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EDUCATIONAL PSYCHOLOGY | RESEARCH ARTICLE

The relationship between resilience and student success among a sample of South African engineering students

Mariza van Wyk^{1,2}, Henry D Mason³, Barend J van Wyk⁴, Tyler K. Phillips^{1,2} and P. Etienne van der Walt¹

Abstract: There is a growing need to understand the role of non-cognitive factors in relation to university students' academic performance and successful adaptation to university life. This study investigated the relationship between the non-cognitive factor "resilience" and student success (academic performance, turnover intentions, brain-body optimisation) among South African university students. This cross-sectional correlational study analysed data from 360 first-year students. Self-report data were collected using the Neurozone Assessment, comprising two subscales:

ABOUT THE AUTHORS

Mariza van Wyk (PhD) is a clinical neuropsychologist with clinical and research experience in both the private and public health sectors in South Africa. She has also completed specialised training at international institutions in the United Kingdom and Germany. Mariza has over 10 years' experience in applied neuroscience research and has published several peer-reviewed articles across different disciplines. These disciplines include clinical psychology, sleep medicine, cognitive neuroscience, and early-childhood development. Mariza is currently the Head of Science at Neurozone.

Etienne van der Walt is an accomplished neurologist with a special interest in psychoneuroimmunology and systems biology. Etienne's 14-year career as a clinical neurologist means he has a deep understanding of the anatomy, biology, and physiology of the brain and the human nervous system. For another decade, Etienne has been spearheading Neurozone, a neuroscience business dedicated to the application of brain science and analytics to enhance true resilience and high-performance capacity.

Henry Mason (Ph.D.) is a social science researcher at the Tshwane University of Technology (TUT) in Pretoria, South Africa. He is registered as a Psychologist with the Health Professions Council of South Africa and holds a Y-rating from the National Research Foundation (NRF) in South Africa. Besides publishing more than 40 articles in scientific journals, Henry has also read over 100 papers at conferences.

Henry's research interests focus on studying the role and application of positive psychology and non-intellective factors in relation to student success.

Barend van Wyk has a passion for technology and the demystification and communication of complex technological, scientific, educational, and management concepts in a novel and fun way. He studied at various institutions, including the University of Southern Mississippi and the University of the Witwatersrand, where he obtained his Ph.D. He has more than 12 years of industry experience in telecommunications and aerospace engineering, has been an academic for 15 years, is an NRF-rated researcher who has published more than 173 peer-reviewed journal and conference papers and has successfully supervised/co-supervised more than 44 doctoral and master's students. His research interests include artificial and computational intelligence, machine learning, and engineering education.

Tyler K. Phillips is a junior research psychologist who recently graduated from the University of Cape Town with a Master of Arts in Psychological Research. His interests include the social psychology of sexuality and gender, as well as the neuropsychology of resilience. Tyler has experience in sleep research (including the application and monitoring of polysomnography), legal consultation (specifically, child custody supervision), screening procedures for systematic reviews, conducting focus groups, interviews, and test batteries, and teaching psychology to undergraduates.

the Brain Performance Diagnostic and the Resilience Index. Turnover intentions were assessed using the Neurozone Assessment, and students' academic marks were obtained via the university's management information system. Correlational analyses revealed significant positive relationships between the *Stress Mastery* and *Positive Affect* components of resilience and academic performance, a significant negative relationship between the *Positive Affect* component of resilience and turnover intentions, as well as significant positive relationships between brain-body optimisation and all three components of resilience (*Stress Mastery*, *Positive Affect*, and *Early-Life Stability*). Through regression analyses, we identified the behavioural predictors that underlie resilience and outline a framework for implementing behavioural interventions to enhance resilience and increase student success. Resilience is an important non-cognitive determinant of student success in first-year students.

Subjects: Neuropsychology; Educational Psychology; Higher Education

Keywords: academic performance; engineering students; resilience; student success

1. Introduction

Research is unequivocal: first-year university students encounter significant stressors as they attempt to transition from school to university life (Bewick et al., 2010; Grøtan et al., 2019; Igbo et al., 2016). High academic expectations amplify the stressful transition to university, especially in light of limited or inaccessible resources, such as financial sustenance and social support (Abdallah & Gabr, 2014; Enoch & Renk, 2006; Mutambara & Bhebe, 2012). The inability to access resources could impinge on students' capacity to adapt to academic expectations, leading to poor academic performance, high attrition rates, and psychological distress (Grøtan et al., 2019; Pillay & Ngcobo, 2010). Within the South African higher education context, where resource scarcities are commonplace, the situation is particularly challenging (Habib, 2016; Scott, 2018).

