Computing Education Pathways from High School to Community College: What Matters to Students?

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Abstract—Schools are increasingly offering opportunities for students to take classes in computer and information sciences, but the numbers and diversity of students who enroll and persist are not always representative of a school's student population. To meet these goals, students' needs and interests must be addressed. This paper will describe what matters for students in high school and community college computing classes. The data include interviews with 30 students (73% Latinx), surveys from 58 students (77% Latinx) and interviews with three counselors (2 college, 1 high school). The findings show that students will engage and persist in computing pathways when they: a) are project-based where those projects are hands-on and allow them to see the results of their work, b) create positive social connections and a sense of belonging, and c) create opportunities for learners to be active agents in their learning. Students will also enroll in computing classes to fulfill requirements for graduation or for a different major, but they are less likely to persist if they don't see the results of their work or have support and encouragement from teachers or counselors. The factors that are most important vary for high school and college students, and counselors are more likely to describe extrinsic sources of motivation. The findings are interpreted using self-determination theory, which provides a framework for understanding how students' sense of autonomy, competence, and connection influence their motivation to engage and persist in computing.

Keywords— high school; community college; student voice

I. INTRODUCTION

Current computer science (CS) for All efforts do not reach "all" youth. In the US, Latinx students earn just 10% of bachelor's degrees in CS; Latinas earn less than 2% [1]. These numbers are likely to decrease in the near future--while computer science enrollments at universities are going up, even during the pandemic, they declined between Fall 2018-20 at two-year colleges [2]. This has long-term implications for transfer; 46% of students who earned a bachelor's degree in Computer and Mathematical Sciences attended a community college [3]. This disproportionately affects Latinx students-- 46% attend two-year institutions, compared to 34% of all undergraduates [4].

To design learning environments that will result in a greater representation of Latinx students in computing fields, we need to understand why they choose to take and persist in CS classes in high school and community college. Previous studies point to individual factors (e.g., a desire to earn money and an interest in programming), relational factors (e.g., encouragement and mentors) and institutional factors (e.g., access to classes) [5], [6], [7]. But these studies focus on a narrow band of CS. While most CS for All efforts prepare students to do computer programming at a university, we are building a computer information systems (CIS) pathway that introduces students to the range of computing options including solving practical problems or improving processes with computing technology, hardware and software management and support, system integration services, management of CIS, networking, cybersecurity, programming, and software development. We use a strength-based perspective that views Latinx youth within a cultural historical context to be agentic in forging their educational and career pathways by drawing on cultural resources to navigate challenges and opportunities [8], [9]. Our research question is: *What matters for high school and college students to enroll and persist in CIS classes?*

Our hypotheses are based in self-determination theory which posits that people become self-determined when their needs for competence, connection, and autonomy are fulfilled [10]. In this framework, learning environments must be attuned to and support students' needs. Studies show that the satisfaction of basic needs is associated with higher levels of engagement, performance, and science identity in college STEM courses [11], [12]. But few studies use self-determination theory to understand why students pursue computer science; one suggests that connection to others is more important for female students than competence or autonomy [13]. While the focus is on understanding intrinsic sources of motivation, such as the desire for knowledge, new experiences, independence and enjoyment, the theory allows that most actions are a combination of both intrinsic and extrinsic motivation. In fact, studies show that students make decisions about whether to persist in computer science in the context of their relationships and institutional factors [14], [15]. Indeed, some of what matters to students is more about extrinsic motivation—they are told or expected to do it, or

there are rewards. In this paper, we describe the usefulness and limits of self-determination theory for understanding why high school and community college Latinx students enroll and persist in computing classes.

II. METHODS

A. Setting

This study took place in a school district that serves more than 20,000 students; 82% are Latinx, 67% speak a language other than English at home, and 78% are eligible for free or reduced meals. The most common step after high school is community college: countywide, 53% of high school graduates enroll in a 2-year institution [2]. The majority of students enroll in the nearby community college, which serves more than 13,000 students and is a Hispanic-Serving Institution with a 45% Latinx student population.

B. Participants

Data collection focused on students in Computing Information Systems (CIS) classes, including IT Essentials, Python Programming, and Network Analysis. The following data come from interviews with 30 students (21 in high school and 9 in college), surveys from 58 high school students (16 were also interviewed), and interviews with three counselors (2 college, 1 high school). The students interviewed were mostly male (63%) and Latinx (73%). Those interviewed were between the ages of 14-23 with a mean age of 18, however age was gathered at the time of the first survey, therefore a 1-year margin of error is present. Of the 58 students who completed a survey, 78% were male, 78% Latinx, and 52% were in 9th grade; 57% reported that they were the first in their family to attend college. No demographic information was collected for the counselors, however they were invited to participate in an interview due to their direct involvement with students.

