Coding Languages: Coding and Computational Thinking in a Language-Diverse Preschool

Abstract

There is an increasing emphasis on coding, computational thinking (CT), and computer science in early childhood, often interchangeably or alongside each other. Additional initiatives promote equity in computer science. The early childhood classroom can be a language-diverse setting including monolingual and bilingual children, second language learners, and children with language-related disabilities. We examined the relationship between CT and coding language knowledge in a language diverse preschool and found that the relationship between coding language and CT appeared different based on children's language experiences. This work could have implications for how we understand the relationship between coding language and CT in early childhood and how we teach coding and CT with consideration of the diversity of young children's language experiences.

Objective/Purpose

Coding, computational thinking, and computer science are becoming increasingly emphasized in early childhood years. However, although initiatives such as Computer Science for All have been promoting broader access and equity in K-12 computer science education, students do not have equal access to these key 21st century skills. Researchers and policy makers often discuss coding and computational thinking alongside or interchangeably to each other, using coding curricula to promote computational thinking or computational thinking assessments to evaluate coding programs. However, research has not examined the relationship between computational thinking and coding language knowledge, particularly for students from minoritized backgrounds. This paper examines how coding language knowledge and computational thinking knowledge relate for children across different dimensions of language diversity in an early childhood setting including bilingual classrooms, limited proficiency in the classroom language, and language-related disabilities and delays.

Framework

Early Childhood Computer Science

Early childhood computer science programs are discussed from the perspectives of both computational thinking and coding or programming knowledge. Although there is not a singular definition of computational thinking, computational thinking is generally agreed to be a set of cognitive skills that allow an individual to think in abstract and algorithmic ways (Grover & Pea, 2013; Wing, 2008). These skills are useful in the computer science and technology environments, but also in daily activities such as writing a recipe, retelling a story, or giving directions to the grocery store, each requiring sequencing (M. U. Bers, 2021).

One of the ways to promote computational thinking is to engage children in learning programming through developmentally appropriate coding languages (M. U. Bers et al., 2022). Bers's Coding as Another Language framework proposes an approach in which children learn coding as a new language, using methodologies similar to those use for teaching written languages (M. U. Bers, 2018, 2019). Like natural written languages, artificial coding languages have rules, vocabulary, syntax, and grammar. As children become fluent in the language by using the language in different contexts, they are greater able to express themselves and create meaning from the language's building blocks through storytelling, poetry, or programming. Previous research has shown an association between computational thinking and coding knowledge, but this research has not included children with language experiences such as language delays, speech or language disabilities, second language learning, or bilingualism (Relkin & Bers, 2020).

Language Diversity in Early Childhood

A language-diverse early childhood classroom can include a breadth of children's experiences, including experiences of bilingualism, monolingualism, limited proficiency in the language of instruction, or speech and language disabilities and delays (Gottfried, 2016). However, minimal research has been done on early childhood computer science education for children with many of these language experiences.

In early childhood, research has suggested that a computational thinking program using tangible robotics provided an opportunity for expression and self-advocacy for a student with a language disability in the general education classroom (Levinson et al., 2021). However, although findings and common sense suggest different disabilities may be associated with different needs in the computer science classroom, most research has talked about disability

broadly rather than the specific experiences of children with language-related disabilities (Blaser & Ladner, 2020; Levinson & Bers, 2022).

There is also minimal research on coding language learning for young second language learners. For children with limited English proficiency, research on the TIPP&SEE program for Scratch suggests the impact of receiving a bilingual CS curriculum may be more significant than that of a scaffolded curriculum (Salac et al., 2021). Research has not yet examined how coding language and computational thinking performance are related in the early childhood setting, including for children with diverse language experiences.

This paper is a preliminary analysis examining whether factors relating to children's language experiences impact children's baseline pre-curriculum assessments relating to a tangible robotics program. We asked two research questions: 1) How did coding knowledge and CT relate for children with different primary languages? 2) How did coding knowledge and CT relate for children when considering the presence or absence of language-related disabilities?

