Navigating STEM Major and Transfer Destination Choices: Community College Student Experiences through the Lens of Practice Theory

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I respectfully acknowledge that my place of employment sits upon the ancestral lands of the Ute, Cheyenne, and Arapaho peoples, and that 48 contemporary tribal nations are historically tied to the State of Colorado and are the original stewards of its lands.

Abstract

Objective/Research Question: This research explores how community college students, who are underrepresented in science, technology, engineering and mathematics (STEM) fields and aspire to vertical transfer in STEM, make choices about majors and transfer destinations. The question is important to advancing equity in STEM, which continues to perpetuate disparities in attainment for minoritized, first-generation, and financially disadvantaged students, who disproportionately enter higher education in community colleges. **Methods:** Using a longitudinal, qualitative research design, the study relied on semi-structured interviewing to generate in-depth evidence about student experiences. **Results:** Findings showed that career goals were uniformly influential to students, yet career information was unevenly available or comprehensible during community college. Students' choices about what to major in and where to transfer were iterative and intertwined, with these choices deeply connected to students' families and lifetime priorities. Delays in student decision-making tended to have less to do with uncertain individual preferences than to a lack of information about a specific STEM major and its alignment with possible future degrees, transfer destinations, and career pathways, as well as contingencies associated with the transfer admission process. **Conclusions/Contributions:** This research demonstrated STEM-specific nuance in how underrepresented community college students navigate major, career, and transfer destination decision-making as well as the influence of family and location-based priorities in student choices. Future research should investigate how to best provide directional support for students' major and transfer destination decision-making, including major-to-career awareness and the academic and personal dimensions of transfer.

Keywords: vertical transfer; underrepresented students; STEM; equity; career planning; qualitative

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Community colleges are vital to advancing equity in baccalaureate education because minoritized, first-generation, and financially disadvantaged college students disproportionately begin their studies in two-year institutions (National Academies of Sciences, Engineering, and Medicine, 2016; Witham et al., 2015). High percentages of Black, Latinx, and American Indian and Alaska Native students seeking undergraduate degrees in science, technology, engineering and mathematics (STEM) enter higher education in community colleges (Wang, 2013a). In addition, community college attendance has itself been found to have a positive effect among female and low-income students on declaring and graduating with a STEM major (Bottia et al., 2020; Hu & Ortagus, 2019). Yet, overall transfer and bachelor's degree completion rates for community college students remain low, roughly 30% and 14% respectively, with completion rates for racially and ethnically minoritized and low-income students only half that of their more privileged peers (Jenkins & Fink, 2016; Shapiro et al., 2017). Despite a substantial literature on the transfer function of community colleges (Bahr et al., 2013), not enough is known about how student experiences differ by major field of study and student background, which limits understanding of what policies and practices promote successful outcomes (Bahr et al., 2013; Bailey et al., 2015; Bragg, 2017; Schudde et al., 2021; Senie, 2016; Smith et al., 2021; Taylor & Jain, 2017). This study adds to recent growth in evidence about what supports and barriers influence the trajectories of community college students who are traditionally underrepresented in STEM fields (Cohen & Kelly, 2019; Dinh & Zhang, 2021; Maliszewski Lukszo & Hayes, 2020; Packard et al., 2012; Wang, 2020; Wang et al., 2020; Wickersham, 2020; Zhang & Allen, 2015; Zhang & Ozuna, 2015; Zhang, et al., 2019; Zhang et al., 2022), building in particular on

Wickersham's (2020) modeling of student pathways selection, by examining student decision-making around two vital aspects of vertical transfer in STEM: choice of major and choice of transfer destination institution.

This longitudinal, qualitative investigation responds to the limited and largely quantitative existing research that has examined how STEM interest and choice behaviors develop among underrepresented students during community college (Johnson et al., 2016; Wang, 2013b; Wang, 2013c). The study explores how STEM goals, personal priorities, and transfer context influence student decision-making over time. It addresses the research question: How do community college students, who are underrepresented in STEM fields and aspire to vertical transfer in STEM, make choices about their majors and transfer destination institutions? Findings are drawn from analysis of multiple semi-structured interviews from an initial sample of 29 underrepresented students in STEM at two community colleges in different states, including 16 who successfully transferred to a four-year institution in STEM over the course of the investigation. The study uses the sociocultural theory of practice, which views student agency as goal driven and shaped by structural and contextual influences.

Literature Review

Academic Context of STEM Major Decision-Making

Among the many roles of community colleges, vertical or upward transfer has long been associated with advancing equity by providing access for students who might not otherwise pursue postsecondary education (Dowd, 2003; Goldrick-Rab, 2016; Laanan et al., 2010; Taylor & Jain, 2017). At the same time, the flexibility of community colleges--including their open enrollment policies, accommodation of full or part-time attendance, and comprehensive offerings--have been argued to be sources of complexity and confusion for students that

contribute to student uncertainty and decision deferral in the selection of majors and transfer destinations (Bailey et al., 2015; Scott-Clayton, 2011). In turn, delays in decision-making can lead community college students to waste time and money through the accrual of excess credits, which has been found to be negatively associated with eventual degree completion (Hodara et al., 2016; Giani, 2019; Roksa & Keith, 2008). These decision-making complexities have tended to be theorized as academic barriers that can be addressed through curriculum alignment and advising reforms that reduce or *structure out* students' need for information and social know-how (Bailey et al., 2015; Deil-Amen & Rosenbaum, 2003; Van Noy et al., 2016).

