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JUNE 22 - 26, 2020 #ASEEVC
Paper ID #30109

Developing Meaningful Studies of Student Success with Equity in Mind – Considering Context (Experience Report)

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Abstract

The National Science Foundation Scholarships in Science, Technology, Engineering and Math (S-STEM) grants are designed to support academically talented students with financial need in earning their 4-year STEM degrees in a timely manner. The grants have recently expanded to include collaborations between 2-year and 4-year colleges, in which community college students apply for a scholarship which is transferable to the participating four year college or colleges. S-STEM programs are required to add social science as well as external evaluation elements to document and assess the benefits of the programs, as well as any unanticipated challenges. The first author serves as social science researcher on multiple S-STEM projects. In that role, the author utilizes quantitative and qualitative research methods to understand the impact of the S-STEM funds on students in different academic settings. In this paper, we describe the ways academic contexts have shaped and re-shaped the study of the S-STEM projects, particularly regarding a) quantitative student comparisons and b) patterns of 2 to 4-year transfer.

Students under study exhibit various markers of systemic oppression by income, citizenship status, gender, ethnicity, and race, indicating a need to consider intersectionality and social justice aims in any comparative data analysis. In addition, the institutions, nearly all designated "Hispanic-Serving Institutions," vary in institutional infrastructure, leading to differing access to student level data and comparison data. While it is tempting to quantitatively compare S-STEM students' course outcomes and time-to-degree directly to all of their peers, S-STEM students earn their scholarships based on merit, and so enter the academic institution excelling academically. The presentation will focus on how the research team developed methods for culling an acceptable comparison group for quantitative analyses, based on available data and our attention to critical theory and intersectionality.

Students with financial need and Students Of Color are more likely to attend 2-year colleges than their peers, thus including 2-year schools in the S-STEM program is a thoughtful improvement upon the "4-year only" model. Yet quantitative data regarding the success of community college recruitment, retention, and transfer of students in the 2-year S-STEM programs through 4-year Bachelors of Science completion have shown great variance across S-STEM partnerships. Contextual information and qualitative data have indicated potential reasons for the disparities that would not be interpretable without a "mixed method" approach to social science research.

The paper will suggest how quantitative and qualitative data combine to enrich the study of S-STEM programs, outline how contextual understanding can support meaningful quantitative comparisons, and point to the benefits of an equity lens to interpretations of quantitative data for making practical interpretations of data and impact.

Introduction

In this paper, I briefly describe “QuantCrit” as a research methodology deriving from critical theory, detail the contexts of S-STEM grants, of which the authors are team members as social scientists and program evaluators, and reflect upon decision making, initial data collection and analyses, and how the reframing of impact studies with an eye towards QuantCrit and critical theory shifted the focus of the study of the S-STEM programs.

Critical theory

Educational researchers who study K12 and higher education bring out the inequity in educational resources, support systems, curriculum, and outcomes across multiple categories of privilege and oppression, such as gender, ethnicity, country of origin, first language, race, and income. Critical educational researchers problematize these inequities, and focus on transformative educational practices that move past providing similar experiences for all learners (equality) and instead create opportunities that build on the funds of knowledge (Moll, 1990) of diverse populations and reshape institutionalized inequities that continue to oppress learners who do not come from the predominantly white, middle class backgrounds of their educators, administrators, and educational leaders (Lynn, et al, 2002).

Critical race theory, extending the framework to focus on race and racism, has five tenets instrumental in conducting educational research, as described by Solórzano (1997, 1998):

1. *The Centrality and Intersectionality of Race and Racism:* While race and racism are central to critical race theory, they intersect with multiple forms of subordination. In this article, we examine the methods of analyzing of different subordinated groups, as there are multiple characteristics (e.g., gender, race, etc.) and their intersections to consider (Crenshaw, 1989, 1991).
2. *The Challenge to Dominant Ideology:* Critical race theory challenges the educational institution approaches that claim to be objective and race neutral but actually privilege dominant groups. In our analysis of S-STEM programs, we question the comparisons of different groups based on traditional educational assessments (that arguably favor dominant groups), as these measures can unfairly attribute unequal outcomes to socially marginalized groups (Yosso, 2006).
3. *The Commitment to Social Justice:* Critical race theory is committed to abolishing racism as well as other forms of subordination (e.g., gender and class). This reveals the “interest convergence” of civil rights gains, indicating that students of color only benefit when their interests converge with those of white students (Bell, 1980).
4. *The Centrality of Experiential Knowledge:* Critical race theory values the experiential knowledge of students of color and lifts up their experiences through qualitative methods such as storytelling and narratives. For our analysis, we argue that these methods will draw out the unique experiences of these students (Delgado Bernal, 2002).
5. *The Interdisciplinary Perspective:* Under this tenet, researchers can analyze race and racism through other disciplines (e.g., sociology, women’s studies, history, law, etc.).

