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Twenty-Four Hours in a Day: A Systematized Review of Community College Engineering Students with Outside Responsibilities

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Abstract

This systematized literature review examines students who are in engineering-for-transfer programs at community colleges and have responsibilities outside of class (such as caring for family or working). Many community colleges across the U.S. offer engineering courses which transfer to a four-year university, and 42.7% of engineering students are enrolled at a community college at some point in their education (NSF, 2019). However, year-over-year retention of students in community colleges is low – freshman-to-sophomore rates of retention hover around 55% on average (Monaghan and Sommers, 2022). One reason for low retention is that community college students tend to have more commitments outside of school than their counterparts at four-year universities. Many colleges offer programs intended to increase retention and engagement among these students (such as research, scholarships, and formal mentorship). In this review, I sought to answer the following research questions:

1) What types of programs are offered to support community college students in engineering-for-transfer programs?
2) What aspects of these programs contribute to the success of students who have responsibilities like employment or caretaking of another person?

The systematized literature review resulted in nineteen peer-reviewed journal articles, published after 2010, collected from the Compendex and ERIC databases. These papers were thematically analyzed and results compared. These papers all addressed, to some extent, the experiences and transfer outcomes of working or caretaking community college students in Science, Technology, Engineering, and Mathematics (STEM) degrees. Results showed that STEM transfer students were more likely to graduate and transfer when programs provide community engagement, networking opportunities with professionals in the field, financial aid, schedule flexibility, and the information students need to complete their degrees. Engineering programs are increasingly focused on recruiting and retaining a diverse student body, which requires supporting those students with responsibilities outside the classroom. The results of this

paper are intended to inform policy makers of programs which can have a positive impact on working or caretaking students at community colleges.

Introduction

Community colleges (also known as junior colleges, technical colleges, or two-year colleges) have historically been an important institution in higher education in the U.S. These colleges provide a starting point for many students who cannot or choose not to attend a four-year university right out of high school. In recent years, these institutions have begun expanding their engineering course offerings. For example, the Colorado Community College System announced its first Associate's of Engineering Science degree program in January 2022. This allows students to complete a degree in two years and enter the work force, but also formalizes an agreement with the largest state schools to ensure articulation of credits so that students may complete a Bachelor's in Engineering after transferring (CCCS, 2022). Several other states have already established similar articulation pathways, including Virginia (VCCS, 2022), Texas (Ogilvie, 2017), and California (Enriquez et al., 2018). Even without these established pathways, many engineering students take prerequisite math and science courses at a community college. According to the National Science Foundation (NSF), 42.7% of employed engineering graduates attended a community college at some point in their education (NSF, 2019).

While many engineering students attend community colleges, not much is known about how colleges support the needs of STEM students. For community college students in STEM programs, time commitments outside the classroom may pose additional barriers to succeeding in class. This paper seeks to synthesize existing research on programs offered by community colleges, with particular emphasis on how they impact students who are employed or caretakers outside of the classroom. By understanding the experiences of these students, we can fully characterize the challenges they face and help these students to complete their undergraduate engineering education.

Research Questions

1) What types of programs are offered to support community college students in engineering-for-transfer programs?
2) What aspects of these programs contribute to the success of students who have responsibilities like employment or caretaking of another person?

Literature Review

Despite a clear demand for community college courses among engineering students, there is not a clear definition of *who* attends community colleges. Community college populations are diverse and difficult to characterize for several reasons. First, community colleges engineering programs have a higher percentage of Black and Hispanic students (Terenzini et al., 2014; Tsapogas, 2004) than universities. Second, these students come from a broader range of academic and socioeconomic backgrounds (Terenzini et al., 2014). Third, engineering students at community colleges tend to be slightly older at their first enrollment, with the average student entering at 20 (as compared to traditional 4-year university students who enter at 18) (Terenzini et al., 2014). Fourth, in addition to starting later in life, community college students have a wide range of commitments external to school, including work, caring for family members, and commuting (Tsapogas et al., 2004; Terenzini et al., 2014). These commitments mean that many community college students are enrolled only part-time. On average, a community college engineering student spends 17 hours per week preparing for class, while a 4-year student spends 27 hours preparing for class. The community college student also spends 34 hours working for pay or meeting family responsibilities, while the 4-year engineering student spends only 9 hours per week working or with family (Terenzini et al., 2014). As a result, community college transfer students take 5-6 years longer to complete an engineering bachelor's degree than their university native peers (Terenzini et al., 2014).

The challenges of community college students are well characterized in the literature (Franco, 2006; Laanan et al., 2010; Van Noy & Zeidenberg, 2017). A 2010 review by Burns summarizes the largest of these challenges as "work and family responsibilities, low-income, inadequate academic preparation, and lack of social capital" (Burns, 2010, p. 54). However, studies on engineering programs specifically represent a small portion of the existing body of literature. There are several synthesis studies published in the last decade which focus on

engineering transfer students (e.g., Ogilvie 2014 and Espino et al., 2022). A 2014 review of literature by Ogilvie shows that engineering transfer students are an emerging area of interest in the wider pool of community college literature, with existing literature characterizing engineering transfer students. More recent studies examine difficulties engineering students face in the transfer process, from confusingly-mapped curricula and transfer policies (Reeping, 2019) to beginning college math and science at lower levels (Laugerman et al., 2015). These papers identify specific challenges, but do not help to explain how community college students may be supported at their institution. The goal of this systematized review is to expand upon the existing literature by identifying programs which contribute to community college student success, particularly for working or caretaking students. In the next sections, I will describe my explicit paper selection methodology including search strings and inclusion criteria.

