"That Sounds like Something Geniuses Do":

Exploring How Vertical Transfer Computing Students Conceptualize PhD Pathways

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Abstract

There are currently too few computer science faculty to meet student demand, and faculty from historically minoritized groups are severely underrepresented. Expanding pathways from community colleges to PhDs is one critical avenue to both grow and diversify the computer science professoriate that has been underexplored. To gain insight into these pathways, this phenomenological study utilizes interviews with community college transfer students in computer science to examine how they conceptualize PhD study as part of their academic trajectories. Findings highlight experiences (e.g., serving as a tutor) that promote early interest in PhDs among this diverse and talented group of students.

Keywords: vertical transfer, STEM, computer science, PhD aspirations, possible selves, phenomenology

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Undergraduate interest in computer science (CS) has boomed in recent years, in part because CS degrees can provide opportunity for upward social mobility (National Academies of Sciences, Engineering, and Mathematics [NASEM], 2018; Sax et al., 2020). Universities have had difficulty growing the CS professoriate to keep pace with increasing interest in the CS major, leading programs to adopt competitive enrollment practices that restrict access to undergraduate CS degrees (e.g., prerequisites for gaining admittance to the major). Such competitive enrollment practices perpetuate gender and racial inequity (Nguyen & Lewis, 2020) and may exacerbate the faculty shortage by limiting who can access the CS major, a gateway for pursuing subsequent graduate degrees and faculty roles. Thus, the discipline is caught in a self-perpetuating cycle of inequity, in which a shortage of faculty leads departments to adopt methods of restricting access to CS majors that, in part, further perpetuate the faculty shortage and reinforce exclusionary policies. Addressing the faculty shortage by expanding pathways to PhD study (Blaney & Wofford, 2021) is critical to disrupting this cycle and building more equitable CS departments.

Beyond simply growing the number of individuals earning PhDs, increasing diversity among those pursuing PhDs would help to promote diversity within CS faculty ranks, leadership positions in the tech industry, and across all levels of CS education (Charleston, 2012; Cross & Carman, 2021; Main et al., 2022; Stout et al., 2018). Research using nationwide survey data to explore PhD pathways among computing majors reveals that vertical transfer students (i.e., those who transfer from community colleges to universities in pursuit of a bachelor's degree) represent a high-achieving and racially diverse group to encourage toward PhDs in CS (Blaney & Wofford, 2021). More broadly, vertical transfer pathways are critical to advancing equity in

higher education (Taylor & Jain, 2017) and STEM degree programs (Bahr et al., 2017; Wang, 2021). In CS, transfer students are disproportionately first-generation college students, from Latine[1] and Indigenous groups, and from low-income backgrounds (Blaney, 2020). Further, because at least a third of undergraduate students attend community colleges for some period of time (Community College Research Center [CCRC], 2022), growing transfer students' representation in the professoriate is one aspect of developing a representative CS faculty.

Social cognitive career theory (SCCT; Lent et al., 1994) and the concept of possible selves (Markus & Nurius, 1986) provide a valuable lens through which we can examine vertical transfer pathways. Briefly, because of its breadth and utility in framing students' degree and career decision-making, SCCT has been applied to studies of graduate school aspirations (e.g., Szelényi & Inkelas, 2011) and community college transfer pathways (e.g., Wang, 2017) to explain how student beliefs mediate the relationship between experiences and attained outcomes. Further, scholarship on possible selves (Markus & Nurius, 1986) provides insight into how college experiences and interlocking systems of inequity shape what students view as (im)possible in relation to their degree and career attainment. Guided by SCCT and possible selves, this study explores how vertical transfer students conceptualize PhD study as a potential component of their trajectories. Specifically, we employed a phenomenological approach (Valentine et al., 2018; van Manen, 1997), using interview data from 18 vertical transfer CS majors across five universities in California to address the following research questions:

1. How do vertical transfer students in CS conceptualize the possibility of pursuing/earning a PhD as part of their educational trajectories?
2. How do vertical transfer students in CS develop their (dis)interest in PhDs?

[1] We consistently use the gender-inclusive term Latine throughout our manuscript, except in instances where we are referring to specific students who identified as cisgender women and/or men.

Review of Literature

Research on STEM graduate education has garnered great attention through avenues such as national reports (NASEM, 2018) and policy initiatives (e.g., removing standardized test scores from admissions procedures; Posselt et al., 2018). Much of this attention has revealed that students' STEM graduate education trajectories remain steeped in disparities that "require substantial cultural change throughout the system" (NASEM, 2018, p. 127). Indeed, students' pathways to STEM graduate degrees are characterized by inequities in structural support (e.g., funding), encouragement to pursue graduate school (e.g., mentoring relationships), and perceptions about STEM graduate degrees and outcomes (Blaney, Wofford, et al., 2022; NASEM, 2018). Although the present study is centrally concerned with how vertical transfer students conceptualize PhDs in CS as part of their future plans, we contextualize our study within broader research on STEM graduate school trajectories, highlighting unique traits of PhD pathways in CS when possible. Below, we first discuss the importance of examining the psychosocial elements impacting students' beliefs about graduate education. We then review more tangible factors (e.g., research opportunities, financial circumstances) that may influence how students perceive the viability of a graduate training. Finally, we discuss the importance of considering vertical transfer as a unique experience shaping pathways to graduate school.

Developing Beliefs About and Aspirations for STEM Graduate Education

Across studies of college students' pathways to graduate education, the importance of students' early aspirations to earn a graduate degree and related psychosocial beliefs are well documented, both across fields (English & Umbach, 2016; Hanson et al., 2016; Trolian & Parker, 2017) and in STEM specifically (Eagan et al., 2013; Szelényi & Inkelas, 2011; Wofford, 2021; Wofford et al., 2022). Several quantitative studies reveal that students' pre-college

educational aspirations remain the strongest predictors of their graduate aspirations near the end of college (e.g., Eagan et al., 2013; Hanson et al., 2016). Put simply, early aspirations have a strong relationship with students' application for, and enrollment in, graduate education, as evidenced by theoretical and empirical studies (Ajzen, 1991; English & Umbach, 2016).

Psychosocial beliefs similarly shape how students consider pursuing a graduate degree. In STEM, extant studies have documented how beliefs about disciplinary science identities (e.g., the extent to which one feels like a "science person") and disciplinary self-efficacy (i.e., confidence in mastering scientific skills) are highly intertwined with how students envision their potential future paths (Kyoung Ro et al., 2017; Merolla & Serpe, 2013; Williams & George-Jackson, 2014; Wofford, 2021). Yet, scholars have acknowledged that such beliefs are shaped by structural barriers and support structures. For example, research has documented how low-income computing students view graduate degrees as "not something for them" (Bond-Trittipo et al., 2022, p. 12). While most higher education studies of science identity and related beliefs have focused on students at universities, some explore students at community colleges and emphasize the role science identity plays in shaping transfer success in STEM (Rodriguez et al., 2017). Further, Wang's (2017) conceptual model on STEM community college transfer pathways articulates how self-efficacy and related beliefs serve as mechanisms that foster transfer student success, providing important theoretical framing for our inquiry (discussed below).

