AI Made By Youth: A Conversational AI Curriculum for Middle School Summer Camps

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Abstract

As artificial intelligence permeates our lives through various tools and services, there is an increasing need to consider how to teach young learners about AI in a relevant and engaging way. One way to do so is to leverage familiar and pervasive technologies such as conversational AIs. By learning about conversational AIs, learners are introduced to AI concepts such as computers' perception of natural language, the need for training datasets, and the design of AI-human interactions. In this experience report, we describe a summer camp curriculum designed for middle school learners composed of general AI lessons, unplugged activities, conversational AI lessons, and project activities in which the campers develop their own conversational agents. The results show that this summer camp experience fostered significant increases in learners' ability beliefs, willingness to share their learning experience, and intent to persist in AI learning. We conclude with a discussion of how conversational AI can be used as an entry point to K-12 AI education.

Introduction

Artificial Intelligence (AI) has permeated our lives through technologies such as smart speakers, self-driving cars, and recommendation systems. This technology is not only affecting our daily lives, but also changing the future of occupations and job markets (Bughin et al. 2018). Thus, it is imperative to create opportunities for the next generation to learn about the fundamentals of AI and develop positive attitudes towards AI and potential careers in the field. There is an increasing effort to bring AI-related learning experiences to learners at their early ages, with recent studies highlighting the positive effects of these efforts on improving students' knowledge, confidence, and attitudes toward future AI or STEM careers (Wan et al. 2020; Alvarez et al. 2022; Vachovsky et al. 2016).

To engage novice learners in AI learning, we need to consider how to teach AI in relevant and engaging ways. One of the ways to achieve this is to leverage familiar and pervasive technologies such as conversational AIs. Conversational AIs are computer programs with the ability to interact with humans through spoken or textual natural language (Van Brummelen, Heng, and Tabunshchyk 2021). Young children naturally talk to conversational AIs in their daily lives: children ask Alexa or Google Assistant about their homework or the SAT word of the day and casually express their feelings to them (Garg and Sengupta 2020). By learning about conversational AIs, young learners can be introduced to the basic but fundamental concepts of AI that are addressed in the AI Big Ideas (Touretzky et al. 2019a), such as understanding computers' perception of natural language, the need for training data sets, and AI-human interaction design.

Although there are recent studies on conversational AI curricula and tools for K-12 learners (Van Brummelen, Heng, and Tabunshchyk 2021; Zhu and Van Brummelen 2021), they have primarily focused on online workshop experiences, or used an existing interface as a learning tool. This experience report is built upon such previous research and provides a detailed description of a complete conversational AI curriculum utilizing AMBY (AI Made By You), a conversational AI development interface created specifically for our target learners (Kumar et al. 2022). We mapped AI lessons to align with the AI Big Ideas for K-12 learners (Touretzky et al. 2019a) and adopted various pedagogical approaches such as "Use→Modify→Create" (Lee et al. 2011a) and Design Thinking (Thoring, Muller et al. 2011; Arık and Topçu 2020) to design engaging learning activities. We then share results from a series of two-week summer camps in 2021 and 2022. We analyzed campers' pre- and post-survey and video assessments to assess any changes in knowledge and attitudes toward AI. The survey results show that the summer camp experience significantly fostered learners' ability beliefs for, desire to share about, and intent to persist in AI learning. Moreover, students' video assessments demonstrated that they learned to conceptualize AI identifying its core characteristics, such as machine learning. These findings suggest that conversational AIs are one promising entry point for K-12 AI education.

Related Work

As AI is increasingly integrated into our daily lives, researchers have begun to systematically study how young learners construct understandings of broad AI concepts (Greenwald, Leitner, and Wang 2021) and develop standards of young learners' AI competencies (Kim et al. 2021; Zhou, Van Brummelen, and Lin 2020). In addition, there is a body of research that shares curricula and tools for teaching AI-related concepts to young learners. For example, Wan et al. (2020) developed SmileyCluster, a collaborative learning environment for teaching machine learning concepts, and showed its positive impacts on students' learning of entry-level machine learning. Similarly, Lin et al. (2020) proposed a chatbot-based curriculum to help young learners understand machine learning concepts. Jordan et al. (2021) built PoseBlocks, a block-based programming environment focusing on helping children understand AI concepts such as face-tracking and emotion recognition. The above studies adopted different AI-related contexts, such as machine learning (Wan et al. 2020; Lin et al. 2020) or face-tracking (Jordan et al. 2021), to introduce AI to K-12 students.

