Updating our Understanding of the Impact of Pre-College Computing Experiences on University Students

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***Abstract*— This WIP Research paper is a follow-up to a study conducted in 2013 by McGill, Decker, and Settle that investigated the effects of pre-college computing experiences on students' decisions to study computer science at university. Their results indicated that the exposure to pre-college computing activities impacted students in different ways, particularly when looking at perceived impact by men and women participants [1, 2]. After six years and a myriad of changes to the K-12 computing landscape, it was time to see if impacts to current undergraduates were different than previously observed. This current study is a pilot qualitative study in which we interviewed seven undergraduate students about their experiences with computing prior to college. We were particularly interested in finding out about the nature of their computing experiences, whether they enjoyed them, and what they would change to make such experiences better for future participants. We used grounded theory and thematic coding to encode the interview transcripts, enabling us to look for common themes among the interview subjects. We are looking for elements in the interviews that could point to key differences in the pre-college computing landscape that have impacted student experiences that are different from those previously observed and thus impacting their experiences in university with computing. The goal of this preliminary study was to get a sense of what aspects of students' exposure to pre-college computing experiences have changed since 2013 and what changes should be made when creating a follow-up to this initial study.**

Keywords—K-12 computing, intent to persist, choice of major, qualitative study

I. INTRODUCTION

Studying the effects of K-12[1] computing experiences on students' decision to study computing and then persist in a computing major has been a topic of interest for many years. While there has been research showing the effects of pre-college computing experiences on student outcomes, our goal was to determine if the changes in the K-12 computing landscape are manifesting differently in students today as opposed to five or more years ago when the McGill, Decker, and Settle studies [1, 2] were published. As such, we started with a qualitative study of a small number of students to gain insight into their pre-college experiences and whether the experience impacted their choices in their college careers. The study was also designed to get feedback from students regarding their experiences, what they liked, and if they had any negative experiences. Having qualitative data could perhaps enhance our understanding of the previous qualitative results. For example, McGill, Decker, and Settle report that 22.3% of students indicated that their outreach experiences involving computing affected their choice of major [1]. However, what is missing from this number is a more nuanced picture of how those experiences impacting the choice. Having some qualitative data may provide insight into key elements that impact student decision making.

II. BACKGROUND

While the current study derives much of its inspiration from the McGill, Decker, and Settle studies [1, 2], others have also looked at student perceptions and impacts on choice of major.

The work of McGill, Decker, and Settle analyzing pre-college computing activities' impact on college students are presented in two papers [1, 2]. The first paper looks at perceived differences of students broken down by self-reported race/ethnicity. The first study [1] reports that 22.3% of students said their experience impacted their decision whether or not to study computer science. 30.1% of students found it to be an overall positive experience while only 5.4% stated the experience was negative. In terms of breakdowns of students' self-reported race, 79.7% of the students interviewed self-reported as being white, while the next largest group, Hispanic/Latino was only 6.9%. While these are positive numbers, there is a clear lack of diversity of responses. Differences were apparent among different ethnicities in terms of their feedback on their sense of belonging which was something we had as a goal in evaluating from a qualitative perspective in our study [1].

The second paper [2], analyzes the results based on student's self-reported gender. In this study, 56.1% of the respondents identified as female, 41.4% as male, and 1.1% as transgender. 39.1% of respondents indicated they had participated in a

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[1] K-12 is the common way of describing schooling prior to college in the United States. It is also becoming a way of denoting pre-college studies in other countries as well, even if their levels are not the same. Throughout this paper, if K-12 is mentioned, it is not intended to imply only to United States schools, but all schooling that happens prior to a student entering college or university.

computing activity, the largest amount of these activities occurring in high school. Interestingly, half the participants stated it had no impact in their choice of major. Men were more likely to have been impacted, with 14.1% of total respondents who indicated it had an impact being male, and 7.1% being female.

