“My Bot Can Talk about Science!”: Fostering AI Learning in a Middle School Science Classroom

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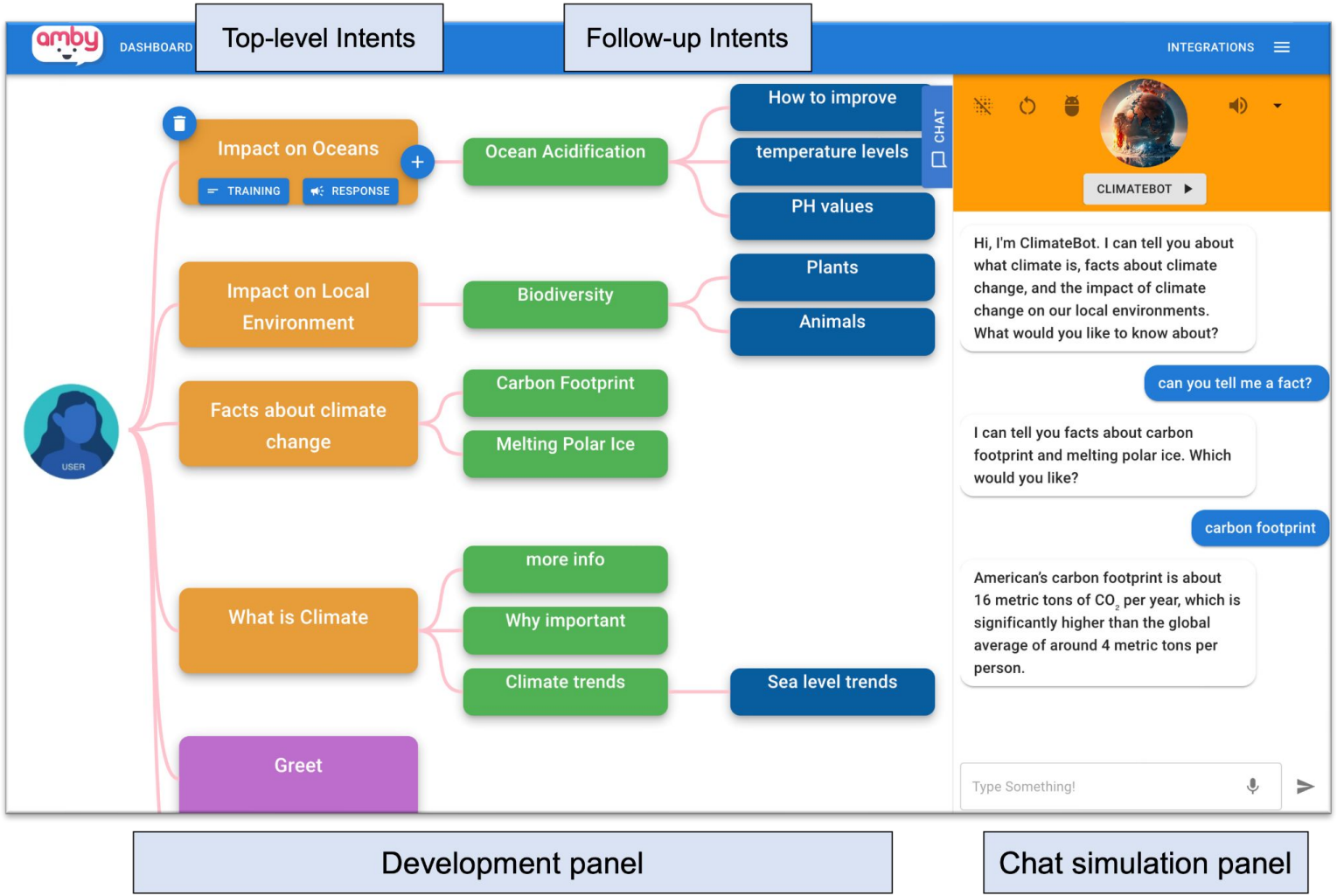
Introduction

