Transfer Students in Computer Science: Examining Barriers, Success Metrics, and Research Gaps

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Abstract

Transfer students play an important role in enhancing diversity within computer science programs. As first-generation college students, minorities, rural residents, and individuals from low-income backgrounds, transfer students represent a demographic critical to fostering innovation and inclusion in the field. However, while significant research has been conducted on transfer students in STEM disciplines, studies specifically addressing their experiences in computer science remain limited. This paper presents a preliminary systematic review of the literature to explore the challenges, successes, and gaps in the support of transfer students in computer science.

CCS Concepts

• **Social and professional topics → Computing education**.

Keywords

Transfer Student; Upward Mobility; Equity

ACM Reference Format:

Nawar Wali and Sara Hooshangi. 2025. Transfer Students in Computer Science: Examining Barriers, Success Metrics, and Research Gaps. In *Proceedings of the 30th ACM Conference on Innovation and Technology in Computer Science Education V. 1 (ITiCSE 2025), June 27-July 2, 2025, Nijmegen, Netherlands.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3724363.3729118

1 Introduction and Motivation

Diversity in computer science remains a critical and widely discussed topic. Although Diversity, Equity and Inclusion (DEI) initiatives have been heavily discussed, their outcomes often vary[19]. Some initiatives achieve measurable success, while others fall short of their intended goals. Governments and universities recognize the importance of fostering diversity, as evidenced by various government projects aimed at increasing representation in STEM fields[2][17]. But why is diversity so essential? A diverse group of individuals brings a wider range of perspectives and ideas, spurring innovation and driving progress through collaborative problem-solving.

Many institutions globally are committed to increasing the diversity of computer science programs. A method to achieve this goal is by creating more accessible pathways for transfer students transitioning from community colleges or two-year institutions to four-year universities. These institutions are not unique to the United States; they exist worldwide, including in countries like Canada, Japan, India, and Thailand, where they serve as bridges between secondary education and higher education or workforce training[37]. Transfer students often represent underserved demographics, including minorities, first-generation college students, rural students, and those from low-income backgrounds. By facilitating their entry into computer science programs, we can leverage the inclusive potential of community colleges worldwide, significantly enhancing diversity and inclusion in the field.

Research has extensively documented the challenges facing these students, particularly in STEM disciplines. Common barriers include the need for financial aid, the phenomenon of 'transfer shock' (a temporary drop in GPA after transferring) [13], low retention rates[33], and inadequate institutional support[29]. Although many studies have explored these struggles in engineering and other STEM fields, there is a significant gap and lack of research specifically addressing computer science transfer students.

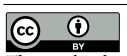
This gap is critical to address because computer science has unique educational and professional dynamics that differ from challenges seen in other fields. Understanding the current landscape, identifying gaps, and building on existing research is essential to develop targeted solutions. To address this gap, this review of the literature aims to provide a preliminary analysis of the current state of research on transfer students in computer science, offering insight into what has been achieved, what challenges persist, and how we can better support these students.

The motivation behind this work is to understand the unique experiences of transfer students in computer science, identify opportunities for intervention, and contribute to the development of effective, evidence-based strategies that promote equity and success in the field.

2 Background and Related Work

While literature reviews on transfer students in other disciplines exist, studies specifically focused on computer science are rare. Research in related fields offers valuable information on challenges and strategies to support transfer students, particularly in STEM disciplines. However, a focused examination of transfer students in computer science can uncover unique nuances and help to tailor support systems more effectively for this field.

For example, Ogilvie [29] presents a literature review examining transfer students in STEM, offering a wide collection of works on the topic. Similarly, Smith et al. [33] conducted a systematic review centered on the persistence of engineering students. This study identified 13 persistence frameworks and highlighted the importance of assimilation structures to bridge the gap between



ITiCSE 2025, Nijmegen, Netherlands

ACM ISBN 979-8-4007-1567-9/2025/06
https://doi.org/10.1145/3724363.3729118

the previous institutions of students and their new academic environments.