Conversational AIs are computer programs with the ability to interact with humans using natural languages. Conversational AI involves a variety of concepts and knowledge related to AI, such as natural language processing, machine learning, dialogue management, and language generation (Jurafsky and Martin 2021). As the potential benefits of conversational AIs for K-12 AI education have been recognized, researchers have begun to develop tools and curricula to help young children learn about conversational AIs. Zhu and Van Brummelen (2021) developed Convo, a conversational programming agent to teach students about creating conversational agents. Van Brummelen, Heng, and Tabunshchyk (2021) developed a curriculum using an existing block-based programming interface, called MIT App Inventor, to help students build conversational agents integrated into mobile apps.

These studies suggest the promise of conversational AIs in increasing students' interest in AI learning (Zhu and Van Brummelen 2021; Van Brummelen, Heng, and Tabunshchyk 2021). This experience report advances knowledge in this space by providing a detailed description of a complete conversational AI curriculum along with its alignment and connections to the AI4K12 Big Ideas (Touretzky et al. 2019a).

Camp Curriculum

To develop an engaging AI summer camp curriculum for middle school students (rising 7^{th} and 8^{th} graders), we put together lessons and activities covering four main components: general AI concepts, unplugged activities, conversational AI concepts, and project activities in which the campers develop their own conversational agents. We designed each lesson around the camp's overall and specific learning objectives, described with the phrase "Campers will be able to" in Table 1. These objectives were adapted from AI4K12 progression charts for the 6^{th}-8^{th} grade-band (Touretzky et al. 2019b) and are aligned with the five AI4K12 Big Ideas; 1) Perception: Computers perceive the world using sensors; 2) Representation and Reasoning: Agents maintain representations of the world and use them for reasoning; 3) Learning: Computers can learn from data; 4) Natural Interaction: Intelligent agents require many kinds of knowledge to interact naturally with humans; and 5) Societal Impact: AI can impact society in both positive and negative ways. Table 1 shows the lesson components of the curriculum mapped to the learning objectives and the corresponding AI4K12 Big Idea. In the following sections, we present detailed descriptions of the four components.

General AI Lessons

Even though we focused on conversational AI, the broad learning goal of our curriculum is to help learners understand general AI concepts. To achieve that, we designed six lessons to introduce general AI concepts. The contents were extracted from existing open source AI lessons, such as MIT (MIT Raise 2020), Experiments with Google[1], PBS Learning, and BBC Learning, and adapted to fit a summer camp. The six lessons included: (1) Intro to AI, (2) Intro to Data, (3) Intro to AI and Machine Learning (ML), (4) AI Bias and Ethics, (5) AI Arts, and (6) AI Music. In Intro to AI, campers were introduced to computer science (CS) as "using the power of computers to solve problems," and AI as the branch of computer science that "combined the power of computers" with the "cognitive abilities of humans." Campers also discussed what they recognize as AI around them. In Intro to Data, campers learned how AI needs large amounts of data by interacting with AI applications like Quick Draw (Jongejan et al. 2017) to better understand how AI learns from analyzing many drawings. In Intro to AI and ML, campers were introduced to the relationship between AI and ML to understand how computers learn and how they can teach computers to learn by interacting with tools like ML4kids (Lane 2021) and Teachable Machine (Carney et al. 2020). In AI Bias and Ethics, campers were engaged in discussions about AI bias and ethics around prompts like "what do you think happens to the opinions of people that code AI applications?" In AI & Arts and AI & Music, campers were introduced to applications of AI beyond CS and STEM to Art and Music by examining music and art that had been created through AI experiments.