Methods

The data collection for this paper followed a systematized literature review process as summarized by Page et al., 2021. I conducted a review of recent literature in September 2022, searching the ERIC and Compendex databases. ERIC contains education-focused articles, particularly those which may be outside the scope of engineering journals. A significant amount of community college-focused literature is published in journals focused more generally on higher education. Additionally, Compendex contains a broad range of engineering journals. Between the two databases I found articles related to both STEM education and community college students. I searched both databases using targeted search strings.

I tested and revised my search strings multiple times. I added several synonyms for working and caretaking (such as custod* and guardian*). I also chose to include “financial need”, since students who work while attending school may only choose to work because of their financial circumstances. I excluded the term “working paper” based on false matches with the “working” keyword. In addition, I excluded the word ‘non-traditional’ (included earlier as a keyword), because a significant number of results within Compendex associated ‘non-traditional’ with methods of solving engineering problems. The search string used for ERIC produced 98,219 results in Compendex, so I narrowed the scope in that database with a shorter search string and control terms. The final search strings for each database are shown in Table 1.

Table 1

Search Strings

Database	Search string	Control term
ERIC	*(engineer*) AND ("community college" OR "junior college" OR transfer* OR associate*) AND (employ* OR "financial need" OR care* OR working OR custod* OR guardian*) NOT "working paper"*	None
Compendex	*engineer* AND ("community college*") AND (work* OR care* OR custod*)*	Education

I reviewed the titles and abstracts to screen results from this initial search. To ensure that all papers included in the final review were timely, scholarly, and relevant to the topic, I developed the following inclusion criteria:

1) Paper was a peer-reviewed journal article
2) Paper was published between 2010 and 2022, since most research on community college STEM programs is more recent than 2010
3) Paper abstract discussed community college students in undergraduate STEM programs (pre- or post-transfer)
4) Paper abstract mentioned a student's time spent on non-school activities, including work, research, or caretaking, or discussed programs intended to assist students with these activities (such as daycare or scholarships based on financial need)

After the initial screening, I retrieved the full-text version of 31 papers (29 from ERIC and 2 from Compendex). I reviewed each of these papers at the full-text level, excluding 12 papers based on the following criteria:

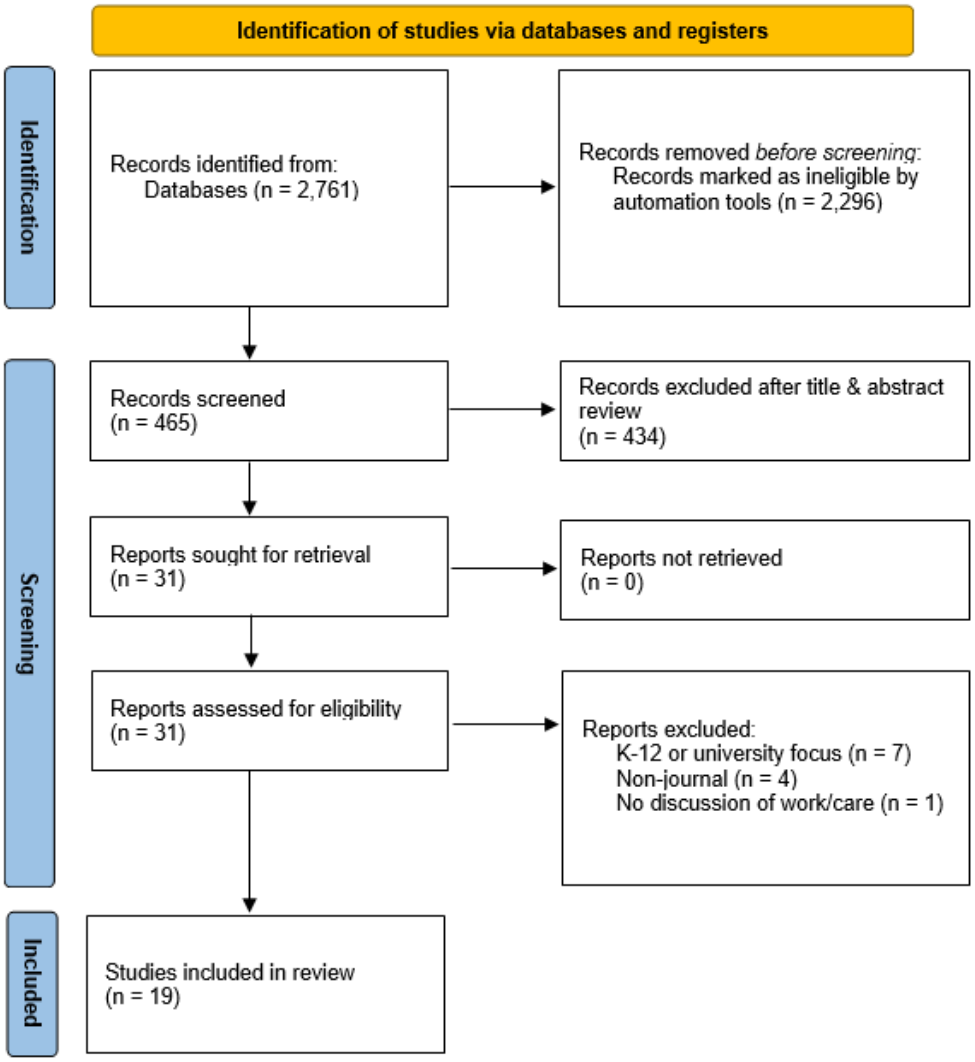
1) Paper was excluded if it was a review, op-ed style article, or book chapter

