THE PARTICIPATORY CO-DESIGN OF PBL FOR ARTIFICIAL INTELLIGENCE EDUCATION IN ELEMENTARY CLASSROOMS

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ABSTRACT

Using the context of artificial intelligence (AI), researchers from two US-based universities partnered with practicing teachers to design an elementary grade problem-based learning (PBL) AI curriculum and educational game to teach AI, computer science (CS), and life science concepts. Four educational researchers, five computer science researchers, and three teachers co-designed an engaging curriculum and educational game that leveraged immersive PBL throughout.

Given the emphasis and encouragement of utilizing inquiry-based approaches when teaching CS in the US (United States Department of Education, 2013), it is important for teachers to be involved in the design process to gain a greater understanding of content and process specific knowledge. In the presentation, we will address how suggestions made by teachers shaped our curriculum development and how our co-design process served as content-specific professional development for teachers. We will also describe the online game and offline curriculum overview in detail.

KEYWORDS: Problem-Based Learning, Computer Science Education, Artificial Intelligence, Participatory Co-Design, Curriculum Design

TYPE OF CONTRIBUTION: Practice-based abstract

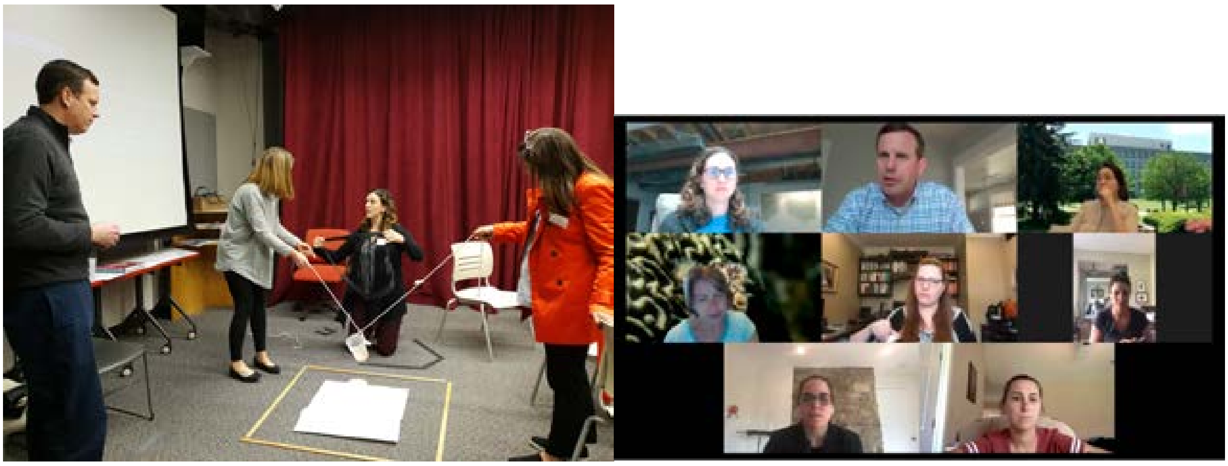
PRESENTATION FORMAT: Roundtable discussion

As an applied science oriented to tackle real world problems, Computer science (CS) pairs well with inquiry-based instructional approaches and have been recommended to be used in conjunction with one another (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 are creating 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 curriculum and online game will integrate CS and artificial intelligence (AI) concepts in addition to life science concepts. While engaging with the offline 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:

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 professional development to teachers to enrich their understanding of PBL, life science, CS, and AI concepts. An example of co-design sessions can be seen below in Figure 1.

