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Early Childhood Preservice Teachers' Perceptions of Computer Science, Gender Stereotypes, and Coding in Early Childhood Education

Fatih Ari[1] · Ismahan Arslan-Ari[1] · Lucas Vasconcelos[1]

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Abstract

The purpose of this exploratory study was to investigate early childhood preservice teachers' perceptions of computer science and gender stereotypes in computer science, and perceptions of coding in early childhood education. Quantitative and qualitative data were collected from early childhood preservice teachers enrolled in a teaching methods course at a large southeastern university in the U.S. Findings showed that participants had misconceptions about what CS is and what computer scientists do. They were also neutral about coding and its integration in early childhood education. Both qualitative and quantitative data supported that the participants did not hold gender stereotypes in CS.

Keywords Early childhood education · Preservice teachers · Computer science · Coding · Gender stereotypes

Introduction

Computer science (CS) education in K-12 has received considerable attention worldwide in the last decade. With many resources freely available and the advances in computing technologies, K-12 educators have been exploring different ways of infusing CS in formal and informal educational settings, expanding to early education years (Bers, 2019). However, many efforts and initiatives of integrating CS education during early education years are mainly extracurricular and voluntary, benefitting students who usually hold high interest in CS and come from families with high socioeconomic status (Funke et al., 2016; Goode & Margolis, 2011). Furthermore, aligned with the general gender disparities in CS, early childhood CS opportunities mostly attract boys (Cheryan et al., 2015). In addition, teaching CS in early childhood education requires developmentally appropriate learning experiences for young children rather than implementing strategies designed for older children (Bers, 2019; Bers et al., 2014). Therefore, there is a need for teaching CS in early childhood in a more inclusive, age-appropriate, and curriculum-integrated manner (Bers, 2019; Lee, 2020). In this sense, involving early childhood teachers in CS education and understanding their perceptions of CS, especially their gender stereotypes, become necessary to infuse CS in early childhood education successfully. A growing body of research focuses on the implementation (e.g., tools, software) of CS education with CS teachers in K-12 settings (Chang & Peterson, 2018); however, research focusing on non-CS teachers, especially early childhood preservice teachers, is scarce. Considering the recent attempts across the world to introduce CS concepts and processes in early childhood education, preparing early childhood teachers for this challenging task becomes a necessity.

Preservice Teachers' Perceptions of CS Education and Coding

Teachers are pivotal for integrating CS education in K-12 classrooms (Butler & Leahy, 2021; Yadav et al., 2017). However, research showed that many teachers hold narrow perspectives about CS education, considering it primarily equivalent to using computers (Li, 2021; Yadav et al., 2014). For instance, Yadav et al. (2014) reported that preservice teachers who were not trained for computational thinking perceived computational thinking as

✉ Fatih Ari
arifatih@mailbox.sc.edu; fatihari@gmail.com

Ismahan Arslan-Ari
arslanai@mailbox.sc.edu

Lucas Vasconcelos
limadel@mailbox.sc.edu

[1] Learning Design and Technologies Program, University of South Carolina, Wardlaw College 130, Columbia, SC 29208, USA

using computer technology whereas those who completed a week-long computational thinking module developed a more accurate conceptualization of computational thinking as a problem solving process using computing concepts with or without computers, in addition to positive attitudes towards integrating it into their future teaching. In a recent study by Butler and Leahy (2021), preservice teachers who completed a specialization in digital learning developed a better understanding of computational thinking concepts and how to teach them to children compared to their initial understandings. Similarly, Connolly et al. (2020) found that preservice teachers who participated in a makerspace program focusing on computational thinking and its integration into teaching demonstrated improved attitudes towards computing and efficacy beliefs in embedding computational thinking in their teaching.

In addition to these, several studies explored preservice teachers' perceptions of and attitudes towards coding and computer programming (e.g., Cetin, 2016, Lloyd & Chandra, 2020; Yukselturk & Altiok, 2017). Cetin (2016) compared attitudes towards programming in two groups of preservice teachers exposed to block-based programming and text-based programming instruction groups over a 6-week period. Study findings showed that preservice teachers' attitudes toward programming were not affected by the programming medium. In another study, Yukselturk and Altiok (2017) found that preservice teachers' negative attitudes toward programming significantly decreased after they worked with Scratch in a semester-long programming course. However, preservice teachers' willingness to take on more programming courses and their efficacy beliefs in learning programming did not change after the course. In a recent qualitative case study by Lloyd and Chandra (2020), senior preservice teachers who had prior experience with programming and robotics demonstrated a clear understanding of what coding and computational thinking are and emphasized the importance of coding skills for students in the 21st century. These findings clearly support the notion that developing an accurate understanding of CS education and positive perceptions about integrating CS education into teaching are crucial for encouraging preservice teachers to integrate CS education into K-12 classrooms (Butler & Leahy, 2021).

