RESEARCH ARTICLE

Resilience, motivation, and persistence in engineering at a South African university of technology

Résilience, motivation et persévérance en ingénierie dans une université technologique sud-africaine

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ABSTRACT

What helps engineering students persist through their demanding academic journey? This qualitative study explores that question through the lens of Ungar's socio-ecological model of resilience, focusing on senior undergraduates at a South African university of technology. We interviewed seven students and used deductive thematic analysis to trace how resilience operates across multiple layers of their lived experiences. Resilience emerged from dynamic interactions across ecological levels. At the microsystem level, motivation was supported by faculty encouragement, peer relationships, and structured curricula. Family, community support, and mentorship formed strong mesosystem influences. At the exosystem level, institutional infrastructure and policies – particularly challenges related to financial aid and load shedding – both hindered and, at times, strengthened resilience. Macrosystem influences included societal perceptions of engineering as prestigious but difficult, shaping students' motivations and stress. Rather than viewing resilience as an individual trait, this study reveals it as a socially embedded process shaped by context. We offer practical recommendations for multi-level support: simplify funding systems, invest in empathetic teaching, align curricula with local realities, and strengthen partnerships with families and communities.

KEYWORDS

Resilience, motivation, engineering students, persistence, socio-ecological

RÉSUMÉ

Qu'est-ce qui aide les étudiants en ingénierie à persévérer dans leur parcours universitaire exigeant? Cette étude qualitative explore cette question à travers le prisme du modèle socio-écologique de résilience d'Ungar, en se concentrant sur les étudiants de dernière année d'une université technologique sud-africaine. Nous avons interrogé sept étudiants et utilisé une analyse thématique déductive pour retracer le fonctionnement de la résilience à travers les multiples facettes de leur expérience vécue. La résilience est née d'interactions dynamiques entre les différents niveaux écologiques. Au niveau microsystémique, la motivation était soutenue par l'encouragement des professeurs, les relations avec les pairs et des programmes structurés. Le soutien familial et communautaire et le mentorat ont exercé une forte influence au niveau mésosystémique. Au niveau exosystémique, l'infrastructure et les politiques institutionnelles, notamment les difficultés

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liées aux aides financières et aux délestages, ont à la fois entravé et, parfois, renforcé la résilience. Les influences macrosystémiques comprenaient la perception sociétale de l'ingénierie comme prestigieuse mais difficile, ce qui a influencé la motivation et le stress des étudiants. Plutôt que de considérer la résilience comme une caractéristique individuelle, cette étude la révèle comme un processus socialement ancré et façonné par le contexte. Nous proposons des recommandations pratiques pour un soutien à plusieurs niveaux : simplifier les systèmes de financement, investir dans un enseignement empathique, aligner les programmes sur les réalités locales et renforcer les partenariats avec les familles et les communautés.

MOTS-CLÉS
Résilience, motivation, étudiants en ingénierie, persistance, socio-écologique

Introduction

Engineering education in South Africa faces significant challenges related to student retention and success (Maphosa et al., 2023), particularly among students from backgrounds that left them less prepared for university (Bladergroen, 2021). Despite the demanding nature of engineering programs, many students manage to persist and succeed in the face of adversity (van Wyk et al., 2022). Our research investigates the role of resilience in supporting engineering students' persistence through a socio-ecological lens, focusing on students at a South African university of technology. The study's findings provide valuable insights for developing interventions aimed at improving student retention, success, and the broader STEM workforce in South Africa.

The South African higher education system is characterised by a complex interplay of socio-economic challenges, institutional limitations, and cultural factors that affect student success. Engineering programs, in particular, are known for their academic rigour, which often leads to high dropout rates, especially among first-generation and financially disadvantaged students (Mkhize, 2024). As noted by several scholars (Bengesai & Pocock, 2021; Motsabi et al., 2020), socio-economic barriers such as financial constraints, poor living conditions, and limited access to resources significantly impact students' ability to persist in their studies. Load shedding (planned electricity outages), and inadequate infrastructure, are also common barriers that impact students' academic progress (Thembane, 2024).

At the same time, societal attitudes like support from family, peers, and mentors towards engineering, coupled with institutional policies can either support or hinder students' resilience (Tinto, 1993). This study aims to fill the gap in the existing literature by focusing specifically on the resilience of engineering students at South African universities of technology and how different ecological factors interact to influence their persistence.

The article starts with a brief overview of relevant literature, situating the study in current conversations around resilience in education, and a motivation for the use of the socio-ecological framework as a lens. The methodology of the study is presented next, followed by the findings and discussion of these. The article concludes with recommendations for practice and suggestions for further research.

