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Summer Coding Camp: Curriculum, Experiences, and Evaluation

Dr. Paea LePendu, University of California, Riverside

Paea LePendu is a Professor of Teaching in the Computer Science and Engineering department at the University of California, Riverside.

Dr. Cecilia Cheung, University of California, Riverside
Mariam Salloum, University of California, Riverside
Pamela Sheffler, University of California, Riverside
Ms. Kelly Downey, University of California, Riverside

I have a masters degree in electrical engineering. After working in industry, I found a passion for education. I am currently a lecturer at UC, Riverside for the computer science department.

Summer Coding Camp: Curriculum, Experiences, and Evaluation

Paea LePendu*[1], Cecilia Cheung[2], Mariam Salloum[1], Pamela Sheffler[2], and Kelly Downey[1]

[1]Department of Computer Science & Engineering, UC Riverside
[2]Department of Psychology, UC Riverside

Abstract

Many education-related organizations in the U.S., from the National Science Foundation down to local districts, have been pushing to introduce computer science concepts into K-12. Nevertheless, many students complete high school never having the chance to learn CS.

We have created a summer coding camp for high-school students (including 8th graders entering 9th grade) and designed a multi-year study to assess its effectiveness as an *informal learning environment*, based on theories of human motivation such as Self-Determination Theory [1].

The camp is a 1-week immersion experience, 9am to 5pm with food and activities, that introduces basic programming via MIT APP Inventor. Lecture material and in-class exercises draw upon meaningful applications, many appealing to "social good." One unique aspect is the inclusion of professional and career development activities that engage students and broaden perspectives on CS and its applications. For example, the camp includes a college information session, alumni talks, off-site visits to nearby companies, and research talks and demos by faculty.

Using a pre-and-post survey design, the current study examines the effects of the camp on student self-efficacy and interest in computing, as well as general school engagement and motivation. Results confirm that participation in the summer camp increased students' self-efficacy and interest in computing, enhanced engagement in school on topics in general, and strengthened intrinsic motivation for completing schoolwork. The effects were similar for boys and girls.

1 Introduction

We are all painfully aware of the disparities in access to computer science education. In California public high schools, nearly 75% of schools with the highest percentage of underrepresented students offer no computer science courses, and in the largest 20 districts, just

*Corresponding author Paea LePendu, sharing first author with Cecilia Cheung & Mariam Salloum.

1% of students are enrolled in any computer science course[2]. Today, less than 5 percent of all bachelor's degrees in computer science are awarded to minority women[3]. The lack of women from underrepresented and low-income families in the technology industry, and particularly in the Inland Empire (a region in Southern California larger than half of US States), presents an opportunity to make a significant difference by way of a new summer coding camp.

We have developed a CS4ALL Code Camp aimed at engaging traditionally underrepresented students in Computer Science, specifically women. The program is inspired by CSforAll, an initiative developed by the National Science Foundation and U.S. Department of Education to empower all American students to become active citizens in our technology-driven world. Similar programs in other parts of the country have been shown to increase the number of students, particularly girls and underrepresented minorities, who study computer science and go on to earn undergraduate degrees in the field. Currently completing its third year, this summertime experience provides a unique lens and an opportunity for us to study attitudes and interest in STEM in *informal learning environments* — a summer coding camp in our case.

Forming our hypothesis in this context, we evaluated the effects of summer camp participation on students' subsequent attitudes and interest in computing and general school engagement. We also examined whether the impact of the camp experiences was equal for boys and girls. Our guiding research questions are:

- Does participation in learning coding via a summer camp confer benefits for students' interest and attitudes in STEM?
- Does camp engagement facilitate students' school adjustment?
- Are there gender differences in the effects of the summer code camp experience?