- Growing momentum to teach AI across K-12 classrooms
- Most current AI curricula and tools are used in informal learning settings (Song et al., 2023; Kim & Kwon, 2024)
- Opportunity to embed AI learning into core subjects such as science
- Conversational AI (e.g., Siri, Alexa, ChatGPT) is already part of students' everyday experiences

We introduce a middle school learning module: “Conversational AI + Science”

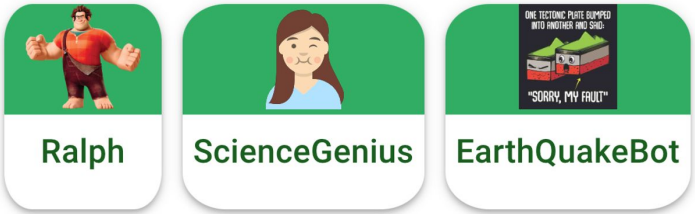
Introducing AI through building science-topic chatbots

Learning Platform: AMBY



“Conversational AI + Science” Learning Module

- 10-hour learning module
  - AI introduction lessons
  - hands-on activities creating chatbots using AMBY
  - chatbot project development
- Adapted from an informal summer camp curriculum (Song et al., 2023)
- Worked with three teachers to integrate science content
- Exemplar Science Chatbots



Overview of Conversational AI Learning Module (Pt 1)

Lesson	Focus	Key Learning Objectives
L1: Intro to AI	What is AI?	- Define AI - Recognize AI characteristics - Give examples like Siri, self-driving cars
L2: Intro to Chatbots	Chatbot Basics	- Identify chatbot examples (e.g., Alexa) - Describe what chatbots can do
L3: Intents	Understanding Intents	- Define and identify intents - Understand training phrases and responses - Create responses for common intents

Overview of Conversational AI Learning Module (Pt 2)

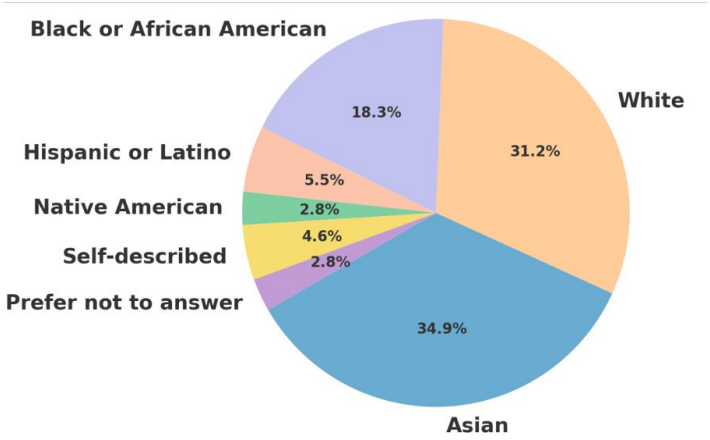
Lesson	Focus	Key Learning Objectives
L4: Follow-up Intents & Design	Designing Conversations	- Define follow-up intents - Learn good design practices: • Set user expectations • Use clear conversational flow • Add helpful fallback and "help" responses
L5: Entities	Understanding Entities	- Define entities - Identify entities from user input
L6: Project Work	Building a Chatbot	- Create a chatbot using AMBY - Apply good design - Test and revise - Peer review and reflect

Research Questions

- RQ1: How do students demonstrate AI and science knowledge through the design and implementation chatbot artifacts?
- RQ2: What changes occur in students' attitudes towards AI after an integrated learning experience?
- RQ3: How do students describe their experiences with AI-integrated science learning?

