Education, Training and Development Practices Sector Education and Training Authority

Matric Mathematics Achievement as a Predictor of University Success in Mathematics-Related Fields and the Implications for Skills Planning

Final Research Report

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Abstract

This research report examines the influence of Grade 12 Mathematics (Matric) performance on subsequent university success in mathematics-intensive disciplines. Drawing on two complementary empirical studies—one employing structural equation modelling (SEM) and the other utilizing Bayesian hierarchical analysis—we investigate both the direct and indirect effects of Matric Mathematics scores on academic outcomes. The SEM study demonstrates that strong Matric performance is a key predictor of early success in introductory mathematics modules, although its influence diminishes as students progress, with credit accumulation and institutional support playing increasingly critical roles. In parallel, the Bayesian analysis reveals that, while Matric scores significantly contribute to academic achievement, socioeconomic factors (notably school quintile) and progression rates emerge as vital determinants of long-term performance. Minimal gender differences are observed, yet students from lower-quintile schools continue to encounter greater challenges. Together, these findings underscore the necessity for enhanced preparatory programs, student support initiatives, and holistic admissions policies to foster a diverse and skilled STEM workforce in South Africa.

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1 Introduction and Rationale

Mathematics is widely regarded as a cornerstone of academic success, acting as a primary conduit into the high-demand areas of Engineering, Computer Science, and the Physical Sciences. In South Africa, where educational disparities persist, Grade 12 Mathematics is especially pivotal. While it serves as an essential determinant for university admissions into mathematically intensive programmes, it also highlights deeper systemic issues in the schooling sector. A learner's Matric Mathematics mark can either open doors to tertiary programmes or foreclose opportunities, reflecting how proficiency in this subject often signifies both individual aptitude and the availability of schooling resources [1, 2].

Crucially, the emphasis on Matric Mathematics as an admissions criterion is not free from critique. Many historically disadvantaged schools, often falling under the low-quintile categories, struggle with limited infrastructure, large class sizes, and arguably a shortage of well-qualified Mathematics teachers. These constraints may appear to undermine learners' preparation, leading to Matric marks that may underestimate genuine academic potential [3, 4]. At the same time, well-resourced schools can bolster their learners' results through intensive support programmes and advanced learning materials. This discrepancy highlights that Matric performance alone, while important, may not fully capture a student's readiness to thrive at university. The concept of mathematics attainment thus becomes entangled with socioeconomic privilege.

Beyond socioeconomic disparities, scholars have interrogated the role of gender in shaping Mathematics achievement and progression. Older research often implied a male advantage in mathematics-based subjects. However, more contemporary studies indicate that these differences are inconsistent and context-specific [9, 10]. In South Africa, certain findings suggest that female students, especially from historically disadvantaged backgrounds, may face subtle forms of discouragement. Factors such as teacher expectations, peer influences, and cultural perceptions around STEM fields can magnify or mitigate gender gaps. Consequently, it becomes critical to probe whether Matric Mathematics achievement interacts with gender, potentially amplifying or masking underlying inequities.

Central to addressing disparities in university success rates are bridging programmes and foundational courses. Their rationale is straightforward: if learners who demonstrated only borderline competence in Matric Mathematics can receive intensive postsecondary support, they may still excel in STEM programmes. Indeed, bridging modules or extended curricula have been linked to improvements in both retention and performance in South African universities [19]. Yet, questions persist about whether these interventions effectively redress entrenched gaps stemming from uneven basic education. For instance, a short-term catch-up programme might not suffice if learners have missed vital conceptual building blocks over many years. The demand for more empirically grounded evidence on the true efficacy of bridging approaches thus remains high.

In response to these complexities, the present research evaluates how strongly Matric Mathematics marks predict student performance in university Mathematics and related fields, while accounting for socioeconomic factors, gender, and other institutional variables. To achieve this, two analytical approaches are employed. First, a structural equation modelling (SEM) framework examines direct and indirect relationships among Grade 12 Mathematics achievement, university course credits in Mathematics, and demographic factors. This method offers insight into whether Matric performance exerts a sustained effect across multiple modules of varying complexity, or whether it mainly predicts outcomes in introductory courses. Second, a Bayesian hierarchical model is used to explore how prior mathematics competency interacts with admission scores, quintile background, and credit completion rates across different cohorts. Bayesian methods enable partial pooling of data, particularly valuable in contexts where different institutions, or even different programmes within the same institution, exhibit distinct teaching practices and resource availability.

