Creating Opportunities for Young Learners with Hearing Impairments to Program, Design, and Learn Language in New Ways

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Abstract

This paper presents the work of a teacher who introduces programming at a school for Deaf and Hard of Hearing to 3rd- through 12th-grade students that prompted them to advance their reading and writing literacies. A case study describes this teacher's interactions with a deaf 12th-grade student while offering a curriculum developed around the Scratch, StarLogo TNG and Etoys visual programming languages called Computer Programming Tools for Schools.

Author Keywords

Deaf Education; English literacy; Programming

ACM Classification Keywords

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General Terms

Human Factors, Design, Languages

Introduction

The goal of a project offered by the first two authors "Computer Programming Tools in Schools (CPTS)," is to provide materials to help teachers introduce programming in a variety of K-12 settings in a visual and flexible way. The third author is a teacher who piloted those materials in a school for learners with hearing impairments. Her work gave the CPTS team unexpected insights worth sharing with others interested in broadening participation in computing. Charlotte attended a CPTS professional development workshop offered to 10 different New England schools during the 2011-2012 and 2012-2013 academic years. Through Charlotte's lens, the CPTS team got to know Ricky, a deaf student who learned to look at language in new ways as a result of learning to program. The CPTS team also worked with Charlotte to introduce the pilot curriculum to a new set of students, who also grew through communicating with others around programming.

Ricky, the Aspiring Game Designer

Ricky worked with Charlotte in a capacity that is common in schools for the Deaf: as an older student (age 21), with a low teacher-to-student ratio. Ricky's case resonates with an earlier study of children learning to program who are missing a sense [1]. While learning to program has been reported to lead to various learning outcomes [2,3], few case studies reveal a connection that Charlotte found in working with Ricky - a bridge to language learning for deaf and hard-of-hearing students.

It is well documented that deaf students struggle to become literate in English [4,5]. Frost advances that the meaning of written words is mediated by phonological representations of spoken words [6] and thus explains why students who cannot hear spoken words struggle with learning to read and write English. Ricky has the additional challenge of reduced exposure to English from growing up in a Vietnamese family. Ricky's educators understood that Ricky's professional life would benefit from a greater ability to read and write English, but had not found ways to improve those skills that resonated with him - until Charlotte introduced him to one of the programming tools in the CPTS curriculum: StarLogo TNG (Figure 1).

Ricky had never programmed before working with Charlotte. He viewed the opportunity to program with Charlotte as a way to prepare for going to college to study video game design. Charlotte introduced him to StarLogo TNG, a simulation and game authoring tool that uses colorful blocks to represent the programming language. Users drag and drop the blocks onto a canvas where they snap together to form sequences of commands that are executed by "agents" in a 3D environment.

Ricky first programmed a simulation that spread a disease among thousands of agents within his StarLogo program. In an interview with Charlotte, she reflected that programming a model of an epidemic provided opportunities for Ricky to not only learn the basics of programming but also to gain a deeper understanding of science vocabulary and English grammar differences. The meaning of and subtle differences between words like "immunity" as an agent's attribute versus "immunize" as a verb became clear when associated with observable behaviors enacted by the agents in the model. Charlotte noted that when asked by others,

Figure 1: a screenshot from a game Ricky programmed using StarLogo TNG.

Figure 2: a screenshot from a Scratch animation by one of Charlotte's 7th-grade students.

Ricky was able to accurately articulate how the model works in American Sign Language (ASL).