Another study explored the identity development of engineering transfer students [9]. By reviewing the existing literature, the researchers emphasized the necessity of customized programs and nurturing environments to foster student success. This work underscores the critical role of institutional culture in shaping transfer student experiences and outcomes.

In addition, Winterer et al. [36] reviewed the literature on Hispanic-Americans in STEM, while Froyed et al. [18] explored broader trends in STEM education for Hispanic students. These studies contribute to understanding how intersectional identities, such as ethnicity and academic background, influence the success of transfer students.

In another study, government-funded programs designed to support transfer students in STEM were reviewed in Ford et al. [17]. The study examined initiatives that aim to improve transfer pathways and promote academic success through financial aid, mentorship, and research opportunities.

Despite significant efforts in STEM fields, there is a notable lack of studies specifically addressing computer science transfer students. Moreover, most existing research on this topic originates from the United States, highlighting a gap in the global academic discourse. This paper aims to address this void by initiating a preliminary discussion on the unique challenges faced by computer science transfer students. While there may currently be limited research on this topic worldwide, we hope that institutions globally can leverage our work.

3 Methodology

Our study is guided by the Kitchenham et al. [22] process on systematic literature reviews in software engineering. We began by defining the purpose of this review, then articulated research questions, followed by developing a review protocol, we concluded by analyzing the data and synthesizing results.

3.1 Formulating Research Questions

This study explores the academic experiences of computer science transfer students and how they are viewed within institutions. It also aims to identify gaps and uncover insights from previous research to guide future strategies for enhancing diversity and supporting transfer students academically and socially. Based on these objectives, we formulated the below research questions based on the following overarching two themes:

Theme 1- Transfer Pathways and Success Metrics:

- RQ1: What frameworks and institutional strategies best support transfer students' successful transition from two-year to four-year computer science programs?
- RQ2: How can these strategies address challenges such as GPA shock, retention, and academic performance?
- RQ3: How does institutional support influence the academic and career outcomes of computer science transfer students?

Theme 2 - Equity and Diversity in Transfer Pathways:

- RQ1: How do transfer pathways contribute to increasing diversity and inclusion in computer science?
- RQ2: What specific barriers and support mechanisms affect underrepresented groups in their transfer journey?

These research questions aim to condense existing findings and provide a framework for advancing the discourse on transfer students in computer science. By doing so, this study contributes to a broader understanding of their role in fostering diversity and highlights actionable steps to enhance their academic and professional success.

3.2 Data Sources and Search Strategy

This review focuses on papers from global education- and computer science-related conferences hosted by ACM, IEEE, and ASEE. These venues were chosen to ensure relevance to computing education research while excluding those with broader applications or less direct focuses on computer science education. In addition, accessibility played a crucial part in our decision. Thus, we decided on the three venues for their alignment with computing education, accessibility and representation of high-impact research.

This initial review did not include poster papers or dissertations, which we plan to explore in future iterations. While we recognize that this methodology may exclude some important works, this paper is intended as a foundational step in exploring the academic discourse surrounding computer science transfer students. Future work will aim to expand upon this foundation and address any gaps by incorporating additional methodologies and resources.

3.2.1 Search Strategy. After selecting the venues of literature, we then conducted a structured keyword search using the methodology to capture literature specifically related to transfer students in computer science.

Keyword Deliberation: A comprehensive list of terms was compiled to represent the intersection of "Transfer Students" and "Computer Science." Key phrases included: "Transfer Students in Computing", "Transfer Students in Computer Science" and "Transfer Students in CS".

Initial Database Search: The initial search was conducted in the ASEE, IEEE, and ACM digital libraries using combinations of the above keywords. As of November 2024 his process generated 157 papers from ACM Library, 248 papers from IEEE Xplore and 749 papers from ASEE Peer.