Sense of belonging has been noted to be a critical part of a student's choice of major as well as intent to persist. Garcia, Lewis, Reges, and Ensmenger [3] explored what elements of a student's character impacts their success. They pointed to student background, experience, culture, aptitude, habit, and attitude. In speaking of what students bring into the field, Colleen Lewis states "Unfortunately, as a CS education community, we have few techniques for building upon students' out-of-domain knowledge and skills. Even worse, we have no clear understanding of how, when, and why various out-of-domain knowledge and skills are productive in CS." (pg. 318)

This statement asserts that these prior experiences and outside knowledge have an impact on students within computing majors that we don't yet fully understand. Since knowledge, or perceived knowledge, builds one's comfort and therefore a sense of belonging in a field, understanding how K-12 computing experiences can give students knowledge that can be applied by them in university [3].

O'Lander [4] discusses the factors that affect a high school student's decision to study computer science. In the paper, O'Lander attempted to answer this question with the use of a quantitative-based study analyzing students' responses to a questionnaire of which he had a sample size of 4127. Results of his study give us insight into helpful factors for student success. He concluded that high success environments improve students' attitudes. He also found there was a gender-based gap in terms of the enthusiasm of students, with boys being more likely to be enthusiastic than girls. This carried over in his findings to students' perception of their abilities with boys being more confident. Students with more mathematics exposure were more confident and more positive in their confidence in computing as well.

Another critical piece of a student's choice of computing as a major appears to be the student's perception of computing in terms of their sense of belonging within the field. Lewis et al. [5] conducted a study involving 7,300 students, 55% identifying as white, and 34% identifying as Asian. From the data presented in the work, we see that male respondents had a higher sense of belonging, as did white respondents. Women were more likely to feel less included.

Building off the sense of belonging, students' confidence in themselves is also a critical piece for their success. In 2016, Buffum et al. discuss using a game-based learning approach to build students' confidence in their abilities and boost students' attitudes towards the field. While the study found there to be positive outcomes for the students enrolled, there was concern of selection bias due to students having chosen to participate already being interested in computing [6].

Students' exposure to pre-college computing activities has improved since McGill and Deckers' study conducted in 2013 [1]. Two such examples come to mind, the introduction of CSforALL movement and subsequent surge in CS enrollment [7,8], as well as the heavy adoption of the Computer Science Principles AP Exam [9]. Specifically, the CSforALL movement has done a substantial amount to improve students' exposure to computer science in their K-12 education [7,8]. Examples of projects the group has worked on is retraining teachers to be better prepared to teach these computing concepts in schools and their project CS Visions to understand K-12 computing adoption so as to increase the overall adoption and design courses effectively. Because of all this work that has been done, an improvement to the number of students who have been exposed to computing concepts in K-12 should have increased, though as we are simply doing a preliminary qualitative study, we do not expect to be able to see this.

III. Methods

The goal of this study was to gather additional qualitative information to help determine what impact, if any, exposure to certain pre-college computing programs has on eventual choice of major or career. The format of the study was to be one-on-one interviews with students at University at Buffalo, which was a sample of convenience. After obtaining IRB approval for this study, participants were recruited from throughout the university on two different social media platforms, Reddit, specifically r/ubReddit, as well as our university's Facebook group. The goal of the recruitment was to target students both from computing majors and non-computing majors, so the advertising targets did not focus on computing student-specific forums or sites. Students were offered a $10 Amazon gift card as compensation for completing the interview.

We were able recruit seven students for face-to-face interviews. At the interview, each student was asked the following series of questions:

1. Prior to attending university did you ever take a computing-related course, camp, or experience?
    a. If a student answered no to this question, questions 2-5 were skipped.
2. Did you find this to be a positive or negative experience?
3. What aspects were particularly positive and what was negative?
4. If you had the ability to do so, what would you change about the course if anything?
5. Did the course impact your decision whether or not to study computer science?
6. (Only asked if answer to question 1 was no) Were these experiences offered at your school or in the area?

All interviews were recorded and then transcribed anonymously. Each participant was given a letter (A-G) to identify their unique interview. Recordings were destroyed after verifying accurate transcription.

