The Participatory Co-Design of a Problem-Based Learning Artificial Intelligence Elementary Curriculum

As an applied science oriented to tackle real world problems, computer science (CS) curriculum pairs well with inquiry-based instructional approaches (United States Department of Education, 2013). Specifically, problem-based learning (PBL) which is characterized with components such as ill-structured problems, learner-centered pedagogy, and authentic practice, is suitable to advance computational thinking skills aimed for CS education (Caceffo et al., 2018). Therefore, we intend to create a PBL immersive learning environment where students adopt the role of environmental scientists and interact with a virtual ecosystem in both online and offline curriculum. The CS curriculum and online game will integrate CS and artificial intelligence concepts in addition to life science concepts. While engaging with the AI curriculum and the online game rooted in PBL, upper elementary students will be guided to collaboratively find the factors causing the recent decline in the native population of yellow-eyed penguins and generate solutions to address identified causes. The research question of our study is as follows:

RQ: How can we create engaging learning experiences integrating AI and life science for upper elementary students by leveraging immersive PBL?

Through a participatory co-design curriculum development project with fourth and fifth grade teachers, researchers from two US universities partnered together to develop an AI PBL curriculum and online game. While the process is currently still ongoing, teachers and researchers began meeting in February of 2020 to learn about PBL, life-sciences, CS and AI and outline the needs of the curriculum to be developed (see Figure 1). This approach to participatory co-design (Penuel et al., 2007) allowed researchers to provide just-in-time professional development to teachers to enrich their understanding of PBL, life science, and CS concepts. AI as a topic was new for all participants, therefore both researchers and teachers were learning together.

Figure 1

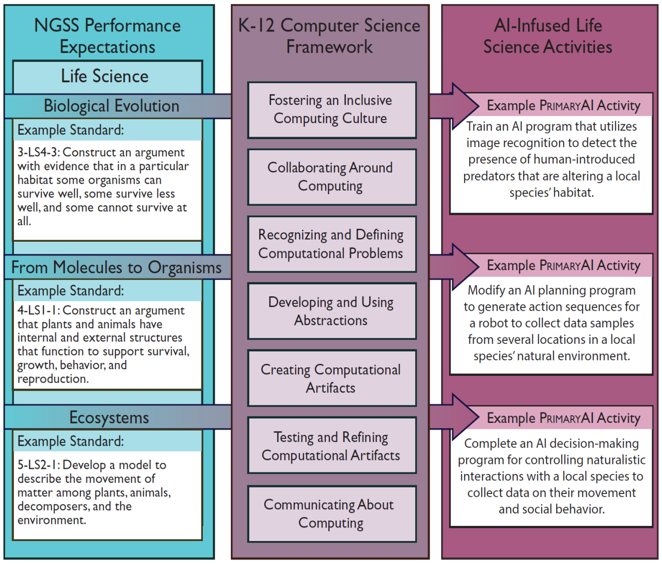
Participants included three teachers with varying years of experience, but who represent three different elementary school settings; urban, suburban, and rural. This allowed researchers a more complete insight into a diversity of student perspectives. Participants also included four researchers; one specializing in life sciences, one specializing in CS education, and two specializing in PBL.

To date there have been 16 design meetings with teachers. Early meetings focused on content learning as well as outlining the overall instructional goals teachers and researchers had for the curriculum. In later meetings, teachers and researchers collaboratively brainstormed offline activities for the curriculum as well as provided practical feedback to the online game design. This allowed incorporation of more discussion opportunities and documentation practices that would enhance classroom PBL experiences for students (see Figure 2).

Figure 2

These co-design sessions have served as a platform for professional development around CS concepts, life science concepts, PBL, AI, and curriculum development (see Figure 3). We have found this method of using co-design meetings to democratically design the curriculum (Shrader et al., 2001) helpful to reduce reported teacher reluctance around teaching new concepts that are outside of their prior knowledge or comfort zone.

Figure 3



Suggestions from teachers included specific prompts to be included in the game design signaling students to talk with partners, prompts that asked students to switch places so partners could experience gameplay, and the addition of an offline science notebook where students could take notes to document their online game journey and make connections between online and offline learning. Teachers also co-developed the driving question for students that covered both online and offline instruction as well as generated a list of culminating activities for students to choose from.

The curriculum covers concepts around animal adaptation, endangered species, understanding common scientific misconceptions, AI planning problems, AI planners, AI content specific vocabulary (e.g., optimization, precondition, postcondition), AI ethics, CT, and CS concepts. Teachers were involved in every aspect of the design process for the offline curriculum and online game development. All design decisions were made collaboratively with teacher voice being integrated and valued throughout the curriculum design process.

The offline curriculum currently consists of four offline lessons designed to introduce students to the driving question, the yellow-eyed penguins and the problems they face as a species, animal adaptation, introduction to AI and its benefits, and an introduction to AI planners and AI planning problems. The decision to use the life science context of endangered species and yellow-eyed penguins was to help teachers feel more comfortable introducing students to the complex and technical content for AI. By taking concepts teachers were already familiar with, we hope to reduce barriers and cognitive load so the focus for teachers can be on understanding AI concepts (Feldon, 2007).

The first lesson introduces students to the yellow-eyed penguin through an age appropriate picture book as well as the number of problems the yellow-eyed penguin faces as an endangered species. Students will complete a physical activity that illustrates the complexities of their problems as well as animal adaptation as it relates to the yellow-eyed penguin. The first lesson concludes with the introduction to the guiding question for the entirety of the PBL unit; what's causing the decline of the yellow-eyed penguin and how can we use AI robots to help?

The second lesson has students participating in a discussion of misconceptions around animal adaptations that helps students frame their initial ideas about why the yellow-eyed penguin is still endangered and cannot adapt to their surrounding challenges. Students will also be introduced to a classic AI planning problem using the context of yellow-eyed penguins and one of their natural predators, the weasel. Through this problem, students will work with manipulatives to create a solution based on their given conditions and needs. By illustrating a simple AI planning problem to students, teachers will share examples of much more complex AI planning problems to highlight why AI is used.

The third lesson introduces students to all of the different ways AI is currently being used to solve problems. This introduction to AI will provide real-world examples of AI and set the context for why AI needs to be understood for many future professions and functions in our society. Students will also get time to discuss how they think AI could be used to help the yellow-eyed penguins.

The fourth lesson has students engage in another AI planning problem where they design their ideal school day. During this lesson, students will be introduced to key vocabulary including, initial state, goal state, possible actions, preconditions, and postconditions. Students will be given cards with all possible actions (e.g., reading, writing, math, etc) with each card indicating a precondition and a postcondition. Students will work in groups to create their ideal school day on an AI planner template paying attention to preconditions and postconditions of each possible action to create their unique AI planner. Groups will then share out their AI planners as well as their reasoning behind how they optimized their school day (i.e. getting all the actions they dislike done first, getting all the actions they like done first, getting all the actions that take less time done first, etc). These discussions will help students understand how different optimizations affect how an AI plan is generated on an AI planner. At the conclusion of this lesson, students will be introduced to the online game and Quest 1.

The first online quest introduces students to the virtual world, the yellow-eyed penguins, and the problem needing to be solved (Figure 4). Students will generate an AI planner to capture photos of the yellow-eyed penguins to help the scientists on the island understand the problems the specific group of penguins is facing.

Figure 4


PrimaryAI
Robot Cam
Data Explorer
Code Editor
Quit
Searching
...
CRYSTAL ISLAND
25%
72 photos
Searching...
Run
Speed Up
Stop
33
PrimaryAI
Robot Cam
Data Explorer
Code Editor
Quit
Back
Relabel
49

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