

Critical Barriers to Engineering Student Success: Strategies and Opportunities: A Systematic Literature Review

**Thandeka Makhanya, Lebogang Bopape, Christopher Mcineka, Nompumelelo Chili and
Mohohlo Tsoeu**

Department of Electronic and Computer Engineering
Durban University of Technology
Durban, South Africa

Thandekahm09@gmail.com, bopapelebo@gmail.com, mcinekact@gmail.com,
mpumy.inno@gmail.com, ms.tsoeu@gmail.com

Abstract

South African Higher education institutions face persistent challenges in engineering student success, with high attrition rates, and extended completion times. This is caused by multifaceted challenges of socio-economic, academic, and institutional factors that continue to shape student retention, progression, and completion. Engineering programmes are mostly affected due to their intensive curriculum demands, high levels of mathematical preparedness, and reliance on specialised infrastructure. This paper presents a systematic literature review that synthesises existing evidence on barriers to engineering student success and identifies opportunities for targeted interventions. Guided by PICo framework and PRISMA guidelines, a comprehensive search of peer-reviewed literature was conducted across major academic databases. Studies were screened, assessed for eligibility, and thematically synthesised. The findings reveal recurring academic barriers such as mathematical underpreparedness, limited academic support, resource constraints, curriculum misalignment, and socio-economic pressures affecting student engagement and persistence. Reported intervention strategies include enhanced academic support, innovative teaching and learning approaches, and curriculum reform. The review provides an evidence-based foundation to inform institutional practices and policy-level reforms aimed at improving learning outcomes, retention, and overall student success in engineering education.

Keywords

Engineering education, critical barriers, Student success, Retention, South African Higher education.

1. Introduction

Engineering education plays a critical role in national development and technological advancement, yet engineering programmes in South African higher education institutions continue to experience low throughput and high attrition rates (Sibisi et al., 2026; Mostert et al., 2025). Socio-economic challenges have been linked to poor student performance, delayed progression, and non-completion (Versfeld et al., 2025; Kheswa et al., 2022). Academic barriers that stem from inadequate preparation at the secondary school level, particularly foundational subjects such as mathematics and physical sciences, which are vital to engineering success (Sepeng, 2025), (Padayachee et al., 2021). Institutional barriers, such as insufficient student support services, outdated curricula, and limited access to modern equipment, create more hurdles to student success (Abbott et al., 2020; Nyemba et al., 2021).

The consequences of these barriers extend beyond individual student outcomes. Low graduation rates in engineering contribute to critical skill shortages in South Africa's economy, hindering industrial development and technological advancements (Council, 2025). Moreover, persistent disparities in engineering education outcomes along lines of race, gender, and socio-economic status perpetuate historical inequalities and limit the diversity of the engineering profession (Sibisi et al., 2025; Garner et al., 2022). Understanding the specific barriers to engineering student success

in the South African context, identifying effective intervention strategies, and exploring opportunities for systemic improvement are essential for developing evidence-based policies and practices. This systematic literature review addresses these needs by synthesizing research on engineering education in South African higher education institutions, with a focus on barriers, interventions, and opportunities for enhancing student retention, progression, and completion.

1.1 Objectives

This study was guided by three questions formulated by PICO framework:

Population (P) – Engineering Students or Engineering Education.

Interest (I) – Academic, Socio-Economic, Institutional Barriers, Interventions, and Opportunities.

Context (Co) – South African Higher Education Institutions.

- RQ1 – What are the critical barriers (Socio-economic, academic, and institutional) to engineering student success in South African higher education institutions?
- RQ2 – What intervention strategies (academic support, curriculum reform, innovative teaching) have been reported to address barriers to engineering student success in South African higher education?
- RQ3 – What systemic and policy-level opportunities exist to reform engineering education and improve overall student success in engineering education in South Africa?

2. Methods

This systematic literature review was conducted following the PRISMA guidelines (Page et al., 2021). The Framework guidelines provide a comprehensive, evidence-based methodology for conducting and reporting systematic reviews to ensure transparency, reproducibility, and rigor.

2.1 Search Strategy

A comprehensive search was conducted across various databases, and search terms were developed from the PICO elements and combined using Boolean operators. Searches focused on barriers to engineering student success and policy recommendations. The review encompasses peer-reviewed studies published in English over the past decade.

Databases searched:

Two complementary search queries were employed during the search in all databases (ERIC, Scopus, IEEE Xplore, Web of Science, and Google Scholar). Query 1 focused on identifying barriers affecting engineering student success, retention, and completion in South African higher education. Query 2 targeted intervention strategies, academic support and curricular reforms implemented to address these barriers. This search approach ensured comprehensive coverage of both problem identification and solution-focused literature.