Literature review

Resilience in education

Resilience has been defined as the capacity to recover from difficulties and adapt in the face of adversity (Masten, 2001). In the context of education, academic resilience refers to the ability of students to overcome significant barriers and achieve success despite facing challenges such as financial hardship, academic pressure, and personal difficulties (Martin & Marsh, 2009). Resilience reflects the dynamic interaction between the challenges an individual faces and their ability to respond and adapt positively to those challenges (Southwick et al., 2014; Wu et al., 2013). At its core, resilience involves a dynamic balance between external challenges and a person's capacity to respond adaptively, fostering well-being even under pressure (Kotzé & Kleynhans, 2013; Southwick et al., 2014).

Both personal traits and external resources contribute to resilience, particularly in academic settings. Students, for instance, may draw on developed beliefs such as a growth mindset (Dweck, 2006), or on personal qualities like optimism (Seligman, 1991) and grit (Duckworth, 2016). Externally, access to supportive networks, socio-economic stability, and campus-based mental health services can strengthen their ability to manage stress (Dockrat, 2016; Lewin & Mawoyo, 2019; Van Zyl, 2016). These factors position resilience as a critical psychological asset linked to academic achievement and student well-being in higher education (Elizondo-Omaña et al., 2007; Kotzé & Kleynhans, 2013).

The interplay between personal traits and external resources holds particular significance for students in lower- and middle-income countries, such as South Africa, where systemic challenges – including poverty, limited resources, and higher rates of trauma – amplify stress and mental health risks (Tomlinson et al., 2022). Strengthening resilience among university students in these contexts may mitigate the impact of such stressors and also enhance academic persistence and success. As van Breda (2018) emphasises, resilience is best understood as a *process* of navigating and negotiating resources, while being resilient is the positive outcome of that process. This process-oriented view aligns with Theron's (2023, p. 1032) observation that resilience among sub-Saharan youths is "complexly interwoven with African ways-of-being and -doing."

Knowledge gap

While resilience is increasingly studied in higher education globally, most research originates from the Global North. In contrast, relatively few studies have explored resilience among South African university students, and even fewer in the context of engineering education. This gap is significant because engineering programs are often highly demanding and can present distinctive challenges that influence students' well-being and success. By investigating how environmental systems and individual factors intersect within South Africa's culturally and structurally complex context, this research can inform how universities and communities design more effective support mechanisms that promote student resilience.

Frameworks

Several frameworks have been developed to understand resilience, including Bronfenbrenner's (1979) ecological systems theory, which provides a comprehensive view of how individuals' development is shaped by multiple layers of environmental influences. While Bronfenbrenner's (1979) work was not specifically resilience-related and focused on the development of individuals and how they adapt to circumstances, it provided a conceptual foundation for later resilience frameworks. Ungar (2011) extends this foundation by shifting attention from human development in general to resilience in particular, reframing resilience as a function of both individual agency and systemic interdependence. Whereas Bronfenbrenner conceptualised layered and relatively distinct systems (micro, meso, exo, macro, chrono), Ungar's (2011) socio-ecological model of resilience emphasises the importance of negotiating between these systems and argues that resilience depends on access to and meaning of resources within specific cultural, social, and political contexts. Ungar (2018) further argues that resilience is not just about individual attributes, it is more about the capacity of an individual's social and physical environment to enable positive adaptation amid adversity.

This relational, systems-based understanding of resilience aligns with African perspectives such as Ebersöhn's (2019) "flocking together" model, which emphasises collective, culturally grounded responses to hardship. Drawing on the principle of *ubuntu*, and in line with van Breda's (2018) position of resilience as process, the flocking together model recognises that in contexts of resource scarcity, resilience emerges through shared responsibility and mutual care, where communities actively mobilise to protect and support their members.

In this study on the resilience and persistence of engineering students at a university of technology in South Africa, microsystem factors include encouragement by lecturers, positive relationships with fellow students, and well-structured curricular requirements. Family and community support as well as mentorship create strong pillars within the mesosystem and are supported at the campus level. Exosystem factors include institutional policies and infrastructure such as access to financial aid and problems like load shedding. At the macrosystem level, societal perceptions of engineering as both prestigious and demanding shape students' aspirations and pressures, underscoring the need for broader cultural and systemic support.

As Ungar et al. (2013) note, Bronfenbrenner himself understood that his model's concentric circles were never meant to imply strict hierarchy or separateness. No one system is inherently subordinate to another: mesosystemic processes are not less important than exosystemic processes, and boundaries between systems are fluid. The nature of any single system is to exist in reciprocal relationships of dependency and influence with all others. This non-hierarchical, interdependent understanding of systems provides a strong foundation for conceptualising resilience as a dynamic, contextually embedded process, which serves as the theoretical foundation for this study.