Although some attempts have been made to understand and improve preservice teachers' perceptions of and attitudes toward CS education (e.g., Yadav et al., 2014), research focusing on early childhood preservice teachers is still in its infancy (Angeli et al., 2016). To our knowledge, there are only a few studies that explored early childhood preservice teachers' experiences with and perceptions of CS education (e.g., Bers et al., 2002; Chang & Peterson, 2018), indicating a need for more research in this area.

Gender Stereotypes in CS

CS as a discipline has been extensively described by educators as a narrow and "leaky pipeline" (Almukhambetova et al., 2021; Berg et al., 2018; Varma & Hahn, 2008). First, the pipeline is narrow because the population in CS is predominantly formed by White males (Beyer, 2014). And second, the pipeline is leaky because minorities (e.g., females and people of color) who decide to join CS face higher attrition rates and end up switching educational and career paths (Clark, 2005; Varma & Hahn, 2008). These two factors lead to a field that lacks gender and racial diversity. In fact, females are critically underrepresented in CS (Graham & Latulipe, 2003; Pantic et al., 2018). Data shows that approximately 25% of professionals in the computing industry were female in 2020 (Bureau of Labor Statistics, U.S. Department of Labor, 2021).

One of the main factors leading to female underrepresentation in CS is stereotypes and misconceptions about the field, and about who can succeed (Pantic et al., 2018). Over the course of their lives, females are continuously exposed to stereotypical representations of a computer scientist as a White male who is highly intelligent, socially inept, works long hours, and chooses to spend time on gadgets and technology (e.g., programming) rather than around people (Cheryan et al., 2015; Vitores & Gil-Juárez, 2016). Meanwhile, females encounter social expectations to be feminine, sociable, and concerned about domestic and family matters (Camussi & Leccardi, 2005). These stereotypes about CS, in many instances, clash with social expectations for females. This undercuts their sense of identity and perceived ability. Specifically, females become unable to envision themselves as computer scientists, and to develop self-perceptions as capable individuals who can succeed in the field. As far as we know, no previous research has investigated early childhood preservice teachers' stereotypical beliefs in CS. Furthermore, considering that the majority of teachers, especially the early childhood teachers, are female in K-12 education (Zha et al., 2020) and that they serve as role models for young children (Master et al., 2014; Olsson & Martiny, 2018), it is important to understand the full extent of their stereotypes in CS (e.g., gender) early in their teacher training programs and offer strategies that would help them debunk such stereotypes before they start their teaching careers.

Hence, with this exploratory mixed methods study, our goal was to understand early childhood preservice teachers' perceptions of CS and gender stereotypes in CS, and perceptions about coding in early childhood education. In this study, we addressed the following research questions:

1. What are early childhood preservice teachers' understandings of CS education in general?
2. Do early childhood preservice teachers hold gender stereotypes in CS?
3. What are early childhood preservice teachers' perceptions of coding and its integration in early childhood education?

Methods

Study Context and Participants

Thirty-four senior early childhood preservice teachers, enrolled in two sections of an early childhood mathematics methods course at a large public university in the Southeast U.S, participated in this study. Due to the COVID-19 pandemic, the course was delivered online. The same instructor taught both sections. All of the participants were female and their ages ranged from 21 to 30, with a mean age of 22.09. Twenty-six of the participants identified themselves as White, four as Black or African American, two as Hispanic or Latino, and one as Asian. Only three participants reported that they had experience with coding prior to this study. To ensure confidentiality, we used pseudonyms when presenting qualitative findings.