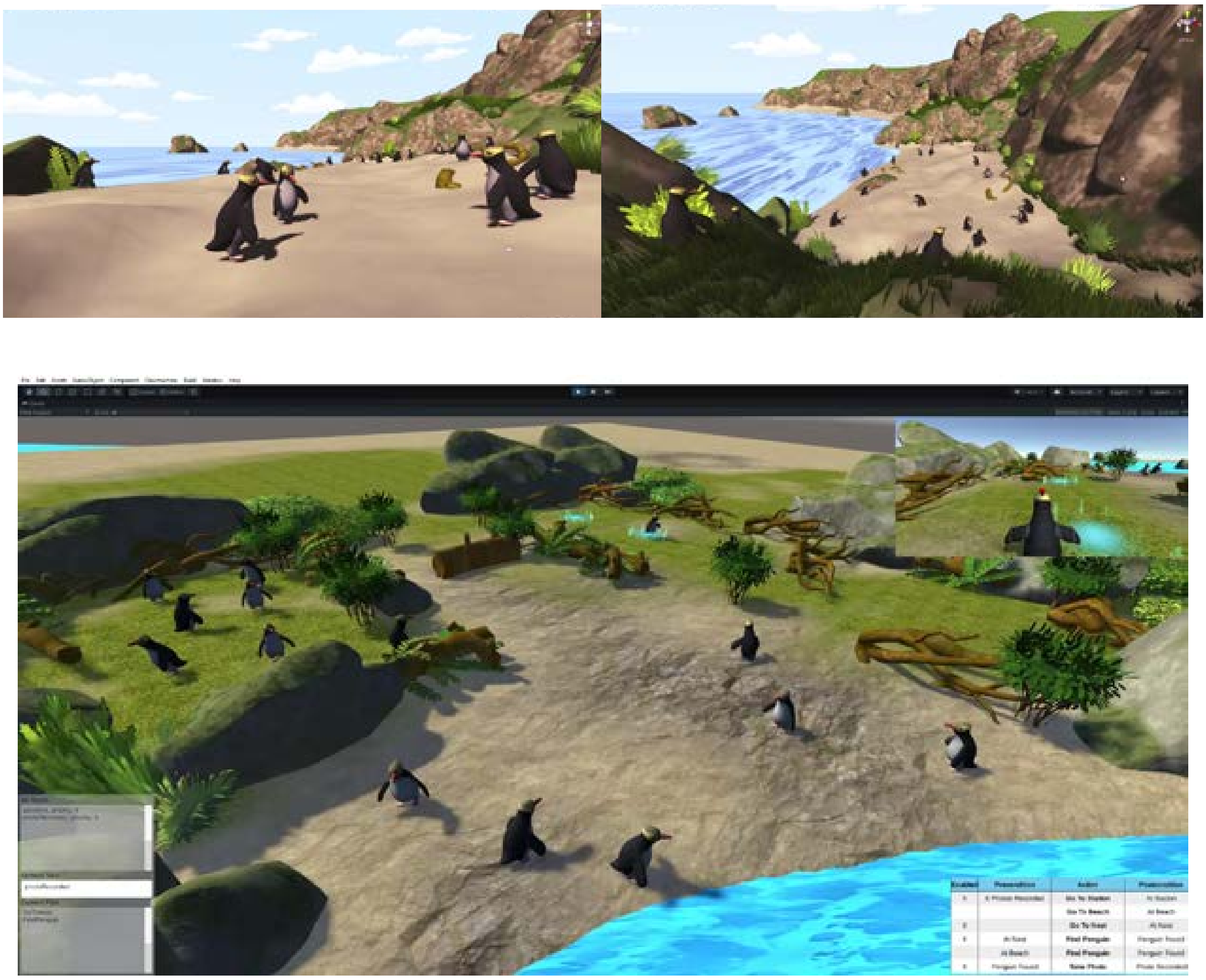
Figure 1. Co-design Sessions with Teachers



Participants included three teachers with varying years of experience, each from either an urban, suburban, or rural school setting. Participants also included four researchers; one specializing in life sciences, one specializing in CS education, and two specializing in PBL.

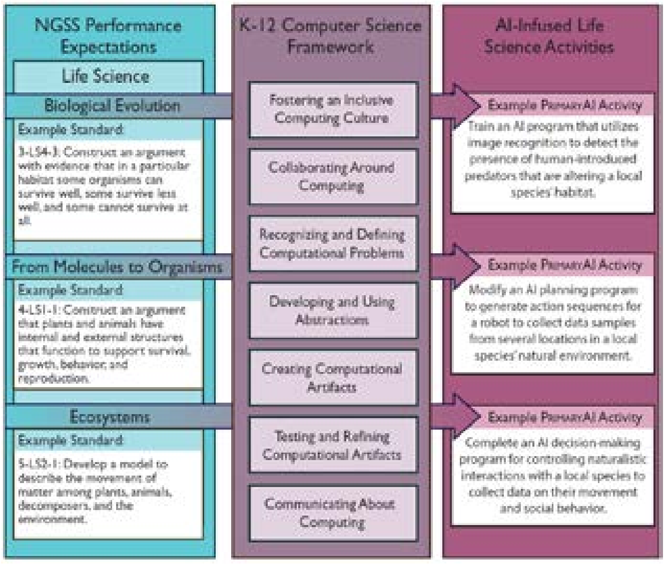
To date there have been 16 co-design meetings with teachers. Early meetings focused on content learning as well as outlining the overall instructional goals for the curriculum. In later meetings, teachers and researchers brainstormed offline activities for the curriculum and provided practical feedback 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. Online Game Interfaces