Research design and methodology

This study employed a qualitative research design. According to Sandelowski (2010), qualitative descriptive studies offer detailed, low-inference insights into participants' lived experiences, making this design suitable for understanding complex processes, such as in the higher education context explored in this study.

Sampling procedure

Participants were selected through criterion-based purposive sampling, aligning with the study's focus on students who could provide rich, insightful narratives regarding resilience (Marshall & Rossman, 2014). The primary criteria included students beyond their first year, ensuring ample exposure to rigorous academic and practical engineering challenges. Initially, emails detailing the study objectives, ethical considerations, and confidentiality measures were sent to senior undergraduate students enrolled in electrical and computer engineering programs. From eleven initial respondents, seven students were selected based on academic seniority and ability to offer rich contextual insights, although gender diversity and representational balance across engineering fields were limited (one female, six males; aged early to mid-20s; one white postgraduate and six black undergraduate students).

Data collection: Semi-structured interviews

Data were gathered using semi-structured interviews conducted remotely via Microsoft Teams, lasting 45-60 minutes. Interviews utilised an open-ended, flexible interview guide aligned with the systems in the socio-ecological framework. Pilot testing refined the interview questions to enhance clarity and conversational tone, thereby facilitating rich participant narratives. The first author conducted the interviews and corrected the verbatim auto-transcription of the audio recordings, ensuring accuracy in data representation.

Data analysis: Deductive thematic analysis (DTA)

Deductive thematic analysis, guided by Braun and Clarke's (2021) methodology, was employed to systematically interpret data. This was achieved by using the six established phases: (i) familiarisation, (ii) coding, (iii) theme development, (iv) theme refinement, (v) theme finalisation, and (vi) reporting. The first author began by immersing himself in the transcripts to gain an overall sense of the material (data familiarisation); this entailed multiple readings of the transcripts, listening to audio recordings, and reflecting on emotional and contextual cues. Coding involved the use of NVivo software for effective data management. Initial coding involved line-by-line reading to ensure no significant data were overlooked. The first author began by immersing himself in the transcripts to gain an overall sense of the material (data familiarisation). Key excerpts were highlighted, such as the following comment from one participant:

> What I really like about positive friends is that they don't really help you only academically, but then they help you also in your everyday needs and in your emotional wellbeing ... that's how they really help me to cope with academic and life generally.

Initial codes, such as, for this example, 'support from friends' and 'emotional resilience' were assigned to relevant segments of text (coding). These codes were then grouped into preliminary themes, labelled, for example, 'Social support network' (theme development). The theme development phase included identifying patterns and relationships among codes. For example, personal coping strategies like 'self-regulation,' 'time management,' and 'grit' were grouped into a cohesive theme reflecting students' internal resources for resilience.

Themes were refined through iterative processes, merging similar themes and separating overly complex ones to enhance clarity and coherence. For instance, to better capture how peer interactions supported both emotional and academic coping strategies, the theme, 'Social support network' was revised to a more precise theme: 'Peer relationships and social support' (refining and defining themes). The theme was finalised in consultation with the full team, ensuring it captured students' lived experiences accurately (finalising the themes).

Finally, the findings were written up with supporting quotations to demonstrate how peer support can significantly influence students' academic persistence. NVivo enabled the research team to track coding decisions and maintain methodological rigour throughout the process. To ensure validity and trustworthiness, reflexivity was actively practised by documenting potential biases and assumptions in a reflective journal throughout the analysis. Peer debriefing and member checking were also conducted, allowing themes to be critically assessed and validated by external perspectives.

Findings and discussion

Based on participants' narratives, the data show how resilience among engineering students arises from the interplay of personal attributes, social support networks, institutional policies, and societal attitudes. The insights are grouped thematically according to these four dominant themes.

Personal attributes

Participants demonstrated various personal attributes that facilitated their resilience, such as self-motivation, a growth mindset, and proactive coping strategies. A common thread in interviews was the students' drive to persevere despite adversity. One participant explained, "*I also motivate myself ... I tell myself that, no, I'm gonna make it ... I should learn from my mistakes, I should just keep on pushing.*" Students consistently noted how shifting their mindset, seeing setbacks as chances to grow, helped them stay focused.

