Persistence, Resilience and Mathematics in Engineering Transfer Capital

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Abstract*—*Contribution: **This paper identifies key personal and academic factors in successful transfer to electrical, computer, and mechatronics (ECM) engineering programs. The findings support prior research on engineering transfer shows that successful students accumulate knowledge and behaviors in their sending institution that enable their progress in the receiving institution.**

Background: **Institutional arrangements and processes, inclusive cultures and practices, social integration, and clear academic requirements support the transfer of students who go from two-year colleges and similar to follow engineering programs at four-year institutions. Various personal attributes are also associated with successful transfer.**

Research Question: **What factors enable transferees to succeed in four-year ECM engineering degree programs?**

Methodology: **Student data were obtained from the receiving institution's registration database and grades administration system. Database queries were used to identify transfer and non-transfer students' performance. Averages and frequencies of passes, fails, repeats, withdrawals, etc., were calculated and compared. There were limited data on students' personal challenges and non-academic strengths.**

Findings: **All the students who attained Bachelor of Science degrees in ECM showed persistence and resilience in their journeys toward an engineering qualification, and had achieved high grades in mathematics at the sending institution.**

***Index Terms*—Engineering transfer capital, nontraditional students, student diversity, transfer students, underrepresentation.**

I. Introduction: "Overlooked Engineers"

Students enrolled in two-year colleges, or similar institutions, who have the potential to attain a four-year engineering qualification, have been described as "overlooked engineers" [1] when their potential to transfer to engineering studies is not realized. Many transfer students are from groups that are underrepresented in electrical engineering, computer engineering or mechatronics (ECM) programs and professions globally. There is thus a concern that participation rates in ECM, relative to population demographics, are skewed, whereby students who might be eligible and well-prepared for ECM programs, and who could excel in an ECM career, do not consider pursuing ECM studies. The lack of diversity in engineering education and the engineering professions poses particular difficulties for developing countries that depend on their higher education institutions to produce engineering graduates for key roles in society. This paper identifies key factors that enable transfer students, coming from a variety of educational institutions and backgrounds, to succeed in ECM engineering programs at a research-intensive university.

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II. The Literature on Transfer Students in Engineering

There is growing body of literature on transfer students that provides insights into the experience of transferring between institutions and programs, as well as the practices that support successful transfer. While most studies are U.S.-based and focus on the transfer from two-year to four-year programs, similar studies have been conducted in Australia [2], Canada [3], Ireland [4] and South Africa [5]. Several studies involve transfer from a more practical qualification (e.g., engineering technician) to a more academic or professionally-oriented one [6]. Many sending institutions traditionally serve first-generation, low-income, and historically underserved students [7], [8]; most studies of student transfer have an explicit focus on students from disadvantaged backgrounds and, with regard to transfer into engineering studies, on identifying "overlooked engineers" [1] and supporting their success. Five themes emerge from the literature: 1) the institutional arrangements that enable or constrain the pathways, structures and processes of transfer, 2) the cultures and practices of different engineering disciplines and their impact on transferring students, 3) the social factors that support students' social integration into the receiving institution, 4) the academic factors that enable transfer students to achieve an engineering qualification, and 5) the personal attributes of successful transfer students. There is considerable overlap across these categories.

A. Institutional Factors

Various institutional arrangements can enhance the graduation rate of students transferring into engineering majors, such as bursaries and scholarships [9], websites and online resources that specifically target transfer students [10], the availability of academic support activities [11], and articulation agreements across sectors [7]. Receiving institutions are not "a monolithic group" [7, p. 103], but differ in terms of their accessibility and inclusivity, and transfer is likely to be more successful when the receiving institution adopts a "transfer receptive culture" [8, p. 252] that includes both pre- and post-transfer support.

B. Disciplinary Factors

To a certain extent, the success of recruitment and retention strategies are influenced by the disciplines to which students are transferring [12]. For example, Electrical Engineering and Computer Engineering programs have similar curricula, but are characterized by different student demographics and outcomes [13]. Several studies suggest that a supportive engineering culture is associated with positive experiences and outcomes [7].