Research has indicated that numerous factors contribute to the low success and high attrition rates within the South African higher education milieu (Banerjee, 2016; Wilson-Strydom, 2015). For example, much of the South African student population comes from impoverished rural areas and informal settlements (Lewin & Mawoyo, 2019; Van Zyl, 2016). In addition to a high proportion of students growing up in under-resourced regions, a significant subset is also first-generation university students (Scott, 2018). Although first-generation students might exhibit higher resilience levels than non-first-generation students (Alvarado et al., 2017), students from disadvantaged and lower socioeconomic backgrounds are predisposed to be at risk for academic failure and drop-out (Banerjee, 2016; Davino, 2013; Van Zyl, 2016). Thus, physical access to a university does not necessarily lead to epistemic access and student success (Tinto, 2012; Wilson-Strydom, 2015).

Significant emphasis has been placed on epistemic access within the South African higher education context (Scott, 2018). The guiding argument is that students who have gained physical access to university via enrolment and registration should be supported in accessing the knowledge that universities can impart through, inter alia, the provision of student development and support (SDS) initiatives (Dockrat, 2016; Tinto, 2012). In this regard, Seidman (2005) proposes that early assessment of potentially problematic areas and intensive and ongoing support are vital aspects to consider when working with at-risk students if the goal is student success.

To date, pre-admission psychometric assessments and other forms of collateral cognitive information, such as school results, have been used as measures to admit students to South African universities (Van Wyk et al., 2015; Opperman & Greyling, 2015). However, research on the exclusive use of cognitive factors in predicting academic success has presented mixed results (Foxcroft & Roodt, 2013). While some researchers have indicated the value of cognitive assessments (Opperman & Greyling, 2015; Richardson et al., 2012), others have indicated that non-cognitive factors are essential in fostering academic performance and life success among (not only) first-year students (Credé & Kuncel, 2008; Dweck, 2006; Marques et al., 2017). Non-cognitive factors refer to skills, knowledge, and behavioural competencies that form part of the predictive map of academic performance. However, non-cognitive factors are not assessed using traditional cognitive measures or test batteries (Farrington et al., 2012).

A growing body of literature has called for further exploration into non-cognitive factors that could promote academic performance among first-year students (Van Herpen et al., 2017; Van Rooij et al., 2013). Moreover, it is imperative to focus on enhancing access to resources that could improve student success (Arnekrans et al., 2018; Bowers & Lopez, 2010). Whereas the concept of student success has traditionally been related to academic performance, recent articulations have emphasised a holistic conception that encapsulates academic achievement, engagement in educational activities, and the cultivation of non-cognitive factors (Mason, 2019; Nelson & Low, 2011; Sinclair, 2019). At an individual level, non-cognitive factors also hold the potential to serve as buffers against stressors that students may experience during the first year of tertiary study, thereby enhancing a sense of resilience (Hostinar & Gunnar, 2015; Nelson & Low, 2011; Van Rooij et al., 2013).

1.1. Resilience

Resilience has been described as an innate capacity rooted in diverse neurobiological systems (Akimova et al., 2009; Jiang et al., 2017; Osório et al., 2017) that also encompasses various genetic, developmental, psychosocial, and environmental factors (Black et al., 2017; Shonkoff, 2016; Southwick & Charney, 2012; Southwick et al., 2005; Traub & Boynton-Jarrett, 2017). Resilience, therefore, is considered a multifaceted construct which manifests as positive adjustment, coping, and learning in the face of challenges and adversity (Southwick et al., 2014; Wu et al., 2013). Thus, resilience points to the dynamic interplay between demands placed on an individual and their subsequent response and positive adaptation to those demands (Kotzé & Kleynhans, 2013; Southwick et al., 2014).

All individuals can draw on an array of intrinsic and extrinsic psychosocial factors that may promote resilient responses to stressors. This is clearly also true of university students. Examples of relevant intrinsic factors are growth-oriented mindsets, psychological hardiness, and optimism (Duckworth, 2016; Dweck, 2006). Extrinsic factors include social support, socioeconomic resources, and the availability of student counselling services within the university context (Docrat, 2016; Lewin & Mawoyo, 2019; Van Zyl, 2016). Resilience, therefore, has been identified as a prominent non-cognitive factor and psychological strength that could promote student success and optimal performance in higher education (Elizondo-Omana et al., 2007; Kotzé & Kleynhans, 2013).

This is especially relevant for students residing in low- to middle-income countries (LMICs) like South Africa, who are faced with both a higher number and severity of psychosocial and socio-economic stressors compared to individuals in high-income countries (Demyttenaere et al., 2004; Sommer et al., 2015). More specifically, individuals in LMICs are exposed to higher levels of early life stress as well as traumatic experiences across the lifespan and are, consequently, more susceptible to the development of serious mental health conditions (MacGinty et al., 2019). Therefore, enhancing students' resilience could not only be a protective factor in the face of the stressors first-year students in LMICs typically face, but can also simultaneously serve as one important determinant of student success.