Middle School Classroom Study

- 6th grade Science, public school in Gainesville, Florida
- 128 students in total, 100 consented to participate in research
- Average age: 11.7 (sd = 0.48)
- Gender: 49 girls, 46 boys, 1 non-binary, 1 prefer not to answer
- Race/Ethnicity Distribution



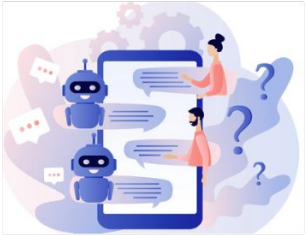
Study Procedure

Pre-survey	Conversational AI Lessons	**AMBY Hands-on Practice**	AI Project Development	Post-survey Post-assessment	Interview
Day 1	Day 1-3	Day 4	Day 5-8	Day 9	Day 10

Data Collection

Pre-/post-questionnaires

Focus group interview



Student-created chatbot artifacts

Post-assessment

Results

- RQ1: How do students demonstrate AI and science knowledge through the design and implementation chatbot artifacts?
- RQ2: What changes occur in students' attitudes towards AI after an integrated learning experience?
- RQ3: How do students describe their experiences with AI-integrated science learning?

Results

- RQ1: How do students demonstrate AI and science knowledge through the design and implementation chatbot artifacts?
  - Chatbot artifact assessment
  - Post AI knowledge assessment

Chatbot Artifact Rubric Dimensions

1. Project ideation
2. Conversational design
3. AI development
4. Knowledge of subject content
5. End-user satisfaction (EUS)
    - Averaged from three external annotators

Rubric Cohen's kappa = 0.82

Chatbot Artifact Rubric Dimensions

1. Project ideation
2. Conversational design
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AI Knowledge

Science Knowledge

Rubric Cohen's kappa = 0.82

Chatbot Artifact Assessment Result

Dimensions	Project Aspects	Mean/Scale	SD
AI - Ideation	Demonstrating Purpose	3.04/4	0.40
AI - Conversational Design	Overall Intents	3.23/4	0.65
	Top-level Intents	3.33/4	0.73
	Follow-up intents	3.13/4	0.77
	Greet intent	3.72/4	0.53
	Default fallback	3.12/4	0.76
	Help intent	2.68/4	1.04
AI - AI development	Training phrases	3.31/4	0.46
	Responses	3.00/4	0.20
Subject - Knowledge of science	Subject topic relevance	2.62/3	0.59
	Depth of content	3.00/4	0.69
AI - End-user satisfaction		3.45/5	0.80

N=51

Post AI Knowledge Assessment

- Substantial mastery of the learning concepts
- 15 questions. 14 multiple choice, 1 open-ended.
- Average correct percentage: 90%.
- Only four questions had an average correct percentage of below 90%
  - identifying better conversational design given a user interaction scenario
  - Identifying entity elements given a user message

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AI Attitude Change from Pre to Post

	Pre		Post		Difference (post-pre)	*p* value	Effect size
	Mean	SD	Mean	*SD*			
Ability Beliefs	2.76	0.60	3.18	0.53	0.43 ↑	< 0.0001	0.71
Identity	2.69	0.59	2.60	0.78	-0.09	0.203	0.14
Intention to Persist	2.89	0.55	2.69	0.68	-0.20 ↓	< 0.0001	0.43

- P value obtained from paired samples t-test between pre and post responses
- Score scale 1-4
- N=92

AI Attitude Change from Pre to Post

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An Attitude Paradox?

Results

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Perceived Impact on Science Learning

- Thematic analysis of student written responses in post-questionnaire
- Prompt: *Did the conversational AI lessons and activities help you understand science concepts you learn from class? If so, how?*

Perceived Impact on Science Learning

- Prompt: *Did the conversational AI lessons and activities help you understand science concepts you learn from class? If so, how?*

52% Yes	48% No
*"It helped my by **refreshing my memory.** It also helped me think about the topic more deeply since I had to **rewrite it in my own words**."*	*"The AI(...) **doesn't tie** into weather, climate, or any science concepts we have learned."*
*"Yes!!! I had to think about **how to explain** something that we learned and **think about different questions**. And you have to understand something to explain it through AI."*	*"Not really because our topic was about astronomy which is space. **In class, we didn't learn much about astronomy**. But I learned somethings like blackholes."*