Query 1:

("engineering student*" OR "engineering education") AND ("South Africa*" OR "South African") AND (barrier* OR challenge* OR obstacle* OR constraint*) AND (success OR retention OR completion OR progression OR throughput OR persistence)

Query 2:

("engineering student*" OR "engineering education") AND ("South Africa*" OR "South African") AND (intervention* OR support OR strateg* OR reform* OR "teaching method*" OR pedagog* OR curriculum) AND (success OR retention OR completion OR outcomes)

All searches covered literature from 2016 to April 2026, resulting in a total of 539 records initially identified across all databases. Following the removal of duplicate records, 423 unique records remained for screening.

2.2 Eligibility Criteria

Inclusion:

- Studies focused on engineering students or engineering education in the South African context.
- Peer-reviewed conference proceedings, journal articles, or book chapters published in academic outlets.
- Studies Published in English between 2016 and 2026
- Studies that address barriers to engineering student success, or intervention strategies, or policy recommendations, or reform opportunities.

Exclusion:

- Opinion pieces without empirical evidence.
- Studies outside higher education institutions.
- Studies focused on non-engineering disciplines
- Studies that focus exclusively on engineering education systems in countries other than South Africa without providing comparative analysis or applicability to the South African context.

2.3 Study Selection Process

The screening process followed a three-stage approach consistent with PISMA guidelines. First, duplicate records were removed, and the remaining records were screened by title and abstract, followed by a full-text assessment of eligible studies, with reasons for exclusion documented. The selection process was recorded using a PRISMA flow diagram, as illustrated below in Figure 1 and 2.

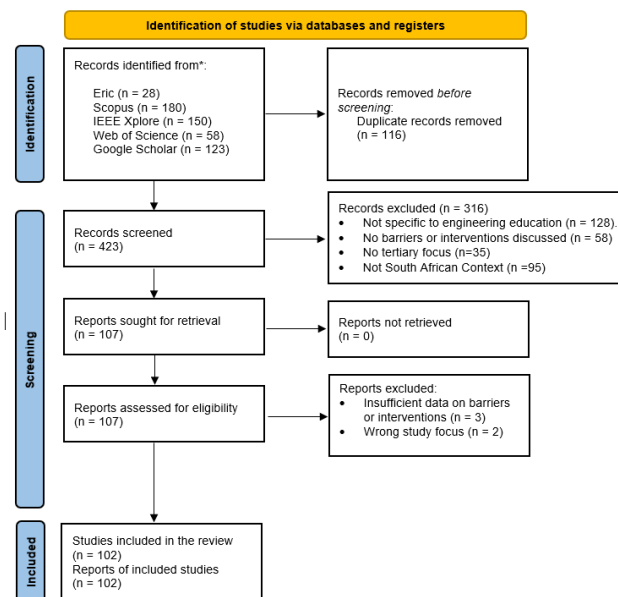


Figure 1. SLR PRISMA flow diagram.

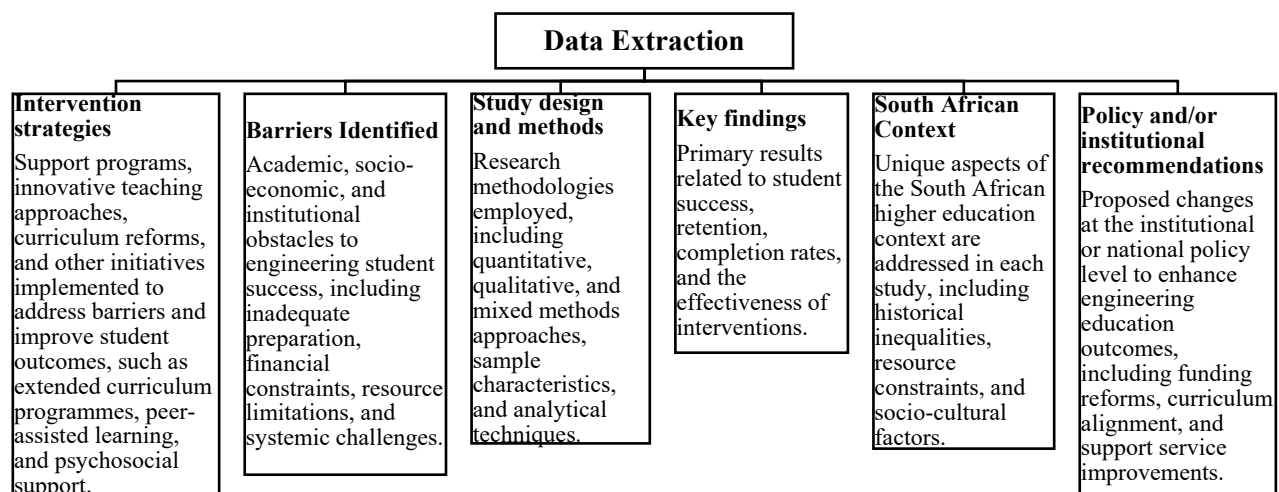


Figure 2. Six domains for data extraction.

