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CyberPLAYce, a Play Space of Creative Intelligent Tools Promoting Personal and Computational Expression for Early Learners

Arash Soleimani
Clemson University

Fig. 1: Children interacting with CyberPLAYce (Prototype A-1)

[cyberPLAYce]

Learning with CyerPLAYce, a Cyber-Physical-Spatial Learning Environment for Elementary Students Promoting Spatial Computational-Thinking

CyberPLAYce is a novel, interactive-computational construction kit for elementary school children and their teachers. CyberPLAYce bridges the physical and digital worlds, allowing young students to bring their ideas, stories and class subjects to life through the construction of cyber-physical environments. The CyberPLAYce construction kit is comprised of hand-sized, magnetic modules integrating a variety of electronic components, and rectangular panels, nearly two-feet measured diagonally, that receive the modules and serve as physical building blocks for constructing cyber-physical environments imagined by children. Through play, children become comfortable with the working modules and panels; subsequently, they are provided matching non-electronic module cards allowing them to quickly compose pattern sequences to map ideas, stories and class content. Additionally, students are provided action and story cards to spark their imagination.

CyberPLAYce merges play and learning in the physical world while transitioning students from consumers of virtual and digital-centric technologies into technological innovators and cyber-playful storytellers.

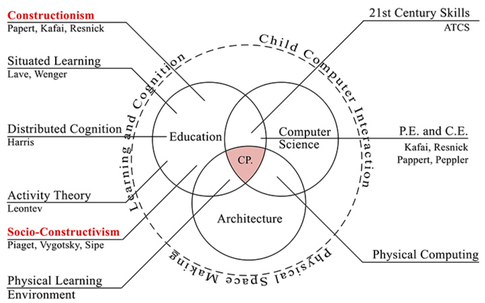


Fig. 2: Bodies of Knowledge

Fig. 3: The kindergarten approach to learning

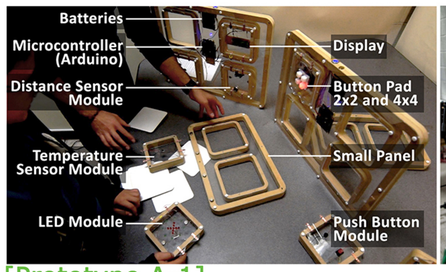
DESIGN INSPIRATION

CyberPLAYce was designed as a 21st century House of Cards (Fig. 4), created in 1953 by famed American designers Charles and Ray Eames. House of Cards is an oversized deck of playing cards featuring imaginative patterns and pictures on their surfaces that children join together to give form to their thoughts. Adding computation to this recipe, CyberPLAYce puts the emphasis on the process of design rather than only considering the final product.

Fig. 4: Children giving form to their thoughts through the spatial reconfiguring afforded by *House of Cards* (1953) (Left) and *CyberPLAYce* (Right)

DESIGN PROCESS: Prototype A-1, A-2 & B-1

The CyberPLAYce construction kit was designed and refined through three iterations based on the feedback received from children and teachers during our studies. The first-functioning CyberPLAYce prototype (A-1) comprised by the open–source Arduino platform, hand-sized, magnetic modules integrating a variety of electronic components, and rectangular panels (Fig. 5). The CyberPLAYce kit consists of five electronic modules: a light module, a temperature module, a sound module, a distance module, and an LCD module.



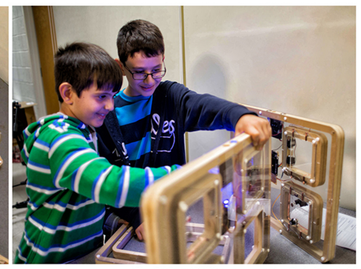


Fig. 5: CyberPLAYce components (Prototype A-1)

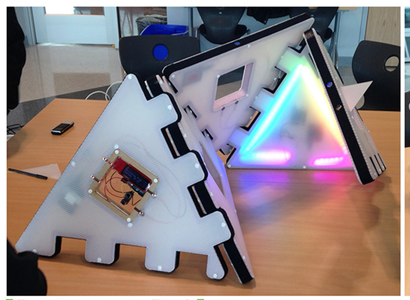
[Prototype A-1]

The initial study informed several minor fixes and refinements including both visual and technical enhancements. In particular: new panels were built with less transparency to improve the spatial experience between children; magnetic connections between the panels were strengthened; and the total number of electronic modules was amplified, based on children's feedback. The abovementioned refinements resulted in prototype A-2 of CyberPLAYce (Fig. 6), the subject of the empirical study described in this section.

Fig. 6: CyberPLAYce (Prototype A-2)

[Prototype A-2]

To facilitate imaginative design activity and promote spatial computational thinking and expression, Prototype B-1 features triangular-shaped panels that feature receiving modules and moving flaps – digitally controlled, motor-driven components.



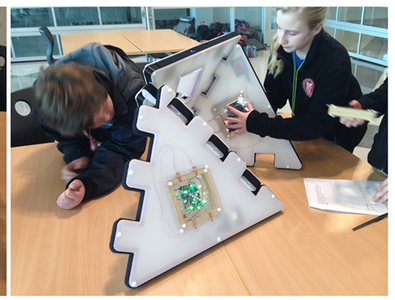


Fig. 7: CyberPLAYce (Prototype B-1)

[Prototype B-1]

When children break down a story or problem into smaller, more manageable segments, they better understand, interpret and construct knowledge (i.e., they think computationally).