Using these tenets of critical race theory as a framework, this paper will discuss the importance of crafting appropriate research questions and methods with a critical eye towards the inequities in education, especially when using quantitative methods in educational research.

"QuantCrit"

"QuantCrit" is a way of utilizing quantitative methods in new, transformation-seeking ways. Rather than focusing on establishing the status quo, quantitative critical studies often uncover systemic forms of oppression evident in schools of engineering in higher education. Rather than assume numbers are neutral, it is our responsibility as educational researchers to consider context as well as consider how numbers might be used to promote deficit thinking about groups we define in higher education (Gillborn, Warmington, & Demack, 2017). A QuantCrit methodology involves attending to two main tasks, according to Stage:

> *1)Use data to represent educational processes and outcomes on a large scale to reveal inequities and to identify social or institutional perpetuation of systematic inequities in such processes and outcomes.*
>
> *2)Question the models, measures, and analytic practices of quantitative research in order to offer competing models, measures, and analytic practices that better describe experiences of those who have not been adequately represented. (p.10, 2007)*

S-STEM grants- contexts for studying programmatic impact

The authors serve as social scientists and evaluators engaged in multiple "Scholarships in Science, Technology, Engineering, and Math" (S-STEM) grants provided by the National Science Foundation. The institutions involved are all Hispanic-Serving Institutions that offer 2-year or 4-year degrees in computer science and information technology. The premise of the grant is to provide high achieving, low income students with educational support through scholarship funds and specialized programming that shorten their "time-to-degree"- the number of semesters students take from enrollment in a program to graduation with the desired Bachelors of Science STEM degree. Scholars are recruited based on their high school and/or transfer GPA and their financial need as assessed by the FAFSA and documented at the institutional level in the financial aid department. In social justice parlance, this form of program falls under the category "distributive justice."

S-STEM institutions under study by the authors

The authors work with 2 S-STEM projects that incorporate four 4-year institutions and 7 community colleges across 3 states. All of the institutions are Hispanic-Serving Institutions, a designation that reflects a student body of at least 25% Hispanic/LatinX students enrolled.

Programs vary in the number of years of programming (one program in year 4 and one program in year 2), the services and program elements that the campuses provide to scholars, transfer agreements between 2-year and 4-year schools, departmental relationships between 2 and 4-year institutions, and even distance among 2-year and target 4-year institutions (from less than one mile to over 200 miles). The geographic regions served by the 2-year and 4-year schools are underresourced, with median per capita incomes lower than state averages in all cases.

The S-STEM programs include annual conference attendance with at least 2 visits to (CONFERENCE REGARDING EQUITY IN SCIENCE AND ENGINEERING). At the 4-year institutions, students participate in undergraduate research, workshops on (SPECIALIZED FIELD OF COMPUTING) specialized curriculum regarding professional skills and critical thinking, mentoring from faculty leads on the NSF grants, and specialized advising from faculty. Others in the department who did not earn the scholarship are encouraged to attend the additional courses and workshops.

Impact Analysis- Does S-STEM "make a difference"?

In this section, we discuss in narrative form how the quantitative studies have shifted as we consider the contexts of the S-STEM computing departments, institutions, the geographic regions, and the political realities of students engaged in the S-STEM programs. We bring to bear the qualitative findings as well as observational data and participatory knowledge that comes from social science study of the work as well as inclusion in programmatic decision-making that comes from having a *formative evaluation* role in the efforts (Ellard & Parsons, 2010).

In beginning to think through the evaluative, impact- related quantitative studies we could imagine for understanding the influence of the scholarships, we began from a relatively positivistic perspective often typical of evaluative studies of programs (Khakee, 2003). Our initial impact questions that we hoped to investigate with institutional research data was like many others studying scholarships for low-income student groups:

Do students who receive S-STEM scholarships earn degrees faster than their peers, as measured by "time to degree" scores measured in semesters?

Are there any demographic differences observed in these "time to degree" scores, in semesters?

Given the actual years it takes to earn Bachelors of Science degrees in the United States (4 years is typical), we developed intermediate research questions to measure impact within three years of the grant start date. At this time, none of the scholarship students would be expected to graduate, yet they would have had some experience at the four-year institution taking courses that relate to their major. Our intermediate research questions to start were:

How do S-STEM students compare with their peers related to grades earned in their major courses?

Are there any demographic differences observed in these grades?

In considering the initial intermediate research questions, it became clear that though our comparison group of "student peers (i.e., all students who did NOT receive the S-STEM scholarship)" was a tempting convenience sample, it did not accurately reflect a true comparison for a variety of reasons.