Other studies have considered how quality mentoring builds self-efficacy, identity, and aspirations in STEM (e.g., Byars-Winston et al., 2015; Robnett et al., 2018) and in computing more specifically (Fryling et al., 2018; Pon-Barry et al., 2017; Wofford, 2023). Especially relevant to our inquiry, Wofford and colleagues (2022) applied possible selves (Markus & Nurius, 1986) and used nationwide survey data to complicate what is known about faculty

support and students' development of graduate aspirations in computing, though their inquiry did not focus specifically on transfer students. In doing so, the authors discussed how faculty support informs psychosocial beliefs (e.g., computing identity), which are positively associated with graduate aspirations (Wofford et al., 2022). However, mentoring is not universally beneficial, and other research has shown that negative interactions with mentors may dampen students' educational aspirations, confidence, and success in STEM (Limeri et al., 2019). Other studies document racial/ethnic and gender disparities in how STEM environments foster aspirations for graduate school and academic careers (Alm & Bailey, 2022; Byars-Winston & Rogers, 2019).

Factors that Shape STEM Graduate School Trajectories

Researchers have pointed to additional higher education environments that may facilitate access to STEM graduate education, including research settings and student organizations (Eagan et al., 2013; Szelényi & Inkelas, 2011). Literature about STEM students' involvement in research has documented how the process of doing research helps undergraduates understand what graduate school may involve and how their interests can be translated into academia (Ahn & Cox, 2016; Dolan & Johnson, 2009). Yet, access to structured research opportunities may be less accessible to transfer students who often have less time to develop relationships with university faculty and learn about such opportunities (Solis & Duran, 2022). In response, some universities have developed specific research programs for transfer students to increase their access to research experiences (Chamely-Wiik et al., 2021). The availability of these influential opportunities may subsequently relate to how students from different backgrounds and trajectories view graduate school as part of their future paths or not.

The presence of financial assistance and scholarships encompass another category of supports that may shape students' perceptions regarding the cost—both real and perceived—of

pursuing STEM graduate school (Malcom & Dowd, 2012; Xu, 2016). McKinney and Burridge (2015) found that Latine community college students were often averse to taking out student loans, and that, for all students, utilizing loans early in one's education negatively predicted retention in the long term, suggesting that community college students may rather discontinue their education than accumulate high levels of debt over time. Other Students of Color—particularly Black students—are significantly more likely than white students to carry high levels of student debt and to default on repayment (Looney & Yannelis, 2015), which can increase pressures to directly enter the workforce rather than pursue an advanced degree (Ostrove et al., 2011; Webber & Burns, 2021). Scholars have also explored financial considerations for graduate education in terms of opportunity cost (Perna, 2004; Stiber, 2000), whereby the salaries that STEM bachelor's degree recipients might earn are viewed as sacrificed earnings if one goes to graduate school (Eagan & Newman, 2010). Opportunity cost may play a critical role in shaping students' aspirations for STEM graduate training, given that such opportunities are assessed through a set of *perceived* benefits for one's life and career. For example, Cossa and Barker (2021) recently documented that some Black students' perceptions of the benefits resulting from a PhD are little more than the status provided by "being able to boast the title of Dr." (p. 155). More research is needed to understand how CS students perceive PhD opportunity costs and benefits.

Vertical Transfer Students' Pathways to Computing Graduate Education

The present study is also guided by decades of literature on equity and vertical transfer degree pathways across disciplines and in STEM (e.g., Jain et al., 2011; Laanan et al., 2010; Wang, 2009). Researchers have documented how vertical transfer pathways represent an important mechanism for expanding access to higher education (Taylor & Jain, 2017), STEM

majors (Bahr et al., 2017; Wang, 2021), and STEM graduate degrees (Wang et al., 2019). Other studies document how STEM transfer students bring unique assets to their universities, which contributes to their success and potential for graduate study (Laanan et al., 2010; Mobley & Brawner, 2019; Starobin & Laanan, 2010). Thus, fostering a transfer receptive culture (Jain et al., 2011), in which transfer students are supported and valued, is essential to increasing access to graduate school. Indeed, Wang et al. (2019) argued that "community colleges hold the promise to complement the route to graduate and professional school" (p. 96). Unfortunately, university programs may fall short of realizing this promise, as other studies document how university faculty endorse transfer stigma and falsely assume that all students in their courses began their degree at the four-year university (Elliott & Lakin, 2020).

In computing, recent studies highlight how efforts to foster equity must include the creation of more transfer-inclusive environments at receiving institutions (e.g., Blaney, 2022; Ireland et al., 2022). These and other studies have similarly documented the importance of fostering a sense of belonging and improving the culture for transfer students as they enter their receiving universities (Blaney, 2022; Blaney, Barrett et al., 2022). However, despite the body of literature exploring the potential of transfer pathways to expand higher education access, scholars have only recently considered transfer students' pathways toward computing graduate programs (Blaney & Wofford, 2021). This research leaves much to be learned about how transfer students in computing conceive of graduate school as a potential part of their degree trajectories.

Complicating PhD Opportunity Costs and Motivation in the Context of Computer Science

Given the lack of research on vertical transfer pathways to CS graduate degrees, this study is guided by broader literature on pathways to graduate school and vertical transfer, which we merge with literature specific to CS contexts. CS continues to lag behind other disciplines in

efforts to bolster diversity in graduate programs, as women make up just over 20% of doctoral recipients in CS-related fields, while Black, Latine, and Indigenous students combined make up only 3.2% (Zweben & Bizot, 2021). Research on students' motivations to pursue a CS graduate degree (not specifically focused on transfer students) documents how such decisions are driven by myriad factors, including a desire to conduct research and advance disciplinary knowledge (Duncan et al., 2020). Still, it is crucial to situate our work in relation to specific career and salary outcomes for CS PhD earners, which inform students' decision making.

Attainment of a graduate degree is associated with increased lifetime earnings (Carnevale et al., 2021; Posselt & Grodsky, 2017). Doctoral degree recipients across occupations earn 43% more in median lifetime earnings than bachelor's degree recipients (Carnevale et al., 2021; Posselt & Grodsky, 2017). The earnings advantage for PhD recipients is narrower in CS, though doctoral degree recipients in CS and mathematics occupations still earn 34% more in median lifetime earnings, relative to bachelor's degree recipients in those occupations (Carnevale et al., 2021). However, these advantages may do little to mitigate perceived opportunity costs of graduate training when weighed alongside starting industry salaries (Eagan & Newman, 2010), given that "differences in earnings by education level start small and grow over the course of a career" (Carnevale et al., 2021, p. 8). This may be especially true for students from lower-income backgrounds and those who accumulate student debt (Malcolm & Dowd, 2012).

