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The Engineering Admissions Partnership Program: A Navigation Strategy for Community College Students Seeking a Pathway into Engineering*

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This paper presents the evaluation of a program designed to improve transfer outcomes for community college students pursuing an engineering degree. The program, the Engineering Admissions Partnership Program (E-APP), was designed to improve the navigational success of community college transfer students through connections to the university. These connections include coordinated academic advising, peer-mentoring, campus visits, and online social and professional networks. The objective of the study is to determine the efficacy of the E-APP and its interventions, which will be measured by increased participation rates and increased university retention rates for E-APP participants. Outcome data for the students are analyzed statistically for significant differences between the quasi-experimental groups (E-APP or not E-APP), matched based on Math ACT scores. The results show significant improvement in first-year retention rates for E-APP participants. The results of this study are both transferrable and scalable. This research may help increase the success of community college transfers to engineering through developing and implementing similar navigational programs across the country.

Keywords: community college; retention; STEM; enrollment partnership programs

1. Introduction

As the United States seeks to graduate more engineers and scientists and to expand and diversify its STEM workforce more generally, community colleges (CCs) can provide a vital source of students for four-year colleges and universities [1]. Nearly half of all undergraduate students enroll at a CC sometime during their education [1, 2], and more than half of all incoming CC students intend to transfer to a four-year institution to receive a bachelor's degree [3, 4]. Despite these intentions, only 25–35% of CC students actually complete the transfer process [2, 5]. Even if the goal is an associate's degrees or certificate, the completion rates are still very low. According to The National Center for Higher Education Management Systems [6], only 28% of first-time, full-time, associate's degree-seeking CC students graduate within three years, and about half do not return for their second year. These rates represent important opportunities for improvement, and improvements are warranted when one considers that CCs are the entry route to higher education because of their accessibility and affordability [7], which results in higher socio-demographic diversity among the student population. Of the eight million CC students in the United States currently enrolled in for-credit courses, 42% are the first in their family to attend college, 46% are receiving financial aid, and 45% are from an underrepresented ethnic minority group [1].

The need for a navigational strategy for successful degree attainment has been identified by Stevens *et al.* in the pursuit of an engineering degree [8]. Employing a navigational strategy also makes sense for CC transfer students. Because the process of preparing for transfer and the transition involved is complex, a student's chances of transferring and completing a baccalaureate degree are greatly enhanced when two-year and four-year institutions work together to facilitate the process and reduce barriers [9, 10]. The research of Handel [11] and a 2007 National Academies report [12] recommend connection-based approaches in designing a successful CC student transfer process. These connections enhance CC students' engagement by building a bridge between CC students and university-level programs. Research has shown that partnership

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strategies between two-year and four-year institutions increase success for CC transfers [13, 14]. Cohort programs in particular have been shown to have a positive effect on the retention of STEM graduates [15]. Whether the programs emphasize connections, partnerships, cohorts, or social integration [14], students who are more integrated into the college environment are more likely to persist [16]. Even though more high school graduates are choosing to attend CCs to fulfill curriculum requirements [17], many studies about STEM persistence at universities do not include CC data in their research [18–20].

Policymakers and researchers have identified improving articulation and transfer agreements at both the state and institutional level as a key method by which to improve bachelor's degree attainment rates [21]. Creating such agreements is no easy task, as it requires faculty and institutions to agree on which courses properly prepare students and to review and potentially revise their courses [11]. The relationship between two-year and four-year institutions is often strained over disagreements about academic preparation, credit transfer, and control of the baccalaureate degree. Not surprisingly, then, despite a 100-year history, CC transfer has never been a reliably productive route to the baccalaureate degree [2]. In addition, two-year and four-year institutions have almost never been recognized or rewarded for the work they do on behalf of transfer students [5].