Student success should not only be measured by traditional institutional parameters like academic performance and attrition rates. A more holistic approach can be adopted where, in addition to institutional parameters, the focus can be on the development of different intra- and interpersonal competencies that can increase students' capacity for high performance and, consequently, student success (Neurozone®, 2017). Increasing an individual's capacity for high performance in this way is subserved by a process called brain-body optimisation (Neurozone®, 2017).

Empirical studies have identified vital drivers that are imperative for optimising the brain-body system. These are (1) foundational drivers (e.g., exercise, sleep; Nota & Coles, 2012), (2) emotional drivers (e.g., social safety, goal-directedness; Walton & Cohen, 2011), and (3) higher-order drivers (e.g., learning, executive function; Lutz et al., 2008). Thus, brain-body optimisation encompasses a state where individuals—here, students—develop the inner competencies to withstand break-down in the face of challenges and adversity. Moreover, it is hypothesised that optimised brain-body integration promotes resilience, thereby serving as a foundation for high performance or for student success (Neurozone®, 2017).

1.2. Rationale and specific aims

The role of resilience as a non-cognitive factor and buffer in supporting first-year students to cope with the stressors within the university context has been the focus of previous research (Arnekrans et al., 2018; Ayala & Manzano, 2018; Haktanir et al., 2021; Kotzé & Kleynhans, 2013). However, the association between resilience and student success, with a particular emphasis on academic marks and turnover intentions, has not been clearly established. Furthermore, the relationship between resilience and the brain-body system requires additional empirical attention (Neurozone®, 2017). Guidelines are also needed to assist persons working in SDS capacities with developing interventions focused on addressing resilience, brain-body optimisation, and student success, especially among first-year students (Davidson et al., 2012; Galante et al., 2018; Mason, 2019).

In light of these arguments, we propose that enhancing and leveraging the resilience of both individual students and student groups might be one mechanism by which student success could be optimised. We hypothesise that the optimisation of resilience among first-year students could positively affect student success by enhancing academic performance, reducing turnover intentions, and boosting brain-body optimisation. As an initial step towards investigating the hypothesis, a correlational study was conducted to explore two research goals. Firstly, we explored the relationship between resilience and student success, operationalised as academic performance, turnover intentions, and brain-body optimisation. Secondly, we set out to identify specific drivers that could inform behavioural interventions to enhance resilience and increase the likelihood of student success.

2. Methods

2.1. Research design and context

A quantitative and cross-sectional correlational design was adopted to conduct the study (Field, 2013). The study was conducted at a South African university that accommodates approximately 60,000 students; nearly 20,000 are first-year students. The student population is representative of the broader multi-ethnic South African demographic profile (51% female, 80.7% African, 8.8% Coloured, 8.1% White, 2.5% Indian/Asian; Statistics South Africa, 2016). Those first-year students who participated were enrolled for courses within the Faculty of Engineering and the Built Environment due to the authors' affiliation with this group.

2.2. Participants

A total of 360 first-year university engineering students participated in the study. There were no specific exclusion criteria implemented because we aimed to include participants who present in varied ways in relation to resilience and the other variables of interest.

The sampled students all participated in a student development and support (SDS) programme at the university. The mean age was 19.62 ($SD = 1.887$), while the majority of participants were male (71.82%), with a significantly lower percentage of female participants (28.18%). The proportion of male to female students in the study is consistent with trends in the field that point to greater male dominance in the engineering profession (Makarova et al., 2019).

Full academic data for 248 participants were available and included in the study (male = 177, female = 71, mean age = 19.67, $SD = 1.98$). Thus, the sample of participants included to investigate the relationship between resilience and student success, with a specific focus on academic performance (grades), was 248.

2.3. Measures

Data were collected using the Neurozone Assessment, which consists of the Brain Performance Diagnostic (BPD) and the Resilience Index. Additionally, academic performance marks were obtained via the university's management information system.

2.3.1. The brain performance diagnostic

The BPD is a statistically validated tool that assesses functioning across ten brain performance drivers by evaluating 68 behaviours and constructs known to enhance a person's capacity for high performance (Neurozone®, 2017). The BPD has demonstrated good reliability with an average Cronbach's α of 0.750 (range: 0.720–0.800) across the different factors. Table 1 provides an overview of the ten drivers that are assessed by the BPD. Participants respond to 164 questions with response options on a five-point Likert scale ranging from 0 (Strongly disagree) to 4 (Strongly agree). Additionally, participants respond to questions focused on time and duration inputs, for example, exercise and sleep duration. Examples of items include "I have a sense of belonging in my personal life", "When facing a problem, I consider