Some CS students may pursue PhDs with a goal of becoming a professor. While PhDs may not be mandatory for all faculty positions—particularly non-tenure track roles and positions at some community colleges (e.g., California Community Colleges; Woodyard & Levy, 2018)—only 4% of new tenure-track assistant professors in CS were hired without PhDs in 2020-2021 (Zweben & Bizot, 2021). Thus, PhDs continue to function as prerequisites for tenure-track

faculty positions across the United States. At the same time, one recent study revealed that a large proportion of CS PhD recipients pursue careers outside academia, and 16% move between job sectors (i.e., academia, industry, and government) over time (Safavi et al., 2018). Given the variety of career outcomes for CS PhD recipients, motivations to pursue CS PhDs likely vary.

Theoretical Perspectives

Our exploration of vertical transfer CS students' conceptualizations of PhD study was guided by social cognitive career theory (SCCT; Lent et al., 1994) and Wang's (2017) adaptations of SCCT to a STEM transfer context. SCCT emphasizes how students' educational and vocational decisions are based on their beliefs in their ability to succeed and the possible outcomes of that success. More specifically, *self-efficacy* reflects one's confidence in their ability to master a task, which predicts their willingness to persist in investing effort (Zimmerman, 2000). Such beliefs are based on mastery experiences where students succeed in learning to perform a task, vicarious experiences where they observe the success or failure of others (especially those whom they perceive as similar to themselves), and encouragement from others (Bandura, 1997). Additionally, SCCT identifies *outcome expectations* as beliefs about the consequences of engaging specific goals or opportunities. Outcome expectations are products of students' access to accurate information about different careers and other experiences that inform students about the viability of success (e.g., messaging about the traits of a person who earns a PhD; Borrego et al., 2018). Collectively, self-efficacy and outcome expectations have been shown to predict goal pursuit and attainment (Pajares & Miller, 1995; Smith & Fouad, 1999).

When it comes to the decision to pursue graduate school, self-efficacy and outcome expectations may be uniquely constrained by limited access to knowledge about graduate study and faculty career opportunities (Gardner, 2007). Prior studies have quantitatively leveraged

SCCT and identity-centered frameworks to explore STEM undergraduates' aspirations for graduate training and degree trajectories, with several scholars finding a positive relationship between early self-beliefs and later STEM graduate school trajectories (Carpi et al., 2017; Merolla & Serpe, 2013; Wofford, 2021; Wofford et al., 2022). For vertical transfer students in STEM (Wang, 2017), degree outcomes and career choices are also shaped by transfer receptivity of university campuses and the larger contexts in which students experience college (e.g., family and financial responsibilities), because they convey robust messages that influence self-efficacy and outcome expectations. Thus, we explored transfer students' perceptions of graduate study, with consideration of family contexts, financial needs, and pre- and post-transfer experiences.

To further understand student meaning-making around PhD study, we leverage the concept of possible selves (Markus & Nurius, 1986). Possible selves closely relate to student aspirations, as students make decisions based on what they believe is (im)possible (e.g., careers that a student can see themselves successfully pursuing). Possible selves can be shaped by transfer processes, structural inequities within transfer pathways, and individual transfer stigma that vertical transfer students might experience at receiving universities (Shaw et al., 2019). More broadly, possible selves can be influenced by gender discrimination, racism, and other structural inequities (Blaney, Wofford et al., 2022). Therefore, it is important to understand the (im)possibilities that vertical transfer students perceive about PhD study, with consideration of how their other social identities (e.g., gender, race) and college experiences shape their trajectories. Merging the concept of possible selves with SCCT—and informed by existing research on the importance of students' early beliefs—we focused our inquiry on the early conceptions that vertical transfer students hold, which may shape their decision to pursue a PhD. These guiding theories informed our research questions, which, in turn, drove our decision to

utilize phenomenological methods. Further, SCCT and possible selves guided our interview protocol, analysis, and the interpretation/presentation of results (discussed below).

Research Design

Our study drew on interview data from a larger study of community college transfer pathways to PhD training in CS. Guided by our research questions which focused on vertical transfer students' conceptions of CS PhDs as a possible educational pathway, we employed phenomenological methods to center students' experiences of meaning making. We used hermeneutic phenomenological methods to interpret "participant experiences as they are lived in the world" and were informed by post-structural phenomenological approaches, as "phenomena do not solely manifest from individuals, but rather are socially produced" (Valentine et al., 2018, p. 465). In so doing, we acknowledge the social constructions that organize relational experiences while staying attuned to participants' lived experiences (Heidegger, 1962; Valentine et al., 2018; van Manen, 1997). Further, according to Valentine and colleagues (2018), the post-structural approach extends "the interpretive focus on *being* towards one of *becoming*," as "phenomena are constantly changing and our understanding of them is inherently partial" (p. 465). By leveraging interview data as a set of texts, we brought (and questioned) our historical self-consciousness and interpretative lens to capture individuals' everyday experiences (Gadamer, 1975). Given our focus on transfer students' experiences with meaning making at a particular moment in time, we were informed by sensibilities from the hermeneutic tradition, but also considered the relational meaning of experience in the post-structural phenomenological approach. Collectively, our phenomenological methods align with our desire to center transfer students' lived experiences to uncover how they form early conceptions about PhDs.

Research Sites and Contexts

Because transfer processes vary widely by state (Jenkins & Fink, 2016), we focused our data collection on transfer students across five receiving universities in California. California represents a unique context for this study, especially in light of recent reforms to increase the proportion of vertical transfer students across universities in the state (Public Policy Institute of California, 2019, 2022). Our goal is to precisely contextualize our study, while extrapolating findings to inform policy and practice within and beyond California. Further, because we focus on students who successfully transferred to five highly selective, research-intensive universities, the participants in our study represent a self-selected group; the characteristics of our research sites provide important context for understanding the study participants and findings that follow.

Participant Characteristics and Data Collection Procedures

We successfully recruited 18 participants from a larger longitudinal survey sample of *N*=82 vertical transfer CS majors who were enrolled as full-time students across five universities described above. Each participant transferred from a community college and entered their university in Fall 2021. Surveys included questions to capture gender, race and ethnicity, parental education, and aspirations for graduate degrees; these questions were used to select interview participants to maximize variation in graduate school aspirations, race/ethnicity, and gender, in keeping with our phenomenological approach.[2] In addition to identity-based characteristics, parental education was a key variable for participant selection because faculty disproportionately come from backgrounds with highly educated parents (Morgan et al., 2021). Participants characteristics and self-selected pseudonyms are shown in Table 1.