Unplugged Activities

Unplugged activities have been employed in various learning contexts to explain CS and AI concepts and improve computational thinking without the use of a computer (Brackmann et al. 2017). Particularly in such environments as summer camps, unplugged activities are valuable for teaching the CS and AI concepts and skills without feeling like school. For these reasons, we included some well-known CS unplugged activities such as Human Crane (Code-it 2015) and Sorting Networks (ComputerScienceUnplugged 2010), and we also created some activities, such as the Yoga activity. The Yoga activity is an unplugged activity we created for this camp where students make a "code" by combining a series of yoga poses, such as a "child pose" and the printed-out algorithm blocks, such as "if ... then." After creating the code, they are asked to do the poses following others' code. For each unplugged activity, we explained the purpose of the activity and related them to CS and AI concepts by providing discussion prompts for campers to share their experiences after each activity.

[1]https://experiments.withgoogle.com/

Table 1: Lessons Mapped to AI4K12 Big Ideas

Components	Lessons & Activities	Learning Objectives "Campers will be able to"	AI4K12 Big Idea
General AI Lessons	1. Introduction to AI	Describe how people sense environment (e.g. hearing) vs how computers sense environment (e.g. using a microphone)	#1: Perception
	2. Introduction to Data	Examine the dataset AI needs to provide meaningful answers	#2: Representation and Reasoning, #3: Learning
	3. Introduction to AI and ML	Describe how data are used for reasoning	#3: Learning
	4. AI Bias and Ethics	Describe ways human biases can be reflected in algorithms	#5: Societal Impact
	5. AI and Arts	Classify images using AI	#1: Perception
	6. AI and Music	Classify sounds using AI	#1: Perception
Conversational AI Lessons	1. Introduction to Chatbots (I)	Describe how a Chatbot functions	#2: Representation and Reasoning
	2. Introduction to Chatbots (II) - (**Use**) Test Existing Project	Identify the AMBY interface	#2: Representation and Reasoning
	3. Introduction to Intents - (**Modify**) Special Intents	Identify and create training phrases and responses for special intents	#4: Natural Interaction
	4. Introduction to Intents - (**Modify**) Existing Intents and (**Create**) New Intents	Identify and create intents	#4: Natural Interaction
	5. Introduction to Follow-up Intents	Identify and create follow-up intents	#4: Natural Interaction
	6. Conversational Design Principles	Identify conversational design principles and create naturalistic interactions	#4: Natural Interaction
	7. Create a Chatbot from Scratch	Create a chatbot from scratch	#4: Natural Interaction

Conversational AI Lessons

We provided lessons that were specifically focused on Conversational AIs and chatbots. We created our own conversational AI development environment called AMBY (AI Made By You) to provide a user-friendly experience to create conversational AIs. The camp's conversational AI lessons were designed closely around the AMBY interface.

AMBY is designed specifically to support middle school learners in learning about conversational AI and creating their own agents. In the Playground (the main development panel) of AMBY, learners can see, develop, and test their conversational agent (Figure 1). Learners can also deploy their agent on a Google Assistant-compatible device by clicking the "Integrations" button on this page. AMBY offers a list of unique functionalities. First, it allows students to customize the avatar and voice of their agent. Second, it provides a visualization of the conversational flow (as shown in the left panel of Figure 1) with a hierarchical visualization of "Main Intents" and "Follow-up Intents." Additionally, a testing panel on the right side pane allows users to test their agents through two modalities, typing and voice input. The conversational AI component of the curriculum is composed of seven lessons: (1-2) Intro to Chatbos I & II, (3-4) Intro to Intents I & II, (5) Intro to Follow-up Intents, (6) Conversational Design Principles, and (7) Build a Chatbot from Scratch. We used the "Use→Modify→Create" pedagogical approach (Lee et al. 2011a) to provide scaffolding during guided hands-on lessons. We provided three sample projects for campers to use and a template project for them to modify through several lessons (Figure 2). Most of the lessons were designed with short content and longer hands-on practice, tailored towards novice programmers. In the following sections, we describe each lesson in detail.