C. Social Factors

Many transfer students attribute their success to social factors, such as support from community college faculty [10], academic advisors at the receiving institution [14], peers (particularly male peers) [15], and their families [1]. Most studies support the importance and value of transfer students' early social integration into the receiving institution [16]. As one study put it "people, not programs, make the difference" [15, p. 28]. Student retention and success are more likely when students experience a sense of community at the receiving institution [8], [17].

D. Academic Factors

In transferring to a four-year institution, students face an increased level of academic challenge as well as difficulties caused by disparities between different curricula [11], [18]. The number of credits students are able to transfer (based on content and competencies) are significant predictors of success [7]. Pre-transfer attainment in mathematics has been highlighted as a success indicator [19]. Prior training in technical fields can provide transfer students with a basic understanding of engineering concepts and principles [6]. Early supportive interventions at the receiving institution—for example, a pre-calculus course [20], an introduction to specialist skills such as Excel [11] or MATLAB [18], or pre-engineering transfer programs such as the "Summer Transfer Transition Program" [21]—are associated with academic success. Initial interventions need to be followed up with tutoring, supplementary instruction, collaborative learning and counseling in support of students' progress and success.

E. Personal Factors

A number of personal factors contribute to transfer students' success, such as curiosity in solving engineering problems and understanding how things work [18], persistence [22], and resilience [23]. Personal characteristics such as being "disciplined, focused, and committed to goals" [15, p. 30] are strongly linked to academic success. Many transfer students experience "transfer shock" in the form of a decline in their GPA scores following transfer to the receiving institution [4], [18]; resilience is shown by students' recovery from such setbacks, often through proactively seeking help [3], [17]. Some studies find that gender, race, ethnicity and prior academic achievement influence graduation outcomes [24], while other studies find that underrepresented minorities remained in engineering programs at rates comparable to other racial or ethnic groups [25], [26].

III. Engineering Transfer Capital

The conceptual framework for this study was developed from Bourdieu's "forms of capital" [27] and its application to higher education practices [28], [29]. Bourdieu proposes three forms of capital that are pertinent to higher education: social, cultural, and economic capital: "*economic capital is in people's bank accounts, [cultural] capital is inside their heads, and social capital inheres in the structure of their relationships*" [30, p. 7]. Bourdieu claims that the higher education system presupposes the possession of cultural capital, which is rarely explicitly taught. The application of cultural capital in education has had the unintended consequence of making faculty and administrators believe that underrepresented students lack the cultural capital required for academic success, and thus encourages "deficit thinking" [28, p. 69]. Deficit thinking is the belief that students who do not succeed at their studies have personal deficiencies, that they are not intellectually capable of advancing, or lack the motivation to learn. It is important to acknowledge that students attain important forms of capital through their prior educational experiences. Laanan and colleagues propose the concept of "Transfer Student Capital" [29, p. 14] to understand the experiences of students who transfer to four-year institutions. "Engineering Transfer Capital," proposed in this paper, builds on this concept, and claims that transfer students have opportunities at the sending institution to accumulate specific forms of capital that enable their success in engineering programs at the receiving institution. In ECM programs, Engineering Transfer Capital matters and can be used to explain students' successes and to understand the ways in which difficulties could be addressed.

The model of Engineering Transfer Capital, Fig. 1, derives from the "forms of capital" theory, and is based on research studies of transfer into engineering degrees. It explains that Engineering Transfer Capital is constructed out of prior social and educational experiences, particularly conditions and experiences in the sending institution. The model shows the key indicators for the accumulation of Engineering Transfer Capital and successful transfer from the sending to the receiving institution. Engineering Transfer Capital can be transferred to the receiving institution, where it can be further nurtured and developed, if supportive conditions and arrangements are available.