1.1 Background

Recognizing the need for stable, reliable two-to-four year partnerships to increase the number of CC students who successfully complete four-year STEM degrees, the National Science Foundation (NSF) has funded the STEM Talent Expansion Program (STEP). Three such funded programs are: the Talent Expansion in Science and Technology Urban Partnership (TEST: UP) between California State University, Fullerton and two CCs; the Science and Technology Reaching Out to New Generations in Connecticut (STRONG-CT) program between the University of Connecticut (UConn) and three CCs; and the Seeking Enrollment and Engagements through Connections (SEEC) project between Iowa State University (ISU) and a multiple-location CC.

The TEST: UP program [22] is aimed at Hispanic-serving institutions, and features a transfer counselor at each CC as well as transfer peer advisors at the University. It also provides supplemental instruction (SI) at the CC, whereby trained SI leaders and faculty coordinators mentor students on how to be successful in STEM courses using best practices, study skills and class management. The program's success is measured by increased retention rates of SI participants in specific courses as well as survey data. The challenges encountered include:

- Securing stable institutional funding for the SI peer facilitators and faculty coordinators involved in offering the SI courses.
- Access to student data. CCs often lack access to information needed to track students' transfer progress, unless it is self-reported. This data tracking problem is recognized nationally.
- CC counselors have broad responsibilities and are not just STEM-focused.
- The challenge in identifying TEST: UP's 'net,' or unique, impact on transfer and degree trends.

The STRONG-CT program [23] is an academic support program for life science students. The program activities at each institution include: individual and group academic support for the core science and mathematics courses, mentoring relationships with senior students, research opportunities to enhance understanding of science, leadership workshops, outreach projects to communities and career counseling.

Outcomes are measured based on improved academic performance and graduation rates of the members. Project success is measured in terms of improved retention and graduation rates. There are at least two limitations of the current STRONG-CT program. First, the number of students directly impacted has been limited due to program design and capacity. Second, much effort was spent supporting students through the foundational science courses.

The SEEC program [24] is a collaborative, connection-based alliance to increase success of CC transfers to engineering. It is different from the TEST: UP and Strong-CT programs in that it is focused on CC transfer students to engineering. The Engineering Admissions Partnership Program (E-APP) was created in 2008 as a SEEC project initiative that was designed to improve the navigational success of CC transfer students through connections to the university. These connections include coordinated academic advising, peer-mentoring, campus visits, and online social and professional networks. This initiative was offered to all in-state CC transfer students in addition to students participating in the SEEC CC.

Initial efforts at determining CC success rates with historical data strongly suggested that CC students had significantly decreased retention rates when compared with other types of students admitted to the College of Engineering [25]. This finding emphasized the importance of implementing the E-APP program.

1.2 Objectives

Using the unique articulation agreement for the SEEC NSF project, this study measures the effect of the E-APP as a social integration or navigational strategy for increasing success of CC transfer students to the College of Engineering. This project contributes to the data-based body of evidence characterizing successful cohort-based strategies for CC transfers to STEM fields. It provides a unique opportunity to measure longitudinal data for CC students participating in the E-APP and their success after they transfer to the College of Engineering.

The objective of the study is to determine whether the E-APP and its interventions result in improved outcomes for transfer students. It is hypothesized that students participating in the E-APP will have greater success in pursuing an engineering degree than students who do not participate in the E-APP. Persistence is measured by enrollment, transfer rates, and retention rates of the E-APP participants and nonparticipants. The results of this study will add to the body of CC transfer research overall and help develop practices that may result in increased success of transfer students to engineering more specifically.

1.3 Conceptual framework

The SEEC project conceptual framework displayed in Fig. 1 [26] illustrates the progression of a CC student toward a degree in engineering and the relevant SEEC intervention strategies. This model reflects the many variables that may impact the engineering transfer student and illustrates the role of the E-APP in transfer student success.