Once we had accurate transcripts, we applied techniques of grounded theory and thematic coding [10]. The first coder went through all of the transcripts and identified themes and created a set of codes and a codebook based on those themes. The second

coder used the codebook to independently code the transcripts and results were compared. Agreement between the coders was over 95%, discrepancies were resolved, and the coding and codebook was considered acceptable and analysis of the codes and transcripts proceeded.

IV. Results

The seven students that were interviewed were in years 1-3 (out of typically 4) of university study. There was one computer science major, one computer engineering major, one nursing major, one business major, and three participants who did not clearly identify their major. There were four men and three women. Two of the students were international students who prior to coming to the United States for university had completed primary and secondary school in India.

The codes that we derived from their responses are presented in Table 1.

TABLE I. Codebook for Interviews

Code	Description
Country	Subject expressed information about country where events took place.
Mandatory	Subject indicated whether event or activity was mandatory or elective.
Enjoyable	Subject indicated whether or not they enjoyed the activity or event described.
Helpful	Subject indicated whether or not they found the experience to be helpful.
No standouts	Subject indicated they had no memory of a positive or negative experience from the event or activity
Understanding	Subject indicated there was a lack of focus on understanding during the event or activity.
Influence	Subject indicated what influence the event or activity had in their future choices.
Comfort	Student indicated the level of comfort/belonging they felt during the event or activity.

All but one of the students had experiences with computing prior to university. The student that did not was a female nursing student (Student G). Her response to question 6 (were there experiences offered in your area) was:

"Yes um actually they were heavily encouraged, I just wasn't comfortable enough to seize the day, wasn't comfortable enough with my math skills."

This response shows that the subject's perceived discomfort with her mathematical ability kept her from taking advantage of computing opportunities.

For the other students we interviewed, we saw a broad range of responses to what computing activities they were engaged in prior to college. Students mentioned having had experience with Microsoft Office, Scratch, and/or web development experience. In fact, each US student interviewed had either experience with Scratch or web development before entering university.

The students who completed their primary and secondary school in India had a disproportionate amount of experience when it came to computer science concepts prior to college. Both of these students ended up studying computer science-related subjects in university, one studying computer science and one studying computer engineering. For these students, they learned a wide variety of computer science-related skills going back as far as grade 3 (approximately 7-8 years old). Both students stated they had had courses covering everything from basic programming and web development all the way up to C++ courses in their pre-college education.

Of the students that had computing experience prior to college, three of them directly stated they enjoyed the experience and found it to be overall positive and helpful. Four of the six students interviewed who stated they had taken a computing-related course prior to college mentioned they found it to be a helpful experience once they came to university, even if they ultimately chose not to major in computer science.

The answers to question 4 of the interview, "4. If you had the ability to do so, what would you change about the course if anything?" gave the most insight into the participants views of positive and negative experiences of the activities they participated in.

One of our interviewees (Student C) mentioned that there was too much of a focus on having students research on their own instead of things being taught in the actual course. He mentions

"I feel like there wasn't enough information about it I guess, you kinda had to like just like you had to like research and stuff. Like I'd rather just learn stuff from the class and then use those methods and applications in the project."

The student appears to be expressing frustration with the lack of guidance and support from the course.

Two separate subjects (B and E) mentioned the impact of the mandatory nature of the activity. The first student stated, "From grade 6 to grade 9, computer was mandatory and we had to submit assignments but we didn't have exams so I didn't learn much". While the second student stated:

"Well It would have been better if it was not a compulsory course, maybe for people who are more interested they could take it as an elective".

Both students express opinions that the course was not suited for everyone, but rather only for those who are interested. Whether that was perception, or influenced by the nature or the structure of the course itself was not explored in the interview.