A pivotal concern animating both analyses is whether apparent underperformance in Matric Mathematics always signals a low likelihood of tertiary success, or if contextual and institutional interventions can offset these deficits. If bridging programmes and targeted support prove decisive, then current admissions policies—often heavily anchored in Matric marks—may merit re-examination. Moreover, if the research reveals that learners from low-quintile schools perform comparably once given equitable resources, the onus shifts to policymakers to improve secondary-level mathematics teaching quality, ensuring a more even playing field. Conversely, should the data show that early underperformance remains a robust predictor of future struggle, then earlier and more comprehensive interventions at school level become even more imperative.

From a national development perspective, this inquiry bears significant implications. South Africa's ability to produce a robust STEM workforce depends partly on the steady supply of graduates adept in quantitative reasoning. If the Matric Mathematics pass rate and the subsequent throughput in STEM degrees remain low or skewed toward privileged learners, the country risks perpetuating existing inequalities in professional fields and stifling broader economic innovation. Thus, understanding how reliably Matric Mathematics forecasts academic success in higher education—and under what conditions it might be supplemented by bridging or foundational support—can guide policy interventions that target the root causes of educational inequity.

In synthesising two complementary analyses, this research aims to offer a deeper, more nuanced perspective than a single method alone could achieve. By linking quantitative modelling—through both SEM and Bayesian hierarchical frameworks—to real institutional outcomes, it also intends to arm university administrators, government officials, and curriculum planners with actionable insights.

1.1 Study Purpose

This consolidated report integrates two complementary approaches — one based on structural equation modelling (SEM) and the other employing Bayesian hierarchical modelling — to answer the overarching question:

> *To what extent does Matric Mathematics achievement predict university success in mathematics-related programmes, and how do other factors (e.g. gender, socioeconomic status, age, or progression rates) moderate or mediate this relationship?*

Findings from both approaches are of strategic importance to policy-makers in both basic and higher education, bridging programme administrators, and key sector stakeholders—such as the ETDP-SETA, who are dedicated to enhancing skills planning in STEM fields.

2 Literature Review

Overview.
In the South African education system, Grade 12 Mathematics has often been portrayed as a *threshold subject*—a defining factor determining which learners can advance into mathematically rigorous postsecondary courses in fields such as Engineering, Health Sciences, and Commerce. Over the years, a rich array of studies has assessed the extent to which Matric Mathematics performance correlates with later academic success, especially in Science, Technology, Engineering, and Mathematics (STEM) disciplines [1, 2]. Yet, this body of research also highlights how socioeconomic inequities, gender dynamics, institutional policies, and bridging or foundational interventions mediate the ultimate impact of Matric Mathematics scores [3, 19]. This chapter offers a comprehensive discussion of these critical factors under the following thematic areas:

1. The status of Matric Mathematics as a threshold subject within higher education,
2. The interplay of socioeconomic and school-related variables (particularly quintile classifications),
3. Persistent questions around gender disparities in mathematics performance and STEM participation,
4. Approaches to academic support (e.g. bridging programmes), and
5. Theoretical and methodological frameworks shaping current investigations.

In weaving together these strands of the literature, the chapter highlights the complexities that surround Matric Mathematics attainment, underscores the enduring debates about its predictive reliability, and points to persistent gaps that inform the present study's objectives.

2.1 Matric Mathematics as a Threshold Subject in Higher Education

For many learners aspiring to enter mathematically intensive fields, Matric Mathematics is the formal measure by which universities assess readiness and potential. In South Africa, a strong performance in this subject typically allows learners to pursue Engineering, Computer Science, or Pure and Applied Science degrees, while a weak performance can curtail such pathways. Scholars often evoke the concept of Mathematics as a "threshold subject" precisely because it can either unlock or bar entry into a wide range of career trajectories [1, 2].

2.1.1 Historical Evolution of Matric Mathematics

The historical roots of Matric Mathematics as a threshold subject can be traced back to earlier educational policies under apartheid, which stratified schools according to race and geography. Schools designated for Black, Coloured, or Indian learners were systematically deprived of resources, resulting in weaker curricular offerings in subjects such as Mathematics and Physical Science [3]. Although contemporary policies aim to redress these inequalities, vestiges of that legacy remain palpable. Some well-resourced suburban and former Model C schools continue to offer advanced mathematics streams, smaller classroom sizes, and specialised Mathematics programmes. In contrast, many township and rural schools, even under more equitable regulations, still contend with overburdened teachers and insufficient preparation, ultimately shaping learners' Matric performance in fundamental ways.