In addition to the E-APP, several programs have been created to address the connection-based needs of transfer students. These include Engineering 100 (engineering orientation offered at the CC), and learning communities offered to students before and after transfer. Learning communities at the university include the Engineer of 2020 (E2020) Scholars Program in the College of Engineering for first-year and transfer students who demonstrate academic potential and financial need. Program participants must also be interested in learning about leadership, entrepreneurship, global awareness, and systems thinking within engineering. Other learning communities include engineering departmental learning communities, the Program for Women in Science and Engineering (PWSE), and the Honors learning communities.

2. Research design and methodology

This study uses data from ISU's Admissions Office, College of Engineering, and Office of Institutional Research with longitudinal student records beginning in 1999. The data were analyzed for all in-state CC transfers students (which include the SEEC CC) and for the SEEC CC separately. This analytical approach is due to the partnership between the SEEC CC and ISU, where the E-APP received special promotion through the other SEEC effect channels shown in Fig. 1.

A conceptual logic model of the E-APP was constructed (see Tables 1(a) and 1(b)) to monitor the program's performance and evaluate its outcomes. The logic model illustrates the rationale behind the program, the chain of events within the program, and the desired outcomes or goals. Logic models identify program elements and show expected connections among them, providing a link to evaluation approaches that stress the importance of having a theory of change that underlies a project [27].

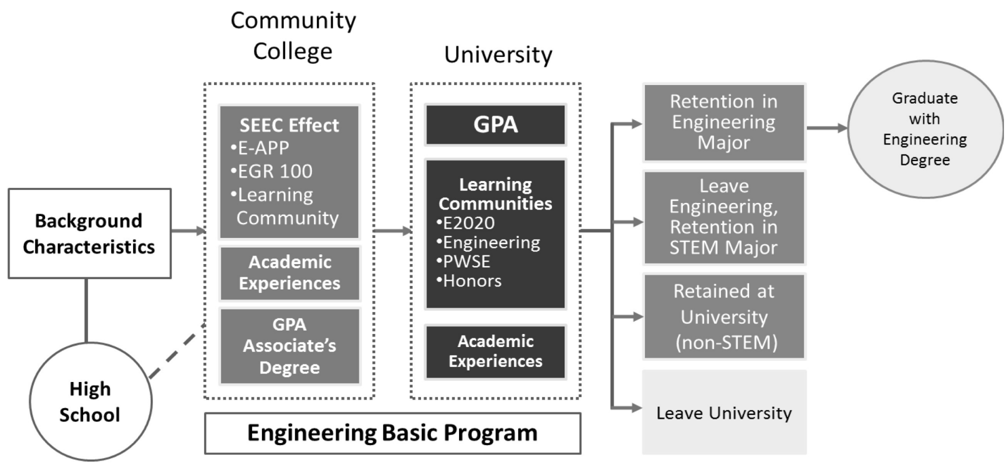

Fig. 1. SEEC model conceptual framework [26].

2.1 Design features: Ex-post evaluation and quasi-experimental applications

A true experimental design for evaluating the impact of the E-APP could not be constructed, as the participants are limited to pre-engineering CC students who signed up for the E-APP. In this case, a quasi-experimental design, in which a matched (but not randomly assigned) comparison group is included in the analysis, was more feasible and appropriate. Thus, quasi-experimental data are used to compare engineering students at ISU who participated in the E-APP and those who did not. One of the limitations of this analysis is that all university data are from a single institution. However, we believe that it is possible to generalize the results from this analysis to other roughly comparable programs designed to enhance the outcomes of CC students transferring into challenging STEM curricula at a 4-year institution.

This study uses an ex-post evaluation approach for estimating treatment impacts of the E-APP to evaluate the effectiveness of the E-APP. Key indicators are participation rates and retention rates compared between E-APP participants and non-participants.

2.2 Data collection

Data on student background characteristics, academic performance, and experiences were analyzed for E-APP participants and nonparticipants. The data include semester-by-semester transcript information for approximately 13 400 students who were admitted to the College of Engineering from Fall 1999 through Fall 2011. The dataset includes academic and demographic variables for 1191 in-state CC transfer students to the College of Engineering.