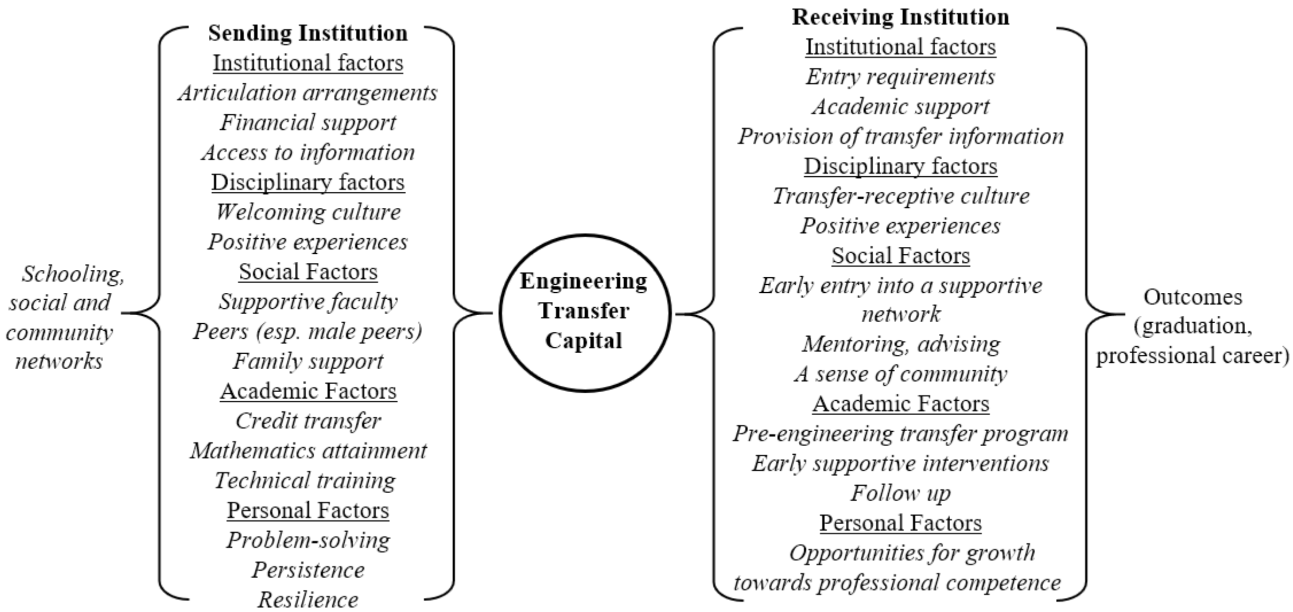

Fig. 1. A model of Engineering Transfer Capital.

IV. A Research Methodology for Studying Engineering Transfer Capital

The research design addresses the overarching research question: *what factors enable transferees to succeed in four-year ECM engineering degree programs?* The research objective was to identify key academic and personal success indicators in Engineering Transfer Capital. The design thus comprises a study of transferee profiles and attributes, as well as comparative analyses of the academic performance of transfer and non-transfer students across ECM programs at the University of Cape Town, a research-intensive university in South Africa. The university was selected as the research site because it offers a high level of challenge to transfer students. In 2017 the university was ranked as the top university in the country, and in the 2016–2017 edition of the *Times Higher Education* World University Rankings it was ranked 148th globally. Gasman *et al.* claim that the selection of a prestigious higher education site can strengthen the reliability of research findings on the "success and socialization" of underrepresented students [31, p. 126].

A. Delimitation and Research Focus

Engineering Transfer Capital is complex, as the model in Fig. 1 shows; and has many interconnecting factors. In this study only persistence, resilience, and pre-enrolment mathematics attainment were selected for study. While the study acknowledges the importance of additional academic and personal factors in Engineering Transfer Capital, as well as institutional, disciplinary, and social factors, these were not addressed in this study.

B. Data Sources

The study used two data sources: 1) student registration data and 2) the academic record of students' progress and results. Ethics clearance for this study was provided by the Engineering Faculty of the receiving institution and permission to utilize the students' registration data and academic records was given by the Director of Student Affairs. The student registration data provided demographic data (e.g., race, gender, school attended, nationality, home language, home address, and financial status), high school results, pre-transfer data (e.g., data of first application to sending and receiving institutions and prior program results), credit transfer, and level of transfer (i.e., whether the student was transferring at the first year, second year, etc.). The academic record provided students' grades in their ECM programs, including the specific grades achieved for different courses, the courses passed or failed, the number of attempts to pass a course, whether or not students withdrew from a course or transferred out of the program, and whether or not permission was granted or denied to continue studies. This database thus provided a quantitative record of both transfer and non-transfer students' entry into, and progress through, the ECM programs. An extensive database can reveal much about students' histories and trajectories [32], their progress, the courses that they appear to be well prepared for, and challenges faced. Moreover, a database that provides longitudinal data reveals patterns over time, which can be more reliable than the results of a short term intervention [33].