Method

Protocol

This paper is looking at data from a larger partnership project bringing tangible robotics to preschool children experiencing homelessness and examining computational thinking learning outcomes for the Coding as Another Language (CAL) KIBO PreK curriculum for three- to five-year-old children. Six classrooms at a preschool serving children experiencing homelessness in Boston, MA took part in this evaluation study with three classrooms teaching the curriculum. Before and after curriculum implementation, children were assessed by researchers on their coding language and computational thinking knowledge. Researchers visited the school and completed assessments in a quiet corner of the classroom. Assessments lasted between ten and twenty minutes. As not all children received the curriculum, this paper is only examining pre-curriculum student data.

Participants

Eighty-four children at a preschool for children experiencing homelessness were enrolled in the study, divided across the six classrooms. Three of the classrooms (27 children) were general preschool classrooms for children ages three and four, while three classrooms (47 children) were part of a structured city-wide universal prekindergarten program for children ages four and five. Children ranged in age at time of assessment from 2.8 to 5.5 years old, with a mean age of 3.9 years old. There was equal representation of boys and girls, with 39 boys and 45 girls participating in the assessments.

The children spoke a variety of languages both at home and at school, and each classroom had one teacher who could provide instruction in English and Spanish. Some classrooms had a teacher who spoke an additional language, but this was not a universal feature across the classrooms. Forty-one children' primary language was English; 28 children' primary language was Spanish; eight children' primary language was Haitian Creole; five children' primary language was Cape Verdean Creole; and two children' primary language was Amharic. Due to the lower numbers of children speaking Cape Verdean Creole, Haitian Creole, and Amharic and the fact that the school did not have teachers for these languages in the classrooms, we grouped the children speaking these languages for statistical analyses.

Due to the young age of the children and the role of preschool as the entry point for children to the education system, not all children with language-related disabilities were diagnosed at the time of the research. For this study, we defined children with disabilities as children identified by their teacher as 1) having been diagnosed with a developmental delay or

disability that would affect their language or communication; or 2) being in the referral process for a disability diagnosis or services related to language or communication. Example diagnoses related to communication and speech included speech and language delay, global developmental delay, and autism spectrum disorder. Fourteen children were identified by their teachers as being diagnosed with or referred for disability services.

Measures

Computational Thinking.

Computational thinking was assessed using the TechCheck assessment (Relkin et al., 2020). TechCheck is a computational thinking assessment for prekindergarten, kindergarten, first, and second grade children, and has been validated for kindergarten, first, and second grade children (Relkin et al., 2020). As the children in this study were between the ages of three and five and were enrolled in preschool, this study utilized the TechCheck PreK assessment. The TechCheck PreK assessment consists of seventeen multiple choice questions, each with three possible answers. Each item is indicated as either correct or incorrect, and children receive a summed score of up to fifteen.

Coding Language Knowledge

Coding language knowledge was assessed using the KIBO Coding Stages Assessment. This is an assessment of coding knowledge specific to the KIBO coding language and was designed to serve as a parallel assessment to the validated Coding Stages Assessment for ScratchJr (de Ruiter & Bers, 2021). Bers's model of Coding Stages suggests that individuals learn coding languages in five stages, similar to the stages of learning to read (M. U. Bers, 2020). These stages are Emergent, Coding and Decoding, Fluency, New Knowledge, and Purposefulness. The assessment accounts for these stages, with six questions specific to the KIBO coding language for each coding stage. Participants must answer five of the six questions in each stage correctly to move on to the questions associated with the next stage.

Language and Disability Information

The preschool provided demographic information relating to each child's primary language. We created indicator variables representing children whose primary language was English, children whose primary language was Spanish, and children whose primary language was a third language. Classroom teachers provided information regarding children's disability diagnoses and referrals.

Analyses

We estimated Pearson's product-moment correlations to examine the relationship between coding knowledge and computational thinking, both for the whole group and within groups of children based on language experience. To answer our first research question, we grouped children by their primary language, and to answer our second research question, we grouped children by disability status. We conducted all analyses using R and the tidyverse package (R Core Team, 2020; Wickham et al., 2019). All graphs were created using the ggplot2 package (Wickham, 2016).

Results

Relationship between Coding Knowledge and CT

Our first research question was if there was a relationship between coding language and computational thinking in early childhood. There was a significant positive correlation between CSA scores and TechCheck scores in the overall group of children ($r(82)$=0.34).