The dataset included 1191 in-state CC transfer students who enrolled in the College of Engineering from Fall 2002 to Fall 2008. The demographics are as follows:

- Female: 81, or 6.8%
- Black: 40, or 3.5%
- White: 967, or 84.5%
- Hispanic: 18, or 1.6%
- American Indian: 10, or 0.9%
- Asian: 43, or 3.8%
- Hawaiian: 0
- US Citizen: 1106, or 92.9%

2.3 Validity and reliability

The data analyzed here are drawn from complete University datasets, so the number of observations is large enough for the findings from statistical results to be reliable and to yield sufficient power for the statistical tests to detect significant differences between E-APP participants and nonparticipants [28]. The measure of participating in the E-APP or not participating in the E-APP has very high validity, as there is very little probability that this variable is miscoded. For this reason, the results of this study may be directly transferrable to other CCs and colleges of engineering. The data were analyzed statistically for significant differences between the quasi-experimental groups (E-APP or no E-APP) using the Pearson chi-square statistic with one degree of freedom [28]. Validity of the chi-square test is also predicated on the assumption of random sampling without replacement from a large normally distributed population. In each test the assumptions necessary to allow for the validity of the test are met. For numerical variables, the t-test for the equality of two means assuming equality of variances was used. The assumption of equality of variances between the groups was tested using an F-test based on the ratio of larger variance to smaller variance before the appropriate t-test was used for either the equal-variances or unequal-variances situation [28].

2.4 Indicators of the E-APP success

The following measures are used to determine success of the E-APP:

1. communication of the SEEC message to pre-engineering students;
2. increasing participation rates of CC transfers in the E-APP;
3. first-year retention rates of E-APP and non-E-APP students admitted to the College of Engineering matched on average mathematics ACT score (to overcome any self-selection bias in the quasi-experimental groups);
4. first-year retention rates of pre-SEEC and SEEC admits to the College of Engineering adjusted for background characteristics.

3. Results

E-APP program logic model

The E-APP logic model (Tables 1(a) and 1(b)) illustrates the resources, activities, and outputs of the program, along with the short-term and long-term outcomes and assessment measures of the project. The short-term and long-term outcomes have been combined due to the short implementation time of the project. No long-term outcomes are available yet.

Each of the program activities (Table 1(a)) represents a connection between the transfer student and the university. The activities of the logic model provide channels of engagement for the CC student in the College of Engineering. According to focus group data, the most meaningful touch points were

Table 1(a). The E-APP logic model

Resources	**Activities**	**Outputs**
What resources are needed to accomplish the activities?	What activities will lead to the project goals?	What are the results and tangible products of the activities?
SEEC team members	Electronic communications	Engineering-specific features for APP
SEEC grant funding	Professional network	Transfer programming recommendations
Transfer advisors	Academic advising	Posters and brochures
Graduate assistants	Peer-mentoring	Network between CC and ISU
Undergraduate peer-mentors	Transfer student campus visits	Data sharing between CC and ISU
College of engineering faculty and staff	Engineering career fairs	Advisor training for CC and ISU academic advisors
Admissions programs	Transfer student events	Peer mentor training
	Social network	

Table 1(b). The E-APP logic model (continued)

Short-term outcomes	**Long-term outcomes**	**Assessment: Measuring progress**
What changes are expected to occur within the short term (e.g., one year)?	What changes are expected over a longer term?	What will be measured to assess progress on objectives and goals?
Transfer students entering engineering with a clear plan and connections that will make for smooth transition and increased retention		Quantitative and qualitative measures of success for students transferring to the College of Engineering
Dissemination of student success reports and best practices		Success in core engineering courses
Key learning experiences and professional development of transfer students		Increased enrollment in pre-engineering at CC
Proactive transfer process for engineering students with multiple points of engagement		Increased enrollment in Engineering 100 at CC
Increased number of engineers		Increased enrollment in engineering LC at CC
Increased diversity of engineers		Increased participation in E-APP
Increased in-state retention of engineering graduates		Increased participation by transfers in learning communities at ISU
Web-based support network		Increased retention rates in Engineering
Connections between students, faculty, staff, and facilities at CC and ISU		Increased retention rates at ISU
Creation of engineering departmental transfer learning communities at ISU		Increase in number of engineering graduates at ISU
Creation and support of CC pre-engineering learning community		
State public policy supporting transfer-friendly culture		

interactions with the academic advisor and peer mentor [29]. The assessment progress outcomes are the measures of success for the E-APP.