2) Paper was excluded if it focused on K-12 students and their expected pathways into engineering, or if it focused exclusively on students who start their degrees at a four-year university
3) Paper was excluded if the results did not discuss financial need, caretaker status, or working status

After excluding these papers, I was left with 19 full-text articles to review. The full breakdown of my data collection methods can be found in Figure 1, below.

Figure 1

Adaptation of the PRISMA flowchart (Page et al., 2021)



I read each of the 19 papers in full, recording the framework, research question, methods, and results. Theoretical and conceptual frameworks were recorded to understand the author's viewpoint and approach to their research. However, only 10 of the19 papers had an explicit framework and there was virtually no overlap among theories used. These frameworks were therefore not used to categorize results. After reviewing the main points of each paper, I used inductive analysis to identify major themes from each paper, discussing the codes with a peer. I followed the steps of thematic analysis as described by Braun and Clarke (2006). To ensure alignment with the research question, I created sub-themes based on elements of STEM programs which contribute to the success of community college students. These were then grouped into themes based on the type of benefit students received, though there was significant overlap among these benefits. While each of the papers discussed working or caretaking students in some capacity, the programs were typically not limited to students in these groups. When comparing the results against my research questions, I therefore did not differentiate between programs that support working or caretaking students specifically and those which support students more generally. However, if a paper noted a particular impact on working or caretaking students, I included this in the Discussion section. The breakdown of these themes is presented in the Results, below.

Results

This paper seeks to answer the following research questions:

1) What types of programs are offered to support community college students in engineering-for-transfer programs?
2) What aspects of these programs contribute to the success of students who have responsibilities like employment or caretaking of another person?

Each paper had between one and four sub-themes, which were categorized into four major themes: Social Capital, Financial & Career Capital, Flexibility, and Information Access. Table 2 shows the sub-themes which fall under each theme. Table 3 provides a breakdown of the themes and sub-themes found in each paper.

Table 2

Themes and Sub-Themes found in Thematic Analysis

Theme	Sub-Theme
Social Capital	Formal Mentorship
	Community Focus
	Family-Focused Policies
	Extracurricular Opportunities
Financial & Career Capital	Financial Aid
	Partnerships
	Research
Flexibility	Remote Engagement
	Time Commitment
Information Access	Academic Skills
	Advising & Transfer Policies

Table 3

Thematic Analysis of Papers Included in Review

Author	Year	Social Capital	Financial & Career Capital	Flexibility	Information Access
Marra et al.	2015	Extracurricular Opportunities		Remote Engagement Time Commitment	Academic Skills
Kruse et al.	2015		Financial Aid Partnerships		
Bahnson	2020	Family-Focused Policies Community Focus	Research		
Sorkin et al.	2010	Extracurricular Opportunities Formal Mentorship	Financial Aid		

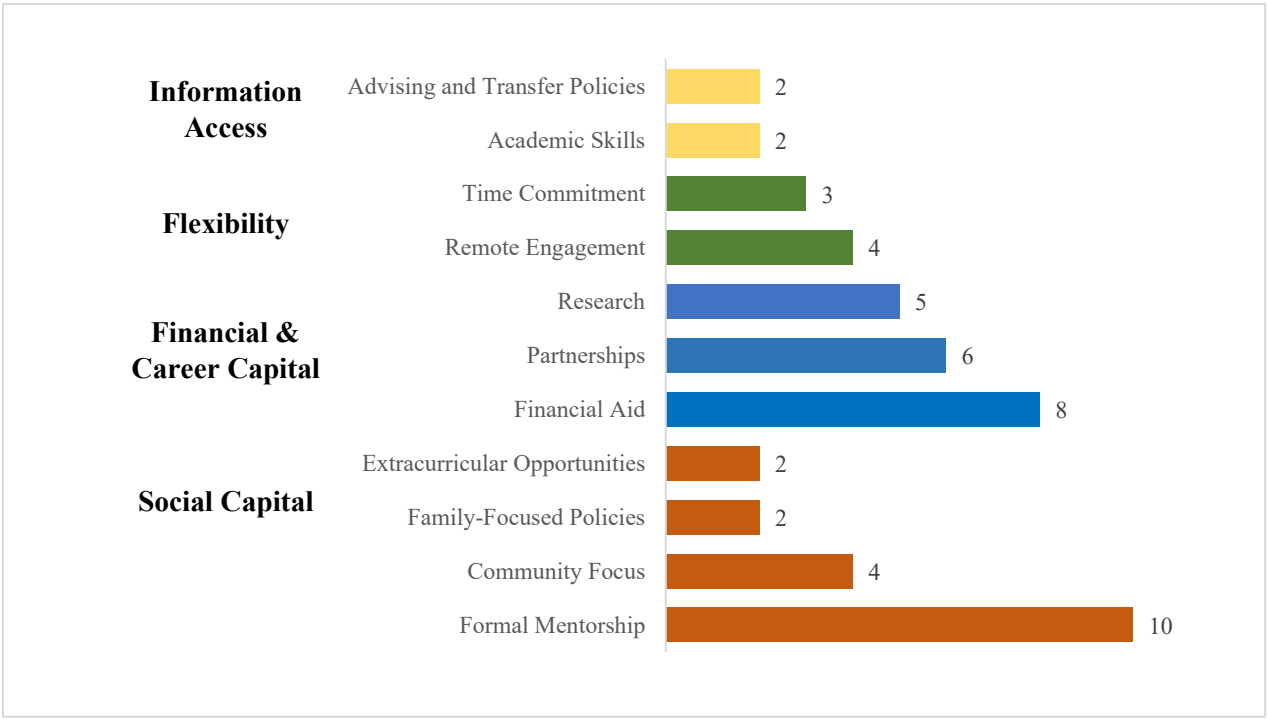
Author	Year	Social Capital	Financial & Career Capital	Flexibility	Information Access
Loeser et al.	2021	Community Focus	Research Partnerships	Time Commitment	
Smith and Wingate	2016	Formal Mentorship	Financial Aid Partnerships		
Sorkin	2018		Financial Aid		
Myers et al.	2015	Community Focus Family-Focused Policies Formal Mentorship			
Rodriguez et al.	2021	Formal Mentorship	Financial Aid Partnerships		
Tuthill and Berestecky	2017		Research		
Sorkin et al.	2019	Formal Mentorship	Financial Aid		Academic Skills
Lenaburg et al.	2012	Formal Mentorship	Research Partnerships		
Wang et al.	2017	Formal Mentorship	Partnerships		Advising & Transfer Policies
Stofer et al.	2021	Formal Mentorship	Research	Time Commitment	
Qaqish et al.	2020	Community Focus Formal Mentorship			
Tupper et al.	2010	Formal Mentorship	Financial Aid		
Lasota and Zumeta	2016		Financial Aid	Remote Engagement	Advising & Transfer Policies