However, this approach to theorizing and addressing the complexities of students' decision-making neglects the broader ecological contexts that shape community college students' lives, goals, and transfer experiences and may not sufficiently account for the particularities associated with specific major fields of study, student background, and community college attendance (Schudde et al., 2021; Wang, 2013a). Indeed, Wang (2013a) found that high school exposure to and performance in math and science was more predictive of White students' intent to major in STEM than that of racially and ethnically minoritized students. Along similar lines, Wang (2013b) also found that students entering STEM pathways in community college contrasted with those entering in four-year institutions directly in that students' high school STEM experiences were more predictive of majoring in STEM among four-year institution entrants compared to community college entrants. This means that aspects of students' community college experiences motivate them to pursue STEM, raising questions about how STEM interest and choice to pursue a STEM transfer pathway emerge and develop during community college attendance (Crisp & Nuñez, 2014; Wang, 2013b). Previous research has pointed to the importance of validating experiences--in the form of STEM course-taking success

(Cohen & Kelly, 2019; Wang et al., 2019), faculty and advising support (Harper & Thiry, 2022; Zhang & Ozuna, 2015), and engagement with mentors, academic support outside class, and transfer preparation and readiness programming (Johnson et al., 2016)--as being positively associated with student choices to pursue STEM transfer pathways during community college. Recent research has also found that students' career goals and opportunities to connect with STEM professionals during community college influence student success by enabling them to see how their majors align with their career goals (Loomer, 2021; Smith et al., 2021). The current study builds on this research base in examining how academic as well as personal influences shape underrepresented students' STEM major and vertical pathway decisions. Moreover, it posits that academic and personal domains are likely to be interconnected influences (Reyes et al., 2019) on students' decisions, yet they have rarely been considered together. Additionally, the study responds to Crisp and Nuñez's (2014) call for additional qualitative research on the role of college experiences in promoting or hindering progress toward vertical transfer among underrepresented students.

Academic Context of Transfer Destination Decision-Making

Limited research has explored the transfer destination choices made by community college students (Tobolowsky & Bers, 2019) and previous research is not STEM-specific. Studies of college choice among underrepresented STEM students who entered four-year institutions directly indicates complex and multifaceted influences on student choices, beyond institutional status and selectivity, including family finances and students' future goals (Chang et al., 2008). Similarly, among community college entrants in general, enrollment decisions have been found to be driven by affordability and career preparation goals, which in turn are based on place and local economic conditions (D'Amico et al., 2019).

For high school students, college choice research has consistently shown the importance of access to early and accurate information and career exposure (Grodsky & Jackson, 2009; Hossler & Gallagher, 1987; Hoxby & Avery, 2012; Morgan et al., 2013). A lack of access to information has also been shown to delay or derail community college students, who are typically left on their own to seek out information and figure out bureaucratic complexities (Bensimon & Dowd, 2009; Wang, 2020; Wang et al., 2017). Research has begun to tease apart the academic and career pathway consequences of community college students' reliance on different sources for transfer information. Evidence is mixed about how access to information influences vertical transfer outcomes, including the role of advising and use of transfer services by community college students (Packard et al., 2011; Schudde et al., 2021; Spencer, 2019; Wang, 2017). Family and peers are the most common way that students navigate the complexities of transfer pathways (Maliszewski Lukszo & Hayes, 2020). However, better alignment in community college students' educational and career goals has been found when transfer information is gained from college personnel and services, rather than from family networks or other sources (D'Amico et al., 2012).

Increasingly, college choice scholars have criticized use of linear and one-time, rational choice decision-making models, arguing instead for frameworks that view student choice about college-going as an iterative and variable process that reflects the lived experience of diverse students, whose choices are influenced by both immediate life circumstances as well as longer-term academic and career goals (Cox, 2016; Iloh, 2018; Tierney & Venegas, 2009). Along these lines, Wickersham (2020) showed for community college students that initial choices of major and transfer destination are shaped and reshaped over time and informed by both lifetime and short-term decision-making timeframes. In her multi-method study of three institutions,

Wickersham specifically found that community college students' pathway selection process was influenced by several priorities: maximizing financial and post-graduation rewards; selecting an appropriate institutional setting; ease of transferring credits; geographical considerations; and social mobility goals. Reyes and colleagues (2019) similarly found that place-based considerations and "geographies of opportunity" (p. 33), which are the specific employment circumstances and potential job prospects in a local area, influenced community college students' decisions and outcomes *during*, and not just after, their undergraduate studies. These findings suggest that not only is general career knowledge important for community college students (Stuart et al., 2014), but that students also need discipline-specific directional support (Prescod et al., 2018) and understanding of how specific majors are configured as academic transfer and career pathways in particular localities (Reyes et al., 2019).

Personal Context of Transfer Pathway Decision-Making

Finances and Basic Needs. Research is beginning to situate vertical transfer decision-making in students' economic and social contexts, and to consider the influence of their adult responsibilities, basic needs, and financial situations more centrally (Goldrick-Rab, 2018; Schudde & Goldrick-Rab, 2015). Financially disadvantaged community college students tend to shoulder many life obligations, including the need to contribute time and resources to their household, which might include their children and spouses, but also their parents, siblings, and others (Reyes, 2011; Wang, 2020). In her longitudinal, mixed methods study of community college students in STEM, Wang (2020) found that low-income and first-generation community college students were more likely than those from more privileged backgrounds to follow deferred, detoured, or interrupted trajectories through community college, often struggling to balance work and family obligations with academics. In contrast, the students in Wang's study

who had access to the most material resources were more likely to follow a standard linear trajectory through transfer pathways. As a result, resource and responsibility differences among community college students could be misperceived by institutional agents involved in transfer advising, support, and admission as differences in student talent or merit.

As a host of recent scholarship makes clear, for many community college students the financial constraint of low-income status operates as an ongoing force influencing students' lives inside and outside of academics (Cox, 2016; Goldrick-Rab, 2016; Goldrick-Rab et al., 2013; Silva, 2013; Wang, 2020), including in the decisions that students make about their majors and transfer destinations. Having a financially disadvantaged background can affect community college students' consistent enrolment, performance, and grades, because of the need to work and struggles to secure basic needs for housing, food, transportation, and healthcare (Broton & Goldrick-Rab, 2018; Maroto et al., 2016). Moreover, community college students who experience basic needs insecurity report higher rates of missing classes and study sessions, opting out of co-curricular activities, not buying required books, and dropping classes due to hunger and housing problems (Mercado, 2017). Rising academic costs also place disparate burden and risks on low-income students. The average cost of pursuing a bachelor's degree has increased over 200% since 1985 and has significantly outpaced the small gains in real household income made by most families (Ma et al., 2016). Yet, need-based Pell grants available to low-income students cover just 29% of recent average costs of school-related attendance at four-year institutions, compared to 79% in 1975 (Protopsaltis & Parrott, 2017).