Primary Languages

When grouping children by primary language, this correlation did not exist for all primary language groups, answering our second research question. As seen in Figure 1, there were still positive correlations between coding knowledge and computational thinking for children whose primary language was English ($r(52)$=0.30) or Spanish ($r(20)$=0.31), both languages spoken in the classroom. However, there was a weak negative correlation between coding knowledge and computational thinking for children whose primary language was neither English nor Spanish ($r(7)$=-0.11).

Disability

Our third research question was if the relationship between coding language and computational thinking performance would be different for children with and without language-related disabilities. As seen in Figure 2, we found what may be a stronger correlation between coding knowledge and computational thinking for children without disabilities ($r(56)$=0.40) than for children with disabilities ($r(12)$=0.28).

Conclusions

This paper looked at the relationship between coding language and computational thinking performance across different dimensions of language diversity in an early childhood setting. As a pilot analysis, these are small samples, but our findings suggest that computational thinking and coding language performance may be less related for children with language-related disabilities or whose primary language is not spoken in the classroom than for their peers with a "standard" language experience.

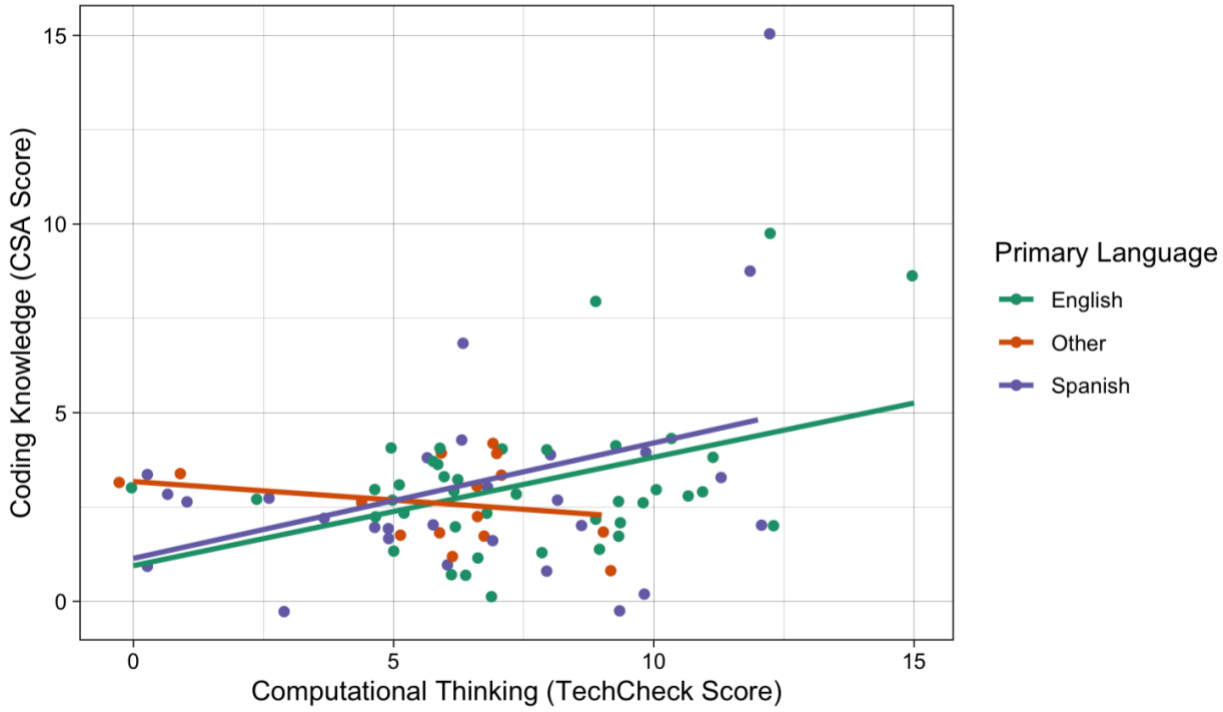
These findings suggest that further work must be done to understand the relationship between computational thinking and coding language knowledge, especially for children who do not fit the schema of how an English-speaking, nondisabled child would communicate in an American classroom.