Table 1. Drivers assessed in the neurozone brain performance diagnostic

Drivers	Examples of Behaviours & Constructs
Exercise	Duration, diversity, balance & flexibility exercises
Nutrition	Dietary balance, intermittent fasting, alcohol consumption
Sleep/wake cycle	Sleep duration, bedtime consistency, alarm snooze avoidance
Silencing the Mind	Times a week, deep breathing, open monitoring
Social safety	Trust, identity, meaning, belonging in personal & student life
Goal-directedness	Negative thought patterns, gratitude, optimism, curiosity
Collective creativity	Student diversity, empathy & compassion, disruptive thinking
Learning	Learning (un)related to the course of study, learning techniques
Abstraction	Divergent thinking, functional flexibility
Executive function	Brain-training, constructive mind-wandering

different possible solutions or break it down into basic parts” and “Please indicate how much time in total you did balance and flexibility exercises in the past week.” The BPD produces a weighted composite score called the brain-body optimisation score (BBOS), indicating how well an individual is optimised for high performance.

In addition to measuring the ten drivers of brain performance, the BPD also evaluates an individual’s turnover intentions. More specifically, the BPD offers a quantitative value indicating how likely a participant is to (a) drop out of their field of study and (b) leave the specific academic institution. This quantitative value is based on items asking: “How likely are you to change your field of study?” and “How likely are you to leave your institution?”. Participants respond to the turnover intention questions on a Likert scale ranging from 0 (Unlikely) to 9 (Likely). The second component of the Neurozone Assessment relates to measuring resilience.

2.3.2. The resilience index

The Resilience Index has been demonstrated to be a reliable and valid measure of psychological resilience (Van Wyk et al., 2022). Development and validation of the Resilience Index entailed collecting data from 686 students from two tertiary institutions in South Africa between May and December 2019.

Concerning scale development, principal component analysis revealed the emergence of three components: (1) *Positive Affect* ($\alpha = .879$), (2) *Stress Mastery* ($\alpha = .683$), and (3) *Early-Life Stability* ($\alpha = .879$; Van Wyk et al., 2022). A component loading of .50 was adopted for item inclusion, which resulted in the retention of 28/53 original items. Table 2 offers an overview of the three components that make up the Resilience Index.

Table 2. The three components of the resilience index

Component	Descriptions	Range of Loadings
1. Positive Affect	Positive Affect refers to positive emotions like optimism, meaningfulness, gratitude, and forgiveness.	0.522–0.753
2. Stress Mastery	Stress Mastery relates to experiences of toxic stress (multiple stressful events accompanied by a lack of control over the events), as well as intrusive thoughts about the past, the future, and feelings of helplessness. Items for this component are reverse-scored.	0.564–0.638
3. Early-Life Stability	Early-Life Stability relates to the degree to which individuals felt, for example, safe, loved, and well looked-after during childhood and adolescence. It also relates to experiencing entrusting and stable relationships with a caregiver and peers while growing up.	0.552–0.830

With regard to validity testing, results show that the Resilience Index has good concurrent, convergent, and incremental validity (Van Wyk et al., 2022).

The 28 items are scored on a 5-point Likert scale ranging from 0 (Strongly disagree) to 4 (Strongly agree). Examples from the *Positive Affect* component include “I am optimistic about my life and my future” and “I have a positive outlook on my ability to cope with setbacks”; examples from the *Stress Mastery* component include “Throughout my life, I experienced several strong stressful events/periods”, and “I tend to think about and be pre-occupied with the past”; finally, examples from the *Early-Life Stability* component include “While growing up (up to age 18), I felt protected against harm”, and “While growing up (up to age 18), I felt loved”.

2.3.3. Academic performance

All participants were registered for academic subjects within first-year engineering courses at a South African university. The academic marks were obtained from university records, and the academic grades were calculated by summing the numerical values of each subject’s scores. Mean scores were calculated based on semester marks, which were all evenly weighted.

2.4. Procedure

The Neurozone Assessment was completed in an online format at the end of the second semester approximately one month before the final exams. Students were invited to complete the Neurozone Assessment at the specific university’s computer laboratories during scheduled times to ensure that data collection did not affect their academic classes and related tasks. The data collection process, which took approximately 45 minutes to complete, was managed by psychometrists at the university who were not affiliated with the study. Following the data collection process, all participants received a standard Neurozone Assessment report, and a feedback workshop was presented to discuss the results, answer participants’ questions, and address concerns. Students were also informed about strategies they could adopt to address the recommendations presented in their Neurozone Assessment reports.

2.5. Data analysis

The data were analysed using IBM SPSS statistics (Version 27). Descriptive statistics were calculated for the BPD, Resilience Index, and students’ academic performance. The Pearson product moment correlation coefficient was used to determine the relationship between the different components of resilience (*Stress Mastery*, *Positive Affect*, and *Early-Life Stability*) and student success (academic marks, turnover intentions, and brain-body optimisation). Based on results from correlational analyses, we ran linear regression in order to determine which behavioural predictors underlie increased *Stress Mastery*, *Positive Affect*, and *Early-Life Stability*.