2 Related Work

We acknowledge previous work in the K-12 space. Several papers have examined the effectiveness of summer code camps for both Middle School and High School students[4,5,6]. Recent work has shown that code camps that highlight computing in the context of digital humanities (DH) have shown positive results in increasing student's self-efficacy and interest in computing[5,6,7,8,9]. One key decision about the code camp offering was the choice of programming language (or coding platform). Wagner et. al. introduced a 3-week code camp for high school students that included an introduction to Java, Robotics, and mobile-app development in MIT App Inventor[10]. The authors concluded that students were quite excited when mobile-app development was introduced, moreover, teaching a visual language followed by Java 'allowed students to gain the confidence necessary to build applications, while reinforcing core concepts.' Sabin et. al. showed that a summer learning experience for girls in 7th - 9th grade using App Inventor boosted computing confidence and interest in computing careers[7], and similar results were reported by[9,10]. Hence, success from previous code camps inspired us to introduce our program using MIT App Inventor. Work by Clarke-Midura et. al.[8] is most similar to our work as it studies the effectiveness of *informal learning environments* on student's self-efficacy, interest in Computer Science, and perception of parental support. We note however, the work differs from this paper as our code camp experience was targeted toward high-school students and focused on

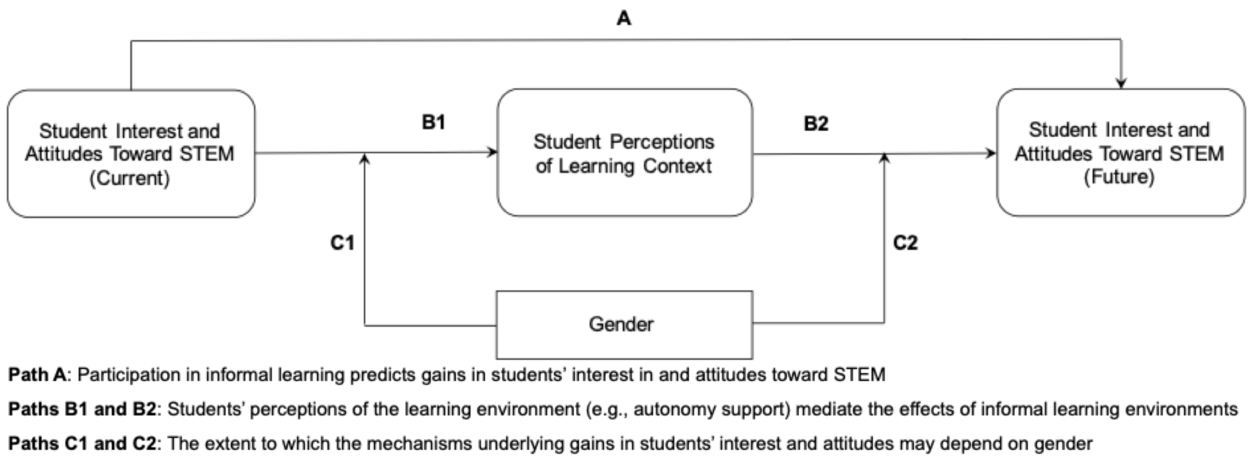


Figure 1: Guiding Process Model of Informal Learning and Student Interest and Attitudes toward STEM

studying student's motivation in-addition to their interest and self-efficacy. Moreover, our program was not limited to the 'coding experience,' as it involved activities to introduce students to various computing career paths, and speakers / panels about the college experience.

In designing and reporting of our code camp study (data collection and evaluation), we attempted to address recommendations outlined by McGill et. al. in the *Recommendations for Reporting Pre-College Computing Activities* (version 1)[11]. All identifiable information of the participants, such as their names, was removed from the dataset prior to data analysis. Some items, such as student demographic data that require 'Specific locations, including city, state, and country' was omitted to ensure anonymity of the authors and institution.

3 Background

Figure 1 presents the guiding theoretical framework for the current research.

There has been growing interest in how *informal learning environments* can maximize children's academic interest, goals, and future choices[12,13,14]. Given that children spend as much as 80% of their waking hours outside of school[15], informal settings, ranging from museums and zoos to community centers and the Internet, present valuable opportunities for children to enhance their learning experiences. Research indicates that learning activities embedded in informal environments are often conducive to children's short- and long-term interest in and attitudes toward science[16,17]. Despite the importance of examining the direct effects of informal settings on children's learning outcomes, little is known regarding how informal contexts shape children's attitudes and achievement in science and related fields. Specifically, scant research has examined the motivational underpinnings of informal learning settings and students' learning outcomes. Knowledge on the mechanisms underlying informal learning is crucial as it can enable educators and parents to improve their approaches to constructing effective informal learning environments and allow researchers to refine theories on the science of learning.