Instruments

This exploratory study implemented a cross-sectional survey design to examine early childhood preservice teachers' perceptions of CS, gender stereotypes in CS, and integration of coding into early childhood education. Quantitative data was collected through an online survey consisting of three subscales: perceptions of coding (5 items), integration of coding into teaching (6 items), and gender stereotypes in CS (5 items). The items measuring participants' perceptions of integration of coding into teaching were adapted from Yadav et al.'s (2014) study. The items measuring participants' perceptions of coding and gender stereotypes were created by the researchers. Two experts, one with a master's degree in CS, reviewed the adapted items for face validity. To check the internal consistency of the subscales, Cronbach's alpha coefficients were calculated. The reliability coefficients for all subscales were good: perceptions of coding ($\alpha = 0.85$), integration of coding into teaching ($\alpha = 0.85$), and gender stereotypes ($\alpha = 0.92$). Lastly, the qualitative data were collected through open-ended questions and an adapted version of the Draw a Computer Scientist Test by Pantic et al. (2018). The test asked participants to draw a computer scientist and explain what their computer scientist is doing, identify their gender and ethnicity, and describe the typical day of the computer scientist.

Findings

The quantitative data were analyzed using descriptive statistics, and the qualitative data were analyzed using inductive analysis through open coding and simultaneous coding (Saldaña, 2016). Two of the researchers analyzed a sample of the participants' responses to open-ended questions and their draw a scientist test individually. Then, they negotiated the discrepancies between their analysis and created a revised coding scheme. The same coders completed the qualitative data analysis using the revised coding scheme and reached an agreement at the end of the coding process. The findings below are presented based on the questions explored in this study, combining the quantitative and qualitative results.

Q1: Preservice Teachers' Perceptions of Computer Science

We asked participants to explain what they think CS is and what a computer scientist does. Qualitative findings indicated that participants held a very narrow perspective regarding the definition of CS and what a computer scientist does. Many participants ($n = 15$) perceived CS as similar to programming and coding, as shown in "the study of programming software" (Tess), "the action of coding" (Samantha), and "programming software for a multitude of purposes" (Aveline). In addition, many participants ($n = 14$) mentioned that CS is about how to use computers and fixing computers. For instance, Ellie thought that CS is "the ability to use and navigate a computer". Similarly, Riley wrote that CS is "the study of how computers work". Interestingly, two participants used the word "science" in their definitions as shown in "using codes and technology for studying science" (Diana) and "working with science through the computer" (Amara).

Additionally, when asked about what a computer scientist does, participants' most referenced activity was developing software and computer programs ($n = 19$). This was followed by learning how to use and fix computers ($n = 6$), creating new ways of using computers ($n = 5$), and doing research ($n = 4$). For instance, Charley explained, "They [computer scientists] create softwares and codes, work with machines, and work with IT things". Another participant mentioned that computer scientists "create new ways to use computers in life" (Randzi). Similarly, Samantha emphasized that computer scientists "work with computers and learn the inside and outside of computers".

With the draw a scientist test, participants were also asked to explain the daily activities of their computer scientist. Aligned with their responses to the open-ended questions, participants indicated in their drawings that their computer scientists were programming (n = 15), and fixing computers and software (n = 5). Participants' drawings also identified activities that were not mentioned in their written responses. These included collaborating with other computer scientists (n = 7), using problem solving skills (n = 3), working with data (n = 3), and playing video games (n = 3).

Together, these findings show that the majority of female early childhood preservice teachers who participated in this study had a very narrow understanding of what CS is and what a computer scientist does.

Q2: Gender Stereotypes in Computer Science

This subscale included five-point Likert-type items, ranging from 1 (strongly disagree) to 5 (strongly agree). Results showed that participants did not hold gender stereotypes in CS ($M = 1.91$, $SD = 0.76$). All of the items in this subscale had a mean score below 3.00. (see Table 1). Among all the participants, only 22 of them completed the draw a computer scientist test. The analysis of participants' drawings was also aligned with the quantitative results as 11 participants drew a female computer scientist and 11 drew a male computer scientist. Also, the majority of the participants identified their computer scientist as White (n = 16). Examples of participants' drawings are provided in Fig. 1.

Q3: Preservice Teachers' Perceptions of Coding and its Integration Into Teaching

Participants were asked, on a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) to rate the importance of coding in early childhood education. Overall, they were neutral about coding in early childhood education ($M = 3.18$, $SD = 0.51$). It is noteworthy that participants perceived coding as helpful for students to become good problem solvers in their lives ($M = 3.47$, $SD = 0.66$) and to choose good careers in the future ($M = 3.29$, $SD = 0.68$). Among all the subscale items, there was one item with a mean score below 3.00 (see Table 2).