2.6. Ethical considerations

The university where the study was conducted provided ethical clearance (reference number: REC/2019/11/003). All participants were informed that participation was voluntary and signed informed consent forms. Students did not receive course credit for participating in the study.

3. Results

We will report firstly on the descriptive statistics, followed by the correlational analyses results, and finally, the findings from the regression analyses.

3.1. Descriptive statistics

Results from the Neurozone Assessment outlined in Table 3 show that both the Resilience Index score and the BBOS (derived from the BPD) are comparable to data collected from student populations studied previously (Neurozone®, 2017). However, the course turnover intentions score appears higher than earlier data (Neurozone®, 2017). Scoring higher on the turnover intentions metric means that students from the current study are more likely to change their study course compared to students assessed previously.

Table 3. Descriptive statistics (N = 360)

Variable	Mean (SD)
Resilience index score	71.360 (9.726)
Stress mastery	39.310 (15.738)
Positive affect	80.970 (10.228)
Early-life stability	78.830 (18.007)
Brain-body optimisation score	60.930 (8.034)
Course turnover intentions	2.240 (2.961)
Academic performance ^a	51.661 (16.554)

Note. ^a: N = 248 (This includes the subset of the total sample for which academic data were available.)

3.2. Correlational analyses

We set out to assess the relationship between the three components of resilience (*Stress Mastery*, *Positive Affect* and *Early-Life Stability*) and student success (academic marks, turnover intentions, and brain-body optimisation).

Table 4 shows that the *Stress Mastery* component of resilience is significantly and positively associated with academic performance ($r = 0.143$), while the *Positive Affect* component has a significant positive relationship with academic performance ($r = 0.129$) and a significant negative relationship with course turnover intentions ($r = -0.122$). In addition, there is a significant positive relationship between the BBOS and all three resilience components: *Positive Affect* ($r = .564$), *Stress Mastery* ($r = .173$), and *Early-Life Stability* ($r = .293$). Finally, we also found a significant negative correlation between (a) course turnover intentions and academic performance ($r = -0.229$), (b) course turnover intentions and the BBOS ($r = -.169$), and (c) a significant positive correlation between academic performance and the BBOS ($r = .152$).

3.3. Regression analyses

Based on the correlational results, we ran regression analyses to determine which Neurozone drivers/behaviours (see Table 1) significantly predict high scores on *Stress Mastery*, *Positive Affect*, and *Early-Life Stability*. These outcomes were selected due to the significant correlations observed with student success variables (academic performance, course turnover intentions, and brain-body optimisation).

Table 5 summarises the results from the regression analyses. These results show that there are seven significant behavioural predictors of *Stress Mastery*, which include, in order of the magnitude of their contribution, the following: negative thought pattern reduction ($\beta = 0.299$), medication avoidance ($\beta = 0.157$), consumption before bed ($\beta = 0.132$), meaning in student life ($\beta = 0.110$), destructive habit avoidance ($\beta = 0.108$), exercise duration ($\beta = 0.104$), and bedtime consistency ($\beta = 0.094$).

Table 4. Correlations between resilience & student success (N = 248)

	Academic Performance	Positive Affect	Stress Mastery	Early-Life Stability	BBOS Index	Course TI
Academic Performance	-	0.129*	0.143*	0.005	0.152**	-0.229**
Positive Affect	0.129*	-	0.243***	0.253***	0.564***	-0.122
Stress Mastery	0.143*	0.243***	-	0.045	0.173**	-0.004
Early-Life Stability	0.005	0.253***	0.045	-0.293***	0.293**	-0.043
BBOS	0.152**	.564***	0.173**			-0.169**
Course TI	-0.229**	-0.122*	-0.005	-0.043	-0.169**	-

Note. Pearson *r* Correlation computed for all variables; one-tailed analyses adopted for all variables due to a priori predictions. BBOS Index = Brain-Body Optimisation Score; Course TI = Course Turnover Intentions; *, *p* = <.05; **, *p* = <.01; ***, *p* = <.001.

Results also show that there are nine significant behavioural predictors of *Positive Affect*. These include the generic parts problem-solving technique ($\beta = 0.259$), meaning in student life ($\beta = 0.210$), negative thought pattern reduction ($\beta = 0.162$), optimism, ($\beta = 0.132$), gratitude ($\beta = 0.109$), meaning in personal life ($\beta = 0.106$), learning techniques diversity ($\beta = 0.102$), belonging in student life ($\beta = 0.101$), and silencing the mind (mindfulness)—times a week ($\beta = 0.088$).

Finally, analyses revealed five behavioural predictors of *Early-Life Stability*. These include belonging in personal life ($\beta = 0.267$), fruit and vegetable consumption ($\beta = 0.136$), gratitude ($\beta = 0.115$), silencing the mind—noise mastery ($\beta = 0.108$), and identity in personal life ($\beta = 0.105$).