Family and Place-Based Priorities. Students' personal context is closely tied to their families and communities, yet the influence of family on college students' pathway choices and progression has not been fully recognized or systematically examined (Bensimon, 2007). In

general, family emotional support has been found to be positively associated with the academic success of low-income undergraduates (Roksa & Kinsley, 2019). Among low-income high school students, decisions about where to apply to college are often shaped by family ties, with students prioritizing institutions located near where their family resides, more so than institutional selectivity (Dillon & Smith, 2017; Howby & Avery, 2013). In rare empirical studies focused on the transfer destination choices of community college students, Jabbar and colleagues (2019; 2017) found that family and geography played central roles in the transfer destination decisions of Latinx students in Central Texas and were particularly influential to women, who prioritized staying local and retaining access to family and community support networks. As is the case for high school students applying directly to college, diversity considerations have also been found to influence community college students' transfer decisions, with students preferring campuses with a large proportion of students with the same racial and ethnic background as themselves as well as campuses where friends have been successful in the past (Black et al., 2015). Finally, too, racially and ethnically minoritized community college students have a strong sense of family obligation and desire to give back to those who have supported and sacrificed for their success (Wang, 2020).

Theoretical Framework

The sociocultural theory of practice is used in this study to understand how underrepresented community college students in STEM choose their major and vertical transfer destination. In simultaneously considering the influences of structure (context) and agency on human behavior, practice theory strikes a middle ground in avoiding overly deterministic explanations of outcomes as deriving from structural forces and overly narrow explanations that assume individuals are unencumbered, fully informed, and equally positioned rational decision-

makers (Ortner, 1984). In keeping with critical theoretical approaches, practice theory assumes that power and knowledge are unevenly distributed in social contexts (Bourdieu, 1977). Recent application of practice theory in education research has focused on micro-level and phenomenological issues (DiGiacomo et al., 2018; Sefton-Green, 2017). The approach here instead takes a meso-level life course view of student experiences as they unfolded over several years.

From the point of view of practice theory, vertical transfer is not achieved, at least not exclusively, through individual volition (agency), but through a series of decisions and actions taken over time that are shaped by the structures and context that individuals encounter (such as resources available in institutional settings and students' personal life circumstances). With regard to students' college-going decisions, Iloh (2018) goes as far as to argue that the very concept of "choice" perpetuates privilege because it obscures the implications of individuals' differential access to financial resources, information, and time associated with the successful pursuit of college. Through practice theory, the analysis brings community college students' perceptions and experiences of major and transfer destination decision-making into view as influencing vertical transfer in STEM. It also centers analysis both *in* and *in between* community colleges and four-year institutions, through reference to students' experiences during community college and to their projections as they plan for eventual transfer, including efforts to reconcile academic and personal priorities in tandem (Schudde et al., 2021; Wang, 2020).

The emphasis in practice theory on explaining the temporal organization of human actions intended to bring about particular outcomes for individuals or groups is an important reason why it is useful to this investigation (Ortner, 1984). Community college course taking, planning, and decision-making--including obtaining and using information--pertaining to vertical

transfer majors and destinations are inherently interconnected actions that students, in conjunction with others, pursue over time. As described above, most existing scholarship focused on vertical transfer relies implicitly or explicitly on rational choice theory in assuming that student choices of major and transfer destination are largely nonproblematic, except when delayed or postponed by student uncertainty and/or by curricular complexity. Practice theory instead supports understanding students' pursuit of STEM transfer pathways as manifesting iteratively in a series of decisions and short-term moves that are intelligible within the context of students' larger plans for their lives (Ortner, 1984), with these plans posited to evolve during and as a result of students' time in community college. Practice theory therefore connects the time dimensions that Wickersham (2020) empirically identifies as short-term and lifetime decision-making frames that are employed by community college students seeking to complete a bachelor's degree.

Methods

Research Design and Institutional Selection

This study is part of a larger, mixed-methods, descriptive case study of STEM student experiences and institutional practices in two- to four-year institutional transfer pathways. The overall research design of the larger study includes surveys and one-time in-depth interviews with seniors who are close to graduating from their four-year institution in STEM; in-depth interviews with faculty and administrators at each participating institution; state policy and institutional context review; and longitudinal, in-depth interviewing with advanced community college students who aspired to transfer to a four-year institution in a STEM major. The current study draws from the longitudinal, qualitative interview sub-study of the overall investigation.

The larger study includes three four-year comprehensive public universities in different states and two paired community colleges (a third community college dropped out after the study was underway). The four-year institutions were selected through a process to identify institutions that surpass their peers in eliminating attainment gaps by graduating high numbers of diverse students. The team accessed the National Center for Educational Statistics (NCES) IPEDs data center to create a database of 1,636 four-year undergraduate institutions. From these, the sample was narrowed using the following criteria: 1) Institutions with greater than 10% racial/ethnic minoritized students; 2) A yearly cohort of racial/ethnic minoritized STEM graduates greater than 25 students; and 3) Racial/ethnic minoritized student graduation rates of over 50% for a six-year period and that was equal to or surpassed the graduation rate of White students. Black and Latinx student degree completion was used as a proxy for general student diversity because outcomes for other groups of interest, such as Pell grant eligibility (as a proxy low-income background) or first-generation college student status, are not available in IPEDS. From the resulting pool of 66 four-year institutions, three were selected that surpassed peer institutions in graduating large numbers of underrepresented students in STEM with each located in different regions of the United States.

The two participating community colleges were selected based on geographic proximity to the participating four-year institutions as well as recommendations by administrators at the four-year institutions. These community colleges each had articulation agreements with the participating four-year institutions. At the beginning of the study (2018), Pacific College (a pseudonym) had a three-year graduation rate of 22% and a transfer out rate of 11%. It is a Hispanic-serving institution with 75% of its students from the local service area and 58% receiving needs-based financial aid. Atlantic College (also a pseudonym) had a graduation rate of

35% and a transfer out rate of 24%. Nearly a third of its students are African American and nearly half are White. Half the students at Atlantic College receive need-based aid and 69% are from its local service area.

Pacific and Atlantic Colleges are in different states, although both state policy contexts incentivize students to complete associate degrees prior to transfer by guaranteeing that 60 credits earned in community college will be accepted into public, four-year institutions. This means that results from this study might not generalize to state policy settings in which vertical transfer can occur earlier and prior to students' earning an associate degree (e.g., Jaeger et al., 2015).