To gauge participants' perceptions of the integration of coding into teaching, we used six items on a four-point scale ranging from 1 (strongly disagree) to 4 (strongly agree). Overall, participants did not indicate high perceptions regarding the integration of coding into teaching ($M = 2.43$, $SD = 0.58$). However, on average, they acknowledged the importance of having background knowledge and understanding of coding and how to integrate it into teaching ($M = 3.03$, $SD = 0.72$). Of all the subscale items, only two items had a mean score below 2.00 (see Table 3), indicating they did not expect to teach coding in their future careers.

When asked about how they could integrate coding in early childhood education, several participants mentioned using games (n = 5), block-based programming such as Scratch (n = 2), and toys designed to teach coding concepts (n = 1). Additionally, two participants mentioned creating a technology center in their classroom where students could "work on coding apps that interest them" (Isabel) and "work

Table 1 Descriptive statistics for the gender stereotypes subscale items (n = 34)

	M	*SD*
I think that boys are better at coding than girls.	1.79	0.91
I think that male teachers would enjoy teaching coding in their classes more than female teachers would.	1.85	0.82
I think that boys are more enthusiastic about learning how to code than girls.	1.97	0.90
If given a choice, I think that boys would be more likely to choose learning how to code than girls.	2.12	0.88
If I needed to choose a student to do a coding demonstration for the class, I think that I would unconsciously ask a boy to share his computer program with the whole class.	1.79	0.81

Note. Scale ranging from 1 to 5: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

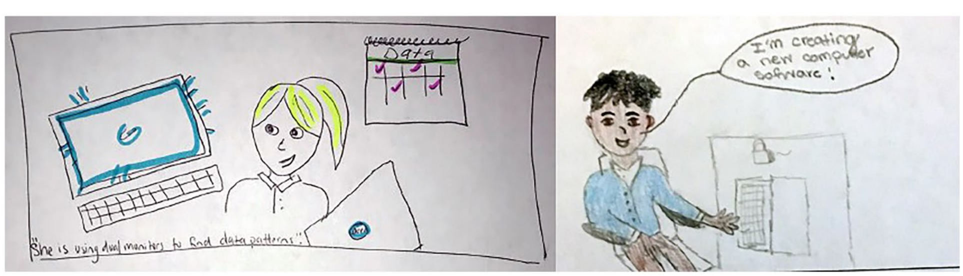

Fig. 1 Example computer scientist drawings of participants

Table 2 Perceptions of coding in early childhood education

	M	*SD*
Teaching kids coding is essential in today's world.	3.12	0.64
Coding should be integrated into the early childhood education curriculum.	3.06	0.60
As an early childhood education teacher of tomorrow, I believe that we should take courses on how to code and how to teach coding in different subject areas.	2.97	0.67
Coding would help kids to become good problem solvers in their daily lives.	3.47	0.66
Coding would help kids to choose good careers in the future.	3.29	0.68

Note. Scale ranging from 1 to 5: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree

Table 3 Perceptions of integration of coding into teaching

	M	*SD*
I can do well in infusing coding and computing into teaching.	2.24	0.74
I expect to use coding and computing skills in my daily life as a teacher.	1.97	0.72
I hope that my future career as a teacher will require the use of coding and computing concepts.	1.94	0.81
I think that the idea of infusing coding and computer science into teaching is interesting.	2.50	0.83
Computer science and coding can be integrated into classroom education in other fields.	2.91	0.79
Having background knowledge and understanding of how to infuse computer science and coding into one's own teaching is valuable in and of itself.	3.03	0.72

Note. Scale ranging from 1 to 4: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

on computer developing apps" (Sydney). Similarly, Rose mentioned establishing a school-wide program for kids to "join and learn more about coding". In terms of subjects, several participants wrote math, art, and science could be possible subjects where coding could easily be integrated. For instance, Kelly wrote, "Students can work in groups and come up with their own coding work through patterns. They can use shapes, colors, or different sized manipulatives to make their patterns." Besides these, eight participants noted that they were not sure about how to teach coding to kids. For instance, Tess indicated having no "experience with coding or computer science" as the main cause for this. Similarly, Ersa and Petra were not sure how to integrate coding, but they would "like to learn how". Additionally, two participants thought that allowing students to use their laptops would mean integrating CS into teaching. For example, Ellie said, CS is "already in the classroom while they [the students] learn to use their laptops". These examples clearly indicate a need to provide training for preservice teachers about coding and how to teach coding in early childhood education.