Observation of Prominence: During our review, we observed that the phrase "Transfer Students in Computer Science" yielded broader results, encompassing papers with additional relevant keywords.

Final Search String: To ensure precision and relevancy, we refined the search string to exclusively focus on "Transfer Students in Computer Science".

Establishing clear inclusion and exclusion criteria was crucial to ensure that the selected papers were both relevant and aligned with the research objectives.

3.2.2 Inclusion Criteria: Papers were included if they met all of the following conditions:

- **Specific Focus on Transfer Students in Computer Science**: The study must explicitly address transfer students as a key demographic within computer science education. This includes research analyzing their academic performance, pathways, retention, or challenges specific to the computer science context.

Venue and Conference	Papers
IEEE	
Frontiers in Education (FIE)	3
RESPECT	1
ASEE	
Annual Conference	21
Virtual Annual Conference	2
ACM	
Inroads	1
TOCE	1
ITiCSE	1
SIGCSE	4
SIGITE	1
ICER	1
Learning @ Scale (L-AT-S)	2
Grand Total	**38**

Table 1: Number of Papers Published by each Venue

- **Primary or Comparative Treatment of Transfer Students**: The paper must directly address transfer students either as the primary population of interest or as a significant comparative group. Examples include studies exploring interventions aimed at improving transfer student outcomes or understanding how their experiences differ from non-transfer students.

3.2.3 Exclusion Criteria: Papers were excluded if they fell into any of the following categories:

- **Peripheral Mentions of Transfer Students**: Studies that only mentioned transfer students as part of a broader dataset without substantive analysis or focus on their experiences were excluded. For instance, papers that merely stated, "Transfer students received lower grades than non-transfer students," without further investigation were not included.
- **Focus on General Undergraduate Populations**: Papers that addressed broader issues in computer science education (e.g., curriculum design for all undergraduates) but did not analyze transfer students as a distinct group were excluded.
- **Non-Academic or Informal Contributions**: Posters, books, editorial columns, or opinion pieces that did not present formal research findings were excluded.
- **Non-Transfer-Specific Initiatives**: Studies that discussed general diversity initiatives in computer science education without focusing on transfer students as a targeted group were excluded. This includes initiatives aimed at broad populations where transfer students were not explicitly analyzed.
- **Different Disciplines**: Papers that focused on transfer students in non-computing disciplines, such as general STEM or humanities fields, were excluded.

By applying these criteria, we curated a dataset that provides a detailed and focused understanding of the challenges, opportunities, and interventions for transfer students in computer science. Future work may broaden these criteria to include other venues or related disciplines to capture additional insights.

The final dataset, compiled after applying the search and inclusion criteria, consists of 38 papers published across the three venues: IEEE, ASEE, and ACM. The dataset includes papers from a range of conferences and journals within these venues. Table 1 highlights the distribution of papers across conferences. ASEE contributed the largest share with 23 papers, followed by ACM with 11 papers, and IEEE with 4 papers.

3.2.4 Data Extraction. To systematically address our research questions, we organized the papers into distinct groups using a set of codes. During the initial read-through, we identified recurring themes and concepts relevant to our research focus.

After thoroughly reading each paper, we applied the codes during a second review. To ensure accuracy, a third review and code validation were conducted by the second author. Once both authors reached a consensus on the codes and their application, we finalized the list of codes and the associated papers. We intentionally kept the codes broad to capture the nuanced aspects of each paper. For instance, several papers discussed the transfer pipeline between community colleges and four-year institutions while also highlighting student struggles. In such cases, multiple codes were applied simultaneously.

The final set of codes is presented in Table 2.

3.2.5 Quality Assessment. To ensure the assigned codes accurately reflected the content of each paper, we took additional steps beyond multiple readings. Given the complexity of academic research, we acknowledged that no single code could fully capture every nuance of a paper's contributions.