Table 5. Behavioural predictors of the three resilience components (N = 360)

Variables	b	Std. error	Beta	t	P	Models R ²
<i>Outcome: Stress Mastery</i>						0.253
Predictors:						
Negative thought pattern reduction	0.066	0.011	0.299	6.056	<0.001***	
Sleep medication avoidance	0.055	0.017	0.157	3.296	<0.001**	
Consumption before bedtime	0.013	0.005	0.132	2.810	0.005**	
Meaning in student life	0.027	0.012	0.110	2.258	0.025*	
Destructive habit avoidance	0.008	0.004	0.108	2.294	0.022*	
Exercise duration	0.012	0.006	0.104	2.207	0.028*	
Bedtime consistency	0.016	0.008	0.094	2.014	0.045*	
Constant	-5.654	1.924	-	-2.939	0.004**	
<i>Outcome: Positive Affect</i>						0.604
Predictors:						
Generic parts problem-solving technique	0.149	0.022	0.259	6.754	<0.001***	
Meaning in student life	0.136	0.026	0.210	5.301	<0.001***	
Negative thought pattern reduction	0.095	0.022	0.162	4.365	<0.001***	
Optimism	0.085	0.027	0.132	3.194	0.002**	

(Continued)

Variables	b	Std. error	Beta	t	P	Models R ²
Gratitude	0.075	0.027	0.109	2.807	0.005**	
Meaning in personal life	0.103	0.040	0.106	2.585	0.010*	
Learning techniques diversity	0.084	0.031	0.102	2.718	0.007**	
Belonging in student life	0.059	0.024	0.101	2.505	0.013*	
Silencing the mind—times a week	0.030	0.012	0.088	2.539	0.012*	
Constant	16.149	3.211	-	5.029	<0.001***	
<i>Outcome: Early-Life Stability</i>						0.249
Predictors:						
Belonging in personal life	0.268	0.053	0.267	5.100	< 0.001***	
Fruit & vegetable consumption	0.102	0.035	0.136	2.919	0.004**	
Gratitude	0.140	0.061	0.115	2.303	0.022*	
Silencing the mind—noise mastery	0.050	0.022	0.108	2.301	0.022*	
Identity in personal life	0.116	0.054	0.105	2.318	0.033*	
Constant	23.175	5.939	-	3.902	<0.001***	

Note. *: $p < .05$; **: $p < .01$; ***: $p < .001$.

4. Discussion

4.1. Resilience and student success

We set out to investigate the relationship between the different components of resilience (*Stress Mastery*, *Positive Affect*, and *Early-Life Stability*) and student success (academic performance, turnover intentions, and brain-body optimisation). There are four main findings from the correlational analyses. These include, firstly, a significant positive association between *Stress Mastery* and academic performance; secondly, a significant positive relationship between *Positive Affect* and academic performance; thirdly, a significant negative relationship between *Positive Affect* and course turnover intentions; and fourthly, a significant positive relationship between the brain-body optimisation score (BBOS) and all three resilience components.

Additionally, we also detected significant relationships between the different variables that make up student success: academic performance had a significant negative correlation with course turnover intentions and a significant positive relationship with the BBOS. At the same time, there was a significant negative relationship between the BBOS and turnover intentions.

4.1.1. *Stress mastery and academic performance*

The results reported in the previous sections indicate that students who score low on *Stress Mastery* tend to struggle academically. According to the items that make up the *Stress Mastery* component, low-scoring students have typically experienced multiple strong, stressful events or periods throughout their lives. Multiple stressful events in this context relate to experiencing a lack of control and feelings of helplessness in the face of stressors (Van Wyk et al., 2022).

This lack of control and helplessness is a vital component of toxic stress (Ridout et al., 2018; Wu et al., 2013). Toxic stress is known to exert altering neurobiological and epigenetic effects and could negatively impact resilience across the lifespan (Lapp et al., 2019; Ridout et al., 2018). Furthermore, exposure to toxic stress predisposes an individual to the development of various psychiatric conditions (Atwoli et al., 2013; Seedat et al., 2004). Such exposure could be harmful to students, especially during the already stressful first-year experience (Bewick et al., 2010; Grøtan et al., 2019; Igbo et al., 2016). Moreover, given the ubiquity of stressors and challenging socioeconomic challenges within the South African milieu, the high prevalence of toxic stress among university students highlights some of the existing fault lines in the South African higher education context (Morgan, 2013; Scott, 2018; Wilson-Strydom, 2015).

Notably, *Stress Mastery* includes items related to intrusive thoughts about past events, concerns about the future, and feelings of helplessness (e.g., “I tend to think about and be preoccupied with the past” and “I often feel that I have little or no control over my environment”; Van Wyk et al., 2022). Therefore, the *Stress Mastery* component comprises both a relatively stable element (the occurrence of several strong, stressful events in the past) and a more state-like element related to current intrusive and incapacitating cognitions. In light of this delineation, it becomes apparent that the relationship between *Stress Mastery* and academic performance is complex and multifaceted.