Participant Sampling and Data Collection

To identify student participants, a directory request was placed at Atlantic and Pacific Colleges to create a list of transfer-ready students, defined as those who had taken 30 or more transferable credits in STEM courses and earned at least 45 credits overall. Regardless of eventual pathway outcomes, the transfer-ready criterion ensured that participating students had already achieved considerable progress in STEM. The total population of transfer-ready STEM students at Pacific College was 251 students. From this pool of students, a stratified sample of 120 students was drawn to include representation by STEM major, racial/ethnic diversity, gender diversity, and diversity in first-generation college and Pell-eligible status. Email invitations were sent to students and 29 signed up for interviews, with 18 participating in baseline interviews. At Atlantic College, the total population of transfer-ready STEM students was 372. After drawing a sample, invitations were sent to half of these students and 33 responded. Further applying the stratified selection criteria, 11 students were scheduled for baseline interviews.

Baseline interviews were conducted in-person at Atlantic and Pacific Colleges in 2019. Students were then contacted by email every six months through fall 2021 and invited to participate in follow-up interviews by Zoom. A gift-certificate was provided as a thank-you and modest incentive for participation. Baseline interviews were 60-90 minutes and covered topics including family background, interest in STEM, choice of major and transfer destination, transfer planning, institutional supports, classroom experiences, co-curricular experiences, challenges, and career goals. Follow-up interviews were typically shorter, and focused on new developments, challenges, and opportunities that had arisen for students. After baseline interviews, a total of 23 students participated in at least one follow-up interview and 18 participated in three to six interviews, which corresponds to two to three-and-a-half years in the study. To date, 16 students successfully transferred to a four-year institution, including two who have graduated. An additional three students were still in community college and/or have completed an associate degree, three students switched out of STEM majors, and seven dropped out of the study. Table 1 lists each participant using a pseudonym. Given the exploratory nature of this study, individual students' background statuses that are provided in Table 1 are for descriptive purposes and are not intended to imply predictive association.

Table 1 [insert Table 1 about here, or as an appendix if too long]

STEM Students Participating in the Study

Data and Analysis

The aim of data analysis for this study followed from that of qualitative research in general, which is to identify patterns and variations in participants' understanding of and responses to conditions and contingencies in social settings (Emerson, 2011). Interviews were recorded and transcribed verbatim, with transcribed interview content constituting the data for

the study. Based on the study's research questions and existing literature, a team of four researchers created a coding framework that specified content domains (e.g., college choice, advising, co-curricular experiences, major choice). Using NVivo for Teams qualitative data analysis software the four researchers piloted the coding framework and further refined and elaborated it through discussions. Inter-rater reliability reflecting coder agreement in applying codes to interview transcript data was high, averaging 90% to 96% agreement. In this study the research team referred to intended field of community college study as "majors" rather than as concentrations or selected degrees because that term was meaningful to and used by students.

The second stage of data analysis for this study was conducted by one team member. Domain codes of interest to the current study were downloaded into Word files. These were: transfer planning; choice of major; college choice; STEM interest; career goals; transfer planning; student concerns and worries; and curricular pathways. Data for each code were further analyzed through sorting and content analysis, in which data across individual students were grouped to reflect emergent and inductively identified substantive categories and recurrent themes and variations. Tallies were used to gauge how commonly student experiences included identified themes within a domain. This second stage of analysis also emphasized identification of inter-connections among categorical domains to discern relationships among phenomena (Maxwell, 2005). Combining deductive and inductive approaches in the overall analysis ensured that results were anchored in the literature and comprehensible, while also reflecting the complexities of students' lived experiences.

Results

STEM Major Decision-Making

The community college students in the study consistently described their interests and decisions to major in STEM as grounded in long-term goals for their lives, especially their intended careers. This meant that choices about majors were intertwined with decisions about what students wanted to become and do in the future, which, in turn, were shaped by their evolving understanding about the careers, opportunities, and lifestyles associated with different fields of study. Ensuing choices about vertical transfer--what to major in after transfer and what four-year institutions to apply to--were part of this decision nexus. The time frame and planning horizon of student decision-making about their major therefore related to students' lifetime trajectories (Wickersham, 2020), based on the "endgame" of a career and realization of a specific "dream job," as Jessica a Pell-eligible, Latina student in aerospace engineering characterized it. Similarly, a change in choice of major entailed a change in future career aspirations.

Table 2 summarizes what students described as influencing their choice of major. It shows that over three-quarters of the sample cited the importance of career goals, including a number (21%) who expressly sought a well-paying career outcome from their choice of major. Nearly a third of the students (28%) cited interest in their major as extending from childhood and a non-overlapping comparable sub-set of students (28%) cited their interest in their major emerging through high school experiences. At the same time, even if students entered community college with a preexisting interest in a particular STEM major or intent to pursue a particular STEM career, results showed that experiences during community college shaped student choices. Three-quarters of the sample cited some way in which their community college experiences influenced their choice of major, ranging from classroom experiences, faculty support, STEM related work experience, undergraduate research or job shadowing opportunities, career workshops, and supportive advisors and peers. Gaining transfer admission to a four-year

institution was a worry for many students, including 24% of the sample whose choice of major was, at least in part, a tactic to secure admission to a particular transfer destination. Finally, too, as described later in the article, over a third of the students held altruistic goals related to their families or communities that influenced their choice of major.

Table 2 [insert Table 2 about here]

Influences on Students' Choice of STEM Major in Community College

Honing Major Choices Over Time

Students' decisions about their majors and associated careers typically involved a discovery and honing process that unfolded iteratively and often due to their community college experiences. Eighteen students in the study (62 %) recounted a honing process during which they refined, further specified, affirmed, and in a few cases changed their STEM major or intended career goal. Jessica, an aspiring Latina aerospace engineer refined her initial interest in astronomy into the more application-oriented engineering pathway after gaining insight into career opportunities with NASA and the U.S. military. Mariella, who is a first-generation Latina student majoring in chemistry, entered community college with the goal of a career as a doctor. Through interactions with supportive faculty and opportunities to engage in undergraduate research at her community college, she decided that research was "just amazing, the best thing." Over time, as she developed her laboratory skills, which she initially considered to be "horrible," faculty mentors helped her to see that at pathway including graduate school and a career as a research chemist was a realistic option for her. She reflected that as a first-generation college student she had never interacted with a research scientist or been exposed to possible careers in research prior to several impactful community college experiences:

> I thought [to myself], what was it in the first place that made me think that I wanted to go to medical school? And I think it was because I didn't feel like I had a lot of options. I had never met any scientists, anyone with a Ph.D. I had a [teacher], who had a Masters, but I thought that was just the next level after you finished undergraduate education.