3.3 Data Synthesis

After the coding was complete, we condensed our data. We aimed to answer our research questions by synthesizing the data through quantitative summary and qualitative description[22]. We showed the frequency of codes to quantitatively summarize the distribution of codes within a group. These findings are shown in Figure 1. We also investigate the results via our research question qualitatively.

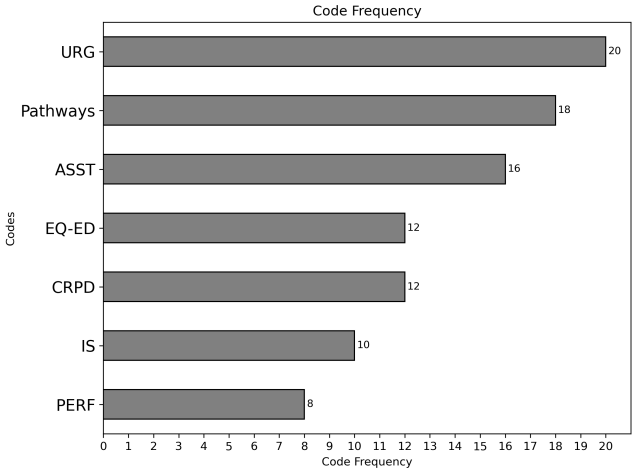


Figure 1: Frequency of Codes Seen in Selected Papers

Code Group	Code	Description
Transfer Pathways in CS Education	**Pathways**	Papers on frameworks and initiatives to ease the transition from two-year to four-year CS programs. Focus areas: articulation agreements, transfer processes, program alignment.
Underrepresented Groups in CS Transfer	**URG**	Studies on the experiences of underrepresented groups (e.g., minorities, women) in CS transfers. Focus areas: equity, inclusion, support mechanisms.
Institutional Support for CS Transfers	**IS**	Research on institutional support and resources impacting transfer student success. Focus areas: financial aid, advising, mentoring, community building.
Career Readiness and Professional Development	**CRPD**	Papers on career preparation for transfer students via industry collaborations and experiential learning. Focus areas: internships, industry partnerships, curriculum enhancement.
Assessment and Success Metrics	**ASST**	Studies on evaluating transfer programs. Focus areas: assessments, retention, program replication.
Academic Performance and Challenges	**PERF**	Papers on GPA shock, academic readiness, and transition challenges. Focus areas: performance gaps, academic support.
Equity in Education Access	**EQ-ED**	Papers on broadening access to education for disadvantaged students. Focus areas: access pathways, systemic inequalities, democratization strategies.

Table 2: Codebook for Categorizing Selected Papers

3.3.1 Sensitivity Analysis. A significant number of papers in our review originated from ASEE, which may have influenced the overall distribution of sources and potentially skewed the pool of papers. While we aimed to conduct a global search, our criteria identified only one study from Ireland, with the rest originating from the United States. This underscores a significant gap in international research on this topic, potentially influenced by barriers such as language, regional focus, and limitations in our choice of venues.

We acknowledge that some studies may not have met the inclusion criteria yet could still provide valuable insights into the experiences and challenges of transfer students in computer science. The exclusion of certain research venues inherently narrows the scope of our findings, which may limit their applicability to broader or more diverse educational contexts. This underscores the need for future research to explore a wider range of perspectives and frameworks to better understand transfer students in computer science globally.

4 Results

In this section, we aim to answer our research questions by categorizing our papers and codes as it relates to each theme and the corresponding research questions in that theme. The preliminary results, shown in Figure 1, show the number of papers in each code group.

4.1 Transfer Pathways and Success Metrics

Financial aid has emerged as a critical factor in both transfer student retention and their decision to transfer in the first place [10]. Collaboration between institutions, particularly between two-year and four-year colleges, plays a vital role in fostering transfer student success. Programs that focus on peer mentoring, industry advising, scholarships, online resources, orientation sessions, and tutoring provide essential support. However, a persistent challenge remains: many students lack the necessary background knowledge to excel in gateway courses, which hinders retention efforts [1].