Main Takeaways

- We present **“Conversational AI + Science” learning module** that integrates AI education into middle school science. This integration model is adaptable across multiple subjects
- We report empirical outcomes of students’ **attitudes, learning artifacts and experiences** in AI-integrated science learning
- Chatbot development can function as a **novel assessment tool** in formal education for both **AI concepts** and **domain knowledge**

Acknowledgement

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Curriculum resources are available at www.campdialogs.org

Q & A

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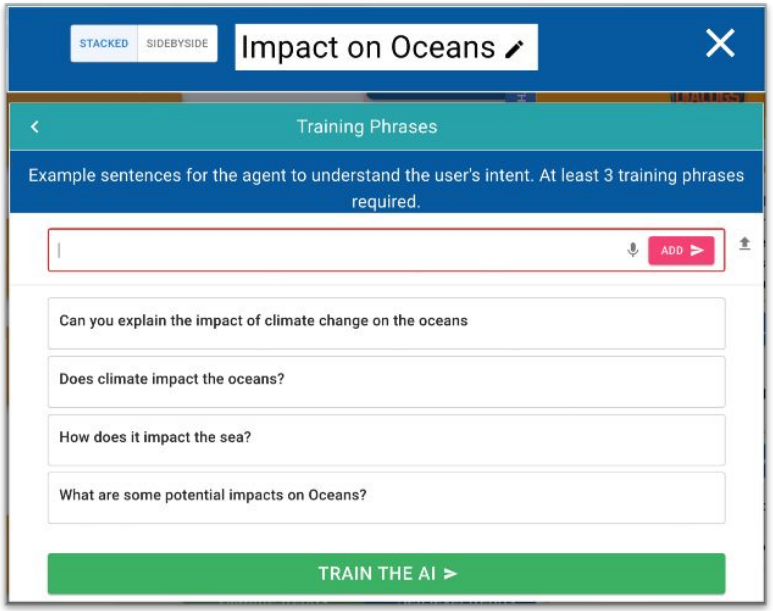
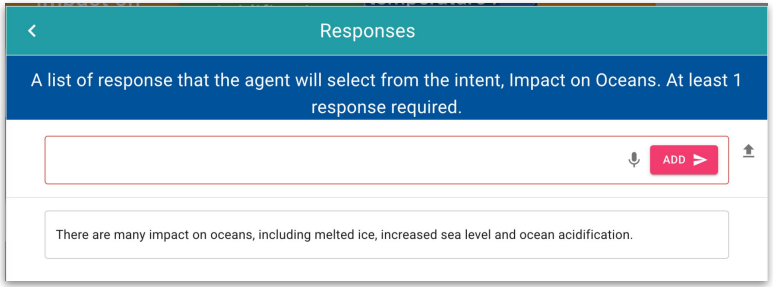
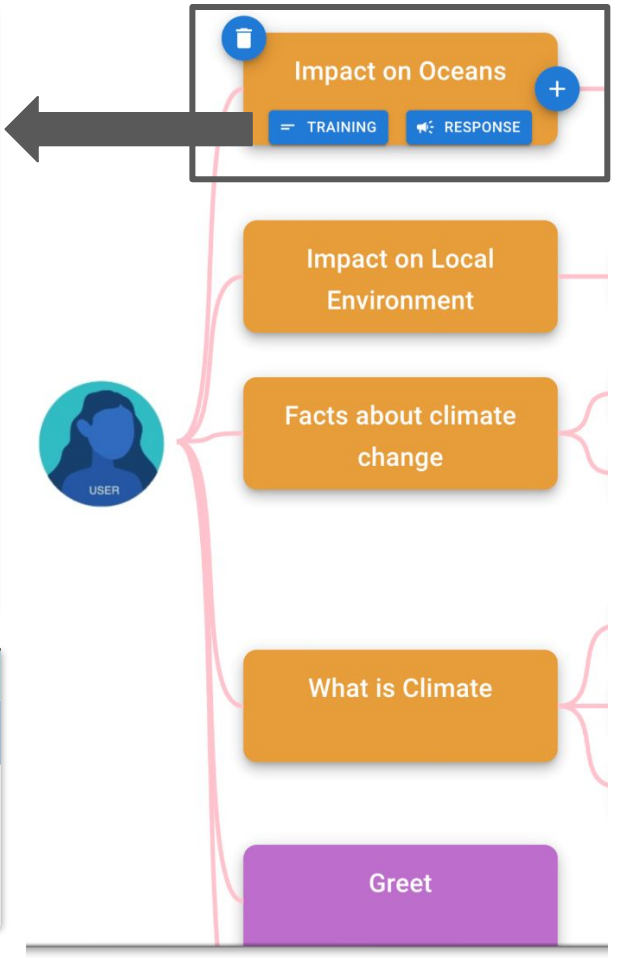
Additional slides