C. Procedures

The study focused on three cohorts of students who enrolled in ECM programs between 2011–2013, and were respectively expected to achieve the qualification and exit the system between 2014–2016, if they completed in the credit-hour minimum.

1) Measuring Persistence: Following Lord *et al.* [26], in this study persistence is defined as completion of studies and achievement of an ECM qualification. Persistence has been researched using mainly interview methods [18], [34], but can be measured by comparative quantitative methods [26], such as the study of attrition, retention and graduation rates [33], [35]. In this study, persistence was measured by comparing transfer and non-transfer students' course grades, attrition, transfer out of ECM programs, academic exclusions, retention, and graduation rate.

2) Measuring Resilience: Resilience is defined as the capacity to recover quickly from academic challenges, such as the much-reported recovery from "transfer shock", but also the tendency to persevere and succeed in education despite personal adversity [36]. Resilience is associated with self-efficacy beliefs [23] and adaptive help-seeking behaviors [3], [10], [17]. Resilience includes "cognitive, affective and behavioral responses to academic adversity" [36]. Resilience can be quantitatively measured by identifying social and academic factors to be overcome [37]. In this study, resilience was measured through the identification of transferee students' financial and educational disadvantaged status, as well as their proactively seeking help after failing a course (for example by enrolling in the "Winter School," an intervention that supports students struggling with basic sciences).

3) Quantitative Case Studies: The receiving institution uses a PeopleSoft application to integrate the registration and academic student data. Database queries were used to construct "quantitative case studies" [38, p. 62] that traced the journeys of individual students from high school to successful completion of an ECM degree. Over 50 quantitative case studies of transferees were constructed; two of the case studies were selected for inclusion in this paper as exemplars of persistence and resilience.

4) Academic Factors: Academic factors, such as grades obtained, were readily available from pre- and post-enrolment academic records for analysis and comparison.

D. Limitations of the Data

Data available for the research study comprised students' registration data and academic records. These included some data on students' personal circumstances. For example, the data gave students' advantaged/disadvantaged status, but very little data existed on personal challenges encountered, such as the difficulties associated with being a black or female student in an environment where such groups are underrepresented. There was practically no data on students' non-academic strengths (e.g., support networks, soft skills).

V. FINDINGS: PERSISTENCE, RESILIENCE AND MATHEMATICS IN ENGINEERING TRANSFER CAPITAL

The research findings are presented in three sub-sections: 1) transfer students' persistence in the challenging environment of the receiving institution, 2) indicators of resilience in response to challenges, and 3) the role of pre-enrolment mathematics achievement in transferees' Engineering Transfer Capital.

TABLE I
NON-TRANSFER STUDENT COURSE GRADES

Knowledge area	Pass %	Fail %	GIP* %	Average grade %
Basic Sciences	82.2	17.1	0.7	61.8
Engineering Sciences	84.0	16.0	0.0	61.2
Practical training	55.0	3.9	41.1	N/A
Complementary Courses	89.2	10.3	0.5	68.3
Final Project	86.1	8.7	5.2	69.0

*Grade in Progress

TABLE II
TRANSFER STUDENT COURSE GRADES

Knowledge area	Pass %	Fail %	GIP %	Average grade %
Basic Sciences	79.9	19.0	1.0	61.0
Engineering Sciences	78.7	21.0	0.0	59.0
Practical training	56.4	15.0	28.6	N/A
Complementary Courses	84.9	14.0	1.0	65.0
Final Project	90.3	10.0	0.0	67.9

A. Finding 1: Persistence in a Challenging Environment

Students' mark records were used to compare the percentages of courses passed and failed and average course marks for non-transfer and transfer students. Transfer students were able to transfer into the receiving institution at different levels, depending on their results at their sending institution. There were five course groups in the new curriculum: 1) the basic sciences (e.g., Physics I), 2) the engineering sciences (e.g., Digital Signal Processing II), 3) practical training (all ECM students are required to undertake short internships, although this is not graded), 4) complementary courses (e.g., Professional Communication) and 5) a final year capstone engineering design project.