3. Literature Review

South African higher education institutions face persistent and multifaceted challenges in achieving successful engineering student outcomes, with low retention rates, extended completion times, and high attrition rates significantly affecting the development of a skilled engineering workforce critical for national economic development. The engineering education in South Africa is characterised by complex intersections of socio-economic disparities and institutional challenges that collectively hinder student success. Understanding these barriers and identifying evidence-based intervention strategies is essential for improving student outcomes and addressing national critical skills shortages in engineering disciplines.

Many students arrive in universities inadequately prepared for the rigorous demands of engineering programmes, particularly in foundational areas such as mathematics and physical sciences (Sepeng, 2025). These academic challenges are compounded by socio-economic factors, including financial constraints, limited access to technology and resources, and poor living conditions, which unequally affect students from previously marginalized communities (Sepeng, 2025; Versfeld et al., 2025). Institutional factors further complicate the landscape of engineering education in South Africa. Universities face resource constraints, including insufficient student support services, outdated curricula that may not align with contemporary industrial needs, limited access to modern equipment and technology, and inadequate lecture capacity (Council, 2025; Nyemba et al., 2021).

These institutional barriers are intensified by systemic issues such as large class sizes, declining government funding, and limited coordination structures that hinder effective student support (Versfeld et al., 2025). Despite these challenges, South African engineering education has witnessed positive innovations in recent years, including the development of extended curriculum programmes, peer-assisted learning initiatives, project/problem-based learning pedagogies, and strengthened industry-academia partnerships (Council, 2025; Abbott et al., 2020; Bolu et al., 2024). However, significant gaps remain between existing interventions and students' actual needs, particularly in areas such as time management, organizational skills, mental health support, and culturally responsive pedagogies (Versfeld et al., 2025).

In conclusion, enhancing engineering student success in South African higher education requires sustained, coordinated efforts across multiple levels, from individual institutions to national policy frameworks. The evidence synthesized in this review provides a foundation for evidence-based reform efforts that can address the critical barriers to student success and create a more equitable, effective, and responsive engineering education system. By addressing academic underpreparedness, socio-economic disadvantage, and institutional constraints through comprehensive, integrated, and contextually responsive interventions, South African higher education institutions can enhance student retention, progression, and completion, ultimately contributing to the development of a skilled engineering workforce capable of addressing the complex challenges facing South Africa and the broader African continent.

4. Results

4.1 Study Characteristics

The distribution of 102 included studies is presented in Figure 3 above, illustrating patterns by publication, study design, and institution type. These studies were published between 2016 and 2026, with about (n=78, 76%) published between 2018 and 2025, reflecting growing research attention to engineering student success in South Africa. A range of methodological approaches were employed, including qualitative (n=34, 33%), quantitative (n=28, 27%), mixed methods (n=32, 31%), and systematic/conceptual papers (n=8, 8%). The sample sizes used varied considerably, from small-scale case studies (n≤20) to large institutional datasets (n≥1000). The research was conducted across diverse South African higher education institutions, including traditional universities (n=45), universities of technology (n=38), comprehensive universities (n=12), and Technical and Vocational Education and Training colleges (n=7).

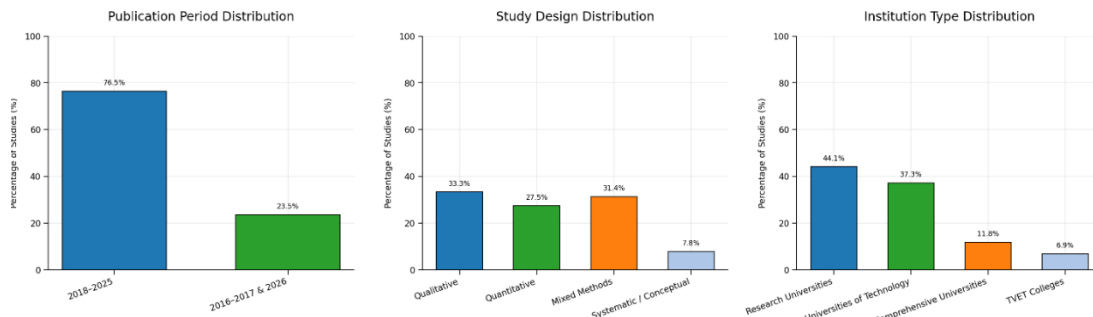


Figure 3. Study distribution by publication, design & institution type.

4.2 Barriers to Engineering students

4.2.1 Academic Barriers

Academic barriers represent the most frequently identified and extensively documented category of challenges to engineering student success, with strong evidence from 78 included studies.

