High School Technology as a NON-predictor of First College Math Course

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Abstract

Previous research has shown that initial mathematics course placement in college is a strong predictor of persistence to an engineering degree. This study examines whether greater access to devices used in high school STEM courses is positively related to a student's college math course placement. Both qualitative and quantitative data were collected and analyzed. In the quantitative analysis, data on freshmen in Engineering and Engineering-related programs from across 20 public institutions within the same state revealed that classrooms with wireless access and the number of devices dedicated for student use in their high schools were not useful predictors of their math course placement in college. This runs counter to intuition and may provide new insight into the effectiveness of technology implementation within high school classrooms. In a qualitative analysis, the type of devices, frequency, and manner in which the devices were implemented in high school math courses were examined.

Keywords

technology implementation, math placement, high school factors, calculus readiness

Introduction

To address the shortage of skilled engineers in the U.S. workforce, previous studies have suggested improving retention rates in postsecondary engineering programs as the most effective approach[1]. Initial mathematics course placement and performance have been shown to be strong predictors of persistence to graduation in the engineering field[2-6]. Therefore, efforts to increase the number of students entering college calculus-ready, and to increase the retention of those starting below calculus are needed. In this paper we discuss partial results of an NSF-funded project (#1744497) addressing this issue at the statewide level in South Carolina (SC).

National Center for Education Statistics data from 2015 indicate that 95.6% of SC two-year college students and 87.7% of first-year students at four-year institutions with Accreditation Board for Engineering and Technology (ABET) accredited programs were from within SC[7], providing a unique opportunity to collect and analyze data within a nearly closed system.

Methods

The results discussed in this paper are part of a larger study incorporating 20 institutions of higher education in SC with ABET-accredited engineering programs.[8] As seen in Figure 1, this is a mixed methods approach to address technology availability in high school as a useful predictor of math course placement in college. The qualitative data is in the form of focus groups which supplemented our discussion with themes related to the effectiveness of technology implementation within high school classrooms. Quantitative data allowed us to develop statistical models to evaluate the wireless access and the number of devices as a predictor of math course placement in college.

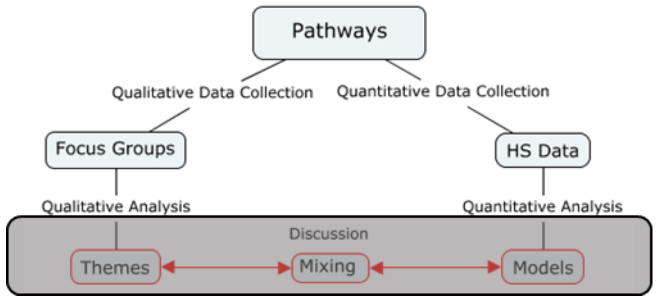

Figure 1. Diagram of the mixed-methods research design. Each aspect of the diagram is discussed in greater detail in the corresponding section below.

Pathways

At the 20 campuses, data on freshmen students enrolled in Engineering, Engineering related, and Business majors were collected, including information on student demographics, current math course, initial math course placement, and Advanced Placement (AP) credits and merged with the SC high school (HS) report card data[9] to identify HS institutional factors that could affect initial math placement in college. Some variables included in the analysis were average ACT score, graduation rate, poverty index, retention rate, percent of classrooms with wireless access, and the number of devices dedicated for student use.

In determining initial math placement, reported math courses were collapsed into the following categories: Developmental Math, Basic Algebra, College Algebra, Trigonometry, Precalculus, Calculus I, Calculus II, Calculus III, Business Calculus, Statistics, Math course not in Calculus chain, and Math course above Calculus III. Then a new variable indicating initial Calculus I or higher placement was created. If no initial and no current math placement were available, students with 3, 4, or 5 AP credits were assumed to place at or above calculus while those without AP Calculus credit were counted as below calculus. Moreover, students without AP Calculus AB or BC credit whose initial and current math courses were Statistics or not in the calculus sequence were not included in the analysis. For each high school, the total number of students, number at or above Calculus I, and proportion at or above Calculus I were determined and merged with the variables of interest from the high school report card data.

Quantitative Data Collection and Analysis: HS Data

In the next phase of the quantitative analysis, the goal was to fit a logistic regression model to identify high school institutional factors that are significant predictors of the proportion of students initially placed at or above calculus. Prior to the model fitting, plots of each of the high school report card variables under consideration against the response variable (proportion placed at or above Calculus I) were examined to determine if a logistic regression model was appropriate. Variables with complete failure to conform to an S-shaped curve were excluded from the analysis, and thus did not proceed to the model fitting. Plots for two technology-related variables, *CTS_class* (the percentage of classrooms with wireless access) and *CTS_tectch* (the number of devices dedicated for student use), are shown in Figure 2 (a and b). Both of these were among the excluded variables.