To date, research on informal learning has primarily focused on documenting the effects of

Measure	2018 Cohort *n*	2018 Cohort %	2019 Cohort *n*	2019 Cohort %	Combined *n*	Combined %
Sex						
Male	23	76.7	19	61.3	42	68.9
Female	7	23.3	12	38.7	19	31.1
Grade						
8th	4	13.3	0	0.0	4	6.6
9th	7	23.3	10	32.3	17	27.9
10th	10	33.3	8	25.8	18	29.5
11th	5	16.7	6	19.4	11	18.0
12th	4	13.3	7	22.6	11	18.0
Ethnicity						
African American	3	10.0	3	9.7	6	9.8
Asian or Pacific Islander	9	30.0	5	16.1	14	23.0
Caucasian	4	14.3	2	6.5	6	9.8
Latino/Hispanic	6	20.0	13	41.9	19	31.1
Multiracial	5	16.5	7	22.5	12	19.7
Other	1	3.3	0	0.0	1	1.7
Ethnicity not provided	2	6.7	1	3.2	3	4.9

Figure 2: Participant Demographics

different forms of learning environments on children's interest and achievement. Despite the importance of this body of work, extant knowledge on informal learning contexts is limited in at least three ways. First, much research has focused on the concurrent associations between participation in informal learning and students' outcomes. As such, it is unclear whether informal learning sets the stage for future gains in students' interest in and attitudes toward STEM. Second, a majority of the research has utilized relatively small samples and did not employ null hypothesis testing to evaluate the impact of informal learning environments on students' outcomes. Third, there has been scant research on whether informal learning experiences, such as summer coding camps, are universally beneficial for all students — particularly students who are underrepresented in the STEM fields.

Drawing on the core tenets of Self-Determination Theory (SDT)[18,1], the current research stipulates that students' perceptions of competence, autonomy, and relatedness underscore effective informal learning environments. According to SDT, competence, autonomy, and relatedness are basic psychological needs conducive to human motivation; once these needs are fulfilled, individuals flourish[19]. Research has consistently demonstrated the importance of self-determination in the formal learning context, such as the classroom[20].

4 Methods

4.1 Camp Demographics and Study Participants

The study spans years two and three (2018 and 2019) of the CS4ALL Code Camp. During these two years nearly 200 early adolescents participated in the camp. The general age range of all camp participants was 13 to 17 years, in 8th through 12th grades. A total of 61 participants completed the survey on the first day of the code camp and one month after the camp concluded.

Participants were recruited from several school districts in Southern California and were from diverse ethnic and socio-economic backgrounds, but all are welcome. In our sample, approximately 31% of the participants were Hispanic-Latino American, 10% were European American, 23% were Asian American and Pacific Islander, and 10% were African American. A majority (54%) of those who completed the survey were Latino/ Hispanic and Asian/ Pacific Islander. There were more boys (69%) than girls in the current sample. Figure 2 presents a summary of participants' demographics.

4.2 Camp Curriculum and Activities

The code camp assumes no prior programming experience ("no experience necessary") and provides a gentle introduction to programming through MIT APP Inventor, which is an educational tool that allows students to easily and quickly develop apps and deploy them on an Android device or emulator[21,22]. This aspect of the camp is expected to enhance students' perceptions of competence, a key dimension in SDT.

The camp is designed such that there is a lecture in the first half of each day, followed by hands-on exercises in the afternoon. The schedule is also packed with team building and professional development activities. Activities include Skype and in-person alumni talks, industry site visits and Q&A with engineers, faculty research talks, and a University career center visit where staff discusses the college application process, various majors in STEM, alumni connections and inspirational stories. These features of the camp align with the dimensions of relatedness and autonomy in SDT.

The code camp was led by a female faculty/lecturer that has extensive experience with teaching lower-level Computer Science courses at the University level. The code camp instruction team also included undergraduate student teacher assistants (TAs); two female TAs and one male TA, all of whom were Computer Science majors. The code camp schedule is provided in Figure 3. Time blocks are highlighted based on the activity type, which includes lectures, hand-on lab activities, and professional or team-building activities. The code camp culminates with a showcase in which students demo an original app that they developed on the final day. All parents and family members are invited to the showcase and both students and the family greatly enjoy this event. One important component of the camp that is emphasized is that learning can continue beyond the camp. Each student is gifted an Amazon Fire tablet and trained to deploy apps developed on the tablet so they can continue to create and showcase their creativity.