Mathematics and physical sciences underpreparedness are the most frequently cited academic barriers to engineering student success. It is reported that most students enrolled in engineering programmes have insufficient foundational knowledge of mathematics and physical sciences (Sepeng, 2025; Padayachee et al., 2021; Versfeld et al., 2025). Advanced engineering concepts are built upon fundamental skills provided by these two subjects, and underpreparedness creates cascading challenges throughout students' engineering education. Moreover, language proficiency, particularly English, which is not a first language to most of the students represent additional significant barriers (Padayachee et al., 2021). The English language barrier hinders the students' ability to comprehend technical concepts and express their understanding in assessments.

4.2.2 Socio-Economic Barriers

Socio-economic barriers disproportionately affect student success from historically disadvantaged backgrounds and create compounding obstacles to academic success. 65 included studies with strong evidence highlight consistent findings across diverse institutional contexts and student populations.

Financial constraint is a critical barrier to engineering student success, not just affecting students' ability to pay tuition fees but also their access to vital resources such as textbooks, technology, transportation, and accommodation (Noutchie, 2024; Sepeng, 2025; Versfeld et al., 2025; Mostert et al., 2025; Steenkamp et al., 2019). In the South African context, limited access to technology and digital resources is a significant socio-economic barrier (Versfeld et al., 2025; Shaw et al., 2021; Snyman et al., 2021). Most students lack access to basic resources such as stable electricity, devices, and cellular data, which leads to uneven participation in online support systems. Sepeng, (2025) discovered that students from disadvantaged backgrounds typically face various challenges related to unstable home environments, lack of study spaces, and inadequate housing. These factors interact with academic demands to create additional stress and barriers to success. Socio-economic disadvantages contribute to increased risk of mental illness, particularly for students from socio-economically disadvantaged backgrounds. Noutchie (2024) identified psychological distress and negative mental health outcomes linked to financial pressures and extended study duration.

4.2.3 Institutional Barriers

Institutional barriers encompass structural, organizational, and resource-related obstacles within higher education institutions that constrain engineering student success. This study represents strong evidence of 71 studies from this review with consistent findings across diverse institutional types and engineering disciplines.

Institutional barriers that hinder student success, as documented by the literature, include but are not limited to counselling services, academic support, and advising capacity, particularly in the context of large undergraduate classes and high staff workloads (Versfeld et al., 2025; Qonda, 2017; Snyman et al., 2020; Sepeng, 2025). Versfeld et al., (2025) identified a significant gap caused by a lack of alignment between existing interventions and students' actual needs, with most existing support services failing to address specific challenges students face. Moreover, literature indicates a small change in engineering curricula since the early independence period, and it lacks professional relevance (Abbott et al., 2020). Outdated curricula and misalignment with industry affect student

engagement and graduate employability, as modern technologies, industry 4.0 concepts, and real-world problem-solving approaches are not incorporated into the curricula (Mitra et al., 2018).

4.3 Implemented and Evaluated Intervention Strategies

4.3.1 Extended Curriculum Programmes

Extended Curriculum Programmes (ECPs) represent the most widely implemented and rigorously evaluated intervention strategy across South African higher education institutions to address inadequate secondary school preparation, 12 studies from this study highlight the consistent findings across multiple institutions and engineering disciplines.

Sutherland (2019) conducted a study to examine whether the extended curriculum programme made a difference to engineering faculty success rates. Quantitative studies report pass rate improvements ranging from 10% to 25% compared to similar students in mainstream programs (Mouton et al., 2025; Snyman et al., 2021). The evidence gathered through literature suggests that while extended programmes provide additional time for foundational skills development, their effectiveness depends on the quality of support provided and the institutional culture surrounding these programmes.

4.3.2 Peer-Assisted Learning and Peer Mentorship

The Peer-assisted learning (PAL) programme supports students in high-risk subjects. These programmes are facilitated by PAL leaders to supplement learning sessions for junior students. These programmes have been widely implemented across South African engineering programs. Moderate evidence is presented by this study with generally consistent findings, but some methodological limitations and context-specific variations.

PAL appeared as a widely implemented and generally effective intervention strategy. PAL programme implemented by the Mechanical Engineering Department at Walter Sisulu University to support students in high-risk subjects improved study skills, time management, communication, problem-solving, and presentation skills (Qonda 2017). PAL programs demonstrate moderate effectiveness in improving pass rates in targeted high-risk subjects, with reported improvements ranging from 5% to 15% (Qonda, 2017). Makala (2021) assessed a PAL program, documenting that students are not equipped with the necessary academic/learning skills to cope with the university environment and that PAL provides valuable peer support, though gender imbalances in PAL participation require attention.