Some participants also relied on organised study methods, such as keeping journals or breaking large projects into smaller tasks. Some also highlighted stress-management techniques, ranging from "*I do some breathing techniques to calm myself down*" to spiritual or meditative practices. This finding echoes definitions of academic resilience as the capacity to overcome adversity through adaptive personal effort (e.g. persisting despite financial or academic hardships). In line with prior studies, students often drew on individual qualities like optimism, *grit*, and a belief in improvement to navigate

challenges. Such personal attributes have been widely identified as resilience-enablers in educational contexts – for instance, *growth mindset* (Dweck, 2006) and *grit* (Duckworth, 2016) have been linked to students' ability to bounce back from setbacks.

Despite the importance of individual determination, our findings also reinforce the observation that resilience is not merely an intrinsic trait. Participants acknowledged that their personal tactics (e.g. positive self-talk, time management, stress-control techniques) were effective only when combined with external support. This aligns with socio-ecological theories of resilience: Ungar (2018) argues resilience depends less on *willpower* and more on the capacity of one's environment to provide support. In other words, even the most determined students thrive best when their personal efforts are met with resources and encouragement from their surroundings. The present study therefore contributes theoretically by highlighting the interplay between individual agency and context – confirming that personal resilience alone is insufficient in a resource-constrained setting.

Practically, this finding implies that while universities should help students develop personal skills (e.g. through workshops on self-regulation or mindset), they must simultaneously ensure supportive conditions, since even the most resilient individuals can be overwhelmed if left to 'sink or swim' on their own. Strengthening personal attributes should be seen as one piece of a larger resilience puzzle, complementary to social and institutional support. While these personal tactics were critical in a highly demanding program, students stressed that they only worked well when combined with broader support systems.

Social support networks

The theme of social support networks emerged as a cornerstone of student resilience. Participants consistently credited family encouragement, peer collaboration, and mentorship with helping them persist through difficulties.

Family influence

Family often provided the first line of emotional and financial support. One participant remarked, "*My mom is always there for me whenever I need anything. She makes sure that I get it ... She's all the support that I have.*" Such encouragement nurtured an optimistic outlook and bolstered students' commitment to continue their studies. However, elevated familial expectations introduced stress, with one student sharing, "*I want to do well so I don't disappoint my parents who expect high marks.*"

Peer collaboration and friendships

Peer support played a powerful role, especially in a resource-constrained context. As one student explained, "*Me and my friends ... we do this thing where every now and then we'd say, 'Okay, for this particular module, we are cross-nighting for this one' ... It made me realise problems that I didn't even know I had because some people would bring up problems that I didn't think to bring up.*" This collaboration not only eased feelings of isolation but also created a sense of shared responsibility. Another student shared, "*we are busy helping each other with our studies in order to be able to understand ... When*

I'm wrong, he corrects me, and when he's wrong, I correct him," illustrating the mutual learning process that fosters both academic and emotional resilience.

This corroborates extensive literature showing that social support is a key protective factor in academic resilience. Decades ago, Tinto (1993) theorized that students' persistence is strongly influenced by their integration into supportive academic and social communities, including affirming faculty and peer relations. Our findings align with Tinto's model: students who felt *connected* – whether through a parent's moral support, study groups with friends, or guidance from a mentor – were better able to withstand academic pressures. Indeed, strong family relationships and peer bonds have been described as the 'social glue' that keeps students anchored during adversity. In a recent South African study, Mapaling (2024) similarly found that resilient engineering students benefitted from constellations of support – family, friends, and institutional allies – operating in concert. This integrated support system echoes Bronfenbrenner's concept of the *mesosystem*, where linkages between home, school, and community reinforce student development.

Notably, our participants also revealed a nuance: while family support was largely motivating, it sometimes came with heightened expectations that added pressure. For example, students felt a strong need to "not disappoint" their parents, which could amplify stress. This duality adds depth to the generally positive portrayal of familial support in resilience literature. It suggests that the *quality* and context of support matter – supportive networks must provide encouragement without becoming sources of undue stress. Theoretically, this underlines the importance of understanding resilience as a relational process with potential tensions; support can both empower and inadvertently burden students. From a practical standpoint, the findings highlight opportunities to leverage and enhance these social networks. Institutions might create programs that formally engage peer support and mentoring, building on organic study groups and mentor relationships that students already find helpful. For instance, participants who benefitted from peer study sessions demonstrated improved problem-solving and reduced isolation, which suggests that facilitating peer mentorship or learning communities could systematically bolster resilience. Likewise, recognising families as partners in student success – through parent orientation sessions or family-inclusive communications – may help align expectations and enlist familial encouragement as a positive force. In summary, reinforcing students' social support networks, while managing the pressures attached to them, is crucial for sustaining resilience in challenging engineering programs.