Author	Year	Social Capital	Financial & Career Capital	Flexibility	Information Access
Wladis et al.	2015a			Remote Engagement	
Wladis et al.	2015b			Remote Engagement	

In total, there were 48 occurrences of the sub-themes across the 19 papers. The sub-themes which occurred most were Formal Mentorship (n=10) and Financial Aid (n=8). These fall into the categories of "Social Capital" and "Financial & Career Capital", respectively. Figure 3 provides a count of each sub-theme. I elaborate on the themes, below.

Figure 2:

Count of Sub-Themes



Social Capital

Social Capital describes the benefits students receive from engaging in social activities. These include mentorship, community engagement, family activities, and clubs.

Formal Mentorship:

Formal mentorship was the most common sub-theme, appearing in ten of the reviewed papers. A key aspect of the mentorship programs mentioned in the literature is that they provide opportunities for students to engage in STEM formally (Sorkin et al., 2019). As a result, students engage in more interaction with faculty, staff, peers, and potential industry connections. These connections can improve a student's sense of belonging in an engineering field (Rodriguez et al., 2021). Mentorship was correlated with transfer and persistence in many of these studies, and this effect is heightened for underrepresented groups (Tupper et al., 2010; Sorkin et al., 2010; Smith and Wingate, 2016). As part of formalized mentorship programs, faculty and staff should receive training on diversity to ensure the success of all students (Myers et al., 2015; Stofer et al., 2021).

While relationships with community college faculty are important, a 2012 study found community college students also thrive with university mentors, including both graduate students and faculty (Lenaburg et al., 2012). Transfer advisor relationships are also important for students to have positive experiences with the transfer process (Qaqish et al., 2020). Any type of mentorship can have positive outcomes, but to help transfer students succeed these formal mentorship programs must span institutions.

Community Focus:

Since community college students are less likely to spend time on campus (Terenzini et al., 2014), it is important that every interaction establishes an inclusive community. Informal community-building and relationships with faculty and staff help students develop a sense of belonging in college (Myers et al., 2015). Additionally, students should be encouraged to integrate their outside lives with academics. Community involvement in research projects can help engage students in problem-solving (Loeser et al., 2021). This is important particularly for students who have a strong sense of cultural and community identity. At United Tribes Technical College, a primarily residential college, the entire community gets involved in STEM education, joining in on environmental research projects led by students (Bahnson, 2020). Qaqish et al. (2020) discusses the importance of community among Black engineering transfer students, emphasizing the importance of communities of practice which span institutions before and after transfer.

Family-Focused Policies:

It is imperative that colleges formally recognize and support students with familial responsibilities. This may come in the form of onsite daycare, a formal policy to allow dependents in the classroom, or (as in the case of United Tribes Technical College) on-campus family housing with an elementary school on campus (Bahnson, 2020). Families also have a major impact on students making the initial decision to pursue a STEM career. A 2015 study by Myers et al. recommends that community colleges involve parents in STEM career promotion, which can increase STEM aspiration in students who aren't sure what their career options are (Myers et al., 2015). When students can integrate their family lives with their academic lives, they are more likely to engage in their education.

Extracurricular Opportunities:

Student engagement in campus activities like clubs can improve social integration and sense of belonging (Marra et al., 2015). Additionally, many of these extracurricular activities serve as opportunities for professional development. Professional development workshops expose students to alternate career paths, such as graduate school (Sorkin et al., 2010). However, many community college students do not spend much time on campus outside of class, due to work and family obligations. This can result in lower engagement with their institution unless flexibility and financial aid are considered.