For the question 5, "Did the course impact your decision whether or not to study computer science?" we call out student F's response:

"like it just isn't how my mind works otherwise would've probably been an engineering major. I'm not really the most creative, like I don't like being creative"

V. Discussion

The first thing that is evident from the interviews is the difference in pre-college computing experiences had by the interviewees that completed their K-12 education in India versus the United States. There was clearly a lot more emphasis on computing education in grade school there at least for these students in particular. Since typical university undergraduates are between the ages of 18-22, the students in our population started schooling 12-16 years ago, well before the CS for All movement had taken shape within the US, and thus it is not surprising to still see a lack of computing education at that level.

The lack of confidence and the impact that had on our interviewee nursing major is another result that reaffirms many of the findings in the literature. O'Lander noted that "Students in more mathematically oriented majors and in majors where programming was stressed had a more positive perception of their computing ability than students in less mathematical and computer-oriented majors" [3, pg. 3]. Student G, indeed has expressed a troubling lack of confidence in her ability to succeed in a computing-related course due to her lack of a strong mathematical background.

Another interesting aspect of this interview was that she also mentioned that her mother was a teacher for some of these computing courses. While she made no mention of her parent's supporting or not supporting her decision to not take computing courses. We do know that parental support can have impacts on participant perception of computing activities [11], In this case, there is no evidence of giving or lack of support. The primary issue stated by the interviewee is her perceived lack of mathematical ability.

Another example of a student's perception of ability negatively impacting their ability to succeed in computing is student F's response to the question about choice of major. In this case, the student feels they lack the creativity necessary to succeed and therefore made the decision to study a different major, business, in this case. Moreover, Student F indicated that they had felt this way prior to taking their intro to computing course in school. The student further mentioned "I knew I was not computer science material", indicating this was a predisposition they had entered the course with, tying into the confidence gap issue presented by Buffum et al. [5].

There are several limitations posed by this study that we were aware of in the design of the study. The study was designed with the belief that confidence, self-efficacy, and sense of belonging are critical in student's selection and pursuit of a major. This places the findings of the study in that epistemological framing. Because our goal was to update and eventually recreate the 2013 McGill, Decker, Settle study [1,2], we did not approach this from social learning theory or motivation theory. Future work may include a larger qualitative study to look at these framings, or may be used to turn the survey into a mixed-methods instrument.

We thought it would be advantageous to gain some first-hand insight into the experiences students have had with these pre-college computing experiences over the last several years. From this study we have not gained information that differs from what has already been found from other previous studies, rather it has given us a sense of direction for where we can go with our planned quantitative study.

A key limitation to studies of this type are the limitations of human recall and memory. We observed students' lack of memory of the experiences they had before college, due to the length of time that had passed since the experiences. However, since this is not a longitudinal study where we have evidence of what the student participated in, we are forced to use their recall as the best measure of the impact of the activities on the students. In an attempt to mitigate this, we worded questions carefully so as to ensure we were able to carry a conversation with the student. In doing this it is possible for some of the questions to have become leading in their nature. Other limitations include the homogeneity of the sample in the sense that they all come from the same university. While there are many different demographics represented in our sample, it is hard to know what bias the common university plays into the subjects and results. University x is a large, public comprehensive university located in the Northeast United States and this type of institution attracts a certain type of student. Other types of institutions attract different types of students and their experiences and recall of experiences may be different.

VI. Conclusion

These interviews are a first step in a larger study to refine and deploy the survey instrument used in McGill, Decker, and Settle [1, 2]. We need to further look at the questions of that survey and the data collected and compare them to the responses we have collected here to look for additional areas for the survey to address.

The idea of comfort and sense of belonging came up as a theme in our interviews and this idea was not addressed in the McGill et al. survey. The results of [2] point to sense of belonging as being a factor for girls' decisions more often than boys. However, a more detailed set of questions than presented in [2] may help illuminate exactly what aspects of belonging impact the student the most.

With all of this in mind, our next steps are to use the information we have learned from this qualitative study and apply them to refining the instrument from [2] for re-deployment with a large number of students (computing majors and non-computing majors) We are considering supplementing our quantitative follow-up survey with additional focused qualitative interviews to get a better overall picture and give more detailed insights into students' experiences.

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