4.3 Study Design

The study utilizes a prospective short-term longitudinal design to collect data from participants on the first and last day of the camp, and four weeks after the conclusion of the summer camp. The current analysis focuses on survey data gathered on the first day of the camp (baseline) and four weeks after the camp concluded.

An opt-in consent procedure is used such that parents must provide consent for their children to participate in the study. Approval from the Institutional Review Board was obtained.

On the first and final days of the camp, participants who agreed to take part completed a brief

	Monday	Tuesday	Wednesday	Thursday	Friday
9:00 – 10:00	Introductions / Ice breaker / campus tour	Lecture: variables, textbox, labels, branches	Lecture: Intro to Animation	Lecture: Animation Continued.	Work on showcase project
10:00 – 11:00	Qualtrics Survey	Lecture: Walk through Lab #2 logic and enhance application	Lab # 5	Lab # 7	
11:00 – 12:00	Lunch	Lunch	Lunch	Lunch	Lunch
12:00 – 1:00	Lecture: Intro to Computer Science. Intro to App Inventor	Lecture: Lists and Canvas components	Lecture: Intro to loops	Lecture: Loops continued (nested loops)	Continue working on showcase project
1:00 – 2:00	Lab # 1	Lab # 3	Lab # 6	Lab # 8	
2:00 – 3:00	Lecture: Algorithms, App Inventor components, conditional statements	Create Lab Visit (3D printing)	Industry on-site visit	Brainstorm showcase project ideas	
3:00 – 4:00	Lab # 2	Campus Scavenger Hunt			Faculty Research Talks
4:00 – 5:00	Open discussion of applications of CS and other topics	Lab # 4		Career Center Visit & Alumni Skype Talk	Qualtrics Survey
5:00 – 6:00	End of Day	End of Day	End of Day	End of Day	Symposium (with parents and family members)

Figure 3: Code Camp Schedule

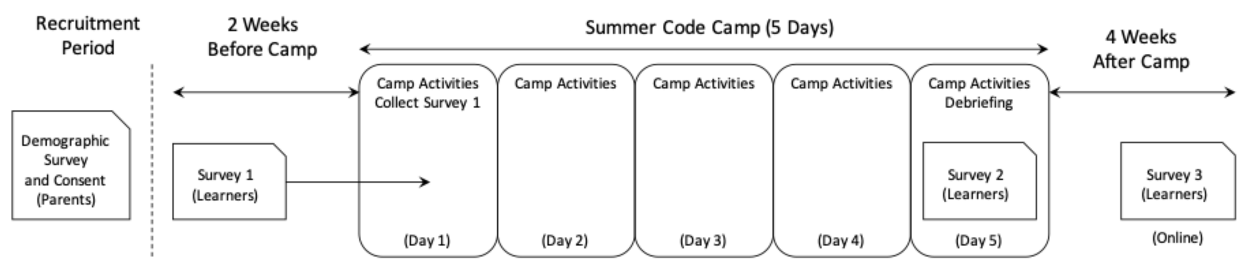


Figure 4: Study Design

survey which assessed their interest and attitudes in STEM. They also responded to questions about their general school functioning, such as school engagement and their motivation for completing homework. Four weeks after the conclusion of the camp, participants completed a short follow-up survey online. Participants receive a $25 gift card upon completion of the final survey as a token of appreciation. Figure 4 presents the design of the research.

Validated measures with high reliability were chosen to assess students' interest and attitudes in STEM, as well as their perceptions of competency in the context of the summer camp. Using a 5-point Likert scale, participants indicate the extent to which they agree with each of the statements in the survey (1 = Not at all true; 5 = Very true). To measure students' interest, a measure adapted from the Academic Self-Regulation Questionnaire[23] was used. Students' attitudes in STEM were assessed with a measure developed by Pomerantz, Saxon, and Oishi[24]. Students' perceptions of competence was assessed with a measure adapted from Steinberg, Lamborn, Dornbusch, & Darling[25]. Demographic information (ethnicity, age, and gender of the child) were obtained from parents. (The full survey instrument can be made available upon request.)

Two sets of analyses are conducted. First, to address the first two research questions, paired t-tests were conducted to examine changes in participants' interest and attitudes in STEM before and after the summer camp. Second, the extent to which the effects of the camp was equal for boys and girls was examined using independent sample t-tests.

5 Results

Data based on a sample of 61 participants were analyzed to understand the effectiveness of the camp in enhancing students' motivation and school engagement.