All interviews, initially conceptualized as hermeneutic conversations that prioritize openness within meaning making (van Manen, 1997), were approximately one hour in length

[2] Due to low responses to initial interview invitations, all *N*=82 survey respondents were invited to participate, and we interviewed all 18 students who ultimately responded.

and were recorded and transcribed verbatim. We conducted interviews via Zoom in early 2022 (during students' second term of the first year at their receiving campus), and participants received a $25 gift card as compensation. Informed by the theories discussed above, the semi-structured protocol included broad questions about aspirations (e.g., "Could you tell me about what you hope to do after earning your CS degree?"), which we tailored with probes specific to participants' stories about PhD-related interests (e.g., "Have you considered graduate school? What about a PhD? Why or why not?"). By introducing an open structure that could be tailored to participants' experiences, we collected data in ways that prioritized students' stories, anecdotes, and recollections pertaining to their lived experiences (van Manen, 1997). We asked follow-up questions to capture what students viewed as (im)possible (Markus & Nurius, 1986) in relation to graduate training (e.g., If you were to pursue a PhD, do you think you would be successful? Why or why not?). In addition, we asked participants about their knowledge of advanced computing degrees (e.g., "What do you know about graduate training in computer science? What about PhD training specifically?") and probed about how they gained that knowledge (e.g., "How, and from where, did you learn about PhD/graduate training?"). These questions were driven by our guiding theories, which emphasize the importance of access to accurate information on which decisions are based (Lent et al., 1994; Markus & Nurius, 1986). Following each interview, the researcher who conducted the interview wrote a summative memo on the discussion, interpretations, and potential influences of the researcher's positionality.

Thematizing as Data Analysis

Hermeneutic and post-structural phenomenology neither *pre*scribe nor *pro*scribe particular methods of analysis (Valentine et al., 2018). Instead, both hermeneutic and post-structural approaches to phenomenology utilize "iterative cycles of interpretation" whereby "the

researcher continuously questions and interrogates [their] existing knowledge and perspectives to better understand the fleeting nature of a phenomenon of interest" (Valentine et al., 2018, p. 465). Interview data were thus analyzed in iterative cycles. This included a reading and re-reading of texts, in which we analyzed transcripts through a process of thematizing with attention to participants' multidimensional realities and our hermeneutic consciousness (Heidegger, 1962; van Manen, 1997; Valentine et al., 2018). In the first cycle of analysis, we were attuned to the wholistic reading of entire interview texts (Vagle, 2018). Next, our team discussed memos drafted by the authors who conducted the interviews, which allowed for preliminary peer debriefing (Spall, 1998). We identified preliminary concepts and themes throughout this discussion and selective reading (Vagle, 2018) and developed a list of themes, interpretations, examples, and counter-examples from these analytic strategies. As part of this process, we looked to our guiding theories (Lent et al., 1994; Markus & Nurius, 1986) to organize constructed themes. Next, the first two authors conducted a detailed, line-by-line review of two interviews to isolate thematic statements (Vagle, 2018), reconciling interpretive disparities before dividing the remaining transcripts for analysis. We isolated themes deductively and inductively using NVivo 20. To ensure trustworthiness, the team met regularly to discuss findings and maintained interview transcripts/recordings.

Positionality

In keeping with our phenomenological approach, we acknowledge that human science is informed by lived experiences, including our own (van Manen, 1997). Our positionalities shaped the construction and interpretation of this research. As a research team, we agree with Arminio's (2001) assertion that the researcher is an "active ingredient" in studies employing hermeneutic phenomenological approaches, and we seek to bring transparency to some of the ways in which

this occurred. We brought a consciousness of our whole selves to our analysis and interpretive discussions in an act of bridling, or "ongoing activity of restraining one's pre-understanding," to ensure that students' full experiences could be presented in the findings (Valentine et al., 2018, p. 466). Collectively, we openly reflected on and explicitly discussed how our positionalities may have informed all stages of the research design and execution, always seeking to return to participants' manifestations of their (im)possibilities and lived experiences as the focus.

We each reflexively drew on our lived experiences and expertise throughout the study. The first author is a white woman, first-generation college student, and assistant professor of higher education who took community college courses during her undergraduate degree program but did not follow a transfer pathway. Though a disciplinary outsider to CS, she has been studying equity in computing for a decade and has studied vertical transfer computing students for five years; she reflected on how those prior research experiences, coupled with her salient identities, guided the design of the approaches used in this paper. She also reflected on how her identities and prior experiences may have shaped the nature of what was shared during the interviews that she conducted. The second author is a first-generation college student and nonbinary Latine scholar of equity in STEM higher education who was dual enrolled in community college classes during high school but did not follow a transfer pathway or study CS. The third author is a white, cisgender woman who also took dual enrollment courses, but did not pursue CS or a transfer pathway. Her scholarly and practitioner expertise—notably regarding hidden curriculum and equity-mindedness in graduate education—was especially salient in conversations with participants. Finally, the fourth author is a white man and professor of instructional technology and learning sciences; also a disciplinary outsider to CS, his scholarship has examined professional development in STEM disciplines and the influence of instructional

and cultural experiences across multiple postsecondary educational pathways. Collectively, our shared commitment to advancing equity in STEM was central to how we approached this work.

Delimitations and Context for Interpretation

Before presenting findings, it is important to clarify the scope and context of our study. First, transfer pathways and standards are widely varied, with variation often resulting from state policy agendas and contexts. All participating institutions were research-intensive universities in California, meaning that results may not be representative of student experiences across other contexts. We relied on interview data from 18 participants, recruited from a larger survey sample of *N*=82. Due, in part, to women's underrepresentation among vertical transfers in CS (Blaney, 2020), only four women were included among interview participants, which limited our ability to capture complexity in how women develop their beliefs related to graduate study. Further, our interview participants included no Black or Indigenous students and only two students identifying as Latina/o, which limits the experiences represented in our data.[3] Finally, to be precise in our inquiry, we focused on students pursuing majors housed in the CS department at their universities; much of the existing literature has examined computing-related majors in the aggregate, including interdisciplinary computing degrees (e.g., data science, computer engineering, etc.). While we draw connections to other STEM fields, more research is needed to determine the extent to which our findings may be unique to CS.

Findings

Our findings document how vertical transfer CS students experience learning about and considering doctoral education (RQ1) and how they developed their (dis)interest in pursuing an advanced degree (RQ2), recognizing that some themes relate to both questions. In our findings,

[3] The survey sample from which participants were recruited included 23 students who identified as women and, separately, one as Black, 11 as Latine, and one as Native Hawaiian/Pacific Islander; all were invited to participate in the interviews.

we distinguish between discussions of graduate education broadly and doctoral training more specifically. In keeping with the study's phenomenological methods, we include direct quotes and counter-examples to present the complexity of how students considered graduate education.

RQ1: Graduate Aspirations and (Im)Possible Selves

We identified four themes capturing how students conceptualized graduate education as a possibility through 1) their tentative understanding of it; 2) "genius" myths about PhDs; 3) opportunity cost considerations; and 4) concerns about timing within broader life plans.

Tentative Understandings and Passive Interests in Graduate Pathways

Participants largely expressed broad and ambiguous interest in graduate study during the interviews, though a few noted specific interest in pursuing a PhD.[4] For example, Nick, an Asian man with college-educated parents, expressed openness to considering graduate school because "my parents and many of my relatives asked me, and they do suggest I go to graduate school." Yet, even with the prodding of family members, Nick conveyed that he had developed only a cursory understanding of PhD degree pathways:

> I learned that you can go and try to do a PhD without going through graduate school. So you could directly go from your bachelor's to joining into a PhD. And yeah, that's as far as I've gone in terms of looking into trying to do a PhD in computer science.

In most cases, participants, including Nick, were not actively seeking out information about graduate programs, rather displaying a passive openness to graduate training.