Mentors and role models

Whether a committed lecturer, a high-achieving senior student, or a community figure, mentors and role models provided students with a morale boost and made them feel understood and encouraged. One participant noted, "*I have a high school teacher who taught me electrical technology ... He's now helping me with electrical engineering and electronics. I called that teacher last week ... He said, 'I believe in you. Just keep on going and never give up'.*" Another participant found mentorship and spiritual guidance from his pastor, who had also studied engineering: "*Luckily he also did the same course, and*

then he'd advise me ... go and have a group ... consult the lecturer." The combination of practical advice on navigating difficult modules or dealing with administrative hurdles, and motivational support reinforced students' belief in their capacity to succeed.

Institutional policies and practices

Students' experiences underscored that institutional structures and practices significantly influence their capacity to persist. Supportive academic environments – exemplified by accessible support services (libraries, tutoring, counselling) and engaged faculty – were frequently cited as resilience boosters.

Financial aid and administrative efficiency

Financial pressures, including the cost of housing, tuition, and everyday expenses, were commonly cited as major hurdles. Virtually all participants faced financial constraints – from difficulty paying fees and securing housing to limited funds for textbooks and transport – reflecting the broader socio-economic barriers documented in South African higher education. In response, many students became adept at budgeting or pooling resources with peers. One student said "*Sometimes we form a group ... share anything we have, like slides or notes, so you don't spend more buying stuff. It really helps.*" Some described inconsistent or delayed financial aid as a trigger for periods of uncertainty and stress but also noted that these hardships reinforced their determination: "*I told myself I was not quitting. I was going to figure out a way to pay for this and finish.*" One student recalled having to commute long distances due to late housing subsidies, stating, "*I was staying in other residences, moving from a residence to another ... close to seven or so ... I also feel like that's something that affected my studies.*" These disruptions highlight the fragility of resilience when institutions operate with inefficiencies that intensify an already constrained environment.

Prior studies confirm that financial stress is a major threat to student persistence: for example, Bengesai and Pocock (2021) and Motsabi et al. (2020) identified *financial constraints, poor living conditions,* and *limited resources* as significant predictors of dropout among university students. In our study, these constraints often forced students to make tough trade-offs (like skipping meals or commuting long distances) and to seek creative solutions such as pooling resources with peers. This resourcefulness can be seen as a form of adaptive resilience, wherein students mobilise whatever is at hand to survive academically. Indeed, some participants remarked that overcoming funding shortfalls ultimately *bolstered* their determination to finish ("*I told myself I'm not quitting; I'll find a way to pay and finish*"). This resonates with Masten's (2001) notion of 'ordinary magic,' where individuals find ways to cope and adapt in the face of everyday adversities. However, it is crucial to recognise that such adaptability has limits. Chronic financial instability is an external stressor that can overwhelm even the most resilient individuals if not addressed. As our findings illustrate, periods of uncertainty due to delayed scholarships or insufficient funds caused significant anxiety, loss of study time, and in some cases, risk of dropout. These outcomes underscore Ungar's (2008) insight that access to material and financial *resources* is a core component of resilience. In other

words, resilience is not just about personal grit – it hinges on whether students can reliably access the economic support they need to focus on learning.

The interplay between financial constraints and other support systems was also noteworthy. Students from low-income backgrounds often leaned more heavily on social networks to compensate for lack of money – for instance, sharing study materials to avoid extra costs or relying on family for small cash infusions when university aid was delayed. This reflects patterns observed by van Zyl (2016), who found that socio-economic disparities tend to ripple into differences in academic experience, necessitating greater external support for poorer students. Our study adds qualitative depth to that understanding by showing how those supports play out in day-to-day student life. Theoretically, the prominence of financial constraints in our data highlights the importance of situating resilience in a structural context. It supports a socio-ecological view (Bronfenbrenner, 1979; Ungar, 2018) wherein *economic factors* at the exosystem level either supply the resources that enable resilience or, when lacking, become relentless stressors that students must navigate. Practically, this theme points to clear interventions: simplifying bursary and scholarship processes, providing emergency financial assistance, and synchronizing funding disbursements with students' needs would remove significant obstacles to persistence. As one student's experience with late housing funds showed, delays and uncertainties in financial aid can derail academic progress – a preventable problem. By ensuring more reliable financial support structures, institutions can dramatically reduce the 'resilience tax' on disadvantaged students, allowing personal and social strengths to be directed towards learning rather than mere survival. In sum, addressing financial constraints is not only a matter of equity but a strategic investment in student success, amplifying the efficacy of all other resilience-promoting efforts.