While it was common for students to refine and develop their choice of major during their community college attendance, results indicated that some STEM fields were easier for students to formulate viable future academic and career plans around than others. The following describes the honing process among students in different STEM major pathways in community college.

Computer Science. Students interested in computer science experienced it as versatile and applicable to numerous fields, which enabled them to connect majoring in computer science to other interests, such as film, for Pete a Pell-eligible, White, male student, and investment banking and economics, for Ken, also a White, male student. Ken had swirled through several higher education institutions before arriving at Atlantic College, where he had his first exposure to coding. Likewise, experiences in coding and programming classes prompted Henry to choose computer science over his initial plan to major in biology. Proactively supportive faculty members and a workshop on careers in computer science held at Pacific College helped students understand opportunities in computer science more clearly. Christopher, who was a Pell-eligible, Latino, first-generation college student, entered community college with the goal of "becoming an I.T. guy." Describing himself as "never the brightest in math," he had excelled in his coursework and a faculty member helped him develop a nuanced view of the computer science field. He successfully transferred and planned to apply to Ph.D. programs in computer science, specializing in encoding and decoding data. Luis, who had a similar background to Christopher,

entered community college with an interest in computer science that was informed by gaming and programming. Through his studies, Luis recounted that his initial interest evolved into a career goal in robotics. Although Luis had not succeeded in gaining transfer admission, as he continued to take classes at Pacific College he further expanded his computer science goals to include specialization in cyber security, which like robotics, he foresaw was "going to be big."

Engineering. In contrast to computer science, students in both Atlantic and Pacific Colleges struggled to gain insight into academic and career pathways in engineering. This created challenges for students because nuanced knowledge of engineering specialties could be important in selecting, planning, and securing transfer admission to a four-year institution. Kai, a Pell-eligible, first-generation college student, described how limited engineering pathway support at his community college had contributed to his earning two associate degrees, in math and computer science, and accruing over 120 credits. He had learned that "some drama" had led to the departure of several engineering faculty and during his studies he had received general advising rather than major specific guidance. Still, over his four years of community college attendance Kai obtained several undergraduate research opportunities that contributed to his "being competitive" for transfer into his preferred four-year institution. Similarly, another Pell-eligible student at the same college, Franco, entered community college wanting to pursue a career in either medicine or aerospace engineering. He decided against aerospace engineering because it was a locally impacted major, which posed greater risks for securing transfer admission. Fond of biology and calculus Franco decided to pursue bio-engineering, but had struggled to overcome gaps in his understanding of this less common engineering sub-field, which was covered only briefly in his coursework. Unfortunately, too, a lack of engineering pathway guidance during community college may have contributed to Franco transferring as a

bio-engineering major to a four-year institution that was on the verge of discontinuing the major, which has led to ongoing uncertainty about Franco's pathway choices.

Biology. The vast majority of students majoring in biology at both community colleges, who composed 31% of the overall sample, chose it as the most common pathway into further professional education and careers in human medicine, veterinary medicine, healthcare, and dentistry. Biology as field was only modestly appealing to these students, several of whom characterized choosing biology as a means-to-an-end. These students had uneven access to gaining additional insights into careers in medicine and healthcare during community college, and only two secured co-curricular placement opportunities related to medicine and health related career interests. Callista, a Pell-eligible, White, first-generation college student, was aware that this absence could disadvantage her in achieving her goals. She described having a "really, really big problem" in not obtaining an undergraduate research opportunity during community college. Despite repeatedly emailing and leaving messages for the placement manager at her intended transfer destination institution over two-and-a-half years, she never heard back about the possibility of engaging in undergraduate research or any comparable experience.

In addition, two students who initially chose to major in biology switched just prior to transferring. This change in major was tactical, prompted by advice from mentors to bolster their competitiveness for medical pathways admission. Angie, a Latina, first-generation college student, switched her associate degree and undergraduate pathway from biology to Italian to set her apart from other students. Similarly, Jennifer, who is also Latina, was advised by a dean to double major in psychology and biology to improve her chances of medical school admission.

In contrast to most students majoring in biology in the study was Lidia, who was the only biology student interested in a laboratory research career. Told to select a major when she entered community college Lidia opted for medical technician. A classmate's enthusiasm for her chosen pathway in clinical laboratory science led Lidia to reevaluate her choice. She switched to biology, eventually transferred in cellular and molecular biology, and recently completed her undergraduate degree. Lidia retained the career goal of laboratory work and is also pursuing employment as a medical records specialist.

Chemistry. Four students in the study chose to major in chemistry, with each of their ensuing experiences in community college leading to distinct outcomes. Maria had little experience with chemistry prior to tentatively selecting it as a major. She began her chemistry coursework in the midst of COVID-19 instructional disruptions, which contributed to significant struggles with grades and led Maria to change her major to psychology. Bora, whose family immigrated to the United States before he was born, had been undecided his first year in community college. His decision to major in chemistry connected to his interest in nutrition and personal history of being bullied as a heavy-set child. After doing well in his STEM courses, Bora wanted to do "something higher" than nursing and decided to pursue a transfer pathway toward medical school. However, after transferring he switched majors from biochemistry to exercise physiology and recalibrated his career goal in the process. Both Erika and Mariella decided to major in chemistry due to their community college experiences, including positive classroom experiences, participation in career awareness workshops, access to undergraduate research opportunities, and the proactive support of highly encouraging faculty members. Both are close to graduating, and Mariella has recently been applying to attend graduate school in chemistry.

Mathematics. The five community college students in the study whose on-ramp into STEM was an interest in math from K-12 education, and considered majoring in it, uniformly struggled to discern associated career possibilities. Physics was also a field that some students had encountered in K-12 education but was associated with unclear career trajectories and was therefore not selected as a major by any student in the study. Adriana and Leticia both recounted challenges figuring out pathways in math and physics, and ultimately choose engineering because, as Adriana had come to understand: "It's easier to get a job as an engineer than with a math or a physics degree since I don't want to be a professor." Leticia was undecided for year after enrolling at her community college. Despite "scoring low" on placement tests, Leticia enjoyed math. She recalled having, "Googled all the majors for math," which led her to consider engineering. An undergraduate research opportunity in community college further led her to choose mechanical engineering, although she was ultimately admitted into a second-choice option of structural engineering at a four-year institution. Zoe, who like Leticia is a Latina, first-generation college student, had always enjoyed math and "was good at it." Despite majoring in math, she explained that she had not found a good source of information about career options associated with math during community college:

> Sometimes I ask professors and haven’t gotten a super great answer. I've tried looking online like using Indeed, job searching sites...I've seen a lot of, 'Oh, you can be an accountant.' But I'm working with such intense mathematical theories, and I don't know if I just want to punch numbers in a calculator all day.