Lesson 1: Intro to Chatbots (I) This lesson provides an introduction to conversational apps or chatbots[2] in an interactive and relatable way. It begins with warm-up questions such as "Have you ever asked your smartphone a question?" and "Did it give you the answer you wanted?". Then, through a demo interaction with a Google Home Mini device, campers asked questions and gauged the Google Assistant's responses. They were introduced to three main kinds of chatbots, namely Rule-based, Intelligent, and AI-based chatbots, and the various things chatbots can do, such as answering questions and making recommendations. Then, they brainstormed what chatbots they would like to create and

[2]During the camp, we used the term chatbots to refer to conversational apps for the ease of understanding.

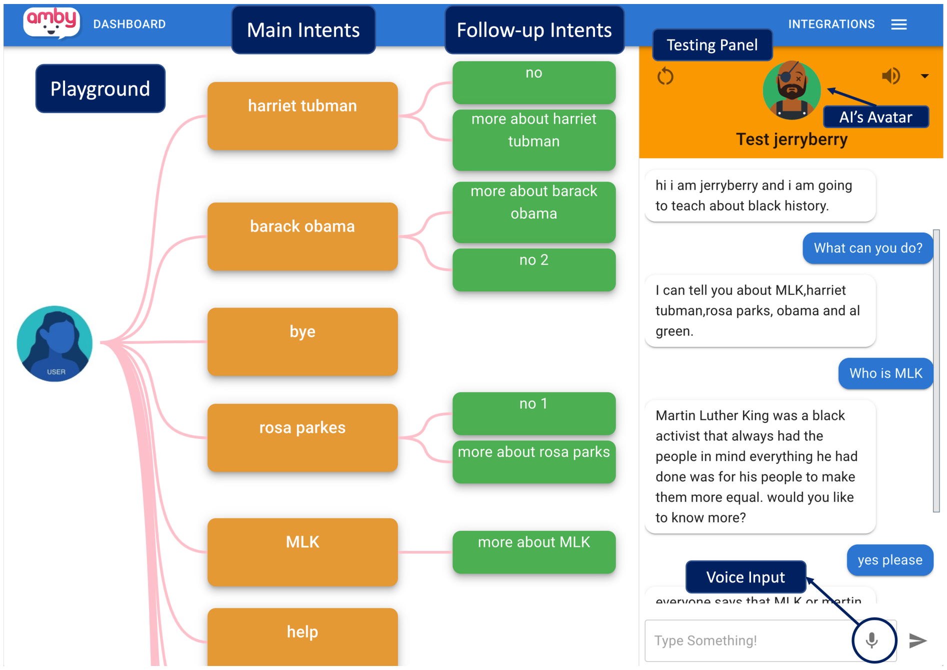

Figure 1: AMBY development environment. The screenshot is the development page for a student project, JerryBerry

why users would need them.

Lesson 2: Intro to Chatbots (II) This lesson aims to introduce the idea of becoming developers of their own conversational apps and working within AMBY. As a warm-up activity, campers were introduced to using a stack of customized cards with samples of developer goals, user utterances, and chatbot responses. Campers were encouraged to group the cards based on chatbot ideas. For instance, one group of cards might contain a developer goal: "a chatbot that recommends music"; user's utterance: "Can you please recommend a fun song?" and chatbot's response: "Sure, Wobble by V.I.C is a fun song." This activity applied the fundamental conversational AI concepts of intents, training phrases, and responses. Then, campers were introduced to AMBY and interacted with pre-built chatbots in the system.

Lesson 3: Intro to Intents (I) - *Special* Intents This lesson covers the concept of intents and special intents. In AMBY, intents represent a state of conversation defined by the user's goal. Developers train the chatbot to recognize a given intent from user input using a set of "training phrases" (example inputs) and designate a list of "responses" for the chatbot to return. For hands-on practice, campers modified the template chatbot "AboutMeBot" across several lessons (see Figure 2). In Lesson 3, campers modified the *special* intents, which are the default intents that the system creates for every agent. Campers customized the "Greet" intent, which is meant to exchange greetings between a user and the chatbot, and the "Default Fallback" intent, specifying what the chatbot will utter when it does not understand what the user says. For example, campers can change the generic Greet intent responses like, "Hi, how are you today" to something more relevant, like "Hi, I'm AboutMeBot, You can ask me questions about the person who developed me."