One example is a transition program emphasizing networking and program standards through workshops, mentoring, and student empowerment activities. These initiatives have proven effective in helping transfer students adjust to new academic environments [2]. While both transfer and native students face similar course-specific difficulties [11], gaps in academic preparation are a significant concern. For instance, students transferring with a C average in prerequisite courses often struggle more in subsequent courses compared to peers with higher grades [14]. This underscores the importance of transfer credit policies that ensure prerequisite courses adequately prepare students.

To address these gaps, initiatives with robust support frameworks, such as mandatory tutoring and professional mentoring, have shown success in boosting transfer rates and degree completion [16]. For example, summer bridge programs have been particularly effective in addressing foundational gaps in mathematics, with one study reporting that 60% of participants eliminated the need for remedial math. Expanding such models to a broader range of students—not just those in specific pathways—could further promote equitable access to engineering and computer science education.

Strengthening transfer pathways between community colleges and four-year institutions has been identified as a key strategy to increase participation in fields like engineering and computer science. Effective articulation agreements and curriculum alignment can reduce credit loss and facilitate smoother transitions for students [20, 21]. Programs that integrate early advising, cohort-building, and financial support highlight the value of intentional interventions in improving transfer student outcomes [15]. By offering scholarships, tailored advising, and extracurricular opportunities, these programs help students adapt both academically and socially to their new environment.

Survey findings show that institutional programs provide spaces for students to grow both academically and personally, making them highly popular among participants [6, 8]. The role of Personal Transition Services Specialists has been particularly effective in helping students adjust to university life.

Near-peer instruction is another promising approach, where students are mentored by individuals only a few years ahead of them academically. For instance, in an NSF S-STEM (Scholarships in Science, Technology, Engineering, and Mathematics) Award program, graduate students mentor undergraduate transfer students through

research-oriented courses. These courses, funded by the U.S.-based National Science Foundation, aim to provide financial support and academic resources to students of diverse backgrounds. The courses, required for scholarship completion, have demonstrated benefits for both scholars and Fellows [32]. Near-peer mentorship provides: psychological and emotional support, assistance in setting goals, exploring career paths, academic knowledge support, and access to relatable role models. Despite these successes, challenges persist. Research shows that transfer students often struggle to adapt to new academic systems, especially when transitioning from semester-based community colleges to quarter-based four-year institutions [34]. Additionally, discrepancies in preparation and performance metrics, such as Basic Data Structures Inventory (BDSI) scores in computer science courses, highlight the need for targeted support to ensure equitable outcomes for transfer students [34].

4.2 Equity and Diversity in Transfer Pathways

Community colleges have become an entry point for students transitioning to four-year universities. This pathway is especially significant for underrepresented students who often face challenges related to transfer decision-making, access to academic and non-academic support, and job placement opportunities. These barriers disproportionately affect minority groups and underscore the importance of equity-focused initiatives [35]. A study using the Laanan-Transfer Student Questionnaire found that transfer students are often first-generation college students (44%), older than traditional students (two-thirds are 21 years or older), and from lower socioeconomic backgrounds. In addition, proximity to home plays a significant role in their decision to transfer [24].

In response to these challenges, institutions have developed programs aimed at increasing diversity in engineering and computer science. For example, the College of Engineering and Computer Science at one university received an NSF (National Science Foundation) S-STEM Scholarship grant to support students with high financial need and underrepresented minority (URM) students in computer science [38]. Similarly, financial, family support, and geographical factors remain the most common reasons for transfer, with women and minorities comprising approximately 61% of transfer students [5].