The CyberPLAYce kit consists of icon and action cards (Fig. 8). The non-electronic cards allow children to compose pattern sequences and map ideas, stories and class content. Children match the cards with the story segments and then create or tell stories through a combination of cards, modules and panels.

Fig. 8: CyberPLAYce icon and action cards to spark students' imagination

RESEARCH ACTIVITY

The CyberPLAYce study posits three research questions for this tangible learning tool:

(1) Can children comfortably use the technology during the storytelling or problem-solving activity?;

(2) To what extent is a modular, multi-sensor design-kit usable?; and

(3) How does CyberPLAYce support children's storytelling experience and enhance their spatial-computational thinking?

The following scenario envisions how CyberPLAYce operates in the classroom setting:

> *One day, in a classroom of 8 year olds, Mr. Smith asks the students to think of the routine tasks the students perform each morning at home. Then he tells his story of "Jane"…. The sun rises just before Jane's alarm goes off. When Jane hears the sound of the alarm, she pushes a button to turn it off. She turns on her bedroom light and her room becomes yellow. Jane walks to the bathroom to take a shower, but first she tests the water to make sure it isn't too hot. After Jane showers, she runs back to her room to turn the light off. Jane sees a rainbow outside her window. On the way out of her bedroom, Jane accidentally slams the door…*

When children break down a story or problem into smaller, more manageable segments, they better understand, interpret and construct knowledge (i.e., they think computationally). Jane's story was broken down in this way (Table 1), and each story segment was defined by concepts and actions.

1. The sun rises just before Jane's alarm goes off.
▶ Peel off the cover of the light sensor (input) to activate Circle LED and Buzzer Module (output).
2. When Jane hears the sound of the alarm, she pushes a button to turn it off (see Fig. 9: LEFT).
▶Push the button on the Buzzer Module (input) to turn it off (output).
3. Jane turns on her bedroom light and her room becomes yellow.
▶Push a button on the 2x2 Button-Light Module (input) to turn on the yellow light (output) (see Figure 9: CENTER).
4. Jane walks to the bathroom to take a shower, but first she tests the water to make sure it isn't too hot.
▶Display the distance on LCD Module (output) using the distance sensor. Use the Circle LED and X Module (outputs) to indicate if the water is too hot (input) using the Temperature Module.
5. After Jane showers, she runs back to her room to turn the light off.
▶Display the distance on LCD Module (output) using the distance sensor (input) when the child moves a hand away from the sensor; then the yellow light in a Button –Light Module on the adjoining panel turns on (output). Push the button on the 2x2 Button-Light Module to turn off the yellow light (output).
6. Jane sees a rainbow outside her window.
▶Push the button on the 4x4 Button-Light Module (input) to turn on the "rainbow" (output) (See Figure 9: RIGHT)
7. On the way out of her bedroom, Jane accidentally slams the door.
▶Activate the Flap Module (output) using the distance sensor (input).

Table 1: The breakdown of Jane's story into segments, as a vehicle to thinking algorithmically and computationally

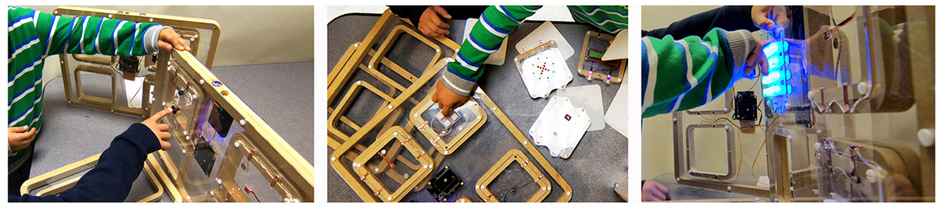


Fig. 9: *CyberPLAYce* (Prototype A-1) – Our scenario unfolding….
LEFT: Push the button on the Buzzer module to turn the alarm off.
CENTER: Push a button on the 2x2 Button-Light Module to turn the bedroom light on.
RIGHT: Push a button on the 4x4 Button-Light Module to turn on the rainbow.

In Prototype B-1, a friction joint was designed and replaced with the magnetic one. The new joint uses Velcro to make temporary connections between the panels while improving the opportunity for children to construct larger structures in the space with lightweight materials, and enhancing their understanding of spatial relations between the objects while receiving instant feedback from the system.

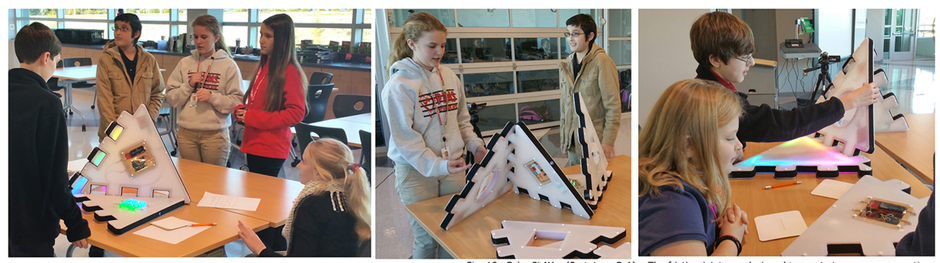


Fig. 10: *CyberPLAYce* (Prototype B-1) – The friction joint was designed to create temporary connections between the panels while offering children the capacity to construct expressive, large structures

CyberPLAYce bridges the physical and digital worlds, transitioning students from consumers of digital-centric technologies into technological innovators and cyber-playful storytellers.

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