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Tangible ScratchJr

Jessica Blake-West, Marina Bers
Jess.blake-west@bc.edu, marina.bers@bc.edu
Boston College, Lynch School of Education and Human Development. MA, USA

Abstract: The need for developmentally appropriate tools in early childhood computer science education has increased greatly in the past decade, as technology becomes further integrated into our daily lives. ScratchJr is a programming environment designed for children ages 5-7 and incorporates playfulness, open-ended exploration, and early literacy concepts into the user experience to meet the needs of young users. In this session, we introduce Tangible ScratchJr, an adapted version of ScratchJr currently in development. Tangible ScratchJr goes beyond the digital realm by incorporating an off-screen programming component with physical blocks, effectively creating a multisensory learning experience for young children. This Hybrid User Interface (HUI) not only enhances hands-on learning and making but also introduces valuable screen-free time to complement the digital affordances of ScratchJr.

Introduction

With society's increasing reliance on technology, there is a growing need for effective computer science education. In the past decade, there has been a push to promote coding in early childhood education, creating a need for the design of developmentally appropriate, effective learning tools (Bers, 2018; Bers et al., 2022). Hands-on learning, such as working with tangible manipulatives, has been shown to be an effective learning method for young children (Evangelou et al., 2010), and there have been many efforts to incorporate tangible learning into early childhood computer science education (González-González et al., 2019). Many of the tangible programming technologies currently available come at a high cost and/or are not designed with an accompanying pedagogy and curriculum (Bakala et al., 2022). ScratchJr, currently a digital programming interface, is a free app used worldwide, with over 40 million users. In addition, ScratchJr has over 60 hours of research-based curricula for both teachers and students (Blake-West & Bers, 2023a). ScratchJr is a developmentally appropriate programming environment because it encourages playful, open-ended engagement, and caters to a wide range of developmental needs due to its low floor, high ceiling design (Blake-West & Bers, 2023b). Despite these affordances, ScratchJr is a digital environment and therefore lacks a tangible component to engagement. Tangible ScratchJr, a new version of ScratchJr still in prototype phase, is being developed to meet this need. There is limited research in hybrid user interfaces, such as this one (Antle & Wise, 2013). Through our iterative design process, we will be able to incorporate real-world testing and feedback, which in turn ensures that the final product will align with practical requirements of educators and effectively address the identified gap in HUI technologies for early childhood education.

Overview of Tangible ScratchJr

Tangible ScratchJr is an adapted version of ScratchJr, which retains all computational and creative power of the digital app, while also allowing users to engage in hands-on, screen free programming. The off-screen portion of Tangible ScratchJr is a set of physical blocks, almost identical to the digital ScratchJr programming blocks. They retain the puzzle piece shape of the blocks, and because they are physical blocks, they snap together as the digital pieces are supposed to convey. One of the key innovations driving Tangible ScratchJr is the incorporation of Aruco Markers on each physical block. These markers, resembling small QR codes, serve as a bridge between the physical and digital realms, facilitating a smooth transition of programming sequences in which children can take pictures of their physical programs and upload them to the digital interface (see Figure 1). This decision was rooted in our pedagogical approach, aiming to make the translation from physical to digital blocks explicit for children. By opting for Aruco markers over other options, such as object recognition algorithms or NFC tags, we provided children with an additional layer of comprehension and an opportunity to engage with a technological language in a more tangible manner.

Figure 1
Tangible ScratchJr in Action

The physical blocks can be made in many ways. We have open-source designs for both 3D printing and laser cutting, as well as printable paper versions, and stencils intended to facilitate cardboard (or any other material) cutting to keep the "maker" aspect accessible to those that may not have access to advanced maker technologies. All homemade blocks can be made compatible with the app, all users need is the printable sticker sheets with each blocks' accompanying Aruco marker.

The Tangible ScratchJr app interface and the design of the physical blocks have both been developed through an iterative process which incorporated children's feedback on the prototype throughout the process. Additionally, Tangible ScratchJr has undergone initial pilot testing, and we are currently in the process of designing multiple implementation studies. A key finding from piloting was that we discovered a strong preference by many children to create their own blocks using our stencil designs, cardboard, and markers, which we are now leveraging in the Tangible ScratchJr experience as we incorporate the new tool into our ScratchJr curricula. In our upcoming implementation studies, we will compare the effects of Tangible ScratchJr on student engagement, classroom collaboration, coding skill acquisition, and computational thinking abilities. In these studies, we plan to introduce ScratchJr and Tangible ScratchJr to two different classrooms using the Coding as Another Language Curriculum for ScratchJr (Bers et al., 2023a, Bers et al., 2023b; Bers & Yang, 2023; Yang et al., 2023).

Applications of Tangible ScratchJr

Tangible ScratchJr has multiple applications, all of which improve an aspect of accessibility to the ScratchJr experience. The use of physical blocks expands engagement opportunities to those that may face challenges with engaging with a touch screen, specifically those that are visually impaired or struggle with fine motor skill development. Additionally, Tangible ScratchJr extends its reach beyond individual accessibility challenges to foster inclusivity in classroom settings. By offering the flexibility to create homemade blocks, Tangible ScratchJr becomes a valuable resource for classrooms with limited device access. This inclusivity ensures that the benefits of Tangible ScratchJr are not confined to a specific technological infrastructure but can be embraced by a wide spectrum of educational settings.

Contributions of Tangible ScratchJr to the learning sciences

While there are many contributions to the field that incorporate tangible programming, Tangible ScratchJr contributes to the smaller pool of hybrid user interfaces (Antle & Wise, 2013). With ScratchJr's worldwide reach and established effectiveness (Bers et al., 2023a; Bers et al., 2023b; Yang & Bers, 2023; Yang et al., 2023), Tangible ScratchJr offers a valuable opportunity to observe the effects of introducing a hybrid model on a global scale. This global observational approach allows us to isolate the modification factor introduced by Tangible ScratchJr, facilitating a precise and comprehensive measurement of the effectiveness of hybrid user interfaces in contrast to traditional graphical user interfaces.

Additionally, Tangible ScratchJr introduces a maker component to the programming experience. By enabling users to create their own physical blocks through various accessible methods, Tangible ScratchJr not only enhances engagement but also instills a "maker" ethos. This hands-on approach empowers learners to become active contributors to their learning journey, fostering a sense of ownership and creativity in the programming experience.

Interactive demo session

In this session, participants will be given the chance to try out different variations and iterations of physical blocks, as well as make their own blocks with our block stencils and Aruco marker sticker sheets. Participants will then be given the chance to test the prototype and upload their physical programs into the digital space, where they can further customize their projects or elaborate on their programs.

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