2.1.2 Predictive Power for First-Year Success

Empirical research consistently finds a positive correlation between strong Matric Mathematics results and success in first-year mathematics modules and quantitatively oriented courses [17]. However, scholars caution that these correlations may not hold uniformly across advanced years of study. [13] posits that Matric Mathematics may accurately gauge preparedness in terms of procedural skills—like algebraic manipulation or basic calculus—but may not account for higher-order problem-solving abilities that become critical in second or third-year courses. Consequently, the subject retains its threshold quality in admissions yet remains an imperfect predictor of long-term academic mastery.

2.1.3 Limitations of Matric Mathematics as Sole Indicator

A growing debate centres on whether Matric Mathematics is overly privileged in university admission decisions. Critics argue that it often reflects not only learners' innate aptitude but also their exposure to quality teaching, smaller class sizes, and additional tutoring—a reality more common in quintile 4 and 5 schools [14]. As a result, while Matric Mathematics is instrumental in identifying numerate individuals, it can overlook students with significant potential who had limited high school resources. Such constraints are exacerbated by the well-documented socioeconomic disparities across provinces, underlining the importance of contextualising Matric results alongside other factors like school quintile.

2.2 Socioeconomic Context and School Quintile Factors

2.2.1 Quintile Ranking and Historical Inequities

Following the end of apartheid, the South African government introduced a quintile system designed to allocate resources more fairly and waive school fees for the poorest learners. Yet, the cumulative impacts of apartheid-era policies linger: Quintiles 1 through 3 schools remain under acute pressure, often lacking well-qualified mathematics teachers or sufficient instructional materials [4]. Pupils in these schools may enter Matric at a fundamental disadvantage, having rarely engaged with higher-level mathematics tasks or extracurricular learning experiences such as Math Olympiads or competitions.

2.2.2 Implications for University Admission

Matric scores in lower-quintile contexts may fail to reflect the full intellectual potential of learners. Conversely, learners from wealthier backgrounds benefit from well-resourced schools, private tutoring, and advanced curriculum tracks that substantially boost their Matric outcomes. Consequently, when admissions committees rely heavily on Matric Mathematics marks, they may inadvertently perpetuate privilege by admitting those already advantaged [3]. Some universities experiment with "contextual admissions," adjusting cut-off points or weighting learners' results according to the quintile of their school [2]. While these approaches can mitigate some imbalances, research evaluating their long-term efficacy remains sparse, indicating a pressing gap in the literature.

2.2.3 Socioeconomic Status Beyond Quintiles

Although school quintiles provide a broad measure of community wealth, finer-grained indicators such as parental education levels, access to home internet, and family income also influence mathematics achievement. According to [18], learners from comparable quintile schools can exhibit vastly different learning trajectories if their home environments differ substantially in resources or parental support. This nuance suggests that, while quintile remains a central lens for policy and research, future studies must account for deeper socioeconomic complexities if they aim to understand or predict success in mathematics-intensive programmes more accurately.

2.3 Gender Disparities and Mathematics Participation

2.3.1 Contextual Nuances of Gender Gaps

Early international studies often indicated a male advantage in mathematics test performance, but more recent inquiries in various contexts, including South Africa, reveal a diminishing or inconsistent gap [9]. Some provinces report near parity in average mathematics scores, while others still observe slight male advantages in advanced topics like geometry and calculus. The conversation has thus shifted from debating whether "boys are better at maths" to examining which structural, social, or pedagogical factors might create or reduce gendered performance differences.

2.3.2 School Environment and Cultural Influences

Gender disparities may be most pronounced in communities where persistent stereotypes discourage female learners from pursuing STEM fields. Such discouragement can come from teachers who unwittingly hold lower expectations for girls in mathematics or from parents steering daughters towards more "traditionally feminine" careers [10]. Conversely, well-trained educators who foster inclusive classroom environments and highlight female role models in mathematics can narrow or eliminate these gaps. Additionally, peer groups play an influential role; some researchers highlight that female learners in supportive peer environments are significantly more likely to form positive mathematics identities.

2.3.3 Interaction with Other Variables

Researchers have recently focused on how gender intersects with socioeconomic status. For instance, female learners from lower-quintile schools may face a "double disadvantage," having to navigate both resource shortages and cultural biases that underrate their mathematical potential [20]. This suggests that policy interventions need to be targeted, considering the compound effect of gender and socioeconomic barriers in shaping mathematics achievement and subsequent university enrolment in STEM.