Another NSF-funded program focuses on creating pathways that go beyond enrolling racially diverse students to actively support their persistence, graduation, and career placement. The program targets students who meet criteria such as being first-generation college students, coming from socioeconomically disadvantaged backgrounds, or belonging to historically underrepresented groups. A key feature of the program is the summer research program for transfer students, which not only bridges academic gaps but also fosters interest in graduate studies by providing hands-on research experiences in computing [28].

Another example is the collaboration between a four-year university and several community colleges, including a Hispanic-serving institution, to promote diversity in engineering and computer science. This initiative focuses on retention strategies for upper-division transfer women students, emphasizing innovative support frameworks and retention programs [7].

A survey conducted nationwide in the United States by the BRAID Research team revealed that upward transfer students tend to be more diverse in terms of race/ethnicity, socioeconomic status, and other demographic factors compared to native computing students. However, these students report lower levels of peer, mentor, and departmental support. This represents a missed opportunity for computing programs to better serve and support this diverse group of students [12].

Challenges persist for minority transfer students, who often demonstrate lower prerequisite course proficiency and grades compared to their non-transfer peers [23]. Efforts to recruit more women and URM students into engineering and computer science have demonstrated the importance of outreach and information sessions at community colleges. For many students, particularly women and minorities, decisions to pursue engineering or computer science are made after enrolling in community college. Programs that engage high school and community college students through university visits and mentorship attempt to improve transfer rates and diversity in these fields [25].

Despite these initiatives, gender disparities remain stark. While more women than men transfer from community colleges to four-year universities, women are far less likely to select engineering and computer science as their major. In a study done in Texas, data from a ten-year cohort study showed that only 2% of female transfer students chose engineering or computer science compared to 11% of male transfers [30].

5 Discussion

In this section, we interpret the findings in the context of the research questions as well as discuss key insights and propose frameworks to address the challenges transfer students face, particularly in computer science programs[22]. While several findings (e.g., the impact of financial aid or institutional mentoring) are consistent with broader STEM transfer literature, this review also identified preliminary CS-specific trends such as preparation gaps in foundational computing concepts (e.g., data structures) and mismatched transfer credit articulation in CS courses.

5.1 Transfer Pathways and Success Metrics

5.1.1 RQ1: What frameworks and institutional strategies best support transfer students' successful transition from two-year to four-year computer science programs? We found that in our literature review, financial aid is a critical factor in transfer student retention and success port-transfer[10]. Students who were able to obtain financial aid were able to focus more on their studies as well as reduced the need for getting secondary jobs. Beyond financial aid, early advising, cohort-based models, and structured pathways have proven effective in helping students adapt to new academic environments [15]. These strategies not only ease the struggles of transferring but also help to create a sense of belonging to the community.

5.1.2 RQ2: How can these strategies address challenges such as GPA shock, retention, and academic performance? The GPA disparity of 0.2 to 0.3 points between transfer and native students highlights the support needed by transfer students [4]. To address this, institutions should focus on targeted interventions, such as summer bridge programs that tackle foundational gaps, especially in high-demand areas like mathematics [16]. Additionally, clear transfer

credit policies can prevent students from being unprepared for advanced courses. For example, ensuring that prerequisite courses taken at community colleges are similar in rigor to those at four-year institutions can reduce academic shock and improve outcomes.

5.1.3 RQ3: How does institutional support influence the academic and career outcomes of computer science transfer students? Institutional support plays an important role in shaping both academic and career outcomes. Programs that integrate mentoring with industry exposure, such as NSF-funded initiatives, help students understand a diverse set of pathways post-graduation [3]. Near-peer mentoring programs have been shown to have success in offering relatable role models and tailored academic guidance, fostering both academic success and a sense of belonging for their students [32]. These findings highlight the importance of creating structured mentorship pipelines within institutions to support transfer students through critical transitions.