Zoe secured a math tutoring position at her community college that led her to consider "becoming a professor," but curiously she never appeared to have encountered support or information about K-12 teaching pathways.

Part of the challenge faced by students interested in majoring in math was its varied configuration as an undergraduate degree and associated career pathway at different transfer destination institutions. Solana had been interested in math since childhood and initially chose economics because of its connection to math. Through coursework at her community college she discovered she loved it and "wanted to learn more." Even though it delayed her community college completion, she changed her major from economics to math as a way to take more advanced math classes. Her plan to transfer and major in actuarial science was undermined, however, when she was denied admission to this limited access major at her preferred transfer destination. Peers encouraged her to consider engineering instead of math, and a faculty member teaching her programming class suggested that she shift to computer science. Still committed to math and wary of "wasting time," Solana planned to apply again to the same four-year institution but this time as an applied math major, which she acknowledged was a "tough path." Notably, Solana's choice of major was configured not only by her interest and talent in math but by the academic and career pathways that were accessible to her at a *specific* four-year institution.

Personal Priorities in Major Pathway Decision-Making

The results described above show that student choices about their majors were closely linked to career goals and often beneficially evolved and developed as a result of experiences during community college. This section expands on these results by describing various ways that student choices about their STEM majors and career pathways were influenced by priorities that connected to family and community. Students who had working-class, recent immigration, and/or first-generation college student backgrounds tended to prioritize pathways associated with lucrative and secure professional employment, which was explicitly mentioned as important by a quarter of the sample (Table 2). For example, since childhood Kai had observed his mother

coming home from work "looking tired" after days spent as a retail manager. It had been "ingrained in him" by his parents that he should attend a four-year institution, "because they didn't go." Christopher, who was a Pell-eligible, first-generation college student, had been inspired to pursue computer science because of his uncle's successful upward mobility through the information technology field. Daniel, whose family had recent immigration experience, prioritized finding a "government job" after completing his computer science degree because of its perceived employment security. As he explained: "Coming from my family background, a government job would help a lot." Also majoring in computer science, Luis' ideas about his future career were influenced by his own experiences with employment in the service and retail sectors. Through robotics applications he foresaw robots doing "menial tasks," such as "cleaning plates," with people like himself, "doing the jobs of maintenance and figuring out how to make the robot work better."

Major-Related Altruistic Goals Connected to Family and Community

As shown in Table 2, for 38 % of the students (n=11) in the study their choice of major transcended the parameters of individual choice in being informed by a sense of family obligation and commitment to advancing the public good. These motivations tended to be grounded in specific family traumas concerning illness, financial struggle, and other hardships. Literally and symbolically, students described wanting to "pay their family back" and devote themselves to careers that would help solve problems that had been endured by family members.

For example, Mariella--who after entering community college as a biology major intending to go to medical school shifted her pathway to chemistry with the goal of attending graduate school and pursuing a career as a research scientist--had multiple close relatives diagnosed with breast cancer. Of her mother's four sisters, three had cancer, which had given

Mariella "fuel to do cancer research" and sparked her curiosity to understand basic questions about the disease and effective drug interventions. Although very painful to Mariella, her aunts' traumas were also inspiring, as she explained, "to see them just fight cancer." Similarly, since childhood, Erika, who was also majoring in chemistry, had watched her father deal with illness. She recalled going with her parents to her father's medical appointments and observing the efficacy of his prescribed medications. She remembered her amazement at the improvement in his quality of life when she chose to major in chemistry in community college, reasoning, "Well, chemistry is doing a lot of things and I liked the subject, so why not?" Luis' choice to pursue computer science was similarly motivated by his family but pertained to financial considerations. He described his pathway choice in terms of desire to "pay back" his father, who has been helping him financially:

> Currently, my view of life is, it's kind of, 'go big or go home.' So, my hope is I can get a good job, and then be able to kind of pay [my father back], like filial piety...The ultimate goal is to get enough financial wealth to be independent and be able to give filial piety to my father.

Some students extended the altruistic connection between their major and future career beyond their families, to the larger community and society more generally. Although inspired by her father's struggle to overcome illness, Erika's chemistry-related career goal was to help those who are financially underprivileged:

> When I got into chemistry, that's what I was really passionate about. I was like, I want to help people like my father and even if it sounds unrealistic, I want to help other people who really need it monetarily. So, that's like my dream.

Students were particularly motivated to help solve environmental and public health problems in their future careers. Charles, who aspired to transfer in computer engineering, hoped to create technological mitigations to climate change:

> Especially climate change, I want to create some type of device that helps. It's getting worse and we're going to have to deal with this. Not the older folks who are making excuses now, [my generation] is going to have to do this when we get older.

Nick, a Pell-eligible, first-generation college student, who earned associate degrees in math and computer science, had just applied to seven four-year institutions at the time of his baseline interview. He connected his goals for personal achievement and success to his goals for advancing collective well-being:

> I've always wanted to succeed and be able to depend on myself. Now that I am learning about these subjects, something that I've always wanted, is to do something that matters... Not just a company to make profit, but to do something for the world or humanity.

Franco, who spent a lot of time in Central America as a child, hoped to put his bio-engineering major to use in public health and, in effect, to become a socially responsible engineer. He explained that he would "really, really, really love to take part in the Peace Corps" and pursue public projects in a foreign country as a bio-engineer. The altruistic goals that connected students' STEM majors to their families and, in some cases, to the broader community, were not external to or outside of academics but were instead central to why students had chosen their major in the first place.

Community College and Transfer Destination Institution Decision-Making

Findings presented so far provide evidence about how student choices about what to major in were bound up in future goals for their careers as well as the well-being of their families

and the broader community. Students' choices about where to study, both what community college to attend and what four-year institution(s) to seek admission to, were similarly tied to students' choice of major, long-term career and life goals, and, in many cases, to family and geographic proximity to home. Table 3 details reasons that students gave for choosing to attend their community college.

