (2020, June). "Whom would you like to talk with?" exploring conversational agents for children's linguistic assessment. In Proceedings of the Interaction Design and Children Conference (pp. 262-272).

[30] Steinbauer, G., Kandlhofer, M., Chklovski, T., Heintz, F., & Koenig, S. (2021). A Differentiated Discussion About AI Education K-12. KI-Künstliche Intelligenz, 1-7.

[31] Touretzky, D., Gardner-McCune, C., Martin, F., & Seehorn, D. (2019). Envisioning AI for K-12: What Should Every Child Know about AI?, Proceedings of the AAAI Conference on Artificial Intelligence, 9795-9799.

[33] UNICEF 2021. Policy guidance on AI for children v2.0. Report available at https://www.unicef.org/globalinsight/reports/policy-guidance-ai-children.

[37] Xiaoyu Wan, Xiaofei Zhou, Zaiqiao Ye, Chase K. Mortensen, and Zhen Bai. 2020. SmileyCluster: supporting accessible machine learning in K-12 scientific discovery. In Proceedings of the Interaction Design and Children Conference (IDC '20). Association for Computing Machinery, New York, NY, USA, 23–35.

[38] Yang, Q., Steinfeld, A., Rosé, C., & Zimmerman, J. (2020, April). Re-examining whether, why, and how human-AI interaction is uniquely difficult to design. In Proceedings of the 2020 chi conference on human factors in computing systems (pp. 1-13).