1) Non-Transfer Students: Table I shows that ~85% of all non-transfer students passed all courses (excluding practical training) with an average mark of 65%.

2) Transfer Students: Table II shows that ~83% of all transfer students passed all courses (excluding practical training) with an average mark of 63%. Their scores were slightly lower on the basic sciences, engineering sciences and complementary courses, but slightly higher on the final projects.

It was expected that the transfer students would perform satisfactorily on the basic sciences, on the basis of their pre-enrolment grades, and ability to transfer credits for courses in the basic sciences from the sending institutions. The 78.7% pass rate for the engineering sciences category was an unexpected result, as most courses in this category were at the second-year level and above, which students could not have transferred to their degree programs since many of these courses are not offered at the sending institutions. This finding suggests that the students were well prepared by the sending

TABLE III
TRANSFER AND NON-TRANSFER STUDENTS' PERSISTENCE (%)

Students	Graduation rate*	Attrition	Academic exclusions	Trans. out	Cont.
Transfer	19.0	8.7	1.7	1.7	68.9
Non-transfer	18.3	8.4	0.6	5.8	66.9

*In a 4-year program, the ideal graduation rate of 25% means that all students pass each year.

TABLE IV
RACE AND GENDER OF STUDENTS IN PERCENTAGE OF REGISTRATION DATA

Group	Race				Gender	
	Black*	Other*	White	Unknown	M	F
Transferees	27%	25%	29%	19%	65%	35%
Non-transfer	30%	15%	40%	15%	80%	20%

*In South Africa the categories of 'black' and 'other' are underrepresented in engineering, even though they represent the population majority.

institutions with the basic theory and techniques that could be extended in the four-year program. Engineering design is not offered in most sending programs, making transferees' achievement in the capstone design projects notable. The data show that a slightly higher percentage of transferees completed the final-year design projects, although with slightly lower marks.

Both groups experienced difficulties in completing their practical training, which although a required part of the EMC qualification is not graded. Of the non-transfer students, only 55% were awarded a credit, 3.9% failed and the rest (41.1%) had to complete the credit at a later date. (Credit for practical training in South Africa is often delayed, due to the difficulties of finding internships in engineering firms that meet the requirements for graduation [35].) For the transferees, 56.4% were awarded a credit, 15% failed and the rest (28.6%) had to complete the credit at a later date.

3) Comparative Persistence Data: Table III compares the persistence of transfer and non-transfer students with regard to their retention across ECM qualifications. The two groups have similar performance indicators with regard to the percentage graduating and the attrition rate in a given year. Academic exclusions (i.e., students not permitted to continue with their studies due to poor academic results) are slightly higher for transferees, but more non-transfer students transfer out of ECM (either to other engineering programs or to other faculties), resulting in a greater overall retention of transferees in ECM programs.

Once enrolled in the receiving institution, transfer students spent, on average, 4.2 years to attain a four-year ECM degree, while non-transfer students took 4.4 years to attain this. The transfer of credits from the sending institution accounts for the transferees' slightly shorter time to complete the four-year program. However, given that all transfer students spent between one to two years at their sending institution, and some spent additional years in practical training or employment before transferring to the receiving institution, they spent 6.2 years, overall, from their first enrolment in the sending institution to completion at the receiving institution. The literature notes similar persistence in transfer students' navigation across institutions and workplaces in search of an engineering degree [6], [40]. The following case study exemplifies transfer students' persistence in pursuit of an engineering qualification.