Discussion

The involvement of early childhood teachers is essential for age-appropriate, gender-inclusive CS education in early school years. Therefore, it is important to understand how early childhood teachers view CS and its integration in early childhood education and to prepare them to introduce CS to young children in inclusive ways. With this study, we explored early childhood preservice teachers' perceptions of CS and their gender stereotypes in CS, and perceptions of coding and its integration into early childhood education. The findings from this study showed that participants held a narrow perspective in terms of a general understanding of what CS is. Similar to Yadav et al.'s (2014) study, the majority of participants perceived CS as coding, and using and fixing computers. Parallel to their conceptualization of CS, they drew computer scientists who were either programming or fixing computers in the drawings (see Fig. 1). These shallow understandings of what CS is and what computer scientists do can be explained by the lack of knowledge of the CS field because preservice teachers, and even many in-service teachers, have very little or no experiences with CS (Lloyd & Chandra, 2020). Additionally, these early childhood preservice teachers had been practicing internship at K-12 schools and many schools nowadays implement camps or programs on robotics and coding. It is possible that the participants may have experienced or heard about such programs at their internship schools, which could possibly be another factor for their limited depictions of CS.

In terms of gender stereotypes in CS, the findings revealed that the participants did not hold gender stereotypes in CS. Both survey and qualitative data (i.e., draw a computer scientist test) supported this finding. For example, among the participants who completed the draw a computer scientist test (n = 22), 11 pictured a female computer scientist. Overall, this finding does not align with research findings indicating gender stereotypes in CS (e.g., Martin, 2004; Pantic et al., 2018). However, it should be noted that participants in these studies also included male participants and in the current study all of the participants were female.

With regards to perceptions of coding and its integration into early childhood education, participants' overall perceptions were not very positive. However, their ratings were higher than the average for several individual statements. For example, participants acknowledged the importance of teaching coding to kids, how coding would help kids become good problem solvers and to make good career choices in the future. Additionally, they reported that having background knowledge in coding and how to infuse coding into teaching is valuable for them. These findings in fact are aligned with the findings from previous studies (e.g., Yadav et al., 2014; Yukselturk & Altiok, 2017) in which preservice teachers reported positive perceptions and attitudes regarding coding after they participated in training on coding and its integration in K-12 education. The participants' low ratings in general may be explained by their lack of knowledge and skills in coding and its integration in teaching as only three participants indicated previous experience with coding in this study.

Conclusion and Implications

This exploratory study was an initial attempt to understand early childhood preservice teachers' perceptions of CS and gender stereotypes in CS, and perceptions of coding and its integration in early childhood education. The findings of this study highlighted the importance of training early childhood preservice teachers about what CS is and how to integrate CS in early childhood education as well as identifying and debunking their CS stereotypes. Implications for practice and directions for future research are discussed as follows.

Implications for Practice

It was evident from the findings that many participants had misconceptions about what CS is and what computer scientists do. Specifically, participants in this study shared a very narrow perspective regarding CS, perceiving it as coding, programming, or using and fixing computers. Also, some participants noted that they were not sure how to integrate coding but would like to learn how. These clearly emphasize the need for training early childhood preservice teachers on CS education, coding, and its integration in early childhood education. Hence, given the global focus on integrating CS in early childhood education, teacher education programs should equip these future teachers with the knowledge and skills needed to integrate CS in early childhood education. However, decision makers in teacher education programs should consider that such training should be integrated into the curriculum of teacher education programs and be continuous (Ray et al., 2020) rather than an isolated, one-shot training. For example, technology integration courses targeting early childhood preservice teachers may offer ongoing CS training and demonstrate integration of both developmentally appropriate plugged and unplugged CS activities into different teaching settings (Mason & Rich, 2019). Additionally, it is essential to provide early childhood preservice teachers opportunities to practice CS skills and knowledge hands-on and develop teaching activities integrating such skills in their corresponding subject areas. Connolly et al. (2020) demonstrated that makerspace has a great potential for providing hands-on CS education to preservice teachers. With busy schedules of teacher education programs, teaching method courses in early childhood education can be a place to seamlessly integrate the use of makerspace into the curriculum where early childhood preservice teachers develop and practice teaching strategies for CS education as they learn how to code and how to teach coding to young children.