Accordingly, we contend that *Stress Mastery* among students should be approached as a dual process. Firstly, it is imperative to raise awareness of and increase accessibility to SDS services on campus for students who need treatment related to toxic stress (Cilliers, 2014; Nelson & Low, 2011). The availability of counselling services could address the relatively more stable aspect of *Stress Mastery*, namely the sequelae related to experiencing multiple significant stressful events/periods in the past. Secondly, behavioural interventions, such as those outlined in Table 5 (e.g., reducing negative thought patterns and cultivating a sense of meaning in life), can help address the more state-like elements of *Stress Mastery* (Mason, 2019).

4.1.2. *Positive affect, academic performance, and course turnover intentions*

The *Positive Affect* component of the Resilience Index refers to positive emotions and characteristics (Van Wyk et al., 2022). These positive emotions and characteristics include optimism, trait mindfulness, gratitude, forgiveness, cognitive reappraisal, and active coping. These can further be divided into relatively stable trait-like aspects (e.g., trait mindfulness, cognitive reappraisal, active coping) and dispositional aspects (e.g., optimism, gratitude), which, in combination, can shape the way an individual approaches and appraises stressors and challenges (Southwick & Charney, 2012; Southwick et al., 2005; Thompson et al., 2011; Wu et al., 2013). Therefore, *Positive Affect* possibly functions as a protective factor in the face of adversity.

With regard to the *Positive Affect* component’s relationship with academic performance specifically, the state-like elements (e.g., optimism) of this component could act as a strong motivational force behind an individual pursuing academic success when, and despite, encountering setbacks (which also speaks to the mastery motivation facet of *Positive Affect*). The trait-like aspects (e.g., cognitive reappraisal and active coping) could serve as powerful cognitive and behavioural strategies to overcome academic challenges and setbacks. The influence of both the

state- and trait-like elements of the *Positive Affect* component could also explain why students who score high on the *Positive Affect* component are less likely to leave their field of study.

Similar to *Stress Mastery*, enhancing students' *Positive Affect* can be achieved by adopting a two-tiered approach. The first part of the approach relates to addressing the trait-like aspects of *Positive Affect* (e.g., cognitive reappraisal and active coping) by improving students' awareness of and access to counselling services on campus in order to assist them in developing strategies that will aid in overcoming personal and study-related adversities and setbacks. The second part of the approach relates to addressing the more state-like aspects by devising and implementing behavioural interventions, for example, assisting students in cultivating a sense of belonging, trust, and meaning in student life, and practicing daily gratitude (see Table 5).

4.1.3. *Early-life stability*

The *Early-Life Stability* component refers to the extent to which an individual formed trusting relationships with caregivers during childhood and adolescence, felt safe and protected while growing up, and had access to sufficient resources to meet all their emotional and instrumental needs (Van Wyk et al., 2022). *Early-Life Stability*, therefore, possibly acts as a buffer against early adverse life events (EALs). Examples of EALs include abuse, discordant caregiver relationships, assault, and neglect. These EALs have been shown to exert a pertinent negative effect on the development of a child's stress response system (Hornor, 2015; Shonkoff, 2016; Traub & Boynton-Jarrett, 2017). Importantly, EALs occur at a disproportionately higher rate in low- to middle-income countries like South Africa in comparison to high-income countries (Demyttenaere et al., 2004; MacGinty et al., 2019; Sommer et al., 2015).

Interestingly, behavioural predictors (Table 5) of high *Early-Life Stability* include interpersonal elements like having a sense of belonging and identity in one's personal life. Identity formation, belonging, and bonding in adulthood might therefore be influenced by early life experiences of attachment like feeling loved, supported, and protected while growing up (all of which are measured in the Resilience Index). Therefore, having access to student support services could both address the potential sequelae associated with experiencing EALs and assist students in developing strategies to form healthy interpersonal relationships in their personal lives as well as in the university context.

4.1.4. *Resilience and brain-body optimisation*

Results also showed significant positive relationships between the brain-body optimisation score (BBOS) and all three resilience components. The BBOS is a weighted composite score based on 68 behaviours categorised across 10 drivers of high performance (see Table 1). These drivers include, for example, exercise, sleep, goal-directedness, collective creativity, and learning. Therefore, the heterogeneity of the behaviours and drivers that make up the BBOS could serve as one explanation for the significant correlations with all three resilience components.

Furthermore, these results support the extant literature indicating that resilience is strongly related to the presence and capacity to access interpersonal (e.g., social relationships) and intrapersonal (e.g., optimism and gratitude) resources to deal constructively with a variety of stressors (Haktanir et al., 2021; Kotzé & Kleynhans, 2013; Nelson & Low, 2011).