Academic support services

Students' experiences underscored that institutional structures and practices significantly influence their capacity to persist. Supportive academic environments – exemplified by accessible support services (libraries, tutoring, counselling) and engaged faculty – were frequently cited as resilience boosters. One participant states "*What I like about our library is that it's always full of people … every time when you go to the library, you get motivated, you get to study also.*" Another participant characterised counselling as "*Every student can go there [counselling], can sit and express their emotions, their difficulties, their pressures that they're having.*" underscoring its role in sustaining mental health and helping students remain on track academically when stressors mount.

Lecturer engagement

The most frequently cited institutional factor in fostering resilience was supportive lecturers. One student stated, "*We had this one lecturer in second year … He was so personally involved with his students … That was a pretty big influence as well for actually continuing and finishing your studies.*" Personal involvement from lecturers reduced the intimidation factor of rigorous engineering modules, while feedback and practical guidance boosted self-efficacy. Another participant also pointed out the importance of

supportive faculty members, sharing his appreciation for a lecturer who extended help beyond his assigned duties: "*There was a time whereby I was doing a different module, and it was really tough … my lecturer was like, I can help you, and then he helped me*." On the other hand, lecturers contributed to stress when test schedules were changed at short notice as one participant commented about a postponed test: "*Now the work is also piling up … it's stressful because you were ready for one date, and then suddenly it's changed.*"

This accords with research on student success in South Africa, which emphasises the role of inclusive institutional cultures and effective support interventions in mitigating unequal preparation and resource gaps. When lecturers showed personal involvement and approachability, or when campuses provided safe study spaces and mental health resources, students reported greater confidence and 'room to breathe' amid their workload. Such findings validate the idea that academic resilience is not developed in isolation but through a supportive campus ecosystem. As the socio-ecological model suggests, the *exosystem* level – institutional policies, infrastructure, and services – can either reinforce or undermine student adaptation. Our data illustrate this vividly: empathetic teaching, clear communication, and well-structured curricula helped cushion students against stress, whereas bureaucratic inefficiencies and resource shortfalls forced students to divert energy toward basic survival needs. This is consistent with Thembane's (2024) observation that inadequate infrastructure (e.g. frequent power outages) and other campus resource challenges are pervasive barriers to academic progress in South Africa. In Thembane's study, as in ours, students had to develop improvised workarounds for institutional shortcomings – a form of resilience that, while commendable, exacts a hidden cost in time and anxiety.

A key pattern in our findings is the 'invisible labour' students perform to compensate for unreliable institutional support. For example, participants described rushing to finish assignments before load shedding or repeatedly chasing administrative offices about delayed bursaries and exam schedules. This aligns with other analyses of previously disadvantaged students' experiences, which note that those from under-resourced backgrounds often face additional hurdles navigating the university system. The significance of this pattern is that it reframes resilience as *relational* rather than *individual*: students' success was facilitated not only by their own tenacity but by how well their university's structures functioned (or failed). Theoretically, this reinforces calls by scholars like Ungar (2008) to view resilience as a quality of the system around the student, not just of the student themselves. Our study contributes to this discourse by documenting specific institutional sore points – e.g. irregular course scheduling and inefficient financial aid processes – and showing their direct impact on student well-being and persistence. In terms of practical implications, the message is clear: universities must actively reduce structural barriers and create a climate of support. Streamlining administrative procedures, communicating schedules and requirements clearly, and training faculty in responsive, *student-centred* teaching are not ancillary tasks; they are central to fostering resilience. This echoes recommendations in the literature advocating for *system-level interventions* to improve student retention. Ultimately, by strengthening institutional structures – making them more reliable, fair,

and attuned to students' realities – higher education institutions can convert resilience from a personal burden into a shared institutional responsibility.

Societal attitudes in a resource-constrained context

Community perceptions of engineering

Many participants described how their communities view engineering studies as both *prestigious* and *formidable*. On one hand, being an engineering student conferred a sense of pride. As one participant remarked, *They think studying engineering is a very big thing … like you're the smartest person in the community.*" Another participant mentioned that "*Everybody thinks engineering is ... like they see it as ... you know, a difficult course and if you can manage to qualify for it then you are very, very smart.*" Similarly, a participant faced scepticism from his community regarding the viability of an engineering career, highlighting a broader cultural sentiment that leaned toward safer, more traditional job choices: "*I would get ... they'd say that you were doing this course, and you've been doing it, and it's unlikely for people to get jobs for this course.*" Such remarks may test a student's resolve but also reinforced their commitment to proving doubters wrong and demonstrating that success is possible through persistence.

