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Prior Experience of Students, Teachers, or Both? Impacts on Affective Factors for Physical Computing

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Abstract: To expand equitable participation in physical computing, we report on an exploratory study for an in-school-time automated-greenhouse project with 8th-grade youth in an urban-ring city of the Northeast US. From pre- and post-surveys, observations, and mid- and post-interviews, we analyzed five affective factors, relative to prior experience of both students and teachers, as well as student race/ethnicity. Our findings have implications for educational design and ensuring that repeated experiences in physical computing improve affective outcomes.

Introduction

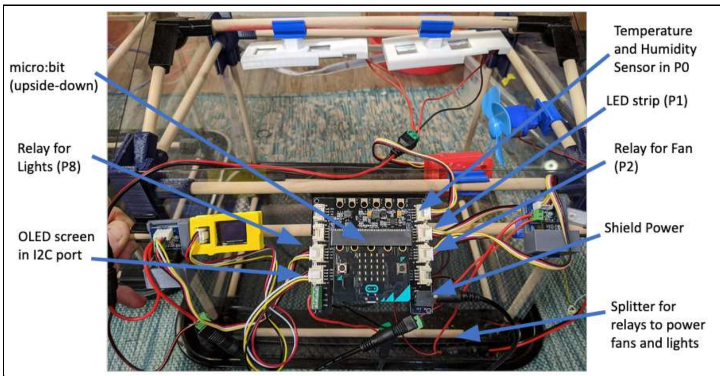
Computing is "a foundational new literacy" through which you can "share ideas in socially and culturally relevant ways", yet current K-12 learning experiences privilege higher-income communities (Blikstein, 2018, p.4). One way to support equitable learning is to embed computation in required classes for STEM disciplines. In particular, computation using devices with strong connections to the physical world, or *physical computing*, shows promise for affective, cognitive, and career outcomes, especially if supported by teacher development. However, experience can also have negative effects for youth and adults in low-quality interventions (Blikstein, 2018).

Drawing on self-efficacy theory (Bandura, 1993), this study centers youth's views on their capabilities in computation, specifically for competency belief and intention for future careers. Building upon previous work in physical computing (Asante et al., 2021; Blikstein, 2018), we developed an automated-greenhouse project to leverage affordances of block-based programming, along with plants that can be studied using all human senses and a variety of sensors (temperature, light, etc.). We hoped that the brief intervention could catalyze youths' orientations towards computing. We based our exploratory study on the question, *in the context of an automated-greenhouse project, what factors impact 8th graders' affective outcomes of interest, competency belief, anxiety, intention for future careers, and connections between coding and science?*

Methods

Participants include 108 students from two teachers' (Ms. B's and Ms. T's) classes of an urban-ring, public middle school in the Northeast US (14% African-American / Black, 4% Asian / Asian-American, 16% Hispanic/Latinx, 59% white, 12% two-plus races/ethnicities; 47% female, 51% male, 2% non-binary). Ms. T had experience teaching with BBC micro:bit, a low-cost microcontroller with built-in sensors, that is programmable through either text- or block-based interfaces, on- or off-line. Ms. B was teaching with micro:bit for the first time. During seven, one-hour class periods in spring 2021, students learned to code micro:bit to control sensors and actuators on a tabletop greenhouse. An outline of the curriculum and a photo of a completed greenhouse are in Figure 1.

Figure 1
Automated Greenhouse and Curriculum Outline



Curriculum Outline
1. <u>how greenhouses work</u>: assemble greenhouse, then plant microgreen seeds
2. <u>coding with functions</u>: manipulate colors of 30-light, LED color-strips
3. <u>using logic statements</u>: incorporate the temperature & humidity sensor
4. <u>more logic statements</u>: automate the circulating- and exhaust-fans
5. <u>design choices</u>: positioning sensors + calibrating LED grow-lamps
6. <u>extra challenges</u> | 7. <u>class showcases</u>

In this mixed-method study, quantitative data were sourced from student pre- and post-surveys, which had 5-point, Likert-style items to measure student affective learning, including five subscales based on self-efficacy theory and validated in previous iterations (Asante et al., 2021; Bandura, 1993): *interest, competency belief, anxiety, intention for future careers,* and *connections between coding and science*. Qualitative data sources were student post-interviews (N=17), mid- and post-interviews with both of the teachers, and field notes and memos.