4.3.3 Academic Support Initiatives

Academic support initiatives encompass a range of interventions, including tutoring programs, academic literacy development, supplemental instruction, and targeted skill-building workshops. Moderate evidence from 10 studies included in this study highlights diverse intervention types and varying levels of evaluation rigor.

Bakama et al. (2025) assessed student performance in tutored versus non-tutored modules in a South African university, finding that tutored students demonstrated improved performance, though effect sizes varied by subject and student characteristics. Jansen & Maphosa (2026) examined a targeted support initiative intervention that improved reading fluency in first-year engineering students. Tutoring programs show consistent but modest improvements in pass rates (5–10%) and student confidence (Bakama et al., 2025). Moreover, kheswa et al., (2022) explored how to assist underprepared students whose academic background was highly suppressed by COVID-19, emphasizing the need for bridging academic gaps.

4.3.4 Psychosocial Support and Life Coaching

Psychosocial support interventions, including life coaching, belonging interventions, and mental health support, have been implemented to address the socio-emotional and psychological challenges facing engineering students. Moderate evidence from 6 studies included in this study highlights promising findings but limited large-scale evaluation.

Plessis et al. (2024) evaluated the impact of a wise belonging intervention on diverse engineering students at a South African research-intensive institution, finding that the intervention improved academic performance (particularly in mathematics), reduced dropout intentions, and enhanced students' sense of belonging and self-awareness. The intervention, based on the difference-education approach, involved watching videos of diverse senior students sharing

their experiences, completing reflections, and surveys. Results indicated that students felt the intervention helped them avoid dropping out prematurely, respond better to failure, and improve self-awareness and academic performance.

4.3.5 Innovative Pedagogies

Innovative pedagogies, including Problem-based learning (PBL) and Project-Based Learning (PjBL) and active learning strategies, have been implemented in various South African engineering programs to enhance student engagement, practical skills, critical thinking and conceptual understanding. Moderate evidence presented is presented by 14 studies from this study with diverse pedagogical approaches and varying levels of evaluation rigor.

PBL and PjBL have emerged as effective pedagogical approaches in engineering education. Abbott et al. (2020) show that adopting PBL centred on real-world problems can broaden engineering curricula in African universities and make programmes more attractive to a wider range of students. Similarly, Awotwe et al. (2025), through a multi-institutional South African study of CDIO-aligned curricula, demonstrate that project-based learning supports meaningful learning experiences and offer practical, data-driven recommendations for educators and policymakers. Maladzhi et al. (2024.) further highlight that industry-linked PBL initiatives provide valuable hands-on experience, exposing students to real engineering challenges while developing problem-solving, critical thinking, teamwork, and professional skills. From a contextual perspective, Swartz et al. (2025.) emphasise the importance of locally relevant and culturally responsive problem-based learning, illustrating how decolonised, context-appropriate design challenges can enhance student engagement and relevance in engineering education.

4.3.6 Curriculum Reforms

Curriculum reforms, including integrated curricula, outcome-based curricula, and industry-aligned curricula, have been implemented in various South African engineering programs to enhance relevance, integration and graduate competencies. Emerging evidence from 8 studies included in this study highlight mixed findings and limited long-term evaluation.

Case et al. (2018) conducted a case study of curriculum reform in the Chemical Engineering Program at the University of Cape Town, documenting faculty and student experiences of a shift to a block-based, integrated curriculum. The study found mixed perceptions: some students valued the focused, integrated approach, while others felt the fast pacing and block structure did not allow enough time for conceptual mastery. Case et al. (2018) explored trade-offs in curriculum design during implementation of an integrated curriculum in chemical engineering, identifying tensions between integration goals and practical constraints such as timetabling, assessment, and faculty workload. Gqibani et al. (2017) examined the move from content-based to outcomes-based curricula, exploring implications for assessment, teaching, learning, and throughput.

4.4 Opportunities for Institutional and Policy-Level Reforms

4.4.1 Policy Reforms for Funding and Grading System

Policy-level reforms to funding and grading systems represent a critical systemic opportunity to address financial barriers and rigid academic structures that constrain student success. Emerging evidence from 8 studies included proposes reforms with theoretical rationale and preliminary evidence.

Financial support reforms were widely identified as a critical lever for improving engineering student success. Noutchie (2024) argues that lowering the undergraduate progression pass mark from 50% to 40% could ease the financial burden on NSFAS-funded students, reduce strain on the funding system, improve retention, support student mental health, and enable more timely degree completion. Beyond grading reforms, studies highlight the need for more flexible and holistic financial support that extends beyond tuition to include accommodation, technology access, and living expenses (Versfeld et al., 2025), alongside policies aimed at strengthening institutional resource availability (Sepeng, 2025).