2.4 The Role of Bridging Programmes and Foundational Support

2.4.1 Rationale for Bridging Interventions

Bridging or foundational programmes aim to help students who may have the will and latent ability but who lacked adequate preparation in Matric Mathematics. Commonly, these programmes include intensive skill-building modules, smaller tutorials, and supplementary mentoring [19]. The notion is that with appropriate scaffolding, academically underprepared students can thrive in mathematically demanding fields, thereby diversifying the population who benefits from advanced educational opportunities.

2.4.2 Variations and Efficacy

South African universities differ in how they structure bridging solutions. Some institutions offer an "extended curriculum" model, where first-year material is spread over two years, allowing learners more time to consolidate foundational concepts. Others implement shorter bridging courses over the summer or mid-year break. While many studies underscore the positive short-term impact of these interventions—such as increased pass rates in core modules—less is known about the long-term retention of these students, especially if bridging programmes do not also address deeper issues like self-efficacy and peer support networks [17, 18].

2.4.3 Supplemental Instruction and Mentoring

Another prevalent strategy is to run peer-assisted study sessions, sometimes referred to as Supplemental Instruction (SI). In these sessions, senior students who have excelled in mathematics facilitate study groups for junior peers. Research from some South African universities suggests that SI not only improves conceptual understanding but also fosters a supportive community for those who feel alienated by the formal lecture setting [2]. In turn, such psychosocial support can be instrumental for female students or those from lower-quintile backgrounds, who may be especially susceptible to feeling "out of place" in high-stakes mathematics programmes.

2.5 Theoretical and Methodological Frameworks

2.5.1 Tinto's Integration Model

Tinto's model of student integration remains highly influential in framing how academic and social factors coalesce to shape persistence in higher education [12]. In mathematics education, "academic integration" includes mastering foundational knowledge and engaging actively with modules, while "social integration" speaks to the sense of belonging learners experience within the campus environment. Studies that have adapted Tinto's framework consistently highlight bridging programmes and tutorials as vehicles for enhancing both forms of integration, particularly during the transitional first year [13].

2.5.2 SEM and Bayesian Hierarchical Approaches

Interest in more advanced quantitative methods arises from the multifaceted nature of the factors that shape mathematics success. Structural Equation Modelling (SEM) enables researchers to unpack direct, indirect, and moderated relationships among variables such as Matric marks, credit accumulation, and bridging programme participation [14]. Meanwhile, Bayesian hierarchical models are suited to nested data structures (students within schools or faculties) and can incorporate prior knowledge, making them valuable for large-scale policy research or multi-cohort analyses in South Africa [16, 15].

2.6 Identifying Key Gaps in the Literature

Although there is consensus that Matric Mathematics exerts a tangible effect on subsequent academic performance, notable gaps endure:

1. **Longitudinal Insight:** Many investigations cease after the first-year of study, yielding limited knowledge on how initial performance extends to second- or third-year modules.
2. **Contextualised Admissions Research:** The impact of "contextual admissions," which modulates cut-offs based on school quintile or other socio-demographic factors, remains under-researched in large-scale, multi-institutional studies [2].
3. **Intersectionality of Gender and Socioeconomics:** More work is needed to unpack how simultaneously belonging to a disadvantaged quintile and identifying as female (or other underrepresented groups) affects mathematics preparedness and bridging success [10].

4. **Long-Term Efficacy of Bridging:** While bridging programmes can yield short-term gains, questions linger about whether these gains persist through advanced mathematics modules or produce a sustained difference in graduation rates.

5. **Qualitative and Mixed-Methods Approaches:** Much of the evidence rests on quantitative data (e.g., exam marks), leaving students' lived experiences less explored.

Addressing these shortfalls could refine both theoretical understanding and practical strategies, ensuring that the complexities of Matric Mathematics and the broader socio-institutional landscape are more fully captured.

2.7 Conclusion

A review of the relevant scholarship underscores that Matric Mathematics, while serving as a threshold subject, cannot be disentangled from the broader socio-educational matrix in which learners operate. Socioeconomic disparities, operationalised through school quintile systems, remain potent influences on both learner preparedness and subsequent success in university mathematics modules. At the same time, gender considerations and bridging interventions add layers of complexity. The interplay among these dimensions is best approached through robust theoretical constructs (e.g. Tinto's Integration Model) and sophisticated methodological tools (SEM or Bayesian hierarchical models) that can offer nuanced insights into direct, indirect, and moderating relationships.