The outputs include peer mentors – successful CC transfers to engineering who are selected to mentor pre-engineering CC students. The peer mentors make frequent contact with the E-APP students through both social and professional online networks. The goal is to connect students at the CC with ISU in as many ways as possible. This includes on-campus activities that allow them to feel part of the university community and to prepare them for transfer into the engineering academic community. Engineering 100, which is offered at the CC, is another connection providing information about the engineering profession, transfer course equivalencies, degree program transfer plans, and individual degree programs within engineering as indicated on the conceptual model shown in Fig. 1.

3.1 Indicators of E-APP success

To determine the effectiveness of the E-APP, specific indicators of success were measured based on the logic model outcomes of the E-APP. Indicators of success of the E-APP include the following:

Communication of the E-APP message between the SEEC CC and ISU.

Advisors and administrators at the SEEC CC have promoted the E-APP to their pre-engineering students through a course in engineering orientation and through academic advising. This SEEC study has resulted in the creation of a new pre-engineering brochure with the following recommendations:

- Join the E-APP—those in the E-APP are retained at significantly higher levels.
- Visit frequently with the ISU academic advisor.
- Meet with your peer mentor.
- Get to know other students at both institutions.
- Join a learning community, to enhance the opportunity for a higher probability of retention.
- Obtain grades of B in all core engineering courses [30].
- Stay connected after transferring from the CC to ISU.

Increasing participation rates in the E-APP.

Participation rates have increased since the implementation of the E-APP. Tables 2 and 3 indicate higher participation rates in the E-APP in the SEEC CC (32.9%), where the E-APP is strongly promoted, over those of all in-state CC transfers (17.9%). Both Tables 2 and 3 show how much opportunity exists to increase the percentage of students participating in the E-APP.

Increased first-year retention of E-APP transfer students over non-E-APP transfer students.

Table 4 shows a statistically significant improvement in one-year retention rates for the E-APP participants retained at ISU. This same group of students was retained at a higher rate in engineering, a result that was not statistically significant perhaps due to a smaller sample size. These results are shown based on the average mathematics ACT score for each group. The mathematics ACT score was used to control for any self-selection bias in the two quasi-experimental groups. The results show there is no statistically significant difference between the mathematics ACT scores for each group; however, not all CC students reported a mathematics ACT score. We assumed for this study that the data were missing completely at random and did not employ imputation methods.

Table 5 shows that for the SEEC CC there was a statistically significant improvement in one-year retention rates for the E-APP group both at ISU generally and in the College of Engineering specifi-

Table 2. Percentage participation in the E-APP for SEEC CC transfer students to ISU engineering

SEEC Project CC Percent participating in the E-APP	
E-APP	32.9%
Non-E-APP	67.1%

Note: For years 2008, 2009, and 2010.

Table 3. Percentage participation in the E-APP for all in-state CC transfer students to ISU engineering

All in-state CC transfers Percent participating in the E-APP	
E-APP	17.9%
Non-E-APP	82.1%

Note: For years 2008, 2009, and 2010.

Table 4. Treatment effect for all in-state CC students admitted to the College of Engineering at ISU

E-APP Effect	**All in-state community college admits to engineering Students admitted for the years 2008, 2009, and 2010 combined**				
Treatment	**% Retained in Engineering**	**% Retained at State University**	**Average Mathematics ACT**	**ACT *n***	**Total *N***
E-APP	74%	**92%**	24.6	57	84
No E-APP	67%	**81%**	25.1	217	386

Notes: Significant differences at 0.05 in bold; retention rates are for first-year.

