The Impact of Non-Formal Computer Science Outreach on Computational Thinking in Young Women

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ABSTRACT

The role of non-formal education in increasing female participation in Computer Science (CS) is a hot topic. Short-term interventions, including programming skill outreach activities, have been reported to increase self efficacy and willingness to pursue computing careers in young women. We explored the impact of a programming outreach activity on three types of measures for 30 female pupils: computing self-efficacy, social participation, and understanding of basic computing concepts. Preliminary results revealed a significant increase in participants' self-efficacy and sense of belonging in computing after the informal learning activity. Students were more focused on tasks when engaging socially with their peers and teachers. A decrease in misconception was observed in uni-structural knowledge but no significant difference was found in multi-structural computing knowledge acquisition. These data provide a baseline for study of the long term impact of outreach activities.

1 INTRODUCTION

There is an ever-increasing number of initiatives focused on introducing CS education to young female pupils in non-formal settings. Nevertheless, the impact of these interventions remains an open question. While promising results have been reported for increased self efficacy [1], little is known about the effectiveness in developing computational skills. We report the assessment of a single-day intervention delivered to a group of novice female pupils from an ethnic minority background.

2 METHODS

Thirty female pupils from an Islamic Bradford (UK) school participated in a 3-hour session, part of a city-wide outreach and skill development programme, Digital Makers, on International Women's Day. The session comprised: *(i)* an introduction on the Digital Divide; *(ii)* a 50-minute workshop on 'Mission Zero': The European Astro Pi Challenge 2022/23 hosted by Raspberry Pi[1]; *(iii)* a panel discussion with female leaders in technology. Our assessment tool captured three key measures of success for the intervention: *(i)* Computer self-efficacy; *(ii)* social participation; and *(iii)* computational thinking in light of a taxonomy that combines Bloom's and SOLO taxonomies [2]. Knowledge of **uni-structural** and **multi-structural** computing concepts (e.g, initialisation, data abstraction, and loops) was measured immediately before and after the Challenge session. Participation was captured with a task-specific, binary (1=on task, 0=off task) measure scored every 5 minutes for each participant during the task. Experiences of self efficacy and attitudes towards STEM were measured through pre- and post-programme surveys, captured before and after the Challenge.

3 RESULTS AND CONCLUSION

Observations revealed that participation decreased steadily over the session. 100% of students were on-task during teacher-led whole class instruction. Students spent 28% of their time interacting with teachers and were more on-task (100%) than when working in pairs (79.5%) or working individually (54%). Paired t-tests demonstrated students were significantly more likely to join a technology club at school after the non-formal education activity (M=2.84, SD=1.46) than before (M=3.47, SD=1.02); t(18)= 2.47, p=0.024. Students were also more confident afterwards (M=4.05, SD, 0.71), than before (M=2.84, SD=0.96); t(18)= 5.75, p <0.001). Notably, they were more motivated before (M=2.79, SD=1.032) than after (M=4.0, SD=1.0); t(18)= 4.65,p<0.001. The results also suggest a sense of belonging to their local computing community was fostered (M=3.68, SD=0.95) compared to ratings before the non-formal education program (M=2.58, SD=1.017); t(18)= 4.60, p<0.001. All p values were adjusted using the false discovery rate correction. Computing knowledge acquisition varied across uni-structural and multi-structural knowledge constructs, with correct answers to a uni-structural construct (abstraction) task almost doubling from 23.8% before to 47.7% after the activity. Fewer students (42.9%) selected wrong answers when applying uni-structural (initialisation concept) knowledge (down from 57.1%) but more students expressed uncertainty about the correct answer (pre-test=9.5%, post-test=28.5%). No improvement was found in multi-structural knowledge application, or the ability to independently write code. These results support evidence about the benefits of informal CS education in improving self-efficacy in underrepresented groups. The role of social participation was reinforced. However, our findings suggest more work is needed to establish the long term effectiveness of such programs in supporting computational thinking.

[1]https://astro-pi.org/mission-zero/

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REFERENCES

[1] Grace Lawlor, Philip Byrne, and Brendan Tangney. 2020. "CodePlus"—Measuring Short-Term Efficacy in a Non-Formal, All-Female CS Outreach Programme. *ACM Trans. Comput. Educ.* 20, 4, Article 25 (oct 2020), 18 pages.

[2] Orni Meerbaum-Salant, Michal Armoni, and Mordechai Ben-Ari. 2010. Learning computer science concepts with scratch. In *Proceedings of the Sixth international workshop on Computing education research*. 69–76.