S-STEM students earned their scholarships through merit— they entered the courses with exemplary records of academic success. Comparing them with all of their course-taking peers would not be a fair comparison, because of inequities in performance to date. Similarly, the metric of selection, GPA, is highly context-dependent, and so building comparisons that match students on high school GPA may or may not be relevant, given high school variability in terms of content, curriculum, and grading practices.

Early in their academic pathways, students tend to shift majors, drop courses, and leave academic institutions altogether. First generation, low income students are more likely than their peers to drop out of college in the first few semesters, indicating that many of the peers our scholars would have in the institutions of interest are self-selecting out (or, depending on your perspective, pushed out) of the institution (Reyes & Nora, 2012). Comparing scholarship students at a course-by-course level with all students enrolled in the same courses could over-sample students who were less committed to the major, and who dropped out of the institution altogether. By looking at a "course-by-course" basis, we would not take into account the longevity of enrollment in the major, equating any student who had ever majored in computer science with those committed to the four-year degree through a 4-year scholarship.

Using the QuantCrit framework, for our intermediate study, we redefined the comparison to focus on students with longevity in the major, to avoid stigmatization of certain groups (e.g., first generation students) who may be more likely to drop out of college early in their careers (Reyes & Nora, 2012). Our institutional research data request allowed for all students who had ever majored in the target major at one of the four-year institutions, and included course enrollment and first time enrollment results (e.g., A-F, I, W) across 6 courses needed for the major. S-STEM students were identified by the institutional research office and they were indicated in a dichotomous variable labeled "S-STEM."

Our comparison study was further refined to focus on students with initial success in the major. Again, our QuantCrit approach takes into account the performance of students in the study, because if some students appear to have academically grown more than others only because they had higher performance at the beginning, this could perpetuate the myth that blames achievement gaps on groups who come from academically disadvantaged backgrounds, such as Hispanics and first generation students (Reyes & Nora, 2012; Yosso, 2006). We included students who a) began the computer science program in the same timeframe, b) earned a grade of A or B in *at least 2 of the first 3* required courses for the major, including 2 computer science course grades and one math course grade. In this way, we create a comparison that reflects the goals of the grant, and not one that spuriously assigns impact to our program because of transitions and fluidity of student enrollment in the institution and in the computer science major. This initial comparison group will be revisited in the final impact study focused on time to degree.

Reconsidering gender, race, and ethnicity demographic variables in the impact study- lack of purpose, potential harm

As we reflected on the initial research question regarding impact, we reconsidered a comparative impact study that related to demographic variables of race, ethnicity, and gender. In this case, we reconsidered the reasoning for our use of demographic variables in the impact study, and considered the lack of theoretical support for our comparison by demographic variables in this case. We realized that while income and race/ethnicity are often correlated, with white students more likely to come from households that do not qualify for Pell grants through the FAFSA, the variable of greatest interest is income, as that is the variable that made students eligible for the scholarships. We note that institutional research data does not often connect financial data with course enrollment and performance data—we will work with our institution leads to consider how to integrate data sets with Pell grant eligibility as well as course level data of students in our program and our comparison groups.

Through our QuantCrit exploration, we are beginning to recognize the ways *performance data* (e.g., course grades, GPA, test scores) disaggregated by gender and ethnicity to show "differences in performance" can be used to support master narratives of superiority and inferiority based on demographic variables (Yosso, 2006). For example, critical theorists would argue that quantitative analyses of demographic differences can reveal achievement gaps where subordinated groups are unfairly stigmatized for low achievement. In addition, critical race theory also posits that quantitative data analyses can also obfuscate intersectional differences (e.g., performance of Latinas versus Latinos, when gender and ethnicity are not disaggregated) (Crenshaw, 1991; Solórzano, 1997, 1998). While we considered comparison data regarding whether or not certain groups of students were differently influenced by the scholarship program, we determined that qualitative studies (e.g., critical race theory's storytelling method) could address that idea in a more holistic way.

Reflection on another readily available data point we considered for comparison

Institutional Research office data often holds data related to prior performance, in the form of high school GPA, SAT scores, and ACT scores. At one point, we considered matching our scholarship students with "like" peers who scored similarly on academic tests. We ran into multiple issues with these hypothesized comparison groups. First, it was clear that SAT and ACT scores were only available for approximately 40% of all students, and that the scores did not exist for community college transfers, many of whom were in our "treatment" group. Transfer students to our four-year institutions did not need to share test scores, and so few did so. We find at open access institutions such as those we serve, as well as where a high proportion of community college students enroll, the data are less uniform that at institutions without much transfer traffic. This complicates matters, including considering "cohorts" of students by grade level (e.g., freshman, sophomore, etc.), as student experiences are diverse, and often involve multiple entry and exit points along institutional, departmental, and career pathways. Another reason the standardized test scores were not selected was because of the persistent evidence that indicates standardized tests may be biased measures when considering socioeconomic status, gender, ethnicity, and race of test takers (Gilborn & Mizra, 2000; Weissglass, 2001).