Financial & Career Capital

Financial & Career Capital describes the benefits students receive from engaging in career-focused activities and receiving financial support. This includes financial aid, professional networking, and research opportunities.

Financial Aid:

College tuition is more expensive than it's ever been, even at community colleges, and the cost is only growing. A 2015 study of community college STEM students indicates that navigating the financial burden of college is a major drawback to transferring, with one participant asking, "Have many people been priced out of higher education, and at what point do students no longer see the return on investment for higher education?" (Kruse et al., 2015, p.

341). Financial aid is needed for students to enter and remain in college, particularly those who are loan-averse due to financial circumstances. Many community college students work long hours to afford college tuition. In a 2015 study of Iowa community college students with STEM aspirations, 62.1% of students worked off campus, and 38.4% worked more than 30 hours per week (Myers et al., 2015). Students who receive large scholarships have greater financial freedom (they do not have to work as many hours), allowing them to engage with faculty, dig into their own engineering identities, and take greater course loads (Rodriguez et al., 2021). Taking more courses is key to maintaining transfer momentum - full-time student status was one of the strongest predictors of transfer in an analysis of 2003-2009 data from community colleges across the U.S., doubling the probability that a student will transfer to a 4-year program (LaSota and Zumeta, 2016). While maintaining academic momentum is a factor in improving graduation rates, scholarships also allow for greater opportunity to engage in campus activities outside of class, increasing students' engagement with their institution (Marra et al., 2015). Several studies at the Community College of Baltimore County showed that targeted scholarship programs (like NSF's Scholarships in Science, Technology, Engineering, and Mathematics Program (S-STEM)) can increase the number of underrepresented minorities (including women) graduating with STEM degrees (Sorkin et al., 2010; Sorkin, 2018; Sorkin et al., 2019).

However, despite the immense positive effects of financial aid, many community college students are enrolled part-time and do not qualify for certain scholarships (such as S-STEM, which requires full-time enrollment). Alternative scholarships for part-time students may improve transfer rates, but these are far less common (Tupper et al., 2010). And while faculty recognize the importance of giving financial aid, this is one of the least common strategies for recruiting students into STEM programs (Smith and Wingate, 2016). Another way for students to earn money while engaging on campus is through work-study programs, particularly in STEM-related roles (Kruse et al., 2015). Whatever the form of financial aid, it is critical for universities and community colleges to partner so that students can afford tuition post-transfer.

Partnerships:

Six of the nineteen papers referenced partnerships as essential to developing strong transfer programs. These partnerships range from university-community college relations (to negate the effects of transfer shock) to industry-scholarship relations (to improve the professional

development aspects of formalized financial aid programs) (Loeser et al., 2021). Rodriguez et al. (2021) found that a partnership between the sending and receiving institution helps students develop their engineering identity. Partnerships with universities also improve a students' aspiration to transfer (Wang et al., 2017), particularly when students form relationships with university faculty and graduate students (Lenaburg et al., 2012). Community college faculty are aware of the importance of partnerships, and many desire to collaborate with members of industry to provide professional development opportunities for students (Smith and Wingate, 2016).

However, professional development is not enough if it does not also help students afford to stay in college. Kruse et al. (2015) discuss the "sticker shock" of tuition when transferring from a community college to a university, an effect which can be worsened when students receive scholarships at the college but not at the university. Financially needy students must be informed about the full cost of their education and their options for paying for college. Wraparound financial aid is needed, and university partnerships can keep financial messaging consistent. One way for universities to encourage transfer and provide financial aid is through funded research opportunities.

Research Programs:

Research programs are a common way of getting students involved in their college and engaged in STEM degrees, but many community colleges do not have a strong research focus. Extracurricular research programs may be started by individual faculty or in combination with university and industry research groups (Lenaburg et al., 2012). These programs must be flexible, though, particularly with family needs. At United Tribes Technical College, the director of the Intertribal Research and Resource Center Jeremy Guinn indicates, "[M]any projects benefit from having children tag along for the adventure. Often explaining a project or something they find in nature to their children is the parents' first opportunity to begin sharing their research with others" (Bahnson, 2020, para. 16). Another study on an intensive geoscience research and internship program revealed that students can be blindsided by the amount of work expected in a research program, potentially leading to attrition (Stofer et al., 2021; Loeser et al., 2021). It is essential that program expectations and possible accommodations are shared with students as early as possible in any research program. Alternatively, research may be incorporated into the

classroom – at Kapi'olani Community College, two STEM courses were redeveloped to be research-intensive. Enrollment in these classes nearly doubled in two years, and more than 30 students presented research papers at a conference (Tuthill and Berestecky, 2017). This type of research offering allows students to pursue research while reserving their out-of-class time for other responsibilities, maximizing flexibility.

Flexibility

Flexibility describes the ability of a program to accommodate a range of schedule constraints. This includes remote engagement opportunities and reducing time commitments.