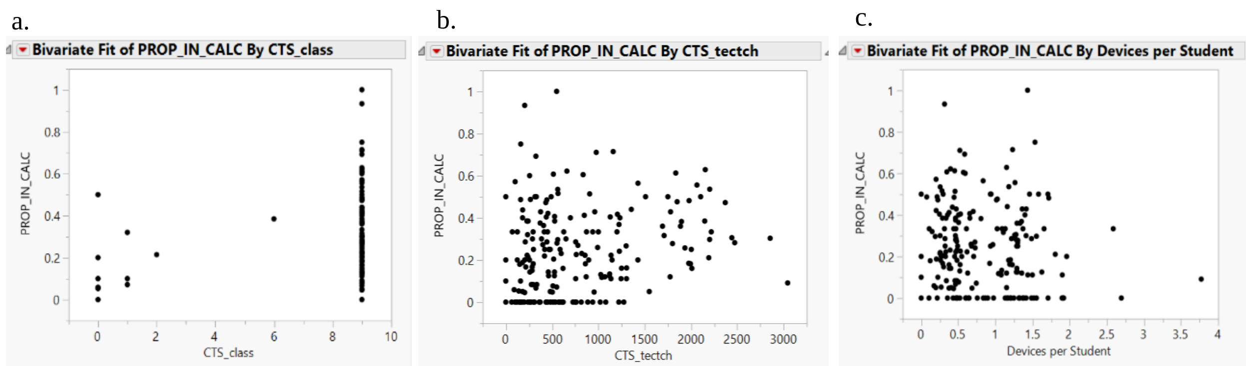

Figure 2. Scatterplots of proportion of students placing into calculus versus (a) the percent of classrooms with wireless access, (b) the number of devices dedicated for student use, and (c) the number of devices per student.

For the *CTS_class* variable each numerical code represents an increment of 10% (e.g. 0 represents 0-10%). As seen in Figure 2, nearly all high schools fell into the highest access category. Within this category, the proportion of students placing into Calculus I spanned the entire range of 0 to 1. Hence, this variable is not useful for predicting calculus readiness. This was confirmed when a logistic model including *CTS_class* as the only predictor gave a max-adjusted generalized r^2 value[10] of only 1.5%.

The *CTS_tectch* variable also appeared to be unrelated to the proportion of students placing into Calculus I, due to the random scatter observed in the plot in Figure 2b. This was confirmed when a logistic regression model with *CTS_tectch* as the only predictor of calculus readiness gave a max-adjusted generalized r^2 value of only 1.4%. To make the argument stronger, the *CTS_tech* variable was normalized by calculating the number of devices per student and plotting that against the probability of placing into calculus. This graph (Figure 2c) also displayed random scatter and had a similarly low value for r^2 of 1.6% during the fitting of logistic regression model. The fact that neither of these technology-related variables were useful for predicting math placement was surprising, and deserved further exploration.

Qualitative Data Collection and Analysis: Focus Groups

The quantitative analysis of the educational pathways and patterns in SC yielded not only the identification of locations with unusual patterns, but also helped to focus the following questions of interest in the qualitative analysis. *What is happening in the schools which produce relatively high rates of engineering majors or students placing into or above calculus? How can those practices be translated to other schools? What are the barriers in the schools observing low rates of engineering and calculus-ready students? What resources can be used to mitigate the differences?* Students were invited to participate in the focus groups based on the college math placement below or above calculus, and on specific demographic and enrollment factors identified in the pathways analysis.

A selection of question asked in the focus groups related to technology and its application are listed in the Table 1. The questions were depicted on posters and hung on the walls. Once students were welcomed and introduced to the purpose and objectives of the study, they obtained dots and were asked to place their dots on the answer choices they identified or agreed with. Posters with dots served as a timeline for the group discussion led by the interviewer. Observational notes as well as dialogues were captured to allow precise and trustworthy evaluation of focus group results.

Table 1. Selected questions asked in the focus group discussions. Bolded answer choices are related to technology.

Question Prompt	Answer choices
What struggles, barriers, or hardships did you encounter that had impact on your academic performance in high school?	**Lack of access to technology**, transportation issues, financial issues, working a job, family duties, extracurricular activities, legal issues, lack of stable home situation, societal expectations, and other
When you were in high school, where did you mostly seek advice about academics (classes, scheduling, college apps, etc.)?	**Internet search**, **school websites**, parent/guardian, siblings, friends, other family member, teacher, and other
What resources were available for mathematics help at your high school? (use as many dots as apply)	Group tutoring, individual tutoring, student-led review sessions, **math software or websites**, academic clubs, teacher-led review sessions, studying with friends, individual help with teacher, other
What helped you achieve success in high school? (use as many dots as apply)	Classmates, people, private tutor, extracurricular activities, job or workplace, religion, academic clubs or group, access to tutoring, good advising, **access to technology**, and other

During the data collection on the posters, some students placed their dots next to the technology related answer choices, which led to the further discussion of this topic in the group with several trends appearing. Students' positive experiences with technology and its implementation in high school were related to graphing calculator skill development, active learning through interactive boards during the classroom period, or online resources such as Khan Academy® or YouTube™ videos as they sought help outside the classroom. In addition, students reported the lack of access to computers or wireless internet, technology or websites not working or not implemented properly, teachers not able or not interested in technology implementation in the classroom, project based learning failure, and improper application of a calculator as negative experiences with technology in the classroom.