Because participants were unsure of their specific aspirations, students who had an interest in graduate school conceptualized master's programs as providing opportunity to learn if a PhD might be right for them. Ann—an Asian woman and international student—described a

[4] On the survey administered approximately two months before the interview, three of the interview participants indicated an interest in earning a PhD in CS.

tempered interest in considering a PhD, saying, “maybe I would be more interested in [a PhD] in the future when I'm getting my master’s...I'm not too sure about it yet.” As a research team, we worry that this strategy of using master’s training to make decisions about PhDs may lead to unnecessary student debt for those who pursue unfunded master’s degrees that are often not required for a CS PhD (Pyne & Grodsky, 2020). However, this strategy may seem pragmatic to students, especially when information about graduate school funding is not widely accessible.

As a counter example—Ryan, a Middle Eastern man, first-generation college student, and international student who previously attended college and worked overseas before beginning community college coursework in the U.S. in 2018—was one of a few students who was intentional about his contemplation of doctoral education, explaining, “I wanted also to explore what research is before going to PhD. I don't want to waste time if something's not gonna click with me. So that's why I wanted to experience research during undergrad.” Ryan’s drive for research experience was rooted in an active pursuit to learn more about what a PhD involves and how that may or may not “click” with his skillset and interests. While incomplete information about PhDs was not a total deterrent, without something to catalyze active interests, students may not conceive of all the possible educational and career pathways open to them nor fully explore that range. Limited access to accurate information may also lead students to be susceptible to popular misconceptions about PhDs, as discussed below.

Myths about PhDs Intimidate Students

About half of the students in our study described PhD training as intimidating. In several instances, students went so far as to label PhDs as “something that geniuses do,” as Rip, a white man and military veteran with college-educated parents, stated. Similarly, August, a non-binary white student with college-educated parents, discussed: “I don't think [a PhD] is right for me, and

[it] seems like a very scary, intellectually demanding environment…I've always assumed that [PhD students] were prodigies." In most cases, these discussions focused on how students perceived PhDs as outside the realm of possibility, so students did not feel the need to gain more information, as they were confident that a PhD was "not for [them]," as several students put it.

Myths about who can succeed in PhD programs were perpetuated by comparisons that led vertical transfer students to feel intimidated or inadequate. Some students discussed "feeling behind" relative to non-transfer peers, while others spoke of general experiences with university students or faculty that made them feel stigmatized for having attended a community college. This was especially prevalent when vertical transfer students compared themselves to non-transfer students who were enrolled in accelerated BS/MS programs—a common offering in CS departments. For example, Ian, an Asian man with college-educated parents, discussed being intimidated by his classmates who were beginning master's level coursework:

> There was a CS panel that I attended. It's a recommended meeting for all CS students…and we were able to attend a lecture with three graduate students who told each one of us like, what they were doing, how they got there, what their recommendations are… I haven't been able to relate to a lot of the same stuff, because, I mean, most of them are taking the MS/BS. And in order to do that, you'd have to have planned it out from the very beginning.

For Ian and other participants, seeing only non-transfer students pursue graduate education perpetuated a misconception that vertical transfer pathways cannot lead to graduate school. Moreover, the invisibility of graduate students who previously attended a community college reinforced transfer stigma and myths about PhDs as impossible for vertical transfer students.

Opportunity Costs Deterred Students from PhDs

All participants expressed some degree of concern over the amount of time required to

complete a graduate degree. Alongside these concerns, students often described how they felt a sense of urgency to get into the workforce and begin earning a stable income. This was especially prominent among students who were older than 25 or described taking longer than they had planned to complete their bachelor's degree. For example, Kate, a white woman with college-educated parents who took several years away from school to care for a parent before returning to pursue a transfer pathway, explained:

> So [earning a PhD] was actually something, when I was younger, that…I thought I wanted to do with my life… At the same time, it's like… 'God, it took me so long for my bachelor's.' Can you imagine, like a 30-year PhD or something?

Kate described how her extended bachelor's degree timeline caused her concern that earning a PhD could take an unimaginable amount of time. Like others, Kate's life circumstances led her to spend more years at the community college than she had initially planned, which shaped her perception of the opportunity costs of graduate school.

Other participants held broader concerns about graduate education leading to a prolonged state of precarity, especially given the obstacles transfer students had already overcome to make it to their university. For example, Michael, a white man with college-educated parents, explained that he had previously considered pursuing a PhD, but was concerned about the financial instability that would come with additional schooling:

> I don't know if I want to do any more school, because I feel like school postpones…your life…Once I have a job, I can really stop worrying about…money so much. If I'm gonna have to spend more time in school, [I'll have to] worry about money and all that stuff.

Echoing Michael's financial concerns, Zach—an Asian man with college-educated parents who spent a decade in the workforce before beginning community college in 2018 with an intention

to transfer—stressed his sense that graduate school would lead to economic precarity that was inconsistent with his life plans. When asked if he was considering graduate school, Zach replied with a sigh, "if I was younger, maybe. But now that I'm older, no... If I want to support a family, I better fix my act now, basically." While both Michael and Zach discussed graduate school as an opportunity cost of financial stability, Zach was the only man to place this in the context of supporting a family, as family planning was more salient among women (discussed below).

Overall, the ways in which students made meaning of the financial precarity and prolonged degree timelines that they associated with graduate training were closely connected to their prior educational experiences, including lengthy transfer admissions processes and extended bachelor's degree timelines. The nature of how students conceptualized graduate education in CS was shaped by an eagerness to enter the workforce, worry that earning a PhD would take a protracted amount of time, and concerns about continued financial precarity. Student calculations of these opportunity costs were essential to how some of them conceived of graduate school as an opportunity not worth the cost to them.

Concerns of Timing and Plans to Delay Graduate School

Some students who were curious about graduate school expressed concern about how to make it fit in their lives. In particular, two women students were uncertain about how to plan for graduate school, given challenges they perceived with their timeline for having children and a career. Gray—a white woman with college-educated parents who identified as a "first-generation engineer" and spent several years working as an artist before returning to community college with an intention to transfer—described how she was "planning on going on to graduate school…to further specialize in computer vision." In addition to "definitely" wanting to further her education, Gray also wanted to "start a family [within] a few short years." She explained that

if, "I go straight to industry, then I would be able to kind of like start my life with my boyfriend, but at the same time, it will be very much harder to go back to graduate school once that happens." Weighing her options, Gray was uncertain about *when* she might go to graduate school. While only four women were interviewed, the saliency with which some of them considered the issue of balancing family and careers is telling of the gendered disparities that remain in computing. Importantly, Gray's decision-making was constrained by her *perception* that graduate school would require her to put her family goals and life on hold.

For a handful of participants, graduate education seemed like a viable pathway, but only if they delayed it, so that they could gain experience in the workforce first. YK, an Asian man with college-educated parents, explained that he was considering graduate school "after I work a little bit more, just so I can gain some work experience." In addition, YK expressed that his interest in graduate school was conditional on having "enough money to fund it." Here, YK's notion of graduate school opportunities was constrained by the funding model common with master's programs, suggesting that misconceptions about how doctoral training is funded may deter students from conceiving it as viable or proactively considering it.