Remote Engagement

Online courses are a popular option for many students who work or care for dependents. A 2015 study by Wladis et al. found that non-traditional student status influenced whether STEM students enrolled in online courses, with the effect being maximized for women at community colleges. The study revealed that 46.8% "of all older students with full-time work and young children enroll in online courses" (Wladis et al., 2015a, p. 102). This trend is stronger in STEM programs than in non-STEM programs (Wladis et al., 2015b). However, students may find it difficult to engage with their classmates and professors in a totally online class. One way to combat disengagement is through online discussion forums or social media, which allow students an opportunity to engage on their own schedule (Marra et al., 2015). However, these remote engagement options should be carefully evaluated to ensure they do not demand too much of a student's time.

Time Commitment

Formal programs, like residential summer bridge programs, can be an excellent way to introduce community college students to university life. However, working or caretaking students may struggle to commit to a long-term program. Loeser et al.'s 2021 analysis of a 120-hour summer research program emphasized that 120 hours is significant for many community college students. Successful bridge programs for community students should be capped at two weeks (Lenaburg et al., 2012). This allows students to maintain a summer job or spend time with family while engaging in a new STEM experience. Regardless of the specifics of any program, it is crucial to communicate time commitments clearly. A 2017 paper by Stofer et al. found that

students were taken aback at the time commitments expected of them during the later stages of a geoscience research and internship program. Students should be provided the information they need to make decisions about their own time and career plans.

Information Access

Information Access describes providing students with the information they need to succeed in their chosen pathway. This includes focusing on essential academic skills and clarifying the enrollment and transfer process for STEM degrees.

Academic Skills

While extracurricular programs, like clubs, research, and bridge programs, can benefit students, academic skills are key for students to excel in an engineering degree and career. However, certain skills are often neglected in the classroom and deserve special focus. A 2015 study by Marra et al. concluded that group projects and teamwork skills are particularly important for community college students, as these skills help students engage in their degree pathway. Additionally, community college students come from a wide range of academic backgrounds and many require additional spatial reasoning development to succeed in engineering (Sorkin et al., 2019). These skills should be emphasized in the engineering classroom. Because many of these students are only on campus for classes, instructors shouldn't rely on students learning these skills outside of class. While academic skills are critical to successful completion of an engineering degree, students must also be provided with clear information on transferring to a university to complete their degree.

Advising and Transfer Policies

Engineering transfer students are tasked with confusingly-mapped curricula and many hoops to jump through in the transfer process. Many of them either do not have adequate advisor-to-student ratios or do not understand that advising is available to them. For students, especially those underrepresented in engineering, to successfully transfer, advising services must focus on providing timely and accurate information (Wang et al., 2017). While meeting with an advisor has a slight positive correlation with transferring, consistent statewide transfer policies and guidelines result in many more successful transfers (LaSota and Zumeta, 2016). In short,

both individual and system-level actions benefit engineering transfer students by reducing confusion about what, exactly, they need to do to succeed.

Discussion

The research questions I posed were:

1) What types of programs are offered to support community college students in engineering-for-transfer programs?
2) What aspects of these programs contribute to the success of students who have responsibilities like employment or caretaking of another person?

To answer these questions, I analyzed nineteen papers and identified four key themes: Social Capital, Financial & Career Capital, Flexibility and Information Access. These themes fit existing theories about transfer student success, such as Laanan's Transfer Student Capital Theory (Laanan et al., 2010). When students are provided with the skills and tools they need, they thrive in engineering programs and transfer at higher rates. I did not find many papers which focused specifically on working or caretaking students, but several papers considered these groups. Planning for the success of these students involves some special considerations, which I discuss below.

For many engineering transfer students, forming a strong community at school can be challenging due to external commitments. Formal mentorship programs can help these students form a strong engineering identity while navigating their degree. These mentorship programs may come in the form of faculty advising, research guidance, or partnerships with industry, but a key to their success is establishing meeting times, since working or caretaking students do not spend much time on campus outside of classes. These programs also benefit from a strong emphasis on community, including both the campus community and a students' own family. Providing opportunities for families to become involved in STEM education is critical for many underrepresented groups. This may take the form of inviting parents to recruitment events, allowing students to bring dependents to class, or establishing an elementary school on the grounds of the college. These actions increase the likelihood of students engaging with their degree outside of the classroom. Finally, engaging in extracurricular activities (like STEM clubs) can help students develop community and engineering identity, but these events must be

balanced with external responsibilities, which for many students includes paid work. To increase the time students spend on campus, colleges should consider providing financial and career support.

Scholarships and other forms of financial aid can benefit many students in STEM fields. This is particularly true if students are financially needy or loan-avoidant. By reducing the cost of college, students they can spend more time on their schoolwork and engaging with their chosen degree. However, part-time students may not qualify for scholarships since they do not meet the requirements of large programs, such as the NSF's S-STEM program. Institutions should advise such students about scholarship opportunities available for part-time students. Partnerships with universities can provide students access to other types of financial aid which encourage them to continue their degree post-transfer, after tuition expenses rise. These partnerships can also help students develop professional skills through workshops, bridge programs, and research opportunities. Each of these has been shown to bolster transfer student success, though time commitments remain a challenge.

Flexibility is key for working or caretaking engineering students to succeed in their degrees. Students should be given opportunities to engage with their professors and classmates while off campus, through online discussion forums or social media. Additionally, the time commitments of any extracurricular program should be carefully considered. Many students juggle work, family, and school, and additional commitments may seem impossible. For these students, shorter programs (such as two-week summer bridge programs) make participation more feasible. Additionally, any program should make students aware of the time commitment before they commit to the program. It is difficult to plan for commitments which are months away. Information access is therefore critical to help these students plan for their futures.