5.1 Motivation for the code camp engagement

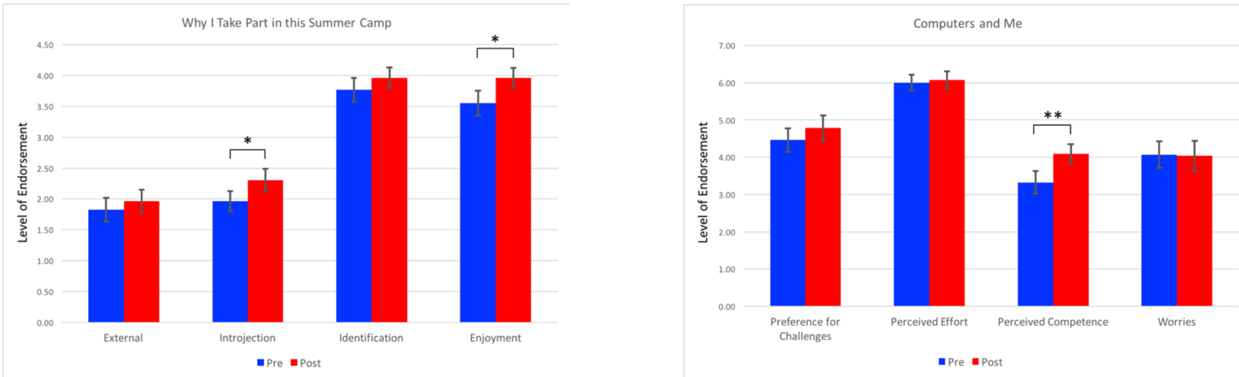
Participants responded to eight questions about their reasons for taking part in the code camp. Students had stronger intrinsic (vs. extrinsic) motivation in general. However, among the four types of motivations assessed (external, introjection, identification, enjoyment), students' enjoyment in the camp significantly increased after they took part in the camp. The mean for enjoyment on the first day of the camp was 3.55, which rose to 3.96 one month after the camp concluded. This difference was statistically significant, $t = 2.10, p < .05$. There was also an increase in participants' introjected reasons (e.g., to avoid a sense of guilt) for engaging in the camp. However, participants' endorsement of enjoyment was substantially higher than their endorsement of introjected reasons. Figure 5 summarizes these results.

5.2 Perceived competence in coding

Participants responded to eight questions on their attitudes toward coding. Two questions tap participants' perceptions of their own competence in coding. Results indicate that participants viewed themselves as more competent in coding after taking part in the camp. Average perceived competence was 3.32 at the start of the camp and was increased to 4.09 a month after the camp concluded. This difference was statistically significant, $t = 3.31, p < .01$. Figure 5 summarizes these results.