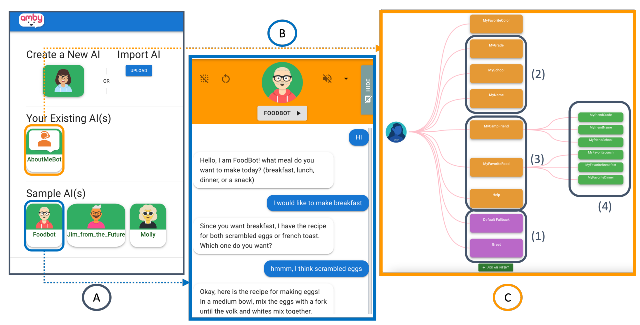

Figure 2: Progression of Conversational AI Lessons within the interface: (A) Dashboard page with sample AIs for campers to *use*, and existing AI, AboutMeBot, to *modify*; (B) Testing panel for campers to interact with chatbots; (C) Playground page for AboutMeBot with (1) Special intents, (2) Existing intents, (3) New intents and (4) Follow-up intents created by campers during lessons

Lesson 4: Intro to Intents (II) - *Modify* Existing Intents and *Create* New Intents This lesson is mostly hands-on with campers further modifying the "AboutMeBot". Campers added more training phrases, created new intents, and updated the existing responses to personalize their chatbot. For the "AboutMeBot", campers created new intents such as "MyFavoritefood" and added training phrases and responses.

Lesson 5: Intro to Follow-up Intents This lesson introduces the concept of follow-up intents, which are intents that are linked to another intent. When the original intent is matched, the next thing the user says is matched to the follow-up intents. Campers created a new intent for the "AboutMeBot" called "FavoriteFood" and added three follow-up intents, such as "FavoriteBreakfast", "FavoriteLunch", "FavoriteDinner."

Lesson 6: Conversational Design Principles This lesson focuses on five conversational design principles: setting user's expectations, conversational flow, conversational markers, "No match" error, and "Help" responses. Campers modified the responses for the "AboutMeBot" to incorporate these conversational design principles. For example, they modified the "Greet" intent response from "Hi, I'm AboutMeBot, You can ask me questions about the person who developed me" → "Hi, I'm AboutMeBot, You can ask me questions about the *name*, *grade*, *school*, *favorite food*, and *favorite color* of my developer." Additionally, campers were taught how to customize the chatbot's voice and the avatar that represents their chatbot.

Lesson 7: Build a Chatbot from Scratch This lesson provides an end-to-end hands-on experience in creating a chatbot. Campers were placed in groups and provided with a worksheet to guide them. There was minimal involvement from camp facilitators, who monitored progress through the checklist on the worksheet and offered help when asked by the campers. This lesson helped campers gain confidence to develop their own chatbots more independently.

Project Activities

After learning about conversational AI through lessons, students engaged in the project activities, where they developed their own conversational agents. To guide their projects, we provided a Project Design Log, developed based on Design Thinking (Arık and Topçu 2020). We chose Design Thinking because of its focus on empathy, which helped students think about the social impact of AI (Big Idea #5).

Students began with an individual project and proceeded to a collaborative, pair-programming project, in which a pair of campers switched roles between the *driver* and the *navigator*. The *driver* is responsible for creating intents and typing training phrases and responses, while the *navigator* provides supports by coming up with the training phrases and checking errors (Celepkolu and Boyer 2018). For pair programming, campers were asked to individually brainstorm 3-5 project ideas and were paired based on these ideas. Both project activities followed the Design Thinking (Thoring, Muller et al. 2011; Arık and Topçu 2020) process: Empathize, Define, Ideate, Prototype, Test.