4.4.2 Strengthened Industry-Academia Partnerships

Strengthened industry-academia partnerships represent a systemic opportunity to enhance curriculum relevance, provide authentic learning experiences, and improve graduate employability. Moderate evidence from the included 12 studies highlights benefits and proposes models with some preliminary implementation evidence.

Bolu et al. (2025) propose a sustainable partnership model centred on experiential learning, curriculum development, and collaborative research, while highlighting challenges such as limited funding, weak institutional frameworks, and low industry engagement. Similarly, Maladzhi et al. (2025) recommend greater industry involvement in student projects, allowing real industry problems to be addressed under academic supervision, particularly in the South African context. Nyemba et al. (2021) further argue that strategic industry partnerships can enhance access to modern technologies through smart procurement, use, and maintenance models, helping bridge persistent gaps between academia and industry.

4.4.3 Culturally Responsive Pedagogies Incorporating Ubuntu Principles

Culturally responsive pedagogies that incorporate African philosophical principles, particularly Ubuntu, represent a systemic opportunity to create more inclusive and affirming learning environments for South African engineering students. Emerging evidence from 6 included studies proposes frameworks with theoretical rationale but limited implementation evidence.

Versfeld et al. (2025) documented that Eurocentric models marginalize non-dominant cultural perspectives and perpetuate exclusionary practices, calling for culturally responsive approaches that centre African epistemologies and values. Mlambo (2021) highlighted that higher education environments are racialized and gendered spaces, hostile towards Black women's bodies and identities, with standards of academic potential continuing to be measured by whiteness, emphasizing the need for decolonized, culturally affirming pedagogies.

4.4.4 Comprehensive Student Support Ecosystems

A comprehensive student support ecosystem that integrates academic, psychosocial, financial, and career support represents a systemic opportunity to address the interconnected barriers facing engineering students. Emerging evidence from 7 included studies proposes a holistic, integrated support model.

The development of comprehensive and integrated student support ecosystems was widely identified as a key opportunity for improving engineering student success. Versfeld et al. (2025) emphasise the need to reassess existing support structures to better align interventions with students' actual needs, recommending structured learning communities, embedded mental-health practices, improved time-management support, and the use of third transcripts or co-curricular records to recognise learning beyond the classroom.

4.4.5 Integrated Mental Health Support

Integrated mental health support represents a systemic opportunity to address the psychological and socio-emotional challenges facing engineering students, particularly those from disadvantaged backgrounds. Emerging evidence from 5 included studies documents mental health challenges and proposes integrated support models.

Versfeld et al. (2025) documented that socioeconomic disadvantages and childhood adversities contribute to the risk of mental illness, with socio-economic disparities affecting students' mental health, and that reluctance among students to seek help due to stigma, fear of judgment, or lack of awareness about available resources limits uptake of existing services. Proposed integrated mental health support models include: embedding mental health support within academic programs to reduce stigma and increase accessibility, training faculty and staff to recognize and respond to student mental health challenges, providing culturally appropriate mental health services that address the specific needs and contexts of South African students, integrating mental health support with academic support services to address the interconnections between psychological well-being and academic performance, and developing early warning systems to identify students at risk and provide proactive support.

5. Discussion

This section presents a tiered ranking of barriers and interventions based on evidence strength, frequency of identification across studies, and reported impact on student outcomes. This prioritization is intended to guide policy development, institutional planning, and resource allocation.

5.1 Evidence-Based Prioritization of Barriers and Interventions

This synthesis presents an evidence-based prioritisation of barriers to engineering student success in South Africa, drawing on the frequency of identification across studies and the reported strength of evidence illustrated by Figure 4. The analysis reveals that academic underpreparedness in mathematics and science, inadequate student support

services, and financial constraints, particularly NSFAS-related challenges, emerge as tier 1 critical barriers, supported by strong and consistent evidence linking them to poor retention, progression, and completion outcomes. A second tier of significant barriers includes academic literacy and language challenges, limited access to digital resources, self-regulation and study-skills deficits, and misalignment between curricula and industry needs, reflecting moderate levels of evidence and impact. A third tier of context-specific barriers, supported by emerging evidence, highlights the influence of infrastructural deficiencies, mental health challenges, limited access to modern institutional equipment, and racialised and gendered institutional cultures. Collectively, these findings underscore the multidimensional nature of student success challenges and provide a structured basis for prioritising targeted, evidence-informed policy, institutional, and pedagogical interventions (Figure 4).

