ScratchJr:
Computer Programming in Early Childhood Education as a Pathway to Academic Readiness and Success

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Learning in early childhood through programming

imagine * program * learn

Overview

Children in kindergarten through grade 2, compared to older children, have fewer opportunities to use powerful educational technologies that provide developmentally appropriate interfaces as well as educationally rich activities. The ScratchJr project aims to develop and study the next generation of innovative technologies for 5-7 year old children to engage in open-ended creative design and digital construction. ScratchJr combines a programming tool with curricular materials that support integrated learning of STEM, math, and literacy, as well as problem solving and other general foundational knowledge skills. An online resource website also provides resources and peer support for parents and teachers.

Research Goals

Development of a version of the Scratch programming environment and accompanying curricular resources which are developmentally appropriate for 5-7 year olds and suitable for immediate implementation in early childhood educational settings.

Evaluation of learning outcomes and documentation of how ScratchJr engages children in three core areas of learning:

- **Domain-specific knowledge** drawn from state and national curriculum framework for early math and literacy
- **Foundational knowledge structures** that apply across many academic domains, such as sequencing, classification, symbols, estimation, and prediction.
- **Complex problem solving skills**, specifically 1) identification of a goal; 2) formulation of a plan; 3) development of an initial attempt at meeting the goal; 4) testing, evaluating, and sharing outcomes; and 5) debugging and revising the initial attempt based on feedback.

Timeline

Phase 1
- Observation of 5-7 year olds using Scratch and Initial prototyping ScratchJr v1
- Development of curricular modules and evaluation methods

Phase 2
- Pilot testing of prototype, curriculum and assessments with: 1 school, 4 Classroom, 15 teacher, 44 students, Pre-K – 2nd
- Iterative revisions ScratchJr v1, development of ScratchJr v2

Phase 3
- Curriculum revisions based on Phase 2 findings. Prototyping of tablet-based ScratchJr Beta-version
- Pilot testing of revised prototype, revised curriculum, and Phase 2 assessments with: 4 schools, 5 classrooms, 5 teachers, 108 students, Pre-K – 2nd

Phase 4
- Iterative revision of Beta-version ScratchJr software
- Development of ScratchJr Release-version
- Implementation of revised curriculum and assessments with: 2 schools, 6 classrooms, 6 teachers, 98 students, K – 2nd

Phase 5 Dissemination
- Release application for free download on the Apple® App Store℠ on June 30th, 2014
- Publish resources, curricula, assessments, and research results online at www.scratchjr.org

Phase 4 Research Agenda

- Refine ScratchJr Beta-version based on classroom implementation data
- Develop ScratchJr release-version.
- Develop and implement curricula to introduce ScratchJr and identify strategies for integrating it into teachers' existing curricular themes and activities.
- Evaluate chidlren's learning of the ScratchJr programming environment with pilot Solve It assessments
  - Programming block comprehension, understanding of symbolic representation of a programmatic command
  - Complex problem solving, program comprehension and reconstruction

Phase 4 Studies

During Phase 4, we conducted 2 studies to document and analyze the age-(in)appropriateness and learning affordances of the features of the Beta-version ScratchJr tablet-based programming environment with N=98 children in grades K-2. Six teachers and several researchers collaborated at two New England elementary schools to implement ScratchJr curricula and evaluate learning outcomes.

Curricula

School A: N=60 K-2nd grade students participated in a researcher-designed curriculum on ScratchJr programming as a self-expressive tool. Children explored features of different expressive genres (collages, stories, and games) and used ScratchJr for hour-long lessons twice weekly.

School B: N=38 Kindergarten students where exposed to ScratchJr as a short-term "center-time" activity for 15-minute sessions twice weekly. Children were encouraged to complete short teacher-directed tasks, and were then free to explore features of the app on their own.

Assessment: "Solve It" Tasks

All participants' learning was assessed using pilot "Solve It" assessment tasks. ScratchJr projects were displayed onto a screen without the program visible. Children were then asked to guess the blocks used and the order in which they were sequenced.

Block Comprehension: "Watch the cat. Can you circle all of the blocks in this cat's program?"

Program Sequencing: "Watch the cat. Can you build this cat's program?"

