

# Teaching K-8 Students Computer Science Using Digital Storybooks

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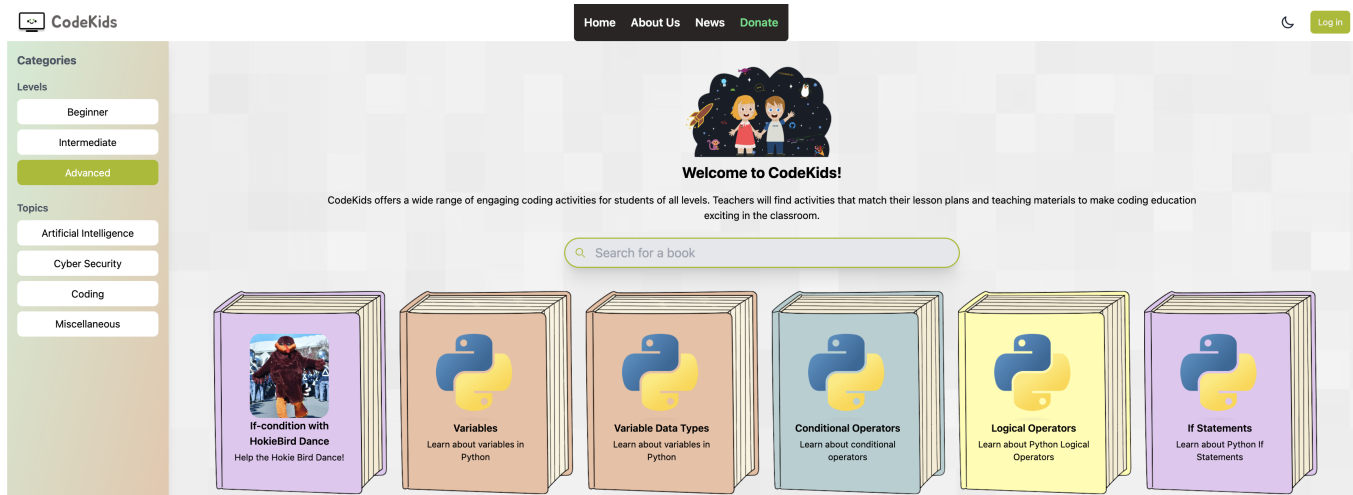


Figure 1: Home page of CodeKids showing advanced books.

## Abstract

**Introduction.** This study introduces CodeKids, a novel web-based platform to teach computer science to elementary and middle school-aged students using interactive digital storybooks. Several books on the CodeKids website were created to target common misconceptions young students form when learning foundational computer science concepts, including variables, conditionals, and loops. The primary objectives of this research are to evaluate student engagement and perceptions of the storybook format and determine if the books help prevent common computer science misconceptions for K-8 students.

**Methodology and Study Design.** This research was approved by the Virginia Tech IRB under protocol number 23-1266. A study was conducted with middle school students in the 6th and 7th grades, where students used two CodeKids books created to teach variables while also targeting commonly associated misconceptions. The books were designed to align with the *Computer Science Standards of Virginia Public Schools* [4] so teachers can seamlessly integrate

the books into their classrooms. Common misconceptions were identified from previous literature from authors including Swidan et al. [3], Žanko et al. [5], and Grover and Basu [2], and questions were created in the books to target the misconceptions. Misconceptions often stem from variable manipulation and the sequential execution of code. 97 students participated in a survey designed to gauge their perception of the books and prior programming experience, and 115 students completed a paper-based examination consisting of multiple-choice and matching questions that targeted specific misconceptions related to variables.

**Results.** Survey results indicated strong engagement with the books, with 82.5% of students responding positively to the interactive activities and examples provided within the books. Additionally, statistical analysis revealed a significant increase in students' perceived understanding of variables post-intervention (Figure 2). However, despite the positive perception of the books and positive self-assessment, examination results highlighted ongoing challenges with addressing misconceptions. Misconceptions remained a problem, particularly those that pertain to the sequential execution of code and variable manipulation. Furthermore, the research revealed a gap between the students' current computer science knowledge and the expectations set in the *Computer Science Standards of Virginia Public Schools* [4] (Figure 3), with most students indicating they have never used variables in programming despite variables first appearing in the fourth grade in the learning standards. This underscores a need for accessible educational

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material such as CodeKids to ensure schools meet the learning standards.

*Future Research.* Future research directions include the development and integration of adaptive learning elements within the storybooks to allow for varying difficulty based on individual student knowledge. Additionally, the development of more interactive program visualization tools is needed to keep students engaged and increase learning outcomes [1]. The books currently incorporate Python Tutor as a program visualization tool; however, students had mixed perceptions of this tool’s usefulness (Figure 4). A new tool where students answer questions as they click through the program will likely be more engaging for students. Lastly, a study should be done with experimental and control groups to understand the sustained impact of these digital books on misconceptions and overall learning outcomes.

### CCS Concepts

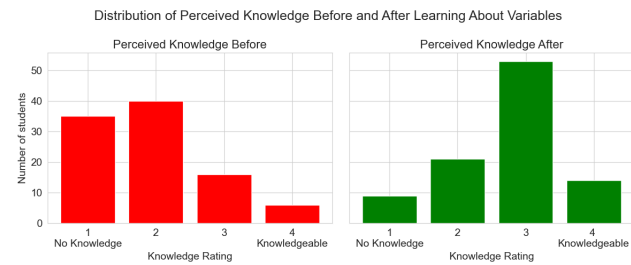
- **Social and professional topics** → **K-12 education; Children;**
- **Applied computing** → **Computer-assisted instruction.**

### Keywords

Computer science education, Digital education, Computational thinking, K-8 education, Misconceptions, Student engagement

#### ACM Reference Format:

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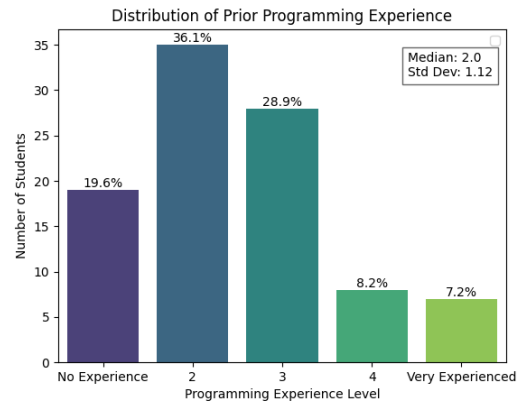


**Figure 2: Distribution of students’ perceived knowledge of variables before and after using the variables books.**

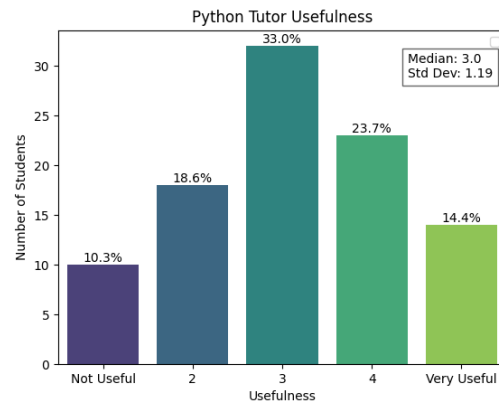
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**Figure 3: Distribution of students ranked prior programming experience.**



**Figure 4: Distribution of students ranked usefulness of Python Tutor.**

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