This positive cultural valuation of engineering aligns with the concept of aspirational capital in resilience literature (e.g. Shelton & Thompson, 2023), where individuals draw strength from the hopes and high regard placed on them by their communities. On the other hand, the same cultural narrative introduced pressures: students felt a profound responsibility to live up to expectations and to leverage their education for upward mobility. In the South African context, it is common for successful students to feel obliged to improve their family's economic situation – a dynamic sometimes referred to as the 'black tax.' Participants shared experiences of relatives expecting them to start earning and contributing financially even before graduation, which added stress to their already heavy academic load. This finding highlights a nuanced pattern: cultural norms can be a double-edged sword, fueling resilience through purpose (the drive to "*change my background*" or make one's family proud) while simultaneously creating anxiety through unrealistically high expectations and role strain.

Cultural norms and economic expectations

In a country where socio-economic disparities are widespread, engineering is often viewed as a pathway to upward mobility. This perspective amplified a sense of responsibility: "*I want to change my background so badly. I want to make it easier for them [family]. They don't have to worry about financial issues like I did when I was growing up.*" explained one interviewee. Yet the same cultural narrative sometimes created unrealistic timelines or outcomes, as relatives expected immediate financial contribution, thereby intensifying stress on the student as one student said, "*I've been told that, yes, hey, you've been doing this course, and you are old now ... you should be helping your siblings now.*" This pressure to contribute back to his family, while daunting, also fueled his resolve to complete his studies.

Linking these observations to theory, it becomes evident that resilience must be understood within its cultural-macrosystem. Bronfenbrenner's macrosystem level – the broader social beliefs, values, and customs that surround an individual – was palpably present in our data. As noted in Ungar's socio-ecological framework, societal perceptions and cultural context shape what forms of coping are available and how success is defined. Our participants' resilience was not just an individual or even micro-social phenomenon; it was intertwined with cultural narratives of education as a route to socio-economic upliftment. This corroborates Ungar's (2008) argument that resilience is culturally embedded, meaning that what 'counts' as resilient adaptation can vary across cultures. Here, persevering in a tough engineering program *despite* financial hardship and community skepticism can be seen as a culturally resonant form of resilience – a way of defying odds and fulfilling a collective hope. The theoretical contribution of this theme lies in illustrating how culture-specific pressures and supports modulate the resilience process. It reminds scholars and practitioners that resilience in a South African township or rural context may manifest differently than in a Western middle-class context, precisely because of these communal expectations and obligations.

Practically, acknowledging cultural norms means that universities and support services should adopt a culturally responsive approach. For example, career counsellors and academic advisors might need to engage with students' families or community leaders to set realistic expectations about the timeline and outcomes of an engineering degree. By doing so, they can help relieve undue pressure on students while maintaining the positive encouragement that families and communities provide. Universities could also celebrate and harness the *collective pride* in student achievements – for instance, through community outreach or family-inclusion events – so that cultural norms become an asset rather than a stressor. In essence, understanding the cultural context allows institutions to better support students in a holistic way, ensuring that resilience is bolstered by cultural values without students bearing an unfair emotional burden. This theme underlines that resilience is not culture-blind: effective strategies to promote persistence must resonate with students' cultural realities and leverage the strengths of those norms, all while buffering students against the possible strains.

Summary

Each of these themes – personal attributes, social support, institutional structures, financial constraints, and cultural norms – illustrates a layer of the complex ecosystem that contributes to student resilience. The patterns in our data reflect an interplay of factors consistent with the socio-ecological model, reinforcing the idea that resilience in higher education is a multi-dimensional, context-dependent process. By integrating our findings with existing literature, we see that our participants' experiences both support and enrich current theories: personal grit matters but is buoyed by external supports; social networks act as safety nets and springboards; institutional efficacy can empower or exhaust students; economic hurdles continue to test resilience in profound ways; and cultural narratives give meaning to the struggle, for better or worse. The practical implication is that improving student success in challenging programs like engineering

requires comprehensive strategies that address all these layers. Interventions must not only cultivate resilient mindsets in students, but also build robust support systems around them, from family and peer engagement to responsive university services and broader socio-economic support. Such an integrated approach acknowledges resilience as a shared endeavour, aligning with emerging frameworks that view student success as a 'geared' interaction of personal, relational, and structural support mechanisms. Ultimately, our study's discussion highlights that to foster resilience and persistence, higher education must move beyond viewing students as solely responsible for their success and instead nurture the environments that enable every student to thrive.

Practical implications and recommendations

This study points to several areas where universities can strengthen the support structures that promote student resilience and academic persistence. While the findings reflect the experiences of a small sample, the patterns across ecological levels suggest a number of practical, system-level interventions.