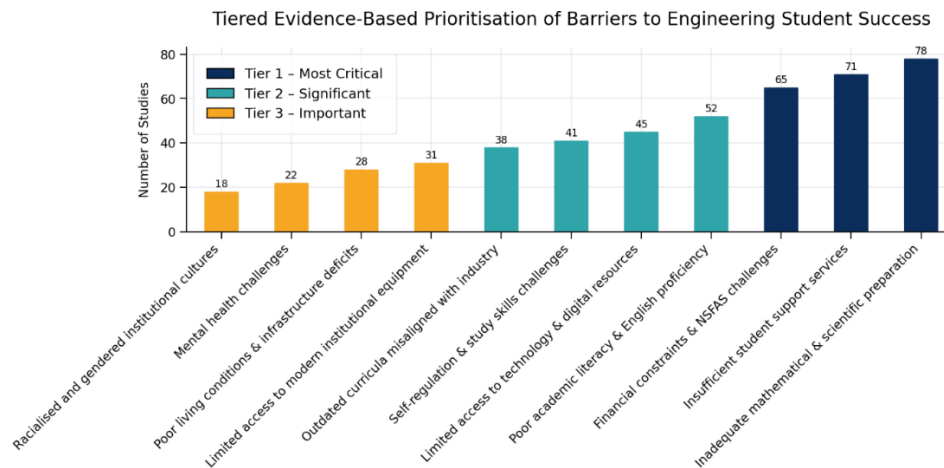


Figure 4. Tiered evidence-based prioritisation of barriers to engineering student success.

5.2 Evidence-based Prioritization of Interventions

This section presents a tiered prioritisation of interventions to enhance engineering student success, based on evidence strength and anticipated impact, illustrated by Figure 5. Tier 1 interventions demonstrate the strongest effectiveness, combining structured academic pathways, peer-supported learning, and financial reform measures that address foundational academic and socio-economic challenges. These interventions show consistent benefits for retention, progression, and overall student performance when supported by adequate institutional commitment. Tier 2 interventions are promising and target learning support, student well-being, curriculum relevance, and partnerships with industry. While their impacts are more variable, they contribute meaningfully to student engagement and graduate readiness when implemented strategically and at scale. Tier 3 interventions reflect emerging or context-specific approaches, including innovative pedagogies, culturally responsive teaching, mental health support, and holistic support ecosystems. Although they hold transformative potential, these interventions require further evaluation, capacity building, and sustained institutional investment to realise system-wide impact.

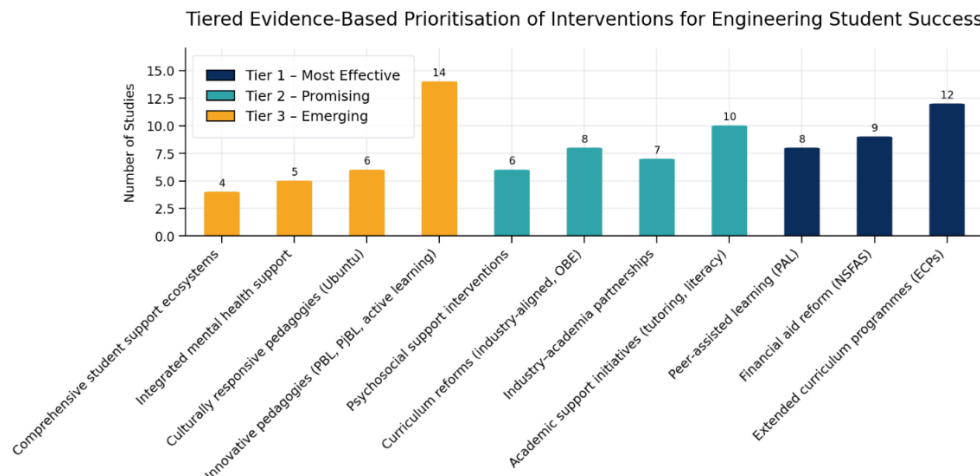


Figure 5. Tiered evidence-based prioritisation of barriers to engineering student success.

5. Conclusion

The findings point to important implications for engineering education practice in South Africa. Improving student success requires integrated, multi-level approaches that address academic preparation, socio-economic support, and institutional capacity at the same time. Isolated interventions may offer limited benefits, but they are insufficient to respond to the complex challenges students face. In practice, student support services need to be redesigned to align more closely with students' lived experiences, particularly in relation to time management, mental health, and academic skill development (Versfeld et al., 2025). Such services should be accessible, culturally responsive, and coordinated across institutional units rather than fragmented.

Curriculum reform remains central to improving outcomes. The literature emphasises the need for curricula that are aligned with industry demands, incorporate innovative pedagogies such as problem-based and project-based learning, and adopt locally relevant, decolonised approaches to teaching and learning (Abbott et al., 2020; Swartz et al., 2025). Engineering programmes must prepare students not only with technical knowledge, but also with problem-solving, teamwork, and professional skills. Strengthening industry-academia partnerships is equally critical, as these partnerships enhance curriculum relevance, provide real-world learning opportunities, and improve access to modern technologies (Bolu et al., 2025; Nyemba et al., 2021).