Table 3 [insert Table 3 about here]

Reasons for Choosing to Enroll at a Specific Community College

Closeness to home and geographic accessibility were paramount to students, over half of who cited location as guiding their community college choice. In turn, location was important for students to maintain family connections, save money by living with family, and reduce transportation costs. For those who did not own or have access to a car, geographic accessibility was important in their being able to make use of public transportation. The influence of family and friends to students' choice of community college was also reflected in a sub-set of students who attended the same institution as siblings, cousins, fathers, and friends, sometimes simultaneously. Others took an opposite approach by relocating within their state to attend a specific community college because of its transfer partnership with a particular four-year institution. These students assumed that attending this community college would give them an advantage in securing transfer admission. For four students this plan worked, although three others ended up changing their preferred transfer destination institution over the course of their community college studies.

Both Atlantic College and Pacific College had well established transfer relationships with one specific transfer destination institution. Half the students who transferred over the course of the study (n=8) transferred to these destinations, which were top choices for most students. The

others transferred to an additional six institutions, four in one state and two in the other. Nearly half the overall sample (48%) applied to multiple four-year institutions, such as Leticia, an engineering student who applied to ten four-year institutions in her state (Table 4). Students who applied to numerous institutions tended to do so out of fear of not gaining admission to their preferred "top choice" institution. For six students this fear was warranted by past experiences of being denied admission to their chosen four-year institution from high school, and for four students it was warranted because they were denied admission to their chosen transfer destination when they applied from community college (Table 3).

Table 4 shows that geographic accessibility and closeness to home was as influential in many students' choice of transfer destination institution as it was to their choice of community college.

Table 4 [Insert Table 4 about here]

Reasons for Choosing Particular Transfer-Destinations

Obligations and ties to family as well as financial considerations frequently meant that students prioritized location when selecting potential transfer destinations. This was particularly true for students from low-income backgrounds, who were sensitive to the increased costs associated with attending a four-year institution after transfer and hesitant to choose institutions in locations that would take them far away from family support networks. These students were uniformly under the impression that "classes will be more expensive" after they transfer. Most were debt averse, and money was a widespread worry. They were concerned not only about increased education-related costs, but by the possibility of having to relocate to a part of the state with a higher cost of living. Mariella, a first-generation student in chemistry, was the only student in the study who applied for admission to selective out-of-state institutions. Although she ultimately

transferred to an in-state institution near her home community, she was aware that she might be making a trade-off. As she put it: "Maybe I will have to trade the place where I would like to go and maybe receive a better education and have more opportunities, for a place where it's closer to home just because it's cheaper."

The cost and location of transfer destinations were experientially so intertwined for students that in four cases those who applied and were denied admission to their preferred, local four-year institution from community college waited a full year to apply for admission again to the same institution. In the meantime, these students continued to take classes at their community college, accruing more credits than they could transfer but making themselves more competitive for the next round of admissions. Lidia, a biology student who recently completed her Bachelor of Science, explained why reapplying to her preferred local institution made financial sense, even if it delayed her overall pathway progress:

> Honestly, the money issues [are most important for me]...I don't dare to apply to those other universities because they're expensive. That's why I'm insisting on [my local university] because it's cheaper. If I were rich, then I would totally go to a private school or something.

A related aspect of students' transfer destination decision-making was the ability to reside with family members, which would be less costly and, in some cases, would ensure that students could continue to support family members in need. This was the case for Lara, a non-traditionally aged student who had a child of her own, as well as for others who for various reasons prioritized proximity to parents, siblings, aunts, cousins, friends, and others. Despite applying to five four-year institutions to continue his computer science studies, Daniel prioritized

attending his local four-year institution to save on living costs. He also wanted to increase his long-term prospects of securing a career in his home community, where he envisioned his future:

> The reason why I want those two schools is because they're both in [my home region] and both would help me get a job here because I want to stay. I really don't want to move anytime soon...The area is really nice. I have most of my friends and family here. I have no reason to move, especially after university if I can get a really good job in computer science. And staying at home would help me save money until I move out.

Transportation could also be a concern. Not all students had access to a car, and instead relied on public transportation. Maria, for example, had never learned to drive and chose to apply to two four-year institutions in her local area that are accessible by bus as possible transfer destinations.

The presence of family and friends in a faraway location made transferring away from their home community potentially more feasible for students. Adriana and Bora both relocated within their state to attend a specific community college but did so with family members or high school friends, respectively. Denied admission when he first applied to a local four-year institution, Luis' father had advocated for him to apply to an online university. Hesitant because of "some bad stigma about online degrees," Luis instead planned to reapply to his local preferred transfer destination as well as several institutions in a distant and expensive part of his state, where his aunt lives. As he explained, "The only reason I even thought about [transfer destinations in that area] is because my aunt is offering to let me stay there." For Solana, a first-generation college student majoring in math, residential and financial considerations were even more complex. In recent years, Solana had been coordinating her employment with her sister so they could support the family financially after their mother became the full-time caregiver to Solana's grandmother. Rejected twice from her preferred local transfer destination, Solana

anticipated that transferring to a four-year institution would be determined less by her own choices and goals than by finances, family, and location. Before she dropped out of the study, Solana contemplated whether she could convince her family to relocate with her:

> Last year, I received my associate degree and tried to get into the actuarial program, but it was impacted. [At that time] I got redirected to [another university]. But it is too far, so I decided to stay. This year I applied again and I got denied again. This year [another university] has accepted me...But my mom needs us because she doesn't take care of herself, of her health. So that's what worries me, I don't want to leave her here. I'd rather the three of us moved. But so far, I don't know what the future holds for me. It depends on my mom.

Since the personal priorities involving location, finances, and family influenced so many students' choice of transfer destinations, these considerations could in turn also affect students' choice of STEM major and specialization. Pathway options in engineering, math, and biology in particular were described by students as varying across different four-year institutions, with the effect that choice of major sometimes contradicted preferred transfer destinations. Lidia was interested in majoring in clinical laboratory science but would have had to apply and gain admission to a specific four-year institution in a distant and rural part of her state. She instead chose cellular and molecular biology as a transfer major since it was available at the local four-year institution where she hoped to attend. Nick, similarly, initially prioritized transferring to a local four-year institution to save money. He chose to major in applied math, instead of his initial choice of computer science, as a strategy to bolster his chances of gaining access to his local four-year institution, where he learned there is greater competition for admission in computer science than math. Unfortunately, Nick was denied admission to two local four-year institutions

and a year later was waiting to hear back from a larger pool of seven applications. Finally, Solana, who as described above hopes to convince her mother and sister to relocate with her when she transfers, planned to major in actuarial science, statistics, or applied math, depending on which four-year institution she gains admission to in her third round of applications.

