Board 36: Evaluating the Long-Term Impact of Pre-College Computing Education Phase 1 Overview

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Adrienne Decker is a faculty member in the newly formed Department of Engineering Education at the University at Buffalo. She has been studying computing education and teaching for over 15 years, and is interested in broadening participation, evaluating the effectiveness of pre-college computing activities, and issues of assessment, particularly in the introductory programming courses. She has been actively involved with the Advanced Placement Computer Science A course since 2011, first serving as a reader, and as part of the development committee for the exam since 2015, serving as higher ed co-chair since 2018. She has received more than $1M in NSF funding for her work in computing education. Active in the computing education community, she is currently the ACM Special Interest Group on Computer Science Education board treasurer (2016-2019) and has served as program co-chair in 2014 and symposium co-chair in 2015 to the SIGCSE Technical Symposium on Computer Science Education.

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Monica McGill is an Associate Professor of Computer Science at Knox College. Her areas of scholarship are serious games and computer science education research with a current focus on diversity and improving the quality of research to examine effective practices on a large scale. She oversaw the recent development of csedresearch.org, a website with manually curated data from over 500 articles and a list of over 50 instruments for evaluating computing education.

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Overview of Project

The goal of this NSF IUSE project is to create the resources and tools necessary for identifying best practices for determining the long term impact of pre-college computing activities on participants, including analyses of data based on gender and ethnicity. The project's scope includes two phases: 1) the identification, review, and analysis of past and current pre-college computing activities and their impact on participants to determine the major influencing variables and 2) the creation and implementation of a formal process for collecting data related to pre-college computing activities, including major influencing variables, necessary for educational researchers to be able to evaluate and analyze the long-term impact of these activities.

Two significant outputs from this project are a repository of the information about pre-college computing education and effectiveness of those efforts (http://csedresearch.org) and the creation of instruments available for measuring the long-term effects of pre-college computing efforts. Currently, the website houses 507 curated articles on pre-college computing education activities from the years 2012-2018; 104 curated evaluation instruments; and guides for writing research questions, reporting activities, and reviewing articles. The site also allows users to submit to either the article repository or evaluation instrument repository through a web form. Combined with the results of the Phase 2 instruments, these elements will create the ability to compare results and to better evaluate the effects of pre-college computing efforts.

Background

To increase the implementation of computer science education in K-12, commercial, governmental, and not-for-profit entities have sponsored numerous initiatives aimed to bring computing to more students and teachers. Some examples include: code.org, Girls Who Code, various NSF-funded programs, and the new College Board AP Computer Science Principles course [1-4]. Our five-year NSF project seeks to determine the long-term impact of these activities and curriculum initiatives as a mechanism for growing the skilled technology workforce within the United States.

In previous work looking at the reporting of data and results of pre-college computing educational activities, it was found that many of the articles fail to report even basic study characteristics [5, 6]. Without some of this basic information, it is difficult to compare initiatives to determine which elements are more effective. It has been found, however, that these activities students participate in during their pre-college years have an impact on their choices of major and their views of a subject area [7, 8]. In particular, [8] shows us that male and female participants, at times, take away differing views about their experience in the activities.

Phase 1 Process

Phase 1 began with a focus group of six computing education researchers and evaluators who took part in multiple online sessions over several weeks to answer the following two research questions:

1. What type of data might be useable and useful for educational researchers and evaluators when measuring the impact of pre-college computing activities? and
2. What type of data might be useable and useful for practitioners who are designing and/or implementing a pre-college computing activity?

The full process for the focus group and the detailed results compiled from the analysis of the discussion is available in [9].

The second step in Phase 1 was to conduct concept testing. This phase was conducted with 8 participants who were asked to do specific tasks with the website and use talk-alouds to describe their experience and give their observations. The feedback from this concept test created several improvements to the site and allowed us to commence with alpha testing. The alpha phase for the website lasted for two months and involved 14 participants who did deeper interactions with the website and helped us to create a set of improvements and bug fixes that needed to be addressed.