Ultimately, the literature points to a central tension: Matric Mathematics is crucial for identifying numerate learners and setting baseline academic standards, yet it may also inadvertently limit opportunities for high-potential students from disadvantaged backgrounds if contextual factors are overlooked. This tension drives the rationale for the present investigation: to gauge the actual predictive efficacy of Matric Mathematics, situate it within the realities of quintile-based schooling, assess how gender might shape academic outcomes, and examine the role bridging programmes play in levelling the field. Such a holistic perspective is imperative if South Africa is to foster both equity and excellence in mathematics-related fields, thereby advancing both individual aspirations and broader national developmental goals.

3 Research Methods

This study integrates two distinct yet thematically aligned empirical investigations—one grounded in structural equation modelling (SEM) and the other employing a Bayesian hierarchical framework—to examine how Matric Mathematics performance predicts university success in mathematics-related fields. Although each study was conducted with a unique dataset and analytic lens, they share overlapping goals, sampling populations, and contextual variables. The overarching objective was to triangulate findings on whether Grade 12 Mathematics results retain their predictive validity once important covariates such as socioeconomic status, prior credit accumulation, and bridging interventions are taken into account. Both studies were carried out in the context of South African higher education, with institutional approvals and ethical guidelines strictly observed. This section synthesises the collective methodological underpinnings of these two studies in a cohesive manner, providing a clear account of the sampling procedures, instruments, data analysis techniques, and ethical considerations.

3.1 Overall Study Context and Setting.

Both investigations were situated within South African universities that attract a diverse student body in terms of race, school background, and socioeconomic status. While the institutional contexts differ in size and focus, they nonetheless share comparable challenges around throughput, STEM readiness, and resource allocation. Traditionally, admissions to mathematics-intensive programmes at these institutions are heavily contingent upon Matric Mathematics marks, supplemented by general academic measures such as the Admission Point (AP) score. Yet, prior studies repeatedly suggested that Matric Mathematics is not an absolute proxy for academic success, especially for learners from lower-quintile schools. Against this backdrop, each study sought to quantify and explain this variability through rigorous analyses, highlighting the potential mediating roles of institutional interventions (e.g. bridging programmes) and student demographic attributes (e.g. gender, SES).

3.2 Participants and Sampling Procedures.

Although the exact sampling processes varied slightly between the two studies, both drew on institutional records of students enrolled in quantitative programmes. The first study (the SEM-based investigation) sampled students who were taking first-year and second-year mathematics modules from five South African public universities (see subsection 4.1.2 for more details). Students were included if they had completed Matric Mathematics, possessed valid NSC data, and were registered for at least two consecutive mathematics modules. The Bayesian approach leveraged data spanning four academic years (2019–2023) from STEM programmes at a comprehensive university, encompassing a broad spectrum of academic achievement—from borderline admissions to top performers.

3.3 Measures and Variables.

Key variables overlapped across the two studies:

- *Matric Mathematics*: final Grade 12 score (0–100%).
- *Socioeconomic Status (SES)*: approximated via school quintile classification (1–5).
- *Gender*: coded as male/female in institutional data.
- *Academic Progression*: number of credits passed or ratio of credits passed to attempted.
- *Support Programme Participation*: coded for extended or remedial track enrollees.

The SEM study centred on performance in three sequential mathematics modules, while the Bayesian study employed a broader measure of average academic marks in mathematics-intensive modules over multiple years.

3.4 Data Collection and Preparation.

Both studies relied on secondary data extracted from university records, with ethics approvals ensuring anonymity of student data. After cleaning and validation, outliers were minimal and missing values handled via listwise deletion (SEM) or Bayesian imputation (Bayesian model). The final datasets were sufficiently robust to enable multivariate analyses, with each methodology chosen to illuminate unique aspects of how Matric Mathematics predicts outcomes and how support or SES factors modify that relationship.

3.5 Analytic Framework: Structural Equation Modelling (SEM).

The first study used SEM to test whether Matric Mathematics affects performance directly or indirectly through credit accumulation and support programme factors. Model fit was judged using CFI, TLI, and RMSEA, with standardised path coefficients indicating direct, indirect, and total effects. This approach provided fine-grained causal-path insights across sequential mathematics modules.

3.6 Analytic Framework: Bayesian Hierarchical Modelling.

The second study specified a Bayesian hierarchical linear model, nesting students within different programmes and years. Priors were set for regression coefficients based on domain knowledge, and MCMC methods were used to estimate posterior distributions. This partial pooling approach allowed the model to capture variation across cohorts, providing a rich understanding of how prior mathematics competency interacts with support status, progression, and AP scores to shape multi-year outcomes.