Some students had a perception that, if they found a job in industry, their employer might pay for their PhD. Ariel, a first-generation and Latina student who described being "very eager to get into the workforce already," explained that she had been told that "your employer will pay for your [graduate] education." Through the continued conversation, it became clear that Ariel was referring to information she received about university graduate assistantships that cover PhD tuition and fees, which she misunderstood as meaning that *companies* consistently pay for their

employees to pursue PhD study.[5] As Bob, an Asian man and first-generation college student, put it, "I guess an idea that I've had in my head is that I'll find a company that will pay for my graduate degree." These students assumed that delaying graduate school was their best option because most employers would pay for it. While some employers may provide graduate tuition benefits to employees—indeed, about 10% of doctoral students and a quarter of master's students receive employer tuition benefits (Gilpin & Kofoed, 2020)—students seemed to overestimate the availability of such programs and were not widely aware of the common practice of funding PhD training through research and teaching assistantships.

RQ2: Developing (Dis)Interest in the PhD

While the themes discussed above provide insight into *what* students thought about graduate education, we constructed three additional themes which capture *how* students became (dis)interested in PhDs. Specifically, we discuss 1) the sources of information available to students; 2) experiences or interest in tutoring, teaching, and learning; and 3) work experiences and exposure to industry. These themes explain how students imagined possible selves that might pursue advanced degrees or, more often, were deterred from considering graduate school.

Limited Sources of Information Shaped Perceptions of PhD Study

The vast majority of students in our study described uncertainty about how to access information about PhDs or other graduate education options, which may explain their reliance on the myths and misconceptions previously discussed. For instance, Ariel, who expressed an evolving interest in graduate school, noted, "I'm definitely looking into [a CS PhD], but…I would personally not know where to even start." Despite her growing PhD interests, Ariel was

[5] The first author interviewed Ariel and clarified that, while some employers might pay for employees to get a PhD, a more common practice is to be paid directly by a university as part of a research or teaching assistantship. In response, Ariel became visibly excited to learn more, and the first author followed up by sending more information after the interview.

unsure of what next steps she could take to learn more. Students also expressed uncertainty about what a PhD entails. Ann explained, “I only know that [PhD students] are doing research, they are sometimes my TAs in classes…that’s basically it.” Ann, like other participants, used limiting terms such as “only” and “basic” to describe her perceived lack of knowledge. More broadly, students frequently characterized the knowledge they possessed about graduate school as insufficient, while simultaneously expressing concern that they did not know how to access more information to guide their decision making. In contrast, our research team recognized that students did possess valuable information that could serve as a useful starting point. This highlights an opportunity for university actors to 1) affirm transfer students’ knowledge and 2) equitably provide information about graduate school logistics (e.g., funding structures, etc.).

Indeed, our conversations revealed that students were curious to learn about PhDs. In some cases, simply asking students if they had ever considered getting a PhD prompted them to express curiosity in learning more. Ann—despite previously saying that she had “never considered getting a PhD”—stated, at the end of the interview, that she was now “thinking of getting into some research, like next quarter or something, just to get a grasp of what it feels like.” Additionally, a couple of students spoke about university programming targeted for transfer students and CS majors that provided basic information about doctoral training, which was their first tangible exposure to such information. These examples point to the critical importance of proactively distributing information about graduate school (e.g., describing PhD programs, funding structures) and scaffolding information so that it is accessible.

Among the few students who had sought out information about graduate school, they frequently relied on knowledge gathered independently on the internet, which did not always portray the full range of experiences one can have in doctoral education. For example, Kate

explained how she used Reddit to gain insight into faculty life and PhD career outcomes, acknowledging that this information may not be reliable: “The people who go on the ‘slash professors’ subreddit aren't necessarily…the people who are like, ‘oh, yeah, I'm so happy at my job.’ But, it just seems like they’re very stressed out. They’re overworked, they’re underpaid.” Kate displayed a savviness about the people likely to use such forums to voice opinions about their careers. Still, despite a faculty career being something she previously “really saw [herself] doing,” the information she gathered from Reddit informed Kate’s conclusion that, “it just seems like perhaps the environment right now isn’t the best.” Notably, Kate and others mentioned that they tended to search independently for information online and without input from professors or other mentors, perhaps because they viewed faculty in large university courses as inaccessible (Blaney et al., 2024). For instance, Gray discussed how students “don’t get that one-on-one time with [university] professors,” and Bob spoke of how the “professor doesn’t know you” within large lecture courses. This underscores the need for faculty to proactively reach out to students.

As a crucial counter example, Jasper, an Asian man with college-educated parents who attended community college off and on before deciding to pursue a transfer pathway, discussed how he learned a lot about PhDs from “my professors and TAs that are either currently attending grad school or have PhDs. I've heard a lot from them about [PhD training in computing].” Jasper’s multiple shared identities (e.g., race, gender, and family background) with populations overrepresented in computing may have eased his access and bolstered his comfort in making connections with faculty, doctoral students, and others to discuss a CS PhD as a real possibility. This example aside, most participants described having “no idea where to go” to learn more about PhDs in CS. Were faculty and institutions to assume greater responsibility for ensuring equitable access to information about such opportunities, students may be less likely to form

foundational impressions based on limited, uncontextualized, and possibly unreliable sources.

A Love of Teaching and Learning Precipitated PhD Interest

When students were interested in PhDs, it was often because of tangible experiences with activities that they associated with being a professor: namely, serving as a tutor or teaching assistant or interacting with instructors or graduate students in a meaningful way. This emerged from interviews with a handful of participants who expressed some level of interest in PhD study. For example, at the end of her interview, Ariel stated that she "could see herself as a CS professor or teacher in general," going on to describe emerging academic career interests:

> I know earlier I said [that] I didn't see myself as an educator. But I feel like in the back of my head, because I love tutoring so much, it's definitely not an opportunity that I'm closed off to… Like, if I could teach to someone who looks like me. I've never had a CS teacher who looks like me. I've had two female CS teachers/professors, and everyone else is like, white male. So, I would just love to show that we're out there.

Here, Ariel described her intrinsic motivation to serve as a role model alongside her experience of being a CS tutor at her community college. Throughout the interview, Ariel began to articulate how her interests in teaching and learning could be compatible with being a CS professor: "I am genuinely interested in looking into a PhD. Like, if I could be a student for the rest of my life, I just love learning, you know?" The opportunity to discuss her love of teaching and learning allowed Ariel to develop a clearer purpose for potentially pursuing a PhD in computing over the course of the interview, and one that would contribute to intersectional equity in the field.

Others also discussed their graduate school interests in relation to a love of teaching. August described how they "really like math and computing education," which made them consider becoming an instructor, though August ultimately wanted to pursue an industry career

where they could use their programming skills to develop educational tools. Rip explained that he had "thought a lot about being a professor" due to how he "really enjoy[ed] teaching." It became clear that an interest in teaching and learning was the primary driver for students who expressed an interest in pursuing a PhD or faculty career during the interview, pointing to the importance of providing access to teaching experiences. Further, providing guidance that helps students see their teaching interests as congruent with a faculty career in CS may be important, especially for students at research-intensive universities like those in our study.