Case Study 1 (Thandi's Long Walk to an Engineering Qualification): Thandi (a pseudonym) is a Xhosa-speaking black woman who grew up in a township and attended a disadvantaged school in East London in South Africa's Eastern Cape Province. She completed Grade 12 in 2001, achieving 70% for English, 60% for Mathematics, and 40% for Physical Science. She was accepted onto the National Diploma in Electrical Engineering at an urban technical institution in 2002 and received her diploma in 2004, with a GPA of 70%. After a gap of seven years, during which time she was employed as an electrical engineering technician, she applied for entry into the Bachelor of Science (Electrical Engineering) at the receiving institution, and was accepted on the basis of her achievements at the sending institution, her experience as an engineering technician, and her age (she was 29). She successfully passed all courses each year, except for Physics 1 which she carried over to her second year and passed in 2012. Her GPA climbed steadily upward: 45.23% in the first year, 57.23% in the second year, 60.56% in the third year and 64% in her final year. Of particular note was her high achievement in the fourth-year electrical engineering design course (78%) and her capstone electrical engineering design project (71%). She was awarded the degree of Bachelor of Science in electrical engineering in 2015.

B. *Finding 2: Resilience in Response to Challenges*

Each year there are approximately 700 students registered for EMC programs at the receiving institution, of whom some 55 are transferees, who thus make up about 8% of the student body. The registration data shows that transfer students are a diverse group; as shown in Table IV, 27% of the students were black South African students and African students from the Southern African Development Community (SADC), while 25% were from other underrepresented groups (such as Indian students). Thus the transfer group comprises 52% underrepresented groups (19% chose not to disclose their racial group). With regard to gender, the transferees comprise 35% women students, a significant increase over the non-transfer group.

The registration data show that 48% of transferees transferred from disadvantaged South African sending institutions, while only 8% transferred from an advantaged institution, Table V. The data did not specify the remaining 44% of institutions, which were coded in the registration data as "college" or "African university". Only 8% of transferees were recorded as receiving bursaries or funding support from a South Africa government source at the receiving institution; this was partly because state funding is only available for the initial qualification at the sending institution and not for a second qualification. Thus many transferees were self-funded, although some transferees from SADC countries would have

TABLE V
DISADVANTAGE STATUS

Group	Sending Institution			Financial Aid
	Disadvantaged	Advantaged	Unknown	
Transfer	48%	8%	44%	8%
Non-transfer	-	-	-	15%

TABLE VI
TRANSFER STUDENT GPA AVERAGES

Year	1st year %	2nd year %	3rd year %	4th year %	5th year %*
Average	63.9	61.2	61.4	60.9	60.3

*Repeated courses or final project marks (following an extension)

been funded by their own governments. The demographic data indicate that many transfer students have had to overcome both financial and educational disadvantage in accessing EMC qualifications. Overcoming financial difficulties and disadvantaged educational backgrounds are confirmed by many other studies to be resilience indicators [7], [8], [37].

All transfer students achieved GPA scores $\geq$ 65% at the sending institution, but these scores tended to decline in the more challenging context of the receiving institution – although most managed to maintain a 60% GPA (Table VI). Actively seeking help, such as proactively finding support after failing a course [16], is associated with resilience in [3] and [17]. Around half of all transfer students (49%) sought assistance after failing a course via the "Winter School", which enabled them to repeat the failed course within the same academic year, instead of the next academic year.

The case study below was selected as an example of academic resilience in the face of considerable challenges.

Case Study 2 (Sipho's Story—a Study of Academic Resilience): Sipho (a pseudonym) is a black, male, Zulu-speaking South African from a disadvantaged rural area in South Africa's Kwa-Zulu Natal province. Sipho completed Grade 12 in 2006 at a remote rural school, obtaining 50% for both English and Mathematics, 30% for Physical Science and GPA of 40%. He applied for entry into the Bachelor of Science (Electrical Engineering) at the receiving institution in 2008 and wrote the required National Benchmark Tests, achieving 42% for Academic Literacy, 48% for Quantitative Literacy and 79% for Mathematics. These scores were insufficient for entry, but Sipho was accepted onto the National Diploma for Electrical Engineering Technicians at a disadvantaged rural University of Technology. He completed a three-year diploma (comprising one year of basic sciences, one year of engineering sciences and one year of practical training as a technician) in 2010. On completion of his diploma, aged 23, he again applied to enter the Bachelor of Science degree program in electrical engineering at the receiving institution, and was accepted on the basis of having passed all his courses and achieving a GPA of 65% at the sending institution. He was given credit for half the first-year courses, and enrolled in, and completed, the receiving institution's "Program for University of Technology Transferees" in 2011. He achieved a GPA of 57.83% in his first year; his highest grade was for Technical Drawing (74%), but he failed Physics (36%), which he repeated in his second year (2012). He passed all second year courses and Physics 1, achieving a GPA of 55.23%. He tackled Physics 2 in his third year (2013), and failed it, achieving a GPA of 48.26%. In his final year he passed Physics 2 with 50% by enrolling in the Winter School. He completed all other courses to obtain his degree in 2014 with a GPA of 54.36%. Many black South Africans, despite achieving high marks in mathematics, struggle in physics, partly due to the lack of adequate laboratories and other resources for teaching science in disadvantaged schools [36].