Table 5. Treatment effect for SEEC CC students admitted to the College of Engineering at ISU

E-APP effect	**CC admits to engineering Students admitted for the years 2008, 2009, and 2010 combined**				
Treatment	**% Retained in Engineering**	**% Retained at State University**	**Average Mathematics ACT**	**ACT *n***	**Total *N***
E-APP	**77%**	**90%**	24.2	33	52
No E-APP	**58%**	**76%**	24.6	47	106

Notes: Significant differences at 0.05 in bold; retention rates are for first-year.

Table 6. First-year retention rates of SEEC CC students admitted to the ISU College of Engineering

	SEEC CC admits to the College of Engineering			
Admit years	**% Retained in Engineering**	**% Retained at State University**	**% Leave university**	**Sample size**
Pre-SEEC (2000–2007)	58.1%	**72.6%**	**27.4%**	275
SEEC (2008–2010)	64.7%	**82.4%**	**17.6%**	136

Notes: Significant differences at 0.05 in bold; retention rates are for first-year.

Table 7. First-year retention rates of all in-state CC students admitted to the ISU College of Engineering

	In-state community college admits to the College of Engineering			
Admit Years	**% Retained in Engineering**	**% Retained at State University**	**% Leave university**	**Sample size**
Pre-SEEC (2000–2007)	65.0%	**79.9%**	**20.1%**	841
SEEC (2008–2010)	68.6%	**84.3%**	**15.7%**	407

Notes: Significant differences at 0.06 in bold; retention rates are for first-year.

cally based on the average mathematics ACT score for each group. Again, the SEEC CC has higher participation rates in, and a stronger promotion of, the E-APP.

Increased first-year retention rates of the SEEC CC students admitted to the ISU College of Engineering over pre-SEEC retention rates.

Table 6 shows significant gains in retention at ISU for the SEEC CC transfers to engineering since the implementation of SEEC and the E-APP. There were no statistically significant differences in background characteristics between the pre-SEEC and SEEC groups.

Increased first-year retention rates of in-state CC transfers to the ISU College of Engineering over pre-SEEC retention rates.

Table 7 shows significant gains in retention at ISU for all in-state CC transfers to engineering since the implementation of SEEC and the E-APP. There were no statistically significant differences in background characteristics between the pre-SEEC and SEEC groups.

An additional indication of a SEEC strategy related to the success of E-APP is the percentage of in-state CC transfers who are participating in learning communities (other than the E-APP, which is measured separately) at ISU. The percentage of CC transfers participating in learning communities is generally increasing (Fig. 2). The SEEC project helped to increase the number of engineering learning communities among College of Engineering departments and helped to establish learning communities specifically for students transferring to ISU. Since learning communities were an integrated strategy within the E-APP, this was considered an indirect measure of success of the E-APP.

4. Discussion

The introduction of the SEEC program correlated with increased success rates for in-state CC transfer students. Before SEEC, CC transfer students left the university at higher rates than they did after the initiation of the SEEC project. This success was the product of a number of specific components of the project, and our experience with the manner in which these components worked to foster positive outcomes from SEEC provides lessons learned that may benefit other efforts to enhance CC student outcomes post-transfer. Among the best practices recommended (see Fig. 1) are the presence of an academic advisor at the four-year institution who works directly with students at the two-year institution, peer mentors at the university, transfer articulation between the institutions, increased connections between the CC and the university which for SEEC included Engineering 100 (engineering orientation offered at the CC), and learning communities offered to students before and after transfer.