Transferring between institutions is challenging at the best of times, but students who work have less time to spend mapping their curricula. Establishing clear articulation agreements and course maps can help these students successfully transfer. Additionally, instructors should focus on important skills needed for engineering (like teamwork or spatial reasoning). Students with heavy outside time commitments are less likely to spend time on extracurricular STEM activities, so classroom time must be allocated for them.

Limitations

This analysis was limited by a scarcity of peer-reviewed journal articles on community college engineering students specifically. Many of the papers reviewed were focused on STEM education more broadly, and the results may not be as applicable to engineering students particularly. Additionally, papers on community college education are published in a wide array of journals. This variety in journals means that many relevant papers may not have been in the databases I used (Compendex and ERIC, exclusively). Finally, these papers discussed a wide variety of programs, but most focused on a small sample population. This means the results may not be generalizable to the broad circumstances of all engineering transfer students who work or take care of another person.

Conclusion

Whole-student engagement in STEM education is necessary to improve recruitment, retention, graduation, and career outcomes for engineering transfer students, particularly for working or caretaking students. This paper detailed several ways that institutions provide these students with key skills and services. Namely, colleges can help students develop career skills through financial aid (which reduces the need to work), formal mentorship programs, research opportunities, and extracurricular activities with a professional development focus. However, it is critical that these programs are flexible, allowing students to bring their dependents with them or engage remotely. It is also key that students are provided accurate information on these programs and on transfer pathways.

More research is needed to understand engineering-for-transfer students who have responsibilities outside the classroom. This paper focused on programs and institutional actions which can improve academic and transfer outcomes for community college students, but I did not find any papers which focused exclusively on students with work or care responsibilities. These students can benefit from programs which consider their unique needs, such as remote course offerings or mentorship programs which demand only a few hours of time. By characterizing the experiences of all community college students, institutions can explore programs and partnerships to improve access to engineering education.

References

*Bahnson, A. (2020). Whole family engagement: STEM education at United Tribes Technical College. *Tribal College Journal of American Indian Higher Education*, *31*(4). https://login.ezproxy.lib.purdue.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1253160&site=ehost-live

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Burns, K. (2010). At issue: Community college student success variables: A review of the literature. *Community College Enterprise*, *16*(2), 33–61.

CCCS, 2022. Associate of engineering science degree pathway. Accessed November 13, 2022. https://cccs.edu/new-students/explore-programs/associate-of-engineering-science-degree-pathway/

Enriquez, A. G., Langhoff, N., Dunmire, E. N., Rebold, T., & Pong, W. (2018, June 23). Strategies for developing, expanding, and strengthening community college engineering transfer programs. 2018 ASEE Annual Conference & Exposition. https://peer.asee.org/strategies-for-developing-expanding-and-strengthening-community-college-engineering-transfer-program

Espino, M. L., Rodriguez, S. L., & Le, B. D. (2022). A systematic review of literature: Engineering identity and students with financial need in community colleges. *Community College Journal of Research and Practice*, *46*(5), 352–363. https://doi.org/10.1080/10668926.2020.1856218

Franco, R. W. (2002). The civic role of community colleges: Preparing students for the work of democracy. The Journal of Public Affairs, 6(1), 119-136.

*Marra, R. M., Tsai, C.-L., Bogue, B., & Pytel, J. L. (2015). Alternative pathways to engineering success: Using academic and social integration to understand two-year engineering student success. *American Journal of Engineering Education*, *6*(2), 69–83.

*Kruse, T., Starobin, S. S., Chen, Y. (April), Baul, T., & Santos Laanan, F. (2015). Impacts of intersection between social capital and finances on community college students' pursuit of STEM degrees. *Community College Journal of Research and Practice*, *39*(4), 324–343. https://doi.org/10.1080/10668926.2014.981893

Laanan, F. S., Jackson, D., & Darrow, M. (2010, June). Experiences of engineering transfer students: From community college to university. In 2010 Annual Conference & Exposition (pp. 15-553).

Laanan, F. S., Starobin, S. S., & Eggleston, L. E. (2010). Adjustment of community college students at a four-year University: Role and relevance of transfer student capital for student retention. *Journal of College Student Retention: Research, Theory & Practice*, *12*(2), 175–209. https://doi.org/10.2190/CS.12.2.d

*LaSota, R. R., & Zumeta, W. (2016). What matters in increasing community college students' upward transfer to the baccalaureate degree: Findings from the beginning postsecondary study 2003-2009. *Research in Higher Education*, *57*(2), 152–189.

Laugerman, M., Shelley, M., Rover, D., & Mickelson, S. (2015). Estimating survival rates in engineering for community college transfer students using grades in calculus and physics. *International Journal of Education in Mathematics, Science and Technology*, *3*(4), 313. https://doi.org/10.18404/ijemst.15099

*Lenaburg, L., Aguirre, O., Goodchild, F., & Kuhn, J.-U. (2012). Expanding pathways: A summer bridge program for community college STEM students. *Community College Journal of Research and Practice*, *36*(3), 153–168. https://doi.org/10.1080/10668921003609210

*Loeser, M. R., Newkirk, M., Gabriel, K. I., & Huerta, A. D. (2021). Development and assessment of an undergraduate research program at a two-year, rural, Hispanic-serving institution: The essential role of partnerships. *Scholarship and Practice of Undergraduate Research*, *4*(3), 22–29.