Training Phrases



Responses





Intents

Dimensions	Project Aspects	Statement for Score of 3 (Meets Expectations)
Project Ideation	Demonstrating purpose	The student has a clear idea of what the bot will do and implements their idea clearly.
	Chatbot Personality design	The agent demonstrates a unique personality through at least two of linguistic and visual choices (avatar, voice, word choice) and demonstrates intentional thought to align with chatbot purpose.
Conversational Design	Overall Intents	Project intents align with its purpose. The project has a balanced overall structure of the intents, has reasonable variation. Some adjustments could be made for streamlined design.
	Main intents	The majority main intents (more than 60%) are mutually exclusive and sufficient in demonstrating the purpose.
	Follow up intents	The agent has multiple logical follow-up intents AND Each follow-up intent is related to its parent intent mostly logically. Most follow-up intents can be triggered properly based on the responses from their parent intents.
	Greet intent	The agent has at least one customized greet response demonstrating its purpose. May not set exact user expectations.
	Default fallback	The response is created by the learner and can redirect the users.
AI Development	Training phrases	Most training phrases are ample, cohesive, and varied within the intent.
	Responses	Most customized intents contain at least one response that is in proper length, logical, and mostly mimic natural conversation.
Knowledge of subject content	Subject topic relevance	The chatbot stays focused on the subject topic, providing consistently relevant responses (excluding intents that handle social requests, such as bye or thank you). Most content provided by the chatbot is correct and informative.
	Depth of content	The chatbot offers detailed and thorough explanations, covering essential concepts of the topic adequately.

5. End-user Satisfaction

- The agent was easy to understand
- The agent understood what I said in this conversation
- In this conversation, it was easy to find the information I wanted
- I knew what I could say at each point of the dialogue
- The agent worked the way I expected
- I would like to talk to the agent again

Student Learning Experiences

Themes	Personalized experience (authenticity)	Engage and Discover: Experiential active Learning	Real world connection	Work with others
Codes	customization; creativtity;	interactive and engaging; hands on experience, fun in general; interesting topic	real-world connection	collaboration; facilitator support
Example Student Quotes	*"The fact we got to make our own unique chatbot talking about a topic we are comfortable with and 'program it.'"*	*"I liked that it was an activity where we could use our imaginations to think about how our certain chatbot speaks"* *"What I liked was the interactive readings & getting to program and starting bot because that had felt engaging to do as well & helped me pay more attention."*	*"I got to experience what its like for developers ho created Alexa, or chat GPT."* *"It was fun to make my own AI which made me think of all the hard work people tools to make other AI's such as google or siri."*	*"I enjoyed having to work with a partner I was not "close friends with" and doing so helped us improve ourselves and focus more on our chatbot. We also got to know eachother more."* *"It was fun learning about the chatbots & I enjoyed making them both by myself and with my partner. The lessons could help me in the future if I study AI or work in AMBY. I liked how the teachers explained the lessons clearly so that we could understand what to do and what things mean."*