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ScratchJr Bots

Abstract: In the early childhood classroom, educators and students are increasingly surrounded by technology, making it critical that young learners realize their potential to be designers rather than solely consumers. Developmentally appropriate programming tools are necessary to address this need, such as ScratchJr, a block-based programming app for children aged 5-7 that allows for play, creativity, and technological empowerment. Because of the increasing body of research on the benefits of hands-on learning and robotics towards these same goals in early education, we developed ScratchJr Bots. This tool integrates the programming capabilities of ScratchJr with a customizable physical robot, enabling interaction through lights, sound, movement, and sensors. ScratchJr Bots introduces young learners to computational thinking and coding through robotics programmed by ScratchJr, while also providing tangible, personally meaningful output.

Introduction

As technology use expands across age groups, the need for robust computer science and robotics education grows. Despite increased proposals over the past decade, educational robotics (ER) technologies remain scarce in early education. (Mangina et al., 2023; Bers, 2018). Although educational robotics programs are often designed for higher education, young children can also benefit significantly. In successful early educational robotics programs, children gain technical skills and computational thinking skills and exhibit increased self-efficacy, collaboration, and creativity. They also show greater enthusiasm for learning and interest in science and technology (Bers et al., 2022; Castro et al., 2018; Zviel et al, 2020). Exposure to robots with variable morphology enhances children's interest and learning. This learning adopts a constructionist approach, empowering students to direct their own learning (Afari & Khine, 2017). A common problem that has reduced the potential success of these interventions is their cost. High costs of robotic tools limit thorough ER implementations, particularly in early education (Mangina et al., 2023).

ScratchJr, a free digital programming environment, prioritizes accessibility, constructivist principles, and creative learning. It also aligns itself with developmental appropriateness by fostering playful, open-ended exploration and accommodates different developmental needs through its low-floor, high-ceiling framework (Blake-West & Bers, 2023). As a fully digital platform, it lacks a hands-on, physical engagement element. ScratchJr Bots was developed to do this by adding the element of robotics to the programming language, and by continuing to develop this prototype iteratively, ScratchJr Bots will be improved with the responses of what young learners enjoy and are inspired by along with the practical needs of educators.

Overview of ScratchJr Bots

ScratchJr Bots integrates a physical robot with the ScratchJr app, allowing users to experience three-dimensional output for their programs. The robot has LED lights, sound sensors, speakers, and motors which can all be programmed from the app. In its original version, ScratchJr encourages the creation of original projects while learning coding and computational thinking. With ScratchJr Bots, a user gets to view their program come to life through the robot instead of a virtual character. The app for ScratchJr Bots maintains many design features of the original ScratchJr app. The programming area, block categories, and the ability to drag and drop blocks into a sequence that smoothly clicks into place remain the same. Three new blocks have been introduced, replacing old blocks that would not be possible with a physical robot: the “Appear” and “Disappear” are now “LED on” and “LED off”, and the motion blocks have been amended to fit the constraints of the spinning motor. The only other difference is the stage, where ScratchJr characters are replaced by a digital representation of the physical robot.

ScratchJr Bots expands on the emphasis on creativity in ScratchJr through the ability to customize the robot’s appearance, not just a virtual character. Users have the freedom to make the body of the robot any shape or size and add arts and crafts materials to make the robot come alive. Additionally, LEDs and sensors can be placed anywhere to emulate features including eyes, a mouth, an arm, etc. While piloting, children took advantage of these affordances and created characters such as a talking snowman, Harry Potter, and a fire-breathing dragon (see Figure 1). The design choice to not give ScratchJr Bots a prescribed appearance was intentional, aligning with Bers’ Coding Playground pedagogy. The freedom to experiment with any art materials and express themselves through the creation of a character allows the user to take risks, tinker with different ideas, and take ownership of their project (Bers, 2020).

Figure 1
ScratchJr Bots Project Examples

ScratchJr Bots has already been implemented in an initial pilot program, and we are currently beginning a larger pilot study in a new setting. After receiving feedback from young users, the technology of ScratchJr Bots and its accompanying curriculum have both been altered to improve ease of use and learning outcomes in parallel. An important insight from the first pilot was that the visibility of the robot's circuit board and mechanical components sparked the children's curiosity, leading them to wonder about how the elements of hardware work and are connected through the wires and circuit board. For its curriculum, we are now adding short lessons on how circuit boards work and how the parts of the Bots like a battery, a motor or LED connect through an electrical system. In future studies, we plan to inspect how this addition and small technological changes for ScratchJr Bots will influence student engagement, shape attitudes towards robotics, foster collaborative behaviors, and support the development of coding and robotics skills.

Applications of ScratchJr Bots

The general application of ScratchJr Bots is a robotics educational program that is designed for young learners. Since the programming language is the same as ScratchJr's, which is designed to be developmentally appropriate for 5–7 year-olds, learning how to program the Bots can be a fun and gentle introduction to robotics. ScratchJr Bots also increases inclusivity in the early robotics education field by being made up of only low-cost parts. Even further, because only one tablet or smartphone with the Bots app is necessary to connect to multiple robots, this technology is an avenue for classrooms with limited access to devices to still be able to explore both coding and robotics. Finally, there is an application for intergenerational learning. While putting the robot together may be too complex for the intended user of the final product, a 5-7 year old, this age group paired with an older child would allow for a shared learning experience about the construction of a robot. This could give the older child the chance to guide a younger learner into a positive and safe experience while encouraging their already sparked curiosity.

Interactive demo session

During this session, participants will be able to try coding with the ScratchJr Bots app to output a physical response from an already built robot. Additionally, they will have the chance to see the robot at every stage of conception and take part in the creation of a new ScratchJr Bot. From wiring and plugging in its electronics to using art materials to make it meaningful to their interests, the participant can experience the potential of creating and operating a personally meaningful robotics project.

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