Discussion

Results of this study are consistent with Wickersham's (2020) finding that community college students' pathway selection is a process that is influenced by students' intent to maximize financial and post-graduation rewards. Career goals were paramount in underrepresented community college students' decisions to major in STEM as well as their ongoing efforts to affirm and refine their choices. A lack of discernible or appealing employment opportunities was a primary reason that students gave for not choosing to major in physics, math, and astronomy.

Although some students in the study entered community college with career goals and a specific major in mind due to childhood and high school experiences, consistent with recent research (Cohen & Kelly, 2019; Johnson et al., 2016; Wang, 2013b; Wang et al., 2019; Zhang & Ozuna, 2015), there were numerous ways in which student experiences during community college prompted and affirmed decisions to major in STEM, helping students hone and further develop their choices over time. This included classroom experiences, faculty support, STEM related work experience, undergraduate research and job shadowing opportunities, career workshops, and supportive advisors and peers. However, access to career information and opportunities was unevenly available. Instances of students seeking but not finding sources of STEM pathway knowledge, guidance, and experiences appeared to be especially prevalent among math, engineering, and biology majors. These results suggest that future vertical transfer research should take into consideration possible major- and pathway-specific differences. It

would also be useful to generate systematic description of effective career-planning guidance, including co-curricular opportunities that are available and useful to community college students.

Individual preference accounted for only part of what influenced the pathway decisions made by underrepresented STEM students in this study. Instead, as other research has shown (Goldrick-Rab, 2018; Jabbar et al., 2017, 2019; Schudde & Goldrick-Rab, 2015), student decisions about *what* to study were often intertwined with decisions about where to study, which in turn were based on family and residential priorities and financial considerations. For some students, the transfer destination priority of staying local was so important that it influenced their choice of major, prompting students to choose pathways that would be more likely to result in their gaining admission to a preferred local four-year institution. Applying to four-year institutions in distant parts of a state was a last resort and, possibly, untenable option for several students in the study whose pathway progress had been stymied by being denied access to transfer locally. Further research should examine the nature and prevalence of detours and delays in students' pathway progression that occur *in between* community colleges and four-year institutions, including through admission practices.

Like Wang (2020), results of this study showed considerable evidence that underrepresented community college students hold altruistic goals, including to improve their family's financial status, address health issues experienced by family members, and help solve public health and environmental problems. Future research is warranted to discern how these interests can be cultivated and sustained (Cech, 2014) as well as how they can inform curricula and programming to attract more community college entrants to STEM, which is an emerging issue in the literature (Prescod et al., 2018; Wang, 2013b).

Singular, one-time explanatory models of major choice, such as decision deferral (e.g., Scott-Clayton, 2011), do not align well with the results of this study. Student uncertainties were due less to an over-abundance of confusing options in community college than to problems finding and understanding the right kind of information, especially information about how specific majors align with careers (D'Amico et al., 2012; D'Amico et al., 2019). It took time and institutional support for students to understand how specific STEM majors related to degree and career pathways, both in general and projectively, into and through *specific* four-year institution transfer destinations. Moreover, students could make timely choices about their major and transfer destination only to be detoured by competitive or confusing vertical transfer admission processes. Calls for transfer programming and policy reform that structures out students' need for information and social know-how (Bailey et al., 2015; Deil-Amen & Rosenbaum, 2003; Van Noy et al., 2016) may need to be tempered with efforts to avoid inadvertently impeding or neglecting underrepresented students' need for navigational guidance to be successful in STEM transfer pathways.

Implications

This study provides ample evidence of how major and career related information and experiences in community college can benefit underrepresented students who aspire to transfer to a four-year institution in STEM. An important practical implication of this is that students need more information about academic and career pathways associated with different majors, not less. In particular, math and physics offered notably little navigational or enrichment opportunities for students who might otherwise have considered pursuing these majors. Biology as a field also appeared to represent few opportunities for students' futures other than careers in medicine and healthcare. Chemistry as a pathway became more viable to students after experiencing laboratory

research and learning about future careers involving research. Math, physics, biology, and other STEM professional associations might consider prioritizing this issue, including creating programming to encourage and enable STEM faculty in both community colleges and four-year institutions to serve as emissaries and interpreters of these fields for students. The American Medical Association and similar professional associations could do more to inform and enable community college students and institutional representatives by building programming around nascent recognition of the importance of pathways from community college to medical school for increasing equity in these professions (Murphy, 2021).

Decisions about what to major in and where to transfer were tightly coupled for many of the underrepresented community college students in this study. In addition, the priority of family figured prominently into these decisions and informed many students' altruistic future ambitions. This suggests that community college and four-year institution programming to support transfer student success would likely benefit from incorporating personally and societally relevant career exploration opportunities for students.

Gaining admission to a *specific* transfer destination was important to many students, who in some cases adjusted their choice of major or extended the duration of their community college studies to increase their chances of securing entry to a local four-year institution. At times, students experienced tension and dilemmas in their efforts to navigate major and location priorities in the context of competitive admissions dynamics in some local four-year institutions and limited access STEM majors. Moreover, the students contending with these transfer pathway complexities were often first-generation college students who may have faced special navigational challenges. A number of students in the study informally "googled" alternative STEM majors and careers in their local area as a way of informing their choices with information

about employment prospects and opportunities. Yet these students may not have found accurate or complete information through online sources, nor been fully able to interpret it. These intersecting findings have implications for advancing equitable undergraduate outcomes for underrepresented students in STEM, yet location and admission considerations tend to be neglected in vertical transfer policy and programming. Major-specific transfer pathway support and interventions, by faculty, policy makers, advisors, industry representatives and others working across community college and four-year institutional boundaries, would likely benefit from taking a geography of opportunity approach (Reyes et al., 2019). In underscoring the influence of geographically bound educational and employment circumstances on students' aspirations and decisions, the incorporation of a geography of opportunity approach would bring formal transfer and curriculum alignment arrangements and programming into closer, ongoing contact with academic and employment pathway conditions, needs, and challenges in specific regions.

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