Programming also helped Ricky to make distinctions in language through working on a StarLogo project inspired by a game called "Rock, Paper, Scissors." Ricky named his program "Rock, Paper, Cut." In ASL, the noun sign for "scissors" is just "cut" repeated, so Ricky was able to confront this confusion for the first time when discussing his project with Charlotte. The architecture of typical StarLogo projects helped Ricky understand that because agents represent objects, the word used should be a noun ("scissors") and not the verb ("cut").
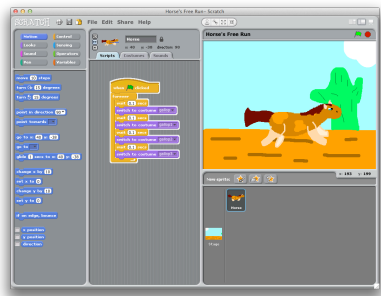
Ricky's experience learning to program follows similar trajectories to novices who have five functional senses (no hearing impairments). He programs with goals in mind, such as desired behaviors for the characters in his game. He recognizes when the program doesn't work as intended and seeks to find the "bugs" and devise debugging solutions. Furthermore, he was able to transfer programming concepts such as initialization, procedures, variables and loops when he moved on to learning ActionScript. Ricky became "literate" in StarLogo TNG and was able to read, write, and even transfer knowledge in the language of "code." Miller [1], concludes his study of a prelingual deaf boy learning to program with LOGO by observing that "the spontaneous development of language is contingent...upon the exposure of individuals to an interactive field of experience where they acquire vocabulary and rule-based knowledge...and where they are capable of practicing and extending this knowledge within contexts that are relevant to them." The programming tool's features of interactivity,

generativity, and immediate visual feedback facilitated the acquisition of programming literacy.

Charlotte's Evolution, 3rd and 7th Graders
Success that Charlotte had with Ricky came through work with Starlogo TNG in the 2011-2012 school year but she also introduced Scratch (Figure 2) to a class of 7th graders during that year that didn't go as well. Scratch is a language that differs from StarLogo TNG in key ways - such as its focus on manipulating two-dimensional images and sounds through a similar visual block mechanism for constructing programs. The CPTS curriculum covers programming topics with multiple tools in order to speak to different needs and interests of a broad range of students. In the year-end interview, Charlotte spoke at length about the success of her work with Ricky and the struggles of teaching the 7th graders. She made concrete plans to investigate the problems she had but still remained optimistic about the prospects of teaching programming the following year. Her motivation is revealed in this statement: "I just feel very strongly that they need to be introduced to some programming language."

Charlotte familiarizing herself with new programming languages is one of the keys in her students developing programming and written language skills. Charlotte asks students to talk and write about projects in programming languages she is still learning herself. These factors paint a picture of a teacher who has deeply personal and firm convictions for teaching programming and valuing student-centered exploration.

In the following year (2012-2013), Charlotte followed a structured curriculum guide when teaching with Scratch to 7th graders since the beginning of the school year

2012. But by the time she started teaching Scratch to 3rd graders in March 2013, she felt comfortable enough to allow the 3rd graders to explore and discover features of the tool on their own, which led to even greater success and enjoyment by the students. The teacher's motivation, skill with the tool and ability to reflect are factors that worked together to enable her to iterate and unlock connections between programming and English among her students. Education reform that seeks to penetrate the core of schooling must focus on promoting the growth of teachers in their understanding of the nature of knowledge and students' role in learning [7], and acknowledge the struggles of changing one's practice over time.

Charlotte discovered that, like Ricky, her 2012-2013 students could also learn language in new ways. Charlotte is currently working with a set of seventh-grade girls such as Lillie (pseudonym), a hearing impaired student with Asperger's syndrome, who are programming animations and drawing inspiration from writing to others through project comment logs on the Scratch online community. This is a significant development for Lillie, who would ordinarily not write unless she had to - preferring ASL to written communications. But she is motivated to write to her hearing peers through the Scratch online community to talk about the projects and as a result her writing has improved.

It is noteworthy that tools designed to lower the entry barrier for novice programmers are being shown to work also work for deaf students - and suggest an added benefit of facilitating English language learning. In fact, rapid successes that deaf children have in acquiring programming literacy may point to the existence of cognitive pathways for connecting a system of abstract symbols and their meaning that are not mediated by phonological representations. Success in learning is empowering and in these cases, learning to program with Scratch and StarLogo TNG built students' self-efficacy and increased their repertoire for creative and personally meaningful expression, helping to compensate for limitations in other forms of expression and providing opportunities to make connections with English language arts.

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