C. Procedures and Measures

Survey data were collected from high school students enrolled in the introductory computing class. Survey items included "How important to you were each of the following reasons for taking this class?", "Please rate the degree to which you believe you belong in the field of technology", and "Right now, how much would you want to learn more about…" The survey took approximately 15 minutes and participants were compensated with a $15 gift card. A subset of high school students was invited to participate in interviews based on their enrollment in the introductory course and their teacher's recommendation. A counseling intern from the school district conducted the interviews over the phone and asked students questions about their reasons for enrolling in the class, what they thought about the class, and their career and education goals. Interviews lasted between 15-30 minutes and participants were compensated with a $15 gift card.

Students at the community college were invited for an interview if they had attended classes at one of the three high schools in the school district and had, within the last three years, either: declared themselves a CIS major, completed any number of CIS units, or were currently (during the time of recruitment) enrolled in a CIS course. Interviews included questions about their experience in high school as well as in the computing classes at the college. Sample questions included: "What led you to take CIS classes?", "Were there any classes or experiences at [school district] or elsewhere thatinfluenced your decision?", and "Did anything or anyone at [school district] help prepare you for the classes?" Interviews lasted between 20-30 minutes long and participants were compensated with a $20 gift card.

Interviews were conducted with two counselors from the community college and one high school counselor who work directly with students in the CIS pathway. Interviews took place over the phone and lasted between 30-45 minutes. Questions included: "What do you think attracts students to the CIS classes?" "What prevents them from enrolling or taking another class?"

D. Data Analysis

The survey data were analyzed by running simple descriptives to describe trends, and t-tests/chi-square analyses to compare mean scores and distributions for subgroups of students. The interview data were analyzed by having one researcher review the transcript to identify examples of the three intrinsic motivation categories in self-determination theory: competence, connection, and autonomy. The researcher compiled quotes that illustrated each category, and they were reviewed by two other researchers to determine which category they fit into and to interpret the findings in the context of self-determination theory. The researcher then reviewed the interviews a second time to identify other themes, such as extrinsic motivation, that did not fit in the initial three categories and those were discussed among the research team.

III. RESULTS

The findings describe "what matters" for students to enroll and persist in computing classes in high school and college. Responses from students primarily fit into the three categories of intrinsic motivation as described by self-determination theory; counselors primarily described extrinsic sources of motivation.

For the high school students, it was important to have classes that are project-based where the work is hands-on in nature and where students are able to develop a sense of competence by being able to clearly see the results of their efforts. In the interviews, students explained that it was important to them to learn skills they can apply to projects that matter to them. Many students could trace their interest in CS to hands-on experiences they had before high school. For example, a college student talked about becoming interested in coding because they wanted to personalize a social media site. For current high school students, performing hands-on work and seeing the results of that work was particularly important. As one stated: "I just remember that it was fun. The teacher would make it fun... I remember that she showed me about programming and we programmed some balls and we controlled it with our phones or iPads." A third student described it as: "[if] it's just reading, answering questions and not being so hands on, you wouldn't really be learning...you would be learning what it is but you wouldn't be learning how to do it." Several other high school students said their favorite

part of class was learning by doing. One student explained: "I was put in [IT Essentials] by my counselor, but as soon as I got in, I like fell in love with it because I didn't know what it was at first. But when we started doing, like, the hands-on experiments, it was a lot of fun." The importance of learning by doing was also clear from the survey results. When asked about their interest in learning about different topics or subjects, students ranked the hands-on and project-based activities the highest. These included: fixing or building computers (79%), computer game design (78%), programming (76%), and protecting data/privacy (71%).

When describing what matters in college, students were more likely to talk about the importance of having learning experiences that create positive social connections and a sense of belonging. For example, students were motivated by being able to connect with people who have a similar background. A college student described their experience in a CIS class: "...it's very open and it's very friendly, because almost everyone there is kind of coming from a similar background where they're taking this because they're local. It's pretty easy to connect with people who are local, because it's like you all share a similar experience where you live." Another college student described how they valued the opportunity to build connections with other students: "...I ended up going to every single supplemental instruction session that we had for my computer science class. And it helped me build a little bit of a community." Connections and support from teachers were also important. As one explained: "the teachers are really open to explaining things and taking their time with you, especially if you do office hours. I feel like my biggest fear switching from English to something in STEM was, I'd be completely behind on any stage and not really understand what's going on, but yeah, they're really good at communicating what you have to learn." Similarly, having support from counselors on the transition to college matters. One student went to a continuation school that provided a lot of individual support: "...we got a lot of help from counselors. They even drove us to [the college] to do the whole assessment task, to go onto the campus, walk us through everything." Smaller class sizes and more support from teachers compared to four-year universities were important to students at the community college. "I feel like [college] classes, in a lot of ways, because when you're a freshman and at a four year, a lot of it's those big 500-person lecture halls. And I feel like being in a smaller class, is just so much better support, and you feel less lost. I don't know. There's also a little bit more personal accountability and stuff." Social connections seemed to play a less important role for the high school students. Some high school students talked about the importance of working with other people in class and having friends to help them. But in their survey responses, social factors such as liking the teacher, or that their friends were in the class, ranked low in importance.

