Designing an Artificial Intelligence Curriculum for Early Childhood Education

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INTRODUCTION

AI EDUCATION IN PRESCHOOL

The components of PopBots are a social robot toolkit with AI activities and assessments located on a tablet. We used these tools in an evaluative study in preschool (ages 4-6) classrooms.
Children are growing up with AI-enabled systems that exhibit lifelike intelligence and social agency.
However, children do not have the tools to leverage this technology in the best way possible.
BACKGROUND

Children treat AI devices like people and don't understand privacy and safety concerns

Children better understand AI devices as they:
- Get older
- Develop socioemotional skills
- Learn programming

Williams, R. et al. My doll says it’s OK. 2018
Druga, S. et al. Hey Google is it OK if I eat you?. 2017
McReynolds et al. Toys that listen. 2017
Kahn, P. et al. Robovie you’ll have to go into the closet now. 2012
BACKGROUND

BIG IDEAS IN AI

- Machine Perception
- AI & Society
- Models and Reasoning
- Machine Learning
- Human-AI Interaction

Touretzky, D. et al., Envisioning AI for K-12: What should every child know about AI?. 2019
TOOLKIT

KEY DESIGN PRINCIPLES

PopBots is a developmentally appropriate, powerful way for young, non-programming children to understand AI

- Hands-On Learning
- End-to-End Learning
- Transparency and Tinkerability
- Creative Exploration

Flannery et al., ScratchJr. 2013
Gordon et al., The Social Robot Toolkit. 2015
Sullivan et al., KIBO Robot. 2015
TOOLKIT

A. PHONE
Learning companion guides children through activities. Social other allows children to comprehend algorithms through social reasoning.

B. LEGO BODY
Hands-on robot allows children to work and learn together.

C. TABLET
Icon-based programming for non-readers. AI activities and assessments.
The robot plays an active role in the curriculum guiding children through activities and explaining its reasoning.
Assessments were completed individually and covered basic functionality and edge cases for each concept.

You tell the robot that strawberries and tomatoes go in the good group. Then you ask the robot where to put chocolate. What will the robot think?
In each session children spent 10-15 minutes completing hands-on activities about AI then completed an assessment.
**KNOWLEDGE-BASED SYSTEMS**

1. Children create a knowledge base with rules
2. Robot remembers past moves and over time gets better at predicting next moves
3. Robot uses knowledge base to choose a move
4. Children connect this to video games and talking toys

**Assessment**

- **Basic Reasoning**
  - Basic Prediction
- **Advanced Reasoning**
  - Advanced Prediction
1. Children label foods as the training set
2. Children test the unlabeled foods as the test set
3. Robot compares test set foods to the training set
4. Children connect this to YouTube and Netflix

Assessment

Initialization
Comparison
Basic Prediction

Robot knows **food group**, **color**, amount of **sugar**, amount of **calories**
1. Children configure the parameters of robot emotions
2. Children input song for the robot to remix
3. Robot outputs song remix according to parameters
4. Children learn that algorithms can be creative.

Assessment

- Initialization
- Basic Parametrization
- Advanced Parametrization
- Direction
- Tempo
We worked with five classrooms with 6 to 22 students in each. We analyzed differences in children’s learning by age, classroom, and interactions with the tablet.
WHAT KINDS OF UNDERSTANDING CAN CHILDREN GAIN ABOUT AI?

Children understood the majority of the information presented in the toolkit, with some differences in understanding depending on the activity.
KB3: “The robot thinks that Sally will play paper. What will the robot play against her?”

SL2: “Which of these is most like a tomato? A banana, a strawberry, or milk?”
KB2: “Sally plays paper 5 times. What does the robot think she will play next?”

Spearman’s Correlation Between Tablet Interactions and Assessment Scores

Positive correlation between amount of time spent playing and getting this question correct.
RESULTS

KB4: “We make all of the rules opposite. Sally plays paper while the robot plays scissors. Now who

Children who spent less time training the robot were less likely to get this question correct.

SL1: “We tell the robot that strawberries and tomatoes go in the good group. Where will the robot

Children in classroom A spent more time testing foods and less time training them.
GM3: “Does the robot’s song always have some of the same notes as the input? Or does the robot play a completely different song?”

Children in Classroom D recorded more of their own songs rather than playing the same ones.
A social robot learning companion and explorative AI activities helped children construct their understanding of AI algorithms.

Some differences because of age, most differences due to interaction with toolkit as revealed by classroom-based analysis.

Students best understood transparent algorithms with strong feedback loops. How can we translate other AI concepts this way?

**BIG TAKEAWAYS**

**PopBots**
Designing an Artificial Intelligence Curriculum for Early Childhood Education
FUTURE WORK

01 IMPROVE LEARNING COMPANION
Use behavioral analysis findings to improve PopBot

02 EXTEND AI CURRICULUM
New algorithms like planning, perception, and reasoning

03 ACTIVITY GUIDES
Develop activity guides for non-experts to use PopBots in homes and schools

04 PACKAGE TOOLKIT
Develop for other platforms and release a stable version
Thank you to Samsung NBNL, the National Science Foundation, and the students, teachers, and parents who participated in this study.
WHY SHOULD WE TEACH AI TO CHILDREN?

- Stereotypes have less impact on young children
- Early STEM experiences are powerful
- Early math and computational thinking curricula exist

Source: NCES Digest of Education Statistics; Science & Engineering Indicators 2008
We developed multiple robot forms to inspire children to learn through creation:

- a. Expressive spinning head
- b. Tangible props
- c. Humanoid and animal forms
- d. Functional mobile & machine-like forms
- e. Robot limbs for expressivity
POPBOT CURRICULUM

TEACHER GUIDE FORMAT

Teacher scripts and lesson guides to lead classroom through AI activities.

- Target STEAM and life skills for every activity
- Activities broken into telescopic subsections
- Critical observation and reflection questions
- Extended activity suggestions for enthusiastic learners
- Concept-related multiple choice questions

SAMPLE ACTIVITY
Each AI activity was designed to introduce AI concepts while reinforcing other life skills.
How did learning about AI change children’s perception of AI?

Before ↑
1. Children felt strongly that robots could learn and that they always follow the rules.
2. For other questions most were unsure.

After →
1. Children felt more strongly that robots could learn, but less strongly that they always had to follow the rules.
2. Many children in the middle chose a side.

Williams, R. et al., A is for Artificial Intelligence. 2019
HOW DOES LEARNING ABOUT AI CHANGE ONE’S PERCEPTION OF AI?

Children who learned the most about AI were more likely to see robots/AI as smart and more like a person.
Researcher: How did the robot work?

Lily (6-years-old): I taught the robot the rules of the game...[then] it would learn as I go.

PILOTTING POP BOT

WHAT DID CHILDREN LEARN

We saw that children could not only use AI in their robots, they could also express different concepts in their own words.
Researcher: So who won more? You or the robot?
Lily: The robot.

Ivy (6-years-old): The robot. Well, at first [I won a lot], but then the robot kept saying ‘I think you will put rock’ and I had put rock so it won. The robot got smarter the more we played.

We saw that children’s understanding of algorithms was anchored in their social interactions with the robot.
Researcher: So who’s smarter now? You or the robot?

Lily: Well...maybe the robot. But I taught it. So actually I’m still smarter for now but I think the robot can get a lot smarter.

PILOTING POP BOT

IMPACT OF CHILDREN LEARNING

Afterwards, children used their new knowledge to grapple with the implications of artificial intelligence.