C. Finding 3: Pre-Enrolment Mathematics Attainment

Many of the transferees were registered for engineering technician diplomas at the sending institutions and to gain entry into the four-year ECM programs were required to have passed all their courses and to have attained a GPA of 65% or higher.

Most sending institutions required high school grades of 50% in mathematics, science and English for entry into engineering technician programs, so the achievement of a 65% GPA attests to transferees' academic strengths. Many transferees had excelled in the sending institution, and all in our database had attained $\geq$ 70% for mathematics. Transferees who wrote the Mathematics National Benchmark Tests (standardized tests offered by the receiving institution) scored at the "proficient" level in mathematics. Thus, as in other transfer studies [16]; [18], attaining good mathematics grades prior to entry into the receiving institution was identified as a key factor in Engineering Transfer Capital.

VI. DISCUSSION: PERSISTENCE, RESILIENCE AND MATHEMATICS

A. Findings - Relationship to Previous Work

The findings of this study confirm prior studies that show that students from underrepresented groups who transfer to engineering degree programs have many strengths, such as persistence [15], [26], [33], high levels of focus and commitment [25], [34], resilience in the face of difficulty [10], [11], [23], and high GPA scores from the sending institution [35], particularly in mathematics [17], [19]. This study found that the increasing level of academic challenge across the engineering program and the disparities between curricula at the sending and receiving institutions did not pose undue difficulties to students with Engineering Transfer Capital.

B. Limitations and Implications for Future Research

This study addressed academic and personal components of Engineering Transfer Capital (persistence, resilience and Mathematics). Studies of additional dimensions, such as institutional, disciplinary, and social issues would further develop the model. A deeper understanding of the indicators might also be revealed using a different methodology, for example an interview-based study. This study did not address the particular difficulties of the women students amongst the transfer groups to ECM programs; further research would be necessary to uncovering these issues, and this could extend the Engineering Transfer Capital model. A follow up study with transfer students could develop additional measures of academic persistence and resilience in successful transfer. Further development work on the predictive validity of resilience, persistence and mathematics would enhance the integrity of these factors as key to Engineering Transfer Capital.

C. Implications for Practice

The Engineering Transfer Capital model could help receiving institutions identify potentially successful ECM engineering students, through factors such as their grades in mathematics from the sending institution. Persistence could be identified from the students' academic record at the sending institution; for example, completion of the prior qualification in the minimum time, and/or achieving above average GPA scores across all courses. Potentially successful students could also be identified by their resilience, as indicated by their completing their studies at the sending institution despite personal challenges. Resilience could also be shown by students' recovery from setbacks at the sending institution, such attending an additional semester to pass a course.

Prior studies that show that student success in engineering programs is more likely when potential academic difficulties are identified early and appropriate interventions offered [11], and that student retention is more likely when campus environments are perceived by students to be supportive and welcoming [12]. While Engineering Transfer Capital identifies potentially successful students, this identification does not eliminate the need for institutional and academic support.

VII. Conclusion

There are students enrolled in STEM courses in two-year colleges (or similar institutions) who have the potential to succeed in Bachelor of Science ECM programs. This study proposes a means to identify these "overlooked engineers" [1]. The contribution that this study makes is the identification of the key personal and academic factors of persistence, resilience and mathematics, for the successful transfer to ECM engineering programs. This was developed from the literature and confirmed in this study by an empirical analysis. The study shows the value and benefit to engineering of supporting transfer students in their education journey towards an engineering qualification.

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