The third area of intrinsic motivation was the opportunity for learners to be active agents in their learning by pursuing courses and activities that are of interest to them and developing a sense of initiative and ownership. For both high school and college students, these opportunities were attributed to teacher support. For example, a college student described how they sought out teachers to help them persist in a

computing class: "I think for the most part classes at [college], the teachers …. are pretty open to helping you. And I think, especially with STEM, you kind of feel a lot of pressure to get everything right away because you don't want to be that person or you don't want to have an inferiority complex because, especially in computer science, let me tell you. You get a couple of snobby people in classes, but I think overall, the teachers are really open to explaining things and taking their time with you, especially if you do office hours." In another example, a high school student described a sense of agency in how they did their work, which was encouraged by their teacher: "...she [the teacher] would let us [work] in partners and we would be able to communicate with our friends and figure out what, what was a problem and not just like a one person thing. And she was pretty open-minded about how we would learn." For both of these students, it was important to have a teacher that created opportunities for them to take an active role in defining who they are and how they learn in the class.

There were fewer examples of external factors motivating students to enroll or persist in computing, and these were voiced primarily by the counselors. For example, they explained that high school students were motivated by learning skills to help them get a paying job, and by the opportunity to earn college credit while they are still in high school. One counselor explained that students take college CIS classes to develop job skills: "I think the attraction is being able to get employed. Someone who's looking into, maybe not that interested in a long educational career and they want to get some technical skills and start working is very attractive." Counselors described another extrinsic motivator for high school students as the reward of earning credit for college: "Students wanted to pass the class with a B or higher because they wanted to get that college credit." While the survey data suggest that most important reason for taking a CIS class in high school was having an interest in the topic (29% selected this as their top reason), other students said the motivation was external: to fulfill a requirement for high school graduation (17% selected), and to develop skills that can help them get a job (16% selected). But the extrinsic motivation was more important for high school students who did not intend to study computing. Those who wrote in a tech-related major when asked what they would major in college were less likely to select the external reason of "it fulfills a requirement for high school graduation" (4%) compared to those who did not write in a "tech-related" major (26%, p = .096).

IV. Discussion

Self-determination theory provides a useful framework for understanding what matters for Latinx high school and community college students to enroll and persist in CIS. From the students' perspectives, what matters is based in intrinsic sources of motivation, which have been shown to be associated with the highest levels of self determination to set and achieve their goals [10]. High school students in this study talked about the importance of project-based learning experiences where they are able to see the results of their work. This finding is consistent with studies that show this approach can improve the recruitment and retention of students from low-income communities and those who are the first in their family to

attend college [16], [7]. The high school students also described valuing a sense of autonomy in some aspects of how they participate, particularly when teachers allow them a choice to work with other students. These findings are consistent with self-determination theory, which suggests that learning environments can satisfy students' need for competence and autonomy by providing well-structured environments that combine challenges with positive feedback, and opportunities for growth [10].

In this study, the importance of having opportunities to do hands-on computing and develop a sense of competence did not matter as much to students taking CIS at the community college. Instead, they described the importance of having a sense of belonging and connection. They talked specifically about the benefits of attending a local college with small classes. Other studies have shown that a sense of belonging is important for persistence in computing, and they also suggest that faculty play an important role in fostering it, particularly among female and minority students [17]. These perspectives are consistent with other community college studies that find peer support is an important predictor of intentions to persist in computing, particularly among female students [14].

Both high school and community college students talked about the importance of having a sense of autonomy to pursue their interests. The specific examples focused on teacher support for them to pursue an approach to learning that worked for them, such as collaborating with their peers. Other studies have found that teachers' support of student autonomy is associated with college students' sense of enjoyment in a chemistry class [11], and with high school students' sense of competence, which in turn predicts their intentions to study science [18]. These findings suggest that a relatively straight-forward way to make computer science learning experiences more appealing for a diverse group of students is to provide opportunities for them to make choices and connect what they are learning to their interests.

Counselors were more likely than students to describe extrinsic sources of motivation for students to enroll and persist in computing classes. This is an important difference that may be influencing how they talk about the classes and the major, and who enrolls. The exception is that students who did not intend to major in a technology field were more likely to describe extrinsic sources of motivation, such as fulfilling a requirement to graduate from high school. Prior research with Latinx high school and college students has identified the importance of other types of external factors in their decisions to enroll and persist in computing, including a desire to give back to family and community [5]. Additional research on the relative importance of intrinsic and extrinsic motivation for Latinx students' enrollment and persistence is needed.

In conclusion, this study suggests that self-determination theory provides a useful framework for understanding the experiences of high school and community college Latinx students in the more applied fields of computing. While these findings provide some insight into what matters for Latinx students taking CIS classes in high school and community college, the generalizability is limited by sample size. While the majority were Latinx, we were not able to identify trends within or across ethnic groups or by gender. Another consideration is that some of the data were collected during distance learning during the COVID-19 pandemic and may not be representative of students' experiences when they attend class in person. The findings are consistent with self-determination theory's claims that students' needs for competence, connection and autonomy must all be satisfied in order to optimize motivation [10]. Additional research on students who are taking CIS courses is needed to understand how CIS courses are and can meet those needs.

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