From a policy perspective, financial support frameworks require reform to address the full cost of study, including accommodation, technology access, and living expenses (Noutchie, 2024; Versfeld et al., 2025). National policies must also address the persistent gap between secondary and tertiary education to better prepare students for autonomous university learning (Versfeld et al., 2025). Investment in infrastructure and digital resources is essential for improving quality and reducing inequalities, particularly through strategic industry partnerships (Nyemba et al., 2021; Versfeld et al., 2025). In addition, gender equity and inclusion policies should be strengthened through targeted support, mentorship, and inclusive learning environments for women and other underrepresented groups (Sibisi et al., 2025; Nel et al., 2016). Future research should focus on rigorously evaluating integrated intervention models, examining culturally responsive pedagogies, and understanding the long-term impacts of COVID-19 on engineering education outcomes.

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Biographies

Prof. Mohohlo Samuel Tsoeu is a prominent South African academic and electrical engineer specialising in Artificial Intelligence (AI), Machine Learning, and Signal Processing. He currently serves as a Professor and the Head of the Department of Electronic Engineering at the Durban University of Technology (DUT). Prof. Tsoeu holds a PhD in Electrical Engineering and an MBA, reflecting a rare combination of deep technical expertise and strategic leadership capability. Before joining DUT, he spent more than 14 years at the University of Cape Town (UCT) as a Senior Lecturer in the Department of Electrical Engineering. During his tenure, he held several influential leadership roles, including Chair of the Transformation Committee and membership on the Dean's Advisory Committee. He additionally serves as an Extraordinary Associate Professor at North-West University (NWU), where he collaborates on advanced research in digital health and deep learning applications. Prof. Tsoeu gained international recognition in 2021 when he received the prestigious Google Research Scholar Award for his work on corpora collection and Natural Language Processing (NLP) for indigenous South African languages such as isiXhosa, Sesotho, and South African Sign Language (SASL). His research contributions are particularly impactful in Sign Language Recognition, with projects involving real-time translation between spoken and signed languages, glove-based wearable technology for SASL data collection, and human-machine interfacing to support the Deaf and Hard-of-Hearing communities. He has also conducted research in Electrical Impedance Tomography and plant health monitoring, contributing to interdisciplinary advancements in medical engineering and signal processing.

Thandeka Makhanya is an academic and researcher in the field of Electronic and Computer Engineering at the Durban University of Technology (DUT), South Africa, where she serves as a Lecturer. She is currently a PhD candidate in Electrical/Electronic Engineering, with research interests centred on engineering education, student retention and success, renewable energy systems, and sustainable engineering solutions. Thandeka has experience in undergraduate teaching, laboratory facilitation, curriculum support, and student mentorship, and she actively contributes to initiatives aimed at improving student engagement and academic progression. She is the Chair of the IEEE-DUT Student Branch, where she leads student professional development, industry engagement, and STEM outreach activities. Her scholarly focus combines technical engineering expertise with educational research aimed at enhancing equity, retention, and student success within South African higher education.

Lebogang Bopape is a Lecturer at the Durban University of Technology (DUT), South Africa, with experience in teaching and academic support within engineering and technology-related disciplines. Her teaching portfolio includes undergraduate instruction and curriculum delivery, with a strong focus on supporting student engagement and

academic development. Lebogang's research interests centre on South African Sign Language (SASL) translation in research and higher education, with particular emphasis on accessibility, inclusive research methodologies, and ethical engagement with Deaf communities. Her work contributes to advancing inclusive education practices through linguistically appropriate research design, data collection, and knowledge dissemination. Lebogang Bopape is committed to promoting equitable access to higher education and research participation through inclusive and context-responsive academic practices.

Christopher Mcineka is a researcher and engineering professional with research interests in computer vision and machine learning, particularly the application of data-driven and intelligent systems to real-world engineering and technological challenges. His work focuses on developing and applying computational models for visual data analysis, pattern recognition, and automated decision-making. In addition to his technical research interests, Christopher is engaged in higher education teaching and student support, contributing to initiatives that enhance learning experiences in computing and engineering-related disciplines. He is committed to advancing research capacity and innovation in artificial intelligence and data-centric engineering within the higher education environment.

Nompumelelo Chili is an academic and engineering professional with experience in higher education teaching, curriculum support, and student development within engineering and technology-related disciplines. Her research interests focus on wireless communication systems and wireless power transmission, with emphasis on modern communication technologies, energy-efficient wireless systems, and emerging applications in sustainable and intelligent engineering solutions. In addition to her research activities, Nompumelelo is actively involved in undergraduate teaching and academic support, particularly in facilitating student learning and transition in engineering programmes. She is committed to advancing quality engineering education, mentoring students, and contributing to research and innovation within the South African higher education environment.