An important result of the SEEC project is a more rigorous data collection and analysis process as well as systems for monitoring efforts to improve CC transfer student achievement. A major reason for this success was the data sharing that occurred between the institutions, which was initiated by the university as a result of the SEEC study. The university took greater responsibility, using its larger institutional resources for data collection and management. In addition, meetings between

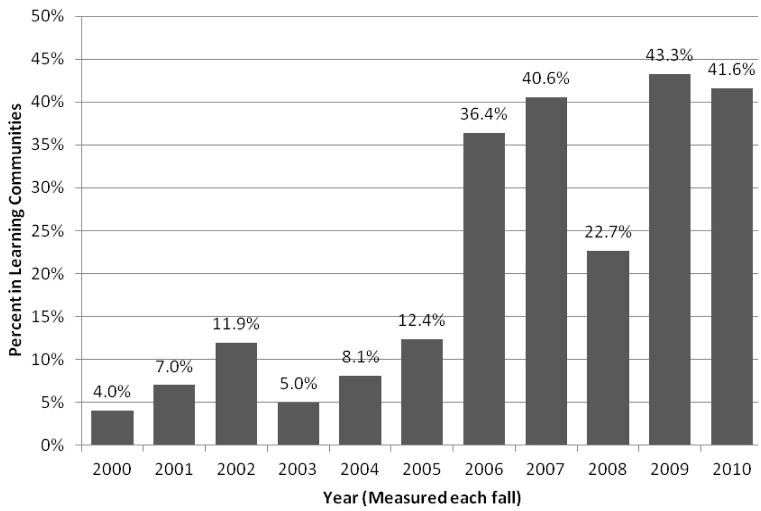

Fig. 2. Percentage of in-state CC transfers who participate in a learning community at ISU.

partner institutions increased data sharing and led to a clearer understanding of the capabilities and limitations of each institution. The geographic proximity of the two-year and four-year institutions increased their ability to collaborate.

In the future, an even more targeted data collection sharing and usage between the CC and the university is desired. The following are among the leading ways to improve the quality and useful applications of data collected:

- Identify pre-engineering students early at the CC to target and measure intervention strategies.
- Obtain more background information about pre-engineering transfer students.
- Include data from focus groups and individual interviews with students prior to and following their transfer to engineering.

In spite of the limitations inherent to the nature of this particular study (a single land-grant state university in the Midwest partnering with state-funded CCs), we believe these results are scalable to working with institutions of lesser or greater size and portable to institutions that are more diverse both geographically and socio-demographically, as well as to institutions under private control. The process discussed in this article could be extended to increase and monitor success for all types of transfer students, and could be expanded to include fields other than engineering. The importance of the transfer pathway warrants a critical examination of its current productivity and potential for growth in programs such as the E-APP.

The initiation and implementation of SEEC was largely dependent on external funding and a favorable relationship between the university and the community college. Due to the success of program strategies, aspects of SEEC continue in various forms at both institutions. Nonetheless, developing and sustaining these types of partnership programs depend on institutional factors such as financial support, leadership, and relationships. Despite agreement that the transfer pathway is an attractive and viable route to a bachelor's degree in engineering, future research will need to address the long-term cost-benefit of such programs to ensure their sustainability.

5. Conclusions

One of the key features of the SEEC project was the implementation of the E-APP, which was developed as a result of both research and practice, to improve the navigational success of CC transfer students through connections to the university. E-APP is central to achieving these outcomes and helping to ensure that CC students and their families are as fully informed as possible about these essential elements of successful academic transition. Despite being in existence for only a short time, the E-APP is already correlated with significant improvements in retention rates of CC transfers to engineering. As a consequence of the relative newness of the E-APP, the data analyzed for this study reflect the low participation rates for the E-APP (32.9% at the SEEC CC, and 17.9% of all in-state CC transfers). As the information about this program and its integrated strategies spreads, it is expected that the participation and retention rates will continue to increase as SEEC and the E-APP move further into the outcome stages of project evaluation.

The findings show how the E-APP, together with other integrated strategies, has made important advancements in the success of CC transfer students into undergraduate engineering programs. Implementation of the connection-based strategies will improve the ability of four-year institutions to promote and support the CC pathway as a viable, even attractive, route to a baccalaureate degree in engineering.

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