Implementation and Outcomes

Camp Context

1) Year 1 (2021) In summer of 2021, we conducted a two-week-long day camp as the first implementation with 14 rising seventh and eighth graders (2 girls and 12 boys, 11 Black/African-American, and 3 White students). The average age of campers was 12.3 (SD=1). Ahead of the camp, we held a one-week professional development to prepare our undergraduate facilitators. In the first year, campers developed their own conversational agents using Google Dialogflow, which is a conversational AI development tool more suited to adult users. The campers in year 1 experienced frustration working with Dialogflow because of the dense text displayed in the interface and difficulty with typing. All these contributed to the team moving forward with the development of AMBY.

2) Year 2 (2022) Two camp sessions were conducted the following year with two major changes to the curriculum. The first was to incorporate the AI4K12 Big Ideas Guidelines aligned with the released curriculum Progressions (Touretzky et al. 2019a). The second was the development team's effort to design AMBY as an interface to make learner interaction smoother and more accessible.

We developed AMBY following four iterative development cycles, beginning with a formative user study in the context of summer camp 2021 and followed by two rounds of usability studies. The findings from these iterative user studies have led us to create the fully functional prototype of AMBY before the year 2 camps. New lessons were created to address general AI in accordance with the AI Big Ideas, as well as to teach learners about the new interface.

Overall, 32 campers participated in the year 2 camps (17 girls and 15 boys, 25 Black/African-American, 5 Hispanic/Latinx, 4 White, 1 Asian, 1 Native American/Alaskan Native)[3]. The average age was 12.7 (SD=0.7). Before the camp started, eight undergraduate facilitators participated in a three-week professional development, extended from the previous year's single week. In the professional development, we addressed facilitators' roles, provided facilitators with opportunities to learn about AI and conversational AI, and invited them to practice teaching lessons in the form of micro-teaching. They also created conversational agents using AMBY. Between the two sessions, we held a three-day-long mini-professional development to address changes in the lessons, activities and schedule.

Detailed Schedule

We organized the camp curriculum into a camp schedule that guided the daily flow of activities for the camp. Table 2 shows our week 1 camp schedule.

Outcomes

1) AI Attitude Survey

We gathered pre/post survey data from 32 campers who participated in the second year along four constructs: ability beliefs, sharing, identity, and persistence. The ability beliefs construct drew items from the BASICS-SQ (Outlier Research & Evaluation 2017) and focuses on perceptions of students' ability to understand AI, with items like: "I can do well in AI" and "I can figure out how to solve hard AI problems if I try." Sharing is from the Personal Creativity Scale (McKlin et al. 2018) and asks students to report agreement/disagreement with prompts like: "I want to share what

[3]Four campers identified as more than one race/ethnicity.

Table 2: Camp Schedule - Week 1

Time	Monday	Tuesday	Wednesday	Thursday	Friday
10:30	Opening Event	Intro to Chatbots (I)	Intro to Data	Yoga Activity	Individual Project Development
11:10	Ice Breakers	Minefield	Intro to AI & ML	Design Thinking	Peer Testing & Feedback
11:45	Pre-survey	AI Ethics & Bias	Intro to Intents (II) - Create New Intents	Individual Project - Empathize, Define	Peer Testing & Feedback
12:20	Lunch				
13:00	Pre-assessment	Intro to Chatbots (II)	Intro to Follow-up Intents	Individual Project - Ideate	AI & Arts
13:35	Pre-video	Facilitators Project Showcase - Use Existing Projects	Conversational Design Principles	Individual Project - Prototype	Finalize Individual Projects
14:25	Intro to AI	Intro to Intents (I) - Modify Special Intents	Modify Existing Responses	Individual Project Development	Interview on AMBY
15:00	Human Crane	Musical Dots	Create a Chatbot from Scratch	Careers in STEM	Fun Friday
15:35	Wind down/Gym time	Wind down/Gym time	Wind down/Gym time	Wind down/Gym time	Fun Friday

* Red: General AI Lessons , Yellow: Unplugged Activities , Blue: Conversational AI Lessons , Purple: Project Activities