5.2 Equity and Diversity in Transfer Pathways:

5.2.1 RQ1: How do transfer pathways contribute to increasing diversity and inclusion in computer science? Transfer pathways are crucial for diversifying computer science programs, as they serve as a gateway for first-generation, older, and socioeconomically disadvantaged students [24]. However, these students often lack access to resources such as peer networks and mentoring, which can limit their sense of belonging and academic success [12]. This disparity suggests an opportunity for computing programs to better leverage the diversity of transfer students by developing inclusive practices that address their unique needs.

5.2.2 RQ2: What specific barriers and support mechanisms affect underrepresented groups in their transfer journey? Underrepresented groups, including women and minority students, face intersecting barriers such as inadequate academic preparation, financial constraints, and limited exposure to career pathways [35]. Programs that can combine academic and professional mentoring with research opportunities, such as summer research initiatives, can potentially bridge academic gaps and bring more interest in CS from underrepresented groups [28]. Institutions must also address structural barriers, such as proximity to campus and inflexible program requirements, which disproportionately affect these students.

6 Research Gaps and Future Directions:

Challenges extend beyond academic performance to social integration. Although native freshmen and transfer students rated their overall social experiences similarly, native freshmen were nearly twice as likely to develop close personal friendships on campus (55%) compared to transfer students (29%) [26]. Additionally, at least one in five native freshmen had participated in student organizations related to their major or intramural sports, highlighting higher engagement in extracurricular and co-curricular activities compared to transfer students. These disparities emphasize the importance of interventions to support transfer students' academic and social integration.

Improving transfer student outcomes requires institutional partnerships that extend beyond individual campuses [27]. Effective strategies include organizing students into cohorts to foster peer support, providing support that is both timely and accessible, defining clear pathways that guarantee graduation within a set timeframe, and helping students develop a clear post-graduation vision early in their academic journey.

Research should evaluate the long-term impacts of these programs on student outcomes, such as graduation rates and career pathways. Based on student feedback, adjustments are being implemented to enhance program effectiveness and address gaps in student preparedness. Future work should focus on the role of undergraduate research opportunities and mentorship in fostering transfer student success and facilitating their transition to four-year institutions and beyond [31].

While these challenges have been well-documented in the U.S., there is a noticeable lack of global literature on transfer students in computer science and other fields. The majority of existing studies focus on the U.S. context, which may not fully represent the diverse experiences of transfer students worldwide. Future research should explore the unique challenges and support systems for transfer students in varying educational systems globally, ensuring that findings can inform policies and practices across different cultural and institutional contexts.

Finally, capturing a broader understanding of transfer student challenges and success requires expanding methodological approaches. This involves integrating qualitative insights with quantitative data to better capture the lived experiences of transfer students. For instance, analyzing participation in co-curricular activities, sense of belonging, and engagement with support services could provide a holistic understanding of the transfer student experience. Additionally, employing predictive modeling to identify at-risk students early could inform targeted interventions, ensuring that resources are allocated efficiently to those who need them most. Expanding the scope of this research internationally would not only enrich the global literature but also provide valuable insights for diverse educational systems worldwide.

7 Conclusion and Future Work

Addressing the systemic barriers faced by transfer students requires a multi-faceted approach that combines financial, academic, and social support. Institutions must collaborate to develop streamlined transfer pathways, equitable policies, and inclusive support frameworks. By focusing on these areas, policymakers and educators can create more effective and accessible pathways for transfer student success, especially in computer science.

This review represents a preliminary step toward a more comprehensive examination of the computer science transfer student experience. While our focus on conference papers from ACM, IEEE, and ASEE ensures alignment with computing education venues, it may exclude relevant journal articles, poster papers, and global studies. In addition, our keyword selection—though precise—may have omitted research under alternative terminology (e.g., informatics, software engineering). Furthermore, while this review aimed to focus on computer science, many findings overlap with broader STEM trends. In subsequent work, we plan to broaden our scope to include more diverse sources, incorporate additional CS-specific constructs such as curriculum alignment, and more clearly delineate CS-specific themes versus generalizable STEM insights.

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