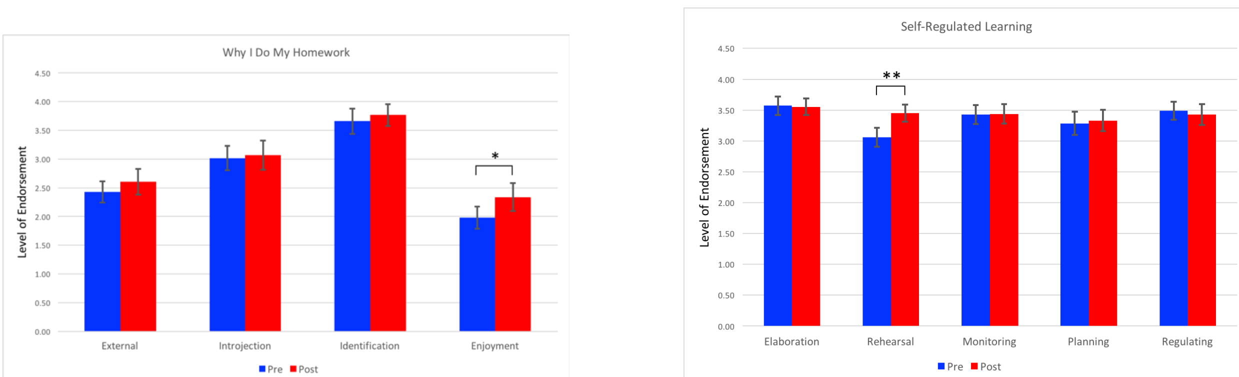
5.3 School-related outcomes

Participants responded to eight questions about their reasons for completing their homework and 30 questions on the strategies they used in regulating their own learning in school. Participants' homework enjoyment was 1.98 at the start of the camp, and this figure rose to 2.34 one month after the camp concluded. This difference was statistically significant, $t = 2.17, p < .05$. Participants' use of rehearsal as a learning strategy was 3.06 at the start of the camp; this was increased to 3.45 one month after the camp ended. This difference was statistically significant, $t = 3.31, p < .01$. Hence, not only was the camp impacting students' camp-related experience, there appears to be a spill-over effect on students' general school engagement. Figure 6 summarizes these results. Significant differences between the pre- and post-levels were highlighted in the graphs with asterisks.



(a) Motivation (b) Perceived Competence

Figure 5: Motivation and Competence



(a) Homework Motivation (b) Self-Regulated Learning

Figure 6: School Related Outcomes

5.4 Gender differences

There were substantially more boys ($n = 42$) who took part in the survey than girls ($n = 19$). Nonetheless, independent sample t-tests were used to examine whether students' learning outcomes differed between boys and girls. On the first day of the camp, there was no difference in students' perceptions of competence, homework motivation, and school engagement between boys and girls, $ts < 1.47, ps > .148$. Likewise, a month after the conclusion of the camp, there was no statistically reliable difference between boys and girls on the outcome measures, $ts < 1.10, ps > .283$. Hence, the camp experiences were similarly effective in these domains of learning for both boys and girls.

6 Discussion

Results show that the code camp is an effective informal learning activity, as it can facilitate students' self-efficacy and engagement in both computing as well as learning in general. Consistent with our guiding conceptual model, features characteristic of this summer camp, including connecting lessons to the real-world with applications, team building, and professional development, seem to matter. Indeed, given that students had no prior experience in coding, the week-long activities appeared particularly effective in instilling a sense of competence in the participants, which may encourage students' future participation in STEM related educational pathways and careers. In addition, the camp likely facilitated students' feelings of autonomy by allowing them to engage in self-directed activities, such as coming up with their own ideas for showcase projects. A sense of relatedness is also likely a consequence of the camp, as students worked in teams and had opportunities to interact with alumni and faculty.

Not only was the camp experience conducive to students' sense of competence in coding, findings revealed a difference in students' school engagement, specifically enhanced enjoyment in homework and heightened motivation in using rehearsal as a strategy to regulate their own learning. This suggests that informal learning experiences could confer "spill-over" effects for students' general school adjustment.

A notable finding is that boys and girls appear to benefit from the camp experience equally. While there was a general increase in students' level of interest, perceptions of competence, and other school-related outcomes, there was no reliable difference between boys and girls both before and after the summer camp. This suggests that informal learning environments may be useful in encouraging female (as well as male) students' participation in coding and STEM related fields, especially when the camp includes features that bolster students' sense of competence, relatedness, and autonomy, and could be a fruitful pathway to encourage female participation in computer-related fields. However, it should be noted that the current sample size, after splitting by student gender, was relatively small. Hence, the lack of difference could be attributed to insufficient statistical power.

6.1 Future research directions

This research provides initial evidence that informal learning contexts such as summer coding camp can build up students' interest and self-efficacy in coding. Although the pre- and post-design allowed for an examination of within-person changes over one month, future research following students for a longer period of time would be necessary to understand whether the effects are sustainable and transferable into differences in students' future education and career choices.

Future research should also attempt to understand the psychological mechanisms underlying successful summer camp experiences. For example, it is unclear whether the experience is more beneficial for students who posses a growth mindset, or the belief that their ability is malleable through hard work, in approaching new learning materials.

7 Conclusion

In conclusion, we created a CS4ALL Code Camp aimed at providing a gentle introduction to computer science for high school students. This informal learning environment introduced students to computer science using a fun, low-stakes approach, which increased both their sense of competency at computer coding as well as their motivation and school-related outcomes. These results have important implications for students as a whole, including women, who are underrepresented in the field. Adopting the ‘no experience necessary’ mantra seems to have many positive effects - interest, enjoyment, confidence, engagement, and broader participation. As evident in the current research, informal learning contexts may aid in the efforts to diversify future interest and pursuit of computer science and other STEM disciplines.

8 Acknowledgements

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