One theme emerging from the focus groups was that teacher attempts to incorporate technology or online resources were ineffective, often as a result of not promoting student engagement (active learning) or not working properly.

> *"My other teacher junior year tried to implement it. But basically, they'd take videos by themselves, put them online, and have us watch them and do our homework at home so then we'd come in and go over it in class. Never really worked out too great."*

Student engagement was found to be important for positive attitudes towards technology. One student appreciated the use of an interactive board during her math courses as she could get practical experience solving examples on the board. Moreover, students admitted difficulties in concentrating for prolonged periods of time when active participation was not required.

> *"The, you know, come up to the smart board and writing on it and things like that, like that was very interactive and helpful."*

The students interviewed had both positive and negative experiences with calculator use in high school. Students who developed a conceptual understanding of an algorithm appreciated the power of this tool for solving complex equations and graphing.

> *"I mean the TI-89, and 83, like, we-we hit that pretty hard in high school. So, I feel like when I came here and actually started taking calculus, like there's some people who like, they can't still like matrices and don't know how like are in and how to do all that stuff when they got here ..."*

On the other hand, students who used a calculator for all computations regretted their calculator dependency once entering college. In consequence, these experiences highlight the importance of critical thinking, conceptual understanding, and application to real-word problems.

> *"I wish I weren't so reliant on a calculator ... because they showed me like for prob and stats, and I know how to do everything on a calculator when I go in that test room, but if they were to ask me pen and paper how to do it I wouldn't."*

Online resources such as YouTube™ or Khan Academy® videos helped students to achieve success in high school, mostly as a resource for help outside of the classroom. Some students did not feel comfortable asking for help because of a language barrier, while others were unable to attend teacher-led help sessions due to work or extracurricular activities.

> *"Khan Academy® was really helpful, and ... And random YouTube™ videos were explaining the concepts was really helpful. Because, I'm like, when I was in high school, when I ask for example a question, and if you get like frustrated, like, you're trying to explain it but you get frustrated, I feel like 'let it go.' I don't wanna ... But having YouTube™, it doesn't get tired of you."*

Despite the fact that wireless and device accessibility were not useful for predicting math course placement, some students reported limited access to a wireless network, especially after school hours or in their households. They reported that this made it challenging to complete assigned work. It was also noticed in the discussions that the availability of wireless access and access to computer labs differed across the schools.

> *"My momma said if we didn't need cable and Wi-Fi we didn't, we didn't have to have it. ... [S]o I had to go to the library when it was opened 'cause in my town it was opened three days a week."*

Lastly, students noticed that some teachers did not see the need for technology implementation in their lectures, which resulted in perceived failure of some well-intentioned programs, such as that at a high school that implemented project-based learning with all students given laptops.

> *"So I actually have a unique case in technology. We started a new little branch of the high school … And uh, it's just supposed to integrate, well it's supposed to be like project-based learning and um ... Then, integrating technology and what you do and teaching. It's got like two teachers to a class, and uh, it's just a weird style of learning. Um, but anyways, so everyone in [technical college] got a laptop, uh but ... everybody in [technical college] would tell you that, uh, they could cheat on literally everything…"*

Discussion: Models, Themes, and Mixing of the Data

The quantitative analysis of how math placement relates to the high school report variables revealed that neither *CTS_class* nor *CTS_tectch* were useful in predicting readiness for calculus. The scatterplots in Figure 2 reveal that wireless access is widely available to schools at all rates of calculus placement, and that many schools with few devices per student had high rates of calculus placement while several schools with many devices per student had low rates of calculus placement. The focus group discussions demonstrate that student success is not reliant simply on having access to the technology but rather on how the technology is implemented.

In conclusion, the focus groups provided valuable information based on the personal experiences of students coming from different backgrounds and high schools that cannot be identified by the scope of the quantitative analysis excluding *CTS_tectch* and *CTS_class* as predictors of math placement. The exclusion of these two variables could be attributed to the possibility of a high school scoring high on both variables, but not implementing the technology properly into the classroom, thus, not positively contributing to the students' performance on a college math placement test. However, this is only an assumption that needs to be explored further.

To summarize the emerging themes related to technology, positive student reflections on technology use in high school included graphing calculator skill acquirement, interactive board implementation, and online resources such as YouTube™ or Khan Academy®. In contrast, calculator dependency, excessive online time, non-functional or ineffective websites, and a lack of teacher interest in technology were negatively viewed. It is important also to note that the discussion in the focus groups did not correspond directly to the technology variables in the high school report card. In addition, use of technology was not the specific or sole aim of focus group discussion. Future work will include the distribution of a questionnaire with specific technology related questions to the principals and teachers in SC high schools with follow-up interviews.

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