*Marra, R. M., Tsai, C.-L., Bogue, B., & Pytel, J. L. (2015). Alternative pathways to engineering success—Using academic and social integration to understand two-year engineering student success. *American Journal of Engineering Education*, *6*(2), 69–83.

Monaghan, D. B., & Sommers, O. K. (2022). And now for some good news: Trends in student retention at community colleges, 2004–2017. *Research in Higher Education*, *63*(3), 425–452. https://doi.org/10.1007/s11162-021-09656-6

*Myers, B., Starobin, S. S., Chen, Y., Baul, T., & Kollasch, A. (2015). Predicting community college student's intention to transfer and major in STEM: Does student engagement

matter? *Community College Journal of Research and Practice*, *39*(4), 344–354. https://doi.org/10.1080/10668926.2014.981896

NSF (2019). The increasing role of community colleges among bachelor's degree recipients: Findings from the 2019 National Survey of College Graduates. https://ncses.nsf.gov/pubs/nsf21309

Ogilvie, A. M. (2017). Understanding transfer student pathways to engineering degrees: A multi-institutional study based in Texas [Doctoral dissertation, Virginia Polytechnic Institute and State University]. VTechWorks. https://vtechworks.lib.vt.edu/bitstream/handle/10919/96022/Ogilvie_AM_D_2017.pdf?sequence=1&isAllowed=y

*Qaqish, O., Grant, C. S., & Bowles, T. (2020). Success factors that shape Black male transfer and academic experiences in engineering. *Community College Journal of Research and Practice*, *44*(10–12), 885–898.

Reeping, D. P. (2019). Identifying asymmetries in web-based transfer student information that is believed to be correct using fully integrated mixed methods. [Doctoral dissertation, Virginia Polytechnic Institute and State University]. VTechWorks. https://vtechworks.lib.vt.edu/handle/10919/95944

*Rodriguez, S. L., Espino, M. L., Le, B. D., & Cunningham, K. J. (2021). The influence of policy implementation in the Midwest: How an SSTEM program broadens participation and enhances engineering identity for community college students. *Education Policy Analysis Archives*, *29*(29). https://eric.ed.gov/?id=EJ1288417

*Sorkin, S., Gore, M. E., Mento, B., & Stanton, J. (2010). Tracking women and minorities as they attain degrees in computing and related fields. *Information Systems Education Journal*, *8*(50). https://eric.ed.gov/?id=EJ1146770

*Sorkin, S. (2018). Long-term follow-up of STEM scholarship students to degree attainment. *Information Systems Education Journal*, *16*(5), 45–55.

*Sorkin, S., Braman, J., & Yancy, B. (2019). Interim awardee outcomes after four years of a STEM scholarship program. *Information Systems Education Journal*, *17*(1), 49–63.

*Smith, C., & Wingate, L. (2016). Strategies for broadening participation in advanced technological education programs: Practice and perceptions. *Community College Journal of Research and Practice*, *40*(9), 779–796.

*Stofer, K. A., Chandler, J. W., Insalaco, S., Matyas, C., Lannon, H. J., Judge, J., Lanman, B., Hom, B., & Norton, H. (2021). Two-year college students report multiple benefits from participation in an integrated geoscience research, coursework, and outreach internship program. *Community College Review*, *49*(4), 457–482.

Terenzini, P. T., Lattuca, L. R., Ro, H. K., & Knight, D. B. (2014). America's overlooked engineers: Community colleges and diversity in undergraduate education. http://hdl.handle.net/2027.42/107460

Tsapogas, J. (2004). The role of community colleges in the education of recent science and engineering graduates. *National Science Foundation Info Brief.* 8.

*Tupper, D. H., Leitherer, B., Sorkin, S., & Gore, M. E. (2010). Strategies for increasing IT enrollment: Recruiting, retaining and encouraging the transfer of women and underrepresented groups to four-year colleges. *Information Systems Education Journal*, *8*(54). https://eric.ed.gov/?id=EJ1146774

*Tuthill, M. C., & Berestecky, J. M. (2017). Integrating undergraduate research at two-year colleges. *Journal of College Science Teaching*, *46*(4), 12–17.

Van Noy, M., & Zeidenberg, M. (2017). Community college pathways to the STEM workforce: What are they, who follows them, and how? *New Directions for Community Colleges*, *178*, 9–21.

VCCS, 2022. Major: Engineering. Accessed November 13, 2022. https://courses.vccs.edu/programs/major/831.ENGINEERING

*Wang, X., Lee, S. Y., & Prevost, A. (2017). The role of aspirational experiences and behaviors in cultivating momentum for transfer access in STEM: Variations across gender and race. *Community College Review*, *45*(4), 311–330.

*Wladis, C., Hachey, A. C., & Conway, K. M. (2015a). The representation of minority, female, and non-traditional STEM majors in the online environment at community colleges: A nationally representative study. *Community College Review*, *43*(1), 89–114.

*Wladis, C., Hachey, A. C., & Conway, K. (2015b). Which STEM majors enroll in online courses, and why should we care? The impact of ethnicity, gender, and non-traditional student characteristics. Computers and Education, 87, 285–308. https://doi.org/10.1016/j.compedu.2015.06.010

*Paper included in literature review