Furthermore, the findings from this study showed that the participants did not hold gender stereotypes in CS. However, this does not indicate that such stereotypical beliefs might not be developed in the future. In fact, half of the participants (n = 11) who completed the draw a computer scientist test depicted male computer scientists and almost half of the participants (n = 16) who completed the survey described their computer scientists as White. This might indicate the existence of certain level of stereotypical notions among the participants, especially considering that all of the participants were female. A teacher who perceives CS careers as more appropriate for White males may unintentionally not direct female students or students of color towards such careers. Therefore, it is important to help preservice teachers to be aware of their CS stereotypes and to train them for more inclusive teaching practice. As a starting point, CS education training for early childhood preservice teachers can include opportunities to inform them about stereotypical beliefs in CS and to advocate for the notion that all students can succeed in CS. As Olsson and Martiny (2018) asserted, exposure to counter-stereotypical role models can possibly change people's aspirations in life. Therefore, such training can be provided by professionals who are counter-stereotypical examples (e.g., a female computer scientist) in the society.

Directions for Future Research

This study expands the literature on CS education by exploring early childhood preservice teachers' perceptions of CS and their gender stereotypes in CS. Preservice teachers' dispositions contribute to the successful development and buy-ins of CS education programs (Butler & Leahy, 2021). Therefore, how early childhood preservice teachers perceive CS, their stereotypical beliefs in CS, coding and its integration in early childhood education are important, particularly towards designing and implementing age-appropriate, gender-inclusive CS education in early school years. The findings of this study acknowledged the importance of providing training to early childhood preservice teachers, not only to get them familiar with general CS concepts but also to show how to integrate CS concepts in their future teaching and how to design and implement gender-inclusive CS education activities. Therefore, future research, especially longitudinal research, is needed to investigate the long-term effects of CS education initiatives targeting early childhood preservice teachers and how participation in such initiatives translates into more inclusive CS teaching practices in early childhood education. Longitudinal studies can also offer insights regarding the relationship between one's disposed beliefs acquired through surveys and interviews, and their actions and implementations in the classroom once they become a teacher.

Although participants did not report prevalent gender stereotypes in CS, many of them showed indications of a certain level of stereotypical notions (e.g., depicting a computer scientist as a White male). Various factors may contribute to developing such stereotypical notions, including but not limited to lack of knowledge or long-term exposure to stereotypical examples and role models through different venues (e.g., news, movies, etc.). As an initial step, future research should explore the underlying reasons for early childhood preservice teachers' stereotypical beliefs in CS. Another avenue for future research can examine the effects of exposure to the counter-stereotypical role models on early childhood preservice teachers' CS stereotypes and their CS teaching practices. Such exposure should introduce early childhood preservice teachers to diverse roles from the CS field and emphasize the importance of including female students in CS education at a young age. Further, this study did not include any male preservice teachers, so future research can also explore if such stereotypical beliefs and the effects of exposure to counter-stereotypical role models differ across male and female early child preservice teachers.

Lastly, early childhood preservice teachers in this study did not have strong negative or positive dispositions towards coding and integrating coding in early childhood education. In addition to lack of CS knowledge and skills, other factors (e.g., motivation, self-efficacy, perceived value) may have contributed to this outcome. Therefore, future research should investigate factors that might influence early childhood preservice teachers' perceptions of coding and its integration in early childhood education. Additionally, future research can investigate whether ongoing engagement with CS activities (e.g., robotics programming), particularly designed for early childhood education, helps preservice teachers develop more positive dispositions towards coding and its integration in early childhood education.

Study Limitations

There are several limitations to this study. First, due to the COVID-19 pandemic, the data were collected online, limiting our ability to supervise the data collection process. For example, it was not possible to confirm whether participants communicated to each other as they were drawing their computer scientists. Next, with open-response items, it was not possible to ask follow up questions based on the answers participants provided. Semi-structured individual interviews with each participant would have provided more in-depth information that could help us understand the underlying factors for their stereotypical beliefs. Lastly, all of the participants in this study were female. Therefore, the findings may not reflect male early childhood teachers' perceptions and stereotypical beliefs in CS, or their perceptions of coding for early childhood education.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

Research Involving Human Participants and/or Animals All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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