I do in the camp with my friends." The identity construct asks students whether they perceive that they have options in AI/STEM careers and is adapted from the BASICS-SQ with prompts like: "I see myself using AI in my future job." Persistence is also adapted from the BASICS-SQ future time perspective construct and is distinct from identity in that it focuses on actions students might take in the near future related to AI learning. The prompts include "I would like to join an AI club" and "I would like to learn more AI in the future." We used campers' composite scores from each construct to conduct a paired-measures t-test comparing pre and post responses. Table 3 shows significant increases from pre-to-post on three of the four constructs: ability beliefs, sharing, and persistence. [4]

Table 3: Pre/Post Comparison by Attitudinal Constructs

Construct		Mean	p	Effect size
Ability Beliefs (n = 31)	Pre	2.91	0.006**	0.530
	Post	3.30		
Sharing (n = 32)	Pre	2.90	0.049*	0.362
	Post	3.18		
Identity (n = 31)	Pre	2.84	0.275	0.200
	Post	3.00		
Persistence (n = 31)	Pre	2.77	0.019*	0.447
	Post	3.10		

Note. * p <.05; ** p <.01; Effect size calculated using Cohen's D

2) Video Assessment

To identify campers' learning about AI, we analyzed video recordings in which campers were tasked to answer, "What is AI?" as if they were explaining AI to their family or friends. They recorded short videos both before and after the camp. In both pre and post videos, campers conceptualized AI with such key words as "robot", "made by human (artificial)", "smart (intelligent)", and "assisting/helping." Also, they often mentioned that AI "talks back to you/can have a conversation with you." Many of them gave a list of what AI can do, such as "telling you a joke" or "helping you with homework". They also gave examples of in-service AIs or IoT (Internet of Things) products, such as "Smart TVs", "refrigerator", or smart speakers such as "Siri", "Alexa", and "Google Home". In the pre-videos, we found more campers showed uncertainty about their knowledge of AI. For instance, three out of 32 campers only said "I don't know" in the pre-videos, but they provided better answers in the post-videos, including key words like "smart", "data", "chatbot", and "self-driving cars".

[4]Differences in N in the table for each construct is attributable to the fact that one participant skipped some items.

3) Students' Projects

Learners created 58 conversational AI projects utilizing AMBY. Project topics varied depending on their interests, including game/sports tutorials, music/movie recommendations, joke telling, information giving, and mental health. We present two examples of projects from 2022 camp sessions.

1. **Jerry Berry** is a conversational agent that gives information about Black history and influential Black figures, such as Martin Luther King Jr. and Barack Obama. This project was built collaboratively by two African-American students. While developing this project, they utilized effective conversational design principles that were taught in the conversational AI lessons (Lesson 6) to make the conversation more natural. For example, to avoid monologue in the agent's responses and a better conversational flow, they broke down the description of Black influencers into nested intents in which the agent's response ends with a question "Would you like to know more?" so that users can choose whether to continue the conversation or not.
2. **ZooBot** introduces interesting facts about animals, as well as tips for people to defend themselves against dangerous animals. ZooBot was one of the projects with the most intents (10 main intents, 38 follow-up intents and 22 follow-up of follow-up intents). In the project demo scripts, one of the students shared their mental models of the conversational flow of their agent:

> *We added many different training phrases so our agent can easily understand what the user is attempting to ask. The following intent we have is the 'greet' intent, which is how the bot asks the user the question on how they would like to proceed. The next intent is*

the 'yes' intent. It recognizes when someone wants to receive animal facts. The 'animal' intent can be triggered after the 'yes' intent, and it will say what animals it can provide facts about.

Their demonstration of their project showed a clear understanding of AI derived from our lessons. For example, they understood the role of training data, which can make their agent more likely to understand the user's intent (taught in lesson 3 and 4); they demonstrate the importance of natural AI-human interactions (lesson 6) by authoring multiple follow-up intents (lesson 5) and allowing users to take multiple conversational turns.