Addressing the list created during alpha testing took approximately six months and then the site was moved into beta testing for approximately two months. Beta testing consisted of an open call for members of the computing education community to visit the site and upon visiting the site, they were asked to take a survey about their experience. Nearly 200 unique users visited the site during the beta testing period, twenty-six (26) completed the survey and three (3) consented to follow up interviews about the site. From this, we created a full list of features and bugs that needed to be added and fixed for the final version of the site to be released. The full website was launched in October 2018 (https://www.csedresearch.org).

Phase 1 Results

The website https://www.csedresearch.org houses three significant works: 1) a repository of peer-reviewed research articles on pre-college computing activities; 2) a repository of evaluation instruments that can be used for assessing effectiveness of interventions at many levels; and 3) guides tailored to computing education for new researchers to design studies, write research questions, and report results. To keep this website current and driven by the needs of the community, we have also provided a review mechanism for researchers and others to submit articles and evaluation instruments for inclusion into the repository.

For the repository of the peer-reviewed articles on pre-college educational activities, the focus group really stressed the theme of the quality of educational research in computer science. Participants' statements about research quality indicated a desire to drive up the general quality of research within the computing educational community so that it matches more mature educational research fields.

To help achieve this, participants in the focus group:

- supported the notion of providing guides or tips researcher, including a general description about what scientific inquiry is and how it pertains to educational research (forming research questions, writing good learning outcomes, assessment, and reporting data in a reliable and valid way).
- suggested that the search capability be powerful and the filtering mechanism be granular through the ability to conduct multi-level searchers and then refine the search on additional variables through a dynamic checklist.
- were in favor of having a method for rating the quality of papers and being able to use this rating system when searching for related articles and activities, with one noting that a "rating system would be very useful for practitioners" as well as researchers.

The analysis of the discussion of the focus group generated a list of potential qualifying questions for including articles in the repository which are printed as Table III of [9].

The results of the alpha testing confirmed that the site was a very good resource and it was easy to use. The issues raised in this phase were successfully fixed before beta testing. Beta testing was conducted in first quarter 2018. During the open beta testing phase, we had approximately 200 visitors to the site and 26 completed our beta testing survey and 3 agreed to follow-up interviews about the site. The results of the beta show us that between 65-90% of the respondents felt that the features of the website (article repository, research guides, and evaluation tools) were helpful to extremely helpful. The results from usability show averages of greater than 5 (out of a 7 point scale) for all aspects of the website, indicating to us that users felt that the site was easy to use and well-organized for the tasks they would like to perform when using the site.

Results of the follow-up interviews for the beta survey revealed that the interviewees viewed the repository as a useful website in its own right, but also saw it as having potential to make bigger changes in the landscape of computing education research. For instance, they believed that the research guides created by the project could, with the right promotion, become a standard way of doing research that many computing education researchers aspire to.

Once the data was curated for inclusion the article side of the repository, we were able to analyze it to determine gaps in the reporting. The results of this gap analysis are reported in [10]. Within [10], we also present Table 6 (available freely on the web at: https://csedresearch.org/guides/) which serves as a guide for the community about how to report on studies in this domain. However, much of the advice is applicable to interventions beyond the pre-college space as well.

For the evaluation instruments, we used the same literature as for the article repository to help us locate the instruments that studies were using to evaluate their participants. We have used the data curated about the evaluation instruments and have determined some general demographic information about the coverage of the instruments [11] and used a model of understanding how non-cognitive affect student achievement devised by Lee and Shute [12] to create a gap analysis for those constructs in the evaluation instruments curated for computing education [13].

Future Work

The next phase of this work involves the creation and deployment of several tools useful to the community for understanding the long-term impacts of the work being done in this area. Among the tools under consideration for development are the housing of certain evaluation instruments directly on the site with data to be collected from the instruments available for analysis as well as a recollective survey for past participants in activities to reflect on the impacts those activities had on their current education and career choices.

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