Additionally, these findings suggest that researchers and teachers need to further consider the range of ways that children will approach materials and content in computer science, coding, robotics, and computational thinking programming. Diversity means diversity, and in a diverse classroom, a student with a weakness in one domain or on one assessment should not be assumed to be underperforming in another domain or on another assessment. Children who preform low in computational thinking might be high performers in coding knowledge, while other children might preform high on computational thinking and struggle with a coding language.

Finally, researchers should further consider how different assessments are accessible or inaccessible in a language-diverse setting. It is possible that different assessments are differently accessible. Researchers should more closely examine how each assessment may be accessible to bilingual children, children for whom the assessment is in a second language, children with language related disabilities, or children with other developmental disabilities such as motor-delays.

Figure 1

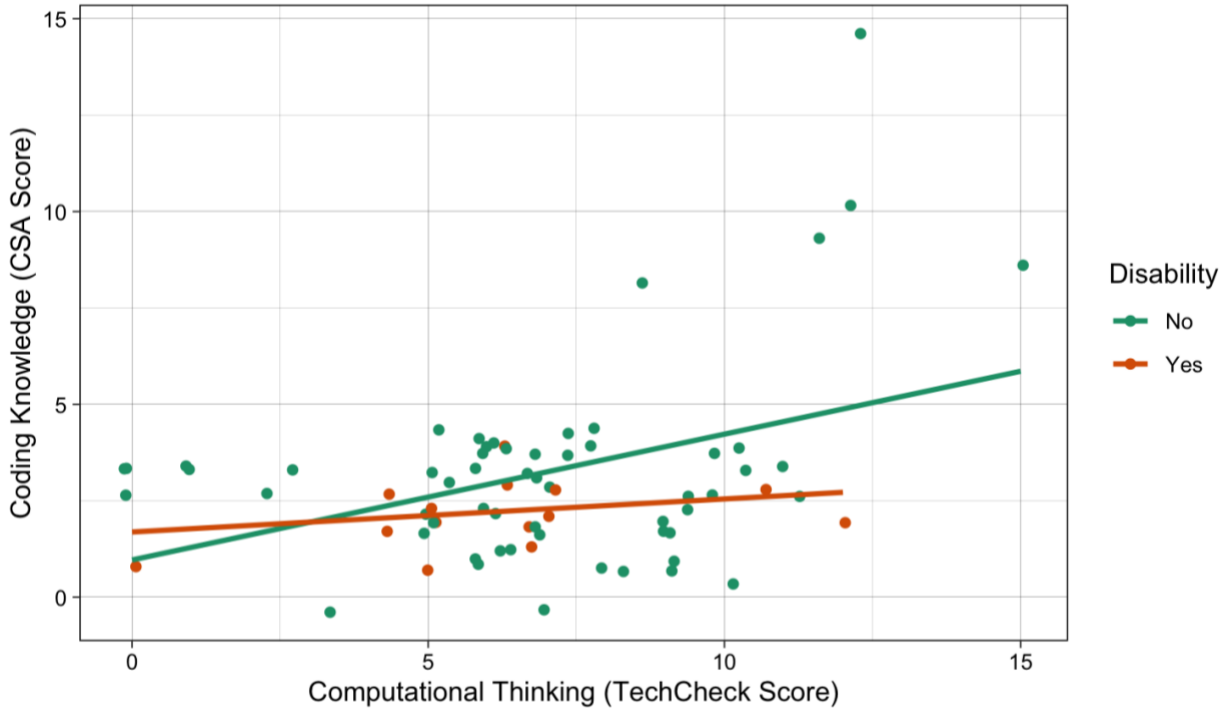
Coding Knowledge and Computational Thinking by Child's Primary Language



Note. Each classroom had a Spanish-speaking teacher with the ability to provide bilingual instruction in Spanish and English. "Other language" includes Haitian Creole, Cape Verdean Creole, and Amharic.

Figure 2

Coding Knowledge and Computational Thinking by Child's Disability Status



Note. Disability refers to 1) having been diagnosed with a developmental delay or disability that would affect their language or communication; or 2) being in the referral process for a disability diagnosis or services related to language or communication. Example diagnoses related to communication and speech included speech and language delay, global developmental delay, and autism spectrum disorder.

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