Results and Key Findings

Solve Its are scores based on errors, and a perfect score is a zero.
All results are reported in terms of logical errors made by students

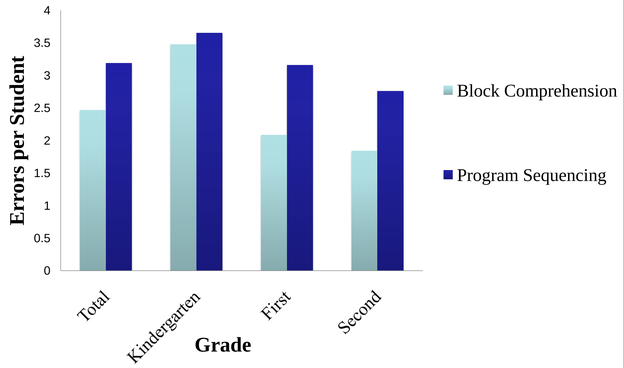
School A

Mean Errors by Grade and Gender

	Kindergarten	First Grade	Second Grade
Male	22.4	18.7	**13.5**
Female	**19.9**	**15.1**	14.4

- Males made more errors in Kindergarten and First Grade on assessments of sequencing ability and block comprehension.
- Females outperformed males in all grades except 2nd, where they had more errors

Mean Errors in Block Comprehension vs Program Sequencing



- All students made more mistakes in program sequencing than block comprehension.
- The older a student, the less likely they were to make any kind of errors on assessments

Schools A and B

Kindergarten Errors by School

School	Grade	Number of Participants	Mean	Significance
School A	Kindergarten	N (boys)=11 N (girls)=10	**X_b=8.73** **X_g=9.90**	t (19)= 0.369, p>0.0125, ns
School B	Kindergarten	N (boys)=22 N (girls)=16	X_b=10.68 X_g=10.88	t (36)= 0.162, p>0.0125, ns

X_b = mean errors for boys; X_g = mean errors for girls

Kindergarten students at School A outperformed their counterparts at School B by an average of 2 points per Solve It task.

Key Outcomes and Next Steps

Figure 1. Screenshot of the ScratchJr programming environment (release version)

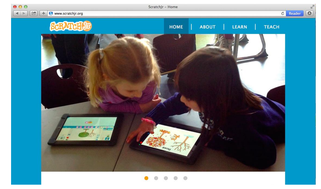


Figure 2. Screenshot of the ScratchJr website (scratchjr.org)

The research from Phases 1-4 has contributed to the successful creation of a final ScratchJr release version, several pilot-tested curricula and assessment methods, and public online resources, as well as numerous published research investigations (accessible from the DevTech Research Group Website).

In Phase 5, we will focus on three project areas for successful dissemination:

1. *Curriculum development:* We will develop Computer Science K-2 units that introduce concepts and skills that can be taught through ScratchJr, and as a foundation for other programming languages.
2. *Assessments*: We will further develop our current Solve It assessment to prepare it for dissemination so others can use it. We will also pilot test new assessment instruments for use with the new curriculum and lesson plans.
3. *Dissemination*: We will disseminate the finished ScratchJr software as an application for iPad and Android tablet platforms. We will also disseminate the curriculum and video-tutorials through our website, as well as other teaching materials in the form of traditional books about best practices to integrate computer programming with Scratch Jr. with other STEM disciplines, as well as literacy.

Publications

Flannery, L. P., & Bers, M. U. (2014) *Going the Distance: Early Elementary Explorations of Measurement through Story-Based Programming.* Manuscript submitted for publication.

Kazakoff, E. R. (2014). *Cats in Space, Pigs that Race: Does self-regulation play a role when kindergartners learn to code?* Unpublished manuscript, Tufts University, Medford, MA.

Kazakoff, E.R., & Bers, M.U. (2014, April). Does learning to code correlate with self-regulation skills in kindergarten classrooms? Poster presented at the American Educational Research Association Annual Meeting, 3 - 7 April 2014, Philadelphia, Pennsylvania.

Flannery, L.P., Kazakoff, E.R., Bontá, P., Silverman, B., Bers, M.U., and Resnick, M. (2013). Designing ScratchJr: Support for early childhood learning through computer programming. In Proceedings of the 12th International Conference on Interaction Design and Children (IDC '13). ACM, New York, NY, USA, 1-10. DOI=10.1145/2485760.2485785

Kazakoff, E.R., & Bers, M.U. (2013). Designing New Technologies for Early Childhood: Results From the Initial Pilot Studies of ScratchJr. Poster presented at SRCD Society for Research in Child Development, 18-20 April 2013, Seattle, Washington.

Kazakoff, E.R.(2012). Defining digital literacy in early childhood. Paper presented at EETC, 14 - 16 March 2012, Salt Lake City, Utah.

Kazakoff, E.R., & Bers, M.U. (2011). The Impact of Computer Programming on Sequencing Ability in Early Childhood. Paper presented at American Educational Research Association Conference(AERA), 8 - 12 April, 2011, Louisiana: New Orleans. Handout

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