The 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. AI Curriculum Development Framework



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 decisions 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 after completing both offline and online learning.

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, 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 and misconceptions, 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 thus allowing teachers to focus on understanding AI concepts (Feldon, 2007).

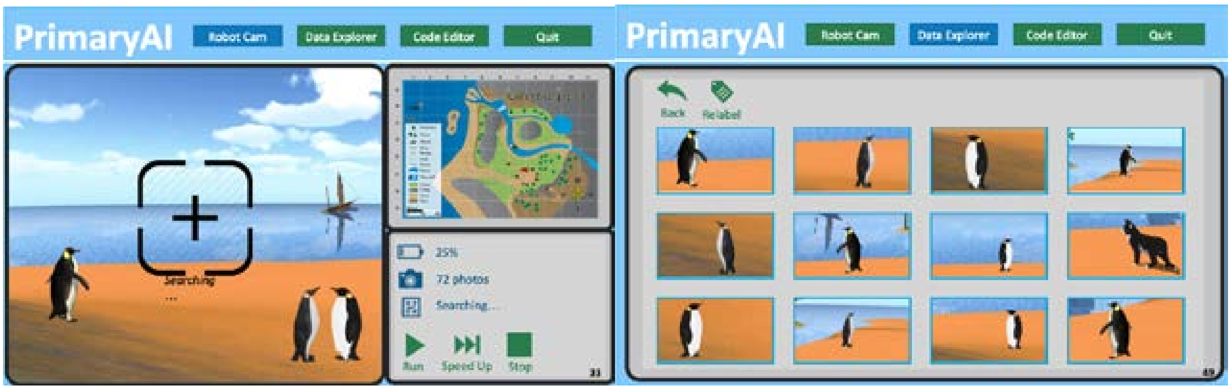
The first lesson introduces students to the yellow-eyed penguin and their problems as an endangered species through videos and age-appropriate text. Students will then complete a physical activity that illustrates the complexities of their problems as an endangered species (e.g. disease, commercial fishing, injuries). 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 our knowledge of science, CS, and AI to help?

The second lesson has students participating in a discussion of misconceptions around animal adaptation that helps students frame their initial ideas about why the yellow-eyed penguin is endangered and cannot adapt to their changing environment. Students will also be introduced to a classic AI planning problem using the context of yellow-eyed penguins and a natural predator, 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 more complex AI planning problems to highlight why AI is helpful to humans.

The third lesson introduces students to different ways AI is currently being used to solve problems. These real-world examples of AI set the context for why AI needs to be understood for many future professions and functions in our society. Students will also engage in an AI planning problem that helps plan a family trip to the county fair. During this lesson, students will be introduced to key vocabulary including, initial state, goal state, possible actions, preconditions, postconditions, and optimization. Students will be given cards with initial states (e.g., county fair has 8 time blocks open), goal states (e.g., you filled all 8 time blocks), and possible actions (e.g., play a game, ride a roller coaster, eat cotton candy). Students will then be given cards for preconditions and postconditions. Students will work in groups to create their AI planners and will then share out their AI planners and their rationale for their choices. Students will also be given a unique AI plan based on their planner to aid in discussions on optimization and how AI machines make AI plans. 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. First Online Quest



Currently, teachers are working through the first implementation of the offline curriculum and online game play created to date. We anticipate future iterations of the Quest 1 curriculum and game will be needed before teachers and researchers can begin work on Quest 2. The team has 3 quests in total planned for the project and anticipate completion by summer 2022.

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