4.1.5. *Academic performance, turnover intentions and brain-body optimisation*

Our results show that, consistent with the literature, participants who expressed a greater likelihood of changing their field of study were also more likely to present with lower academic success (Gopalan et al., 2019; Lewin & Mawoyo, 2014). Because the factors associated with turnover intentions were not investigated, it is unclear what motivated students' intentions to leave their study field. However, based on reports in the empirical literature, it could be hypothesised

that the stressors associated with university life (Bewick et al., 2010; Grøtan et al., 2019), along with limited access to resources such as financial sustenance and social support (Abdallah & Gabr, 2014; Mutambara & Bhebe, 2012) could negatively affect students' capacity to remain resilient and engaged in their academic pursuits (Scott, 2018).

Finally, we found that students with higher BBOSs also tended to perform better academically and were less likely to leave their field of study. The BBOS represents the optimisation of several intra- and interpersonal competencies and is, therefore, a holistic and encompassing indicator of high performance and likely contributes positively to student success (Neurozone®, 2017).

4.2. Limitations and directions for future research

The findings reported in this study should be interpreted in light of certain limitations. Firstly, a cross-sectional research design was adopted. Hence, the study did not explore the dynamic nature of concepts such as resilience. Data collection at different times during the student lifecycle could have sketched a different picture. Secondly, the external reliability of the results is subject to certain limitations. The study was conducted among students at a single faculty at a single South African university. Furthermore, the sample size of 248 students prevents generalisability of the relationship between resilience and academic marks. Thirdly, another limitation around generalisability relates to the sample mainly consisting of men (71.82%), even though men make up 49% of the entire student body at the institution where the data was collected. While the gender distribution of the Engineering Faculty included in this study is congruent with other institutions, generalising the results to the student body at large should be done with caution. Fourthly, the study only included first-year engineering students who attended the SDS programme, and therefore does not necessarily represent all first-year students enrolled in engineering programmes. Lastly, the measurement of the academic marks was prone to certain limitations. Numerous extraneous factors not controlled by the study design could have affected students' academic marks.

The limitations discussed above pave the way for further research. Future studies could adopt longitudinal designs to capture the dynamic variability of resilience during the student journey. Researchers could consider incorporating qualitative methods alongside quantitative data sources to explore students' experiences in greater depth. Finally, it is suggested that persons working in SDS environments should utilise the findings reported here to develop support programmes for engineering students to optimise resilience in addressing student success.

4.3. Summary and conclusion

The study investigated the relationship between resilience and student success. Results revealed significant positive relationships between the *Stress Mastery* and *Positive Affect* components and academic performance, a significant negative relationship between *Positive Affect* and turnover intentions, as well as significant positive correlations between the brain-body optimisation score and all three components of resilience. Based on the results from regression analyses, we provided a framework of what type of behavioural interventions can be implemented to increase *Stress Mastery*, *Positive Affect*, and *Early-Life Stability* in order to increase the likelihood of student success in first-year students.

The findings make several basic and applied contributions to the literature as well as to persons working in the SDS field. As a basic contribution, the study highlighted the importance of resilience concerning student success. Moreover, the findings support the growing body of evidence regarding the significance of non-cognitive factors in helping students during their university experiences. At an applied level, the findings serve as the basis for the operationalisation of SDS services for engineering students. By focusing on the critical drivers of brain-body optimisation, we propose that SDS staff could develop and offer intervention programmes that help enhance students' resilience as they deal with the inevitable challenges encountered during the university experience.

Finally, this study pointed to the specific relevance of resilience as a non-cognitive factor that could enhance student success. Regardless of cognitive factors, resilience can therefore help first-year students navigate the demanding transition from school to university. Thus, by embracing resilience, students could develop the foundational skills that promote their brain-body optimisation and academic success.

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Disclosure statement

Authors M. van Wyk, T. K. Phillips, and P. E. van der Walt work for an organisation that develops behavioural assessments and interventions.

Author contribution

Authors at Neurozone (M. van Wyk, Phillips, & van der Walt) are primarily focused on researching resilience and the factors that compromise it or enable it to be enhanced. This research draws broadly from neuropsychology, systems science, and organizational psychology. While these authors study resilience for the general population, they have foci in occupational settings (e.g., organizations) and in populations that may be more susceptible to threats to their resilience (e.g., young adults such as university students). Hence, the authors sought in the current paper to investigate the relationship between resilience and a student population residing in a low- to middle-income country, where threats to resilience also tend to be higher. Authors affiliated with Tshwane University of Technology (Mason & B. van Wyk) shared interests with the Neurozone-affiliated authors in enhancing the resilience of university students with specific reference to engineering students.

Data Availability Statement

In line with the type of consent obtained from participants, the data supporting the findings of this study will be made available upon reasonable request.

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