Improve administrative clarity and timing

Unpredictable bursary disbursements and vague communication about test dates created significant stress for students. Streamlining these systems and improving transparency could free up students' time and energy to focus on learning, rather than managing uncertainty.

Strengthen lecturer–student relationships

Participants valued encouragement, accessibility, and simple acts of recognition from their lecturers. Workshops that support lecturers in building relational teaching practices – including active listening and clear feedback – could improve students' confidence and academic engagement, especially in large or high-pressure courses.

Create peer mentorship and study group structures

Students often turned to peers for academic and emotional support, particularly when formal services felt impersonal or difficult to access. Building on this strength by formalising peer mentorship programs and study group facilitation would build on this existing strength and help create a stronger learning community.

Curriculum design for flexibility

Engineering programs that rely heavily on labs and fixed schedules need to account for external factors like load shedding and transport disruptions. Additional universal timetable slots for missed classes, open-access software (student licensed) or open labs for after-hour use, and additional tutorial support like lecture recordings can help students keep up when conditions are unpredictable.

Connect students with community-based support

Several participants drew strength from local mentors, religious leaders, or family members working in engineering fields. Universities can benefit from recognising and

engaging these community relationships, for example by inviting external mentors into orientation or career events.

Review the scope and relevance of academic support services
Students who used counselling and tutoring services found them useful. Periodic review of the effectiveness of these services helps ensure they remain responsive to evolving needs.

Targeted support for first-year students
Informed by Motsabi et al. (2020), institutions should consider gathering detailed profile data to guide the design of personal and social development programs, especially for first-generation students. These could include assertiveness and self-regulation workshops, peer mentorship, counselling, and structured team-building activities during orientation.

These recommendations highlight that nurturing student resilience is not the job of a single office or department. It requires coordinated, ongoing attention to the systems that shape students' everyday experiences of learning and belonging.

Limitations and future research

Several limitations should be acknowledged when interpreting the findings. First, the sample was small and context-specific. With only seven participants, the study prioritised depth over generalisability. While this allowed for rich, detailed accounts, it may not capture the full range of student experiences across different departments, years of study, or socio-economic backgrounds. Future studies could expand the sample or include multiple institutions to explore how resilience manifests in other contexts.

Second, the study used a deductive framework based on the micro, meso, exo and macro systems in the socio-ecological model, which provided structure but may have limited the emergence of unanticipated themes. A combined inductive and deductive approach could enrich the analysis and allow more space for novel insights, especially those specific to South African higher education.

Third, the research offers a snapshot in time. Resilience is dynamic, shaped by personal growth, shifting responsibilities, and changing external conditions. A longitudinal design could help capture how students' coping strategies and support systems evolve over their academic journey.

Lastly, while this study focused on students' voices, future research could include the perspectives of lecturers, advisors, and support staff. Understanding how they perceive and respond to student resilience could inform more coordinated institutional approaches.

Conclusion

This study explored the factors that support or undermine resilience among engineering students at a South African university of technology. Drawing on Ungar's (2011) socio-ecological model, it showed that student persistence is shaped not just by individual

characteristics, but by the dynamic interaction of personal, social, institutional, and cultural systems.

Students described how relationships with lecturers, support from peers, and encouragement from families and community mentors helped them navigate a demanding academic environment. At the same time, recurring challenges such as delayed funding, unreliable infrastructure, and inflexible teaching practices made their academic journeys more difficult. While many students found ways to adapt, the pressure to continually overcome systemic barriers came at a cost to their time, energy, and mental well-being.

The findings point to the need for coordinated efforts across all levels of the university experience. Rather than expecting students to carry the full burden of resilience alone, institutions can shape learning environments that foster a sense of connection, trust, and responsiveness. This includes timely administrative systems, flexible curriculum structures, and teaching approaches that recognise students as whole people with complex lives.

These findings are echoed in Mapaling's (2024) 'gears of connectivity' framework, which builds on Ungar's (2011) socio-ecological model by emphasising how student support must operate across interconnected levels. Like mechanical gears, support mechanisms in higher education must shift in tandem to meet students' evolving personal, academic, and social needs. This approach highlights the importance of integrated, flexible strategies that not only address gaps but also proactively nurture student development and well-being.

In focusing on students' lived experiences, this research invites universities to see resilience not as an individual trait, but as a collective outcome – one that emerges when systems work together to support student success in meaningful and sustainable ways. Ultimately, resilience grows strongest not in isolation, but through the everyday workings of a system that listens, adapts, and cares.

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