Discussion

In this paper, we shared an innovative conversational AI curriculum for middle school summer camps. The design of the curriculum is closely connected to AI4K12 Big Ideas (Touretzky et al. 2019a) and the development team's work on the AMBY interface. Findings suggest that this approach successfully supported middle school learners in gaining a well-rounded understanding of AI. Some components of our curriculum addressed curricular suggestions from previous studies. For example, the content of the conversational AI lessons aligned with the "app-building tutorials" and "Alexa skill tutorials" of Van Brummelen, Heng, and Tabunshchyk (2021)'s work. In addition, our curriculum provided more support and scaffolding by adopting Use→Modify→Create pedagogical approach (Lee et al. 2011b) and Design Thinking (Thoring, Muller et al. 2011). The biggest difference in the current work is the co-design and integration between our curriculum and our conversational AI development interface, AMBY. While Van Brummelen, Heng, and Tabunshchyk (2021) used an existing tool, MIT App Inventor, we created our interface specifically for middle school learners. AMBY and the camp curriculum were developed together in a synergistic manner: we included lessons, tutorials, and hands-on activities specifically to help campers understand and use AMBY. At the same time, when we observed children encountering usability challenges with AMBY during the camp, our development team was able to make formative changes to improve the interface.

The implementation of our curriculum suggests the promising potential of conversational AI as an effective entry point to K-12 AI education in informal settings. We found a significant increase in campers' attitudes in three out of four constructs, including ability beliefs, sharing, and persistence in AI learning. These findings indicate improvements in students' beliefs in their ability to understand AI and to create projects using AI, in their comfort with sharing their work with friends and family, and in actions related to AI and learning AI that they would like to take in the future. There was no significant difference for the identity construct. One possible reason to explain this null result is that we intentionally did not describe AI-related jobs as the "best" career path. Since most of our campers have not started or are in the early stage of forming professional identities (Erikson 1993), we wanted to give these youth time to explore various possibilities before deciding on their future careers.

We have also reported findings from the pre-post videos where campers explain what AI is. It is notable that more campers tried to conceptualize AI by mentioning the characteristics of AI in the post-videos, instead of merely listing the examples of AI services, which was seen more often in the pre-vidoes. For example, in one post-video, a student said "AI learns and becomes intelligent based on the output you give and then it shows intelligence through inputs you give it as tasks". This suggests that the student has begun to grasp the basic concepts of training and test data and how they are used for machine learning, which is related to the AI Big Idea number 3: "Computers can learn from data" (Touretzky et al. 2019a).

Lastly, from the projects created by campers, we found that our lessons and project activities helped them learn about important AI Big Ideas, such as "Natural Interaction" (Big Idea 4), and the "Social Impacts of AI" (Big Idea 5). In conversational AI lessons, we provided a series of conversational design principles for natural human-AI interaction design (lesson 6). We could observe campers applying these principles by adding greetings and social talk, or breaking agents' information-giving monologues into nested intents (see Jerry Berry example). This suggests campers' learning gain in AI Big Idea #4: "Making agents interact comfortably with humans is a substantial challenge for AI developers" (Touretzky et al. 2019a). In addition, when generating project ideas, students started with empathizing with people around them, a step in line with Design Thinking. For the Jerry Berry project, for example, the campers considered the social impact of their agent that tells stories of successful Black figures in history to empower Black people, which is related to the AI Big Idea #5: "AI applications can impact society in both positive and negative ways" (Touretzky et al. 2019a).

Conclusion

We have reported on a novel conversational AI curriculum for middle school summer camps. Our curriculum consists of four main components: general AI lessons, unplugged activities, conversational AI lessons, and project activities. Each component is composed of a series of lessons and hands-on activities. The outcomes of the implementation indicate the promise of conversational AI as an entry to K-12 AI education, identifying the positive impacts on students' attitudes, AI conceptualization, and understanding of social impacts of AI. The findings suggest many important directions for future work. First, there is much to explore regarding how to foster general AI knowledge through the specific context of conversational AI. Second, this work has been conducted in an informal setting, which limited the opportunity to formally assess learner knowledge. Future work should investigate assessment of learning in the context of conversational AI. Finally, future work should investigate conversational AI learning experiences with a broader set of learners in terms of geography, race/ethnicity, and age.

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