Muddying the water- how qualitative data provide further reinterpretations of impact

In our initial plans for studying scholars over time, we brought naïve assumptions about whom our scholars would be, and how to address a "fair comparison" in our study of the impact of our program. As we began interviews and focus groups in our studies at multiple institutions, we found context variables that further complicated our work. As we take a mixed method approach, the data help inform our evolving quantitative study. The following are realities we did not prepare for in our study of "time to degree" with students studying computer science in our target departments, and the questions that arose based on these findings.

1) Many of our scholarship students, particularly our transfer students, were not enrolling in computer science as their first college experience. In fact, some earned degrees in other fields first, and are new students in their chosen STEM degree. As we consider "time-to-degree," at what point do we start "counting" semesters? At time of scholarship, or from high school graduation? How would this data shift our impact data, and how would we gather data from previous attempts at higher education?

2) While we were assuming a "one way" transfer process, from 2-year to 4-year school, we found institutional policies that streamline transfer of credits are creating patterns of transfer that differ from the norm—students co-enroll, or enroll in the community college following time in the four year institution. As we consider "time-to-degree," how will we classify students who move back and forth through institutions? How will we make sense of semesters of co-enrollment?

3) Financial aid policies differ across schools we study, including how tuition is accounted for, and credits paid for. For example, at one institution, each credit costs additional funds that are capped by financial aid, while at others, tuition remains stable at full time enrollment (e.g., from 12 credit hours to 18 credit hours). These policies have implications for students, particularly students with limited financial support. As we consider ability to graduate in a timely way, how do we make sense of course enrollment limitations that may unequally plague our scholars?

Qualitative findings- money is only part of the benefit

In interviews and focus groups, students indicate a myriad of benefits of the scholarship, including a) feeling acknowledged as a competent computer scientist, b) a peer group of like-minded computer science students, c) internship opportunities that arose from conference participation, d) opportunities to showcase and develop their technical skills among peers and professionals, e) networking practice, and f) abatement of financial worry. In fact, not all students mentioned the financial benefit of the scholarships when describing their experience, and many relate to the financial benefits in terms of paid work they did not need to continue during their schooling. These nuances will be important to document in impact studies, and yet it will be difficult to tease apart differences that arise from financial gain and from programming considerations.

Summary of critical theory and QuantCrit journey

Our journey in exploring research methods with a QuantCrit lens is summarized in Table 1. This table provides our original and critical research questions and measures, as we have delved into critical theory and its QuantCrit approach, faced challenges in our data collection, and experienced enlightening and culturally-sensitive stories and narratives from qualitative methods.

Table 1. Research Questions and Measures

Original Research Questions	**Original Measures (Data)**	**Critical Research Questions**	**Critical Measures (Data)**
Intermediate Research Questions			
How do S-STEM students compare with their peers related to grades earned in their major courses?	Institutional Research data: all students, time to degree	How do S-STEM students compare with their peers (with similar backgrounds such as major, time in major, and course grades in major) related to grades earned in their major courses?	Institutional Research data: S-STEM students, and matched sample based on major, time in major, and course grades in major
Are there any demographic differences observed in these grades?	Institutional Research data: demographic information	To what extent did the experiences of S-STEM students (by demographics) contribute to their overall success?	Qualitative data: interviews, focus groups
Final Research Questions			
Do students who receive S-STEM scholarships earn degrees faster than their peers, as measured by "time to degree" scores measured in semesters?	Institutional Research data: all students, grades	Do students who receive S-STEM scholarships earn degrees faster than their peers (with similar backgrounds such as major, time in major, and course grades in major), as measured by "time to degree" scores measured in semesters?	Institutional Research data: S-STEM students, and matched sample based on major, time in major, and course grades in major
Are there any demographic differences observed in these "time to degree" scores, in semesters?	Institutional Research data: demographic information	To what extent did the experiences of S-STEM students (by demographics) contribute to their overall success?	Qualitative data: interviews, focus groups

Conclusions and implications

S-STEM programs redistribute resources to low income students so that they have the means necessary to participate in greater depth in their STEM departments, often receiving additional curricular, co-curricular, and extra-curricular resources and opportunities along with an additional layer of mentoring that support success in the STEM disciplines. When resources are shifted to support low income students, we believe the gaps between low income and moderate income students can be overcome. However, it is important to problematize the scholarship effort as an additive one that does not change any systemic disadvantage experienced by low income students- the programming that accelerates and elevates success for low income students is a vital element. As we continue to address inequity in higher education, we find it valuable to consider how measurement practices influence the work of transforming engineering education.

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