MANOVA and ANOVA in SPSS® were used to analyze quantitative data. For all analyses, the dependent variables were those in the research question. For MANOVA, the independent variable was prior experience, a hybrid variable for both students *and* teachers, from binary self-reports of whether or not they had previous experience learning or teaching coding (i.e., "MsT-yes" indicates that both teacher *and* student had experience, whereas "MsB-no" indicates that neither teacher *nor* student had experience). For ANOVA, we ran individual tests for the dependent variables, using three levels of race/ethnicity based on over- or under-representation in US STEM careers (Asian / Asian-American + white; African-American / Black + Hispanic/Latinx; and two or more races/ethnicities). Qualitative data were coded deductively per the five dependent variables, the four experience combinations, and race/ethnicity, then axially to identify possible connections amongst variables (Saldaña, 2009).

Results

MANOVA analyses show that *before* this project (but after Ms. T started a different micro:bit project), there was a significant main effect of LearnerAndTeacher experience on the set of five dependent variables [V(Hotelling's trace) = 0.299, F=1.969, p =0.017] and on Competence Belief (F=7.402, p <0.001). *After* the project, we found a significant main effect of LearnerAndTeacher experience on the set of dependent variables [V(Hotelling's trace) = 0.384, F=2.529, p =0.002], and on Intention for Future Careers (F=7.707, p =0.004).

In terms of between groups, before the project there were significant effects of LearnerAndTeacher for MsB-no vs MsT-yes (Mean difference=-2.7776, p =0.022) on Interest. There were also significant differences on Competence Belief for MsB-no vs MsT-yes (Mean difference=-2.4461, p <0.001) and MsB-no vs MsT-no (Mean difference=-2.0878, p =0.002). After the project, significant effects of LearnerAndTeacher are observed on MsB-no vs MsT-yes (Mean difference=-1.7139, p =0.037) on Competence Belief. There are significant differences on Intention for Future Careers for MsB-no vs MsT-yes (Mean difference=-3.2402, p =0.005) and MsB-no vs MsT-no (Mean difference=-2.9406, p =0.020). There are significant differences on Anxiety for MsB-yes vs MsB-no (Mean difference=-2.6552, p =0.012) and significant differences on Connection between Coding and Science for MsB-no vs MsT-yes (Mean difference=-1.6945, p =0.034).

ANOVA results show no statistically significant differences between white and Asian students, relative to their Black and Latinx or multiracial peers, on the *pre*-survey, but there were differences on the post-survey (mean difference = 1.79, p = .004). This difference is especially concerning given the directionality; for over-represented students, anxiety slightly decreased, but anxiety increased for peers from under-represented groups.

Qualitative analyses of observations and teacher-interviews suggest that some differences might be due to group dynamics, as groups of three students often had one student disengaged. Interview data show that anxiety, competency belief, and career intention might have been affected by the lack of time for further activities, and also by students' pre-existing interests in careers they saw as not coding-intensive.

Discussion

This study shows the importance of both student and teacher experience for education in physical computing. The data suggest that inexperienced students, teachers, or both might feel no impact or even negative impact on affective outcomes, supporting the idea that interventions should be sustained across grade-levels and school-years. Further work is needed to elucidate possible causal mechanisms of some of the more correlational findings in this and related scholarship. The next iteration will include Ms. B as now experienced with micro:bit, plus four more teachers, at least two of whom have experience teaching Python in text-based development environments ($N \approx 375$ students). This work is necessary to ensure that well-intentioned efforts at promoting equity in computing are successful in impacting youth's affect towards computation in socially and culturally sustaining ways.

References

Asante, C. K., Semerjian, A., Xu, P., Jackson, D., Cheng, Y., Chasen, A., Shah, A., Brett, J., & Broadstone, M. (2021). An integrated STEM and computing curriculum for the human-technology frontier: The case of a smart greenhouse. *Connected Science Learning*, *3*(2). https://bit.ly/CSL-3_2

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, *28*(2), 117–148.

Blikstein, P. (2018). *Pre-college computer science education: A survey of the field*. Google LLC. https://goo.gl/gmS1Vm

Saldaña, J. (2009). *The coding manual for qualitative researchers*. Sage Publications, Inc.