Work and Field Exposure Led Student Paths Away from the PhD

Several students described how they were deterred from considering graduate education, especially as they gained exposure to industry. For example, a conception of the computing industry as a path to social mobility without the need for advanced education was specifically what drew NC, an Asian man and a first-generation college student, to computing:

> My family was low income when I was growing up, so it kind of influenced me to want to get a job that pays well. And computer science [undergraduate] degrees are known for the availability of jobs that are well paying, and usually some places have good benefits.

NC's desire for a high-paying industry career cemented his path away from graduate education. Similarly, Ian discussed being drawn toward industry work and applying what he had already learned, stating, "my main goal right now is to just, I want to start doing the projects. I want to start putting what skills I've learned to the test. I don't see myself doing research." Ian explained that he developed his career interests without information about graduate school options:

> Actually, I don't know too much about graduate programs. I'm not too interested in becoming a master's student, though. I don't plan on taking a PhD or doing a master's. I think when I'm done, I'm just going to go back to my hometown and pursue a job.

For some students, like NC and Ian, the lure of industry was so strong, that they did not consider exploring graduate school as a possibility.

Meanwhile, Ethan's industry exposure included information that certain specialized fields would require advanced education and that, "if you want to do something more niche like that, it is good to go to get your doctorate." Still, Ethan, a Latino man with college-educated parents, explained how he learned from industry mentors and community college professors that employers "really prioritize what have you done versus what have you studied. It's the hands-on experience that is more important for computer science." His experiences with the tech industry led Ethan to conclude, "I'm pretty much thinking that I'm probably just gonna stick with a bachelor's." Other students, like Bob, spoke at length about internship experiences that fostered an excitement and eagerness to enter the workforce and gain more industry experience, leading them to be uninterested in learning more about graduate school options. In Bob's case, he participated in an internship program at a large tech company that was specifically designed to support community college students and eventually recruit them to their company. None of the students we interviewed discussed comparable programs designed to develop an early interest in graduate school, pointing to missed opportunities to build momentum toward graduate study.

Discussion and Implications

Our study builds on existing literature on vertical transfer by extending the scope to understand pathways from community colleges to graduate programs in CS. Here, we applied SCCT, informed by Wang's (2017) work on vertical transfer in STEM and the theory of possible selves (Markus & Nurius, 1986), to consider both *what* and *how* vertical transfer students in CS conceive of graduate education and PhD training, in particular. This study extends the literature on computing graduate school pathways (e.g., Wofford et al., 2022), focusing specifically on

transfer students. Because at least one-third of undergraduates will attend community colleges at some point in their educational pathway (CCRC, 2022), increasing vertical transfer students' access to PhDs is a critical aspect to developing a more diverse and representative CS faculty.

We document vertical transfer students' understandings of PhDs as hampered by limited exposure, misconceptions and myths about PhDs as "for geniuses," and concerns of opportunity costs. Collectively, these forces may constrain vertical transfer students' outcome expectations—a key component of realizing one's goals through the lens of SCCT—and lead them to view PhDs as impossible, despite prior evidence illustrating disproportionately high PhD aspirations among vertical transfer students in CS (Blaney & Wofford, 2021). Students' conceptions of doctoral education—and whether or not they develop an interest in it—are integrally linked to how they are exposed to information about graduate school pathways and the experiences they have during their undergraduate education. As an example, participants discussed far greater exposure to industry careers than academic career paths, which deterred them from seeking out further information about graduate education and constrained their ability to envision the possibility of pursuing academia. This imbalanced exposure to industry may also speak to universities' continued gatekeeping in academia, as vertical transfer students may not have opportunities to fully develop disciplinary self-efficacy (Lent et al., 1994) for graduate education when exposure to industry careers is more readily available. Our findings highlight how pressure to enter the workforce and become financially secure also inhibited students' perceptions of themselves as able to pursue graduate study, expanding upon other recent studies of low-income computing students (Bond-Trittipo et al., 2022). For students who were open to considering graduate school, and specifically a PhD, their understandings were sometimes shaped by misleading, incomplete, and inaccessible information. Consistent with SCCT, limited

information may hinder the development of self-efficacy and outcome expectations that would fuel PhD aspirations. At the same time, students' openness to PhDs illustrates the value of opportunities to acquire more concrete understandings of doctoral education and its prospects.

Our data also support the salience of possible selves, showing how "under conditions of limited educational or economic opportunity, occupational choices will be dictated more by job availability, self-efficacy, and outcome expectations than by interests" (Markus & Nurius, 1986, p. 109). These findings emphasize how access to accurate information about graduate study may shape student pathways. In other words, early PhD interests can be curtailed by myriad forces that lead transfer students to view PhDs as "not for them." We preemptively reject a deficit-based explanation for why participants may not consider PhDs as a viable option and instead place responsibility for properly conveying the feasibility and value of PhDs on institutions, as part of larger efforts to develop a transfer receptive culture (Jain et al., 2011). Due, in part, to the challenges we uncovered, transfer students remain an untapped group for diversifying the CS professoriate, despite the talents and diverse interests that they bring to their universities, as illustrated by our findings.

Deconstructing Hidden Curriculum and Distributing Information about Academic Careers

The importance of transfer support structures at receiving universities is well-documented (Bahr et al., 2013; Wang, 2017). Building on Wang's (2017) theoretical expansions of SCCT for STEM transfer student success, our use of SCCT and possible selves provides a more nuanced look at the connections between post-transfer supports and potential futures for vertical transfer CS students. We suggest that university support structures, like transfer centers and counselors, should provide accessible information about graduate study and a comprehensive range of career opportunities in industry *and* academia. Failure to provide broad access to information about

graduate school will perpetuate the hidden curriculum status of such information and, therefore, inequity in who conceives of academic careers in CS as possible.

Vertical transfer students may experience a "transfer tax" from having to decipher an entirely new institution, transfer stigma about their educational trajectory, and limited time to gain the experiences at their receiving university that would make them competitive for PhD admission (e.g., research experience; Shaw et al., 2019; Solis & Durán, 2022). Further, transfer stigma and negative social comparisons may constrain students' self-efficacy and outcome expectations associated with graduate school. We suggest that universities provide tailored information about graduate education options to vertical transfer students, which may contribute to a transfer-receptive culture and expand vertical transfer students' views of what is possible and attainable. For instance, even the simple exercise of directly asking students about interest in doctoral training within the context of our interviews was enough for some students to consider PhD training as a possibility when it had not previously been envisioned as a possible self. Further, some participants perceived that graduate school requires students to put their life and family goals on hold; thus, providing students with accurate examples demonstrating the possibility of living a full life during graduate school may expand what transfer students view as possible. If professors and TAs were to more regularly divulge information about their career trajectories, while inquiring about students' interests in PhDs and faculty life, they may be able to demystify these pathways to a more diverse group of students.

Supporting Graduate School Interests Through Teaching and Tutoring Experiences

In addition to efforts to distribute information more broadly about PhD training, we identify other tangible practices that may shape vertical transfer CS students' early interest in pursuing such pathways. Prior research has emphasized the importance of undergraduate

research experiences in building pathways to STEM graduate programs (e.g., Eagan et al., 2013; Strayhorn, 2010). Yet, our findings suggest that some students may develop their initial interest in PhDs through their experiences serving as a tutor or teaching assistant. Informed by SCCT and possible selves, we view these mastery experiences as mechanisms to bolster students' self-efficacy and outcome expectations, as they provide opportunities to envision a faculty role as a possible self. As others have noted, universities can do more to tap into and support racially/ethnically minoritized students in STEM by recognizing their strengths and the communities from which they draw social support (Burt et al., 2019). For example, informational materials that emphasize how a diverse STEM faculty is critical to the advancement of knowledge and society may foster positive PhD outcome expectations and self-efficacy for students from minoritized groups. Accessible information about the different options open to PhDs, like careers at community colleges, could support transfer students' development of career goals that integrate their various interests and values.

Because the students in our study were interviewed during their first year at their receiving universities, participants primarily discussed teaching and tutoring in relation to experiences at the community college. Our findings point to the importance of helping students connect their interests in teaching and learning with the possibility of becoming faculty, particularly at teaching-focused institutions like the ones where vertical transfer students begin their degrees. For some transfer students, formative experiences at teaching-focused community colleges may mean that serving as a tutor may play a more pivotal role in initially piquing their academic career interests, relative to research experiences which transfer students may be exposed to later in their degree programs. By connecting students' teaching interests with PhD training, CS programs may be able to pique transfer students' interest in PhDs and academic

careers. This may represent one strategy for addressing the faculty shortage that is currently limiting access to the field and thus perpetuating a lack of diversity in computing. Further, PhD admissions processes and programs should recognize and value the tutoring and other teaching experiences that students might bring with them. It will also be important to ensure that teaching and mentoring opportunities are equitably available to students.

Increasing Financial Accessibility of Graduate Programs

Providing tailored information that demonstrates how graduate school can be financially accessible may also go a long way in encouraging transfer students to consider PhDs as viable. Our findings show that comparable information about industry careers is widely available, so it is vital to make graduate education information (e.g., PhD funding structures, graduate assistantships) equally accessible. This may help students make informed decisions regarding master's degrees, as students should have access to accurate information about how PhDs may be a more affordable alternative to master's programs, especially in light of our findings that transfer students consider pursuing master's programs to find out if a PhD is right for them. While PhD study may not be of interest to all CS students, ensuring equitable access to these pathways is critical to diversifying the professoriate (Blaney & Wofford, 2021).

Finally, because the students in our study placed high value on financial stability promised by the CS workforce, we stress the importance of tailored structures to support students who have been previously underserved by transfer processes. In particular, transfer students may benefit from early admissions guarantees and funding commitments from PhD programs, which could improve students' perceptions (and actual experiences) of financial security during PhD study. Recognizing that transfer students may disproportionately have additional family and financial obligations (Blaney, 2020) makes it critical that universities take steps to improve

working conditions in PhD programs, which includes ensuring that all graduate students are paid a living wage. Such efforts may represent a first step in helping transfer students view PhDs as a feasible option that is compatible with their financial needs.

Directions for Future Research

Research on STEM vertical transfer success often focuses on the predictors of whether or not students successfully transfer to a university or attain a bachelor's degree. However, our study underscores the importance of examining stratification in the specific degrees and careers pursued by students, as well as post-transfer experiences that may shape those degree and career outcomes. Importantly, some studies of vertical transfer experiences document how popular initiatives to support students (e.g., first-year experience programs and initiatives) may exclude students who transfer from a community college (Townsend & Wilson, 2006). Building on that literature, we identify how common efforts to increase access to graduate study may similarly exclude transfer students. For example, while BS/MS programs may have gained popularity in CS as a tool for increasing access to graduate degrees, these program offerings may be perceived as inaccessible to transfer students, further contributing to their perceptions that graduate study is "not for [them]." As a next step in advancing this line of work, research should consider how beliefs about graduate study develop into matriculation to various graduate programs.

Our findings point to myriad experiences that expand and constrain vertical transfer students' conceptions of graduate training as (im)possible, which we translate into implications for how to build more accessible pathways from community colleges to PhDs and other graduate degree programs. These implications include the importance of correcting myths and deconstructing the hidden curriculum, increasing exposure to tutoring and TA opportunities, and increasing the availability (and visibility) of guaranteed funding for PhD study, which can

enhance interest, perceived value, and expectations for success. As a next step, future research might use a wider range of methods to examine the extent to which specific interventions and experiences (e.g., serving as a TA or tutor, attending information sessions about PhDs) may shape key outcomes (e.g., graduate school aspirations) among vertical transfer students.

Conclusion

By exploring how vertical transfer students develop ideas about PhDs and related career trajectories, we identify strategies to diversify PhD programs and subsequently expand access to faculty careers. This study provides new insight into the pathways vertical transfer students in computer science may follow to doctoral education and careers in academia by exploring students' conceptions of the PhD. Participants held mixed conceptions of graduate education, including more than one misconception, and their (dis)interest in PhD training was often informed by a lack of accessible and reliable information about graduate programs. Yet, we identify tangible experiences (e.g., working as a tutor) and values (e.g., desire to be a role model) that may develop transfer students' interests in PhD study and academic careers. If professors and can provide early and frequent exposure to what graduate education pathways entail, as well as guidance about how interests in teaching and learning may relate to possible academic careers, they may foster expanded conceptions of possible selves among transfer students.

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Table 1. Overview of Interview Participants

Pseudonym	Gender	Race	First-generation	Age	Year entered CC
Ariel	Woman	Latina	Yes	21	2018
Jasper	Man	Asian/Asian American	No	23	2015
Nick	Man	Asian/Asian American	No*	21	2019
NC	Man	Asian/Asian American	Yes	21	2018
Zach	Man	Asian/Asian American	No**	30	2018
Mel	Man	Asian/Asian American	No	19	2019
Ethan	Man	Latino	No	21	2018
Gray	Woman	White	No**	25	2014
Michael	Man	White	No**	27	2013
Bob	Man	Asian/Asian American	Yes	20	2013
YK	Man	Asian/Asian American	No*	19	2020
Ann	Woman	Asian/Asian American	No	21	2019
Rip	Man	White	No	32	2011
Ryan	Man	Middle Eastern or Persian	Yes	32	2018
Kate	Woman	White	No*	29	2012
Ian	Man	Asian/Asian American	No	20	2019
August	Non-binary	White	No*	22	2019
Jeff	Man	White	Unknown	29	2017

Note. *Indicates that one parent earned a graduate degree, and **indicates that two or more parents earned a graduate degree. Zach was the only participant who reported having a parent (specifically, a father) with a PhD. CC = community college.

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