3.7 Ethical Considerations and Confidentiality.

Strict protocols safeguarded student identities (e.g., data anonymisation, secure servers). Researchers obtained clearances from the relevant university ethics committees and ensured participants were informed about the research goals. Adherence to the Belmont Report and local guidelines assured responsible data handling, fostering trust among stakeholders.

3.8 Study Limitations.

Both approaches in this study rely on observational data, limiting strict causal inference. While the advanced modelling techniques help isolate plausible relationships, unmeasured confounders could still affect outcomes. Differences in outcome measures (sequential modules vs. average marks) also complicate direct comparisons, though they allow for broader validation of results. Nevertheless, the complementary nature of SEM and Bayesian models, along with varied samples, enriches the reliability and practical relevance of the findings.

3.9 Conclusion.

By drawing on large, representative datasets from multiple institutions and leveraging rigorous analytic strategies, these two studies provide convergent insights into how Matric Mathematics shapes academic success in quantitative fields. Both analyses emphasize the importance of support for learners with underdeveloped mathematics foundations and highlight the moderating roles of SES, progression rates, and institutional practices. In capturing both the direct predictive power of Matric scores and the complex interplay of additional factors, the research underscores the need for nuanced, evidence-based policies aimed at improving throughput and equity in South Africa's STEM programmes.

4 Results

4.1 Descriptive Analysis: Contextualisation of the Results

To provide an overarching perspective on the study's cohort, this section explores key demographic distributions—focusing specifically on Race, School Quintile, and Gender. By examining how these factors intersect, we gain a clearer understanding of students' backgrounds and how they might influence access to and performance in the mathematical sciences.

4.1.1 Distribution of Race by School Quintile and Gender

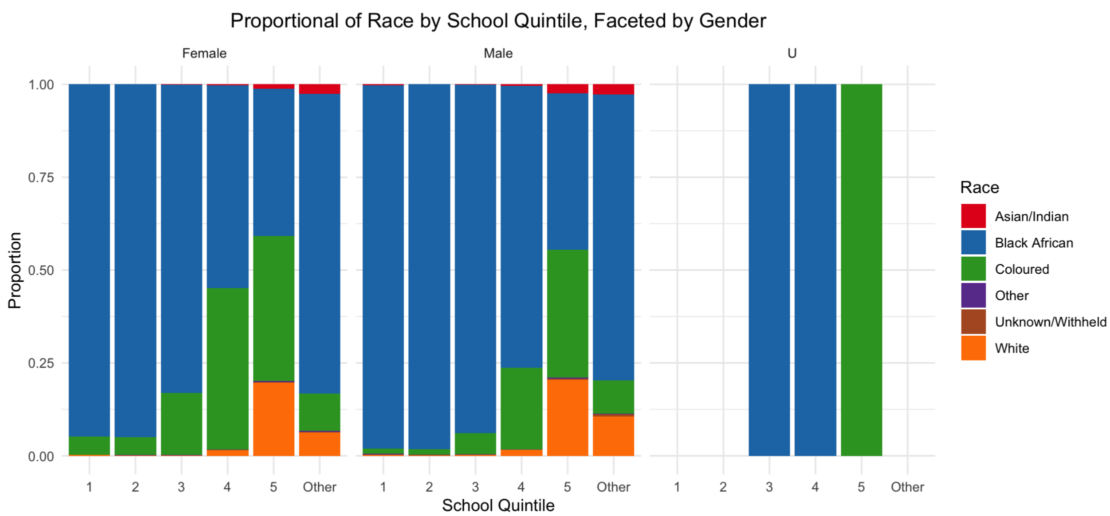

Figure 4.1: Proportional distribution of Race by School Quintile and Gender.

In Figure 4.1, the proportional distribution of Race is shown by School Quintile (1 through 5, plus "Other"), with separate panels for Female, Male, and "U" (unspecified) gender. Across nearly all Quintiles, Black African (blue) emerges as the largest group, while Coloured (green) follows as the second-largest category, especially at higher Quintiles (4 and 5). Smaller segments appear for Unknown/Withheld (orange), Asian/Indian (red), and Other (purple).

4.1.2 Heatmap Analysis: Intersections of Race and Gender

Guiding Question: *How do Race and Gender intersect among the student population, and what does this tell us about patterns of access in the mathematical sciences at universities?* Figure 4.2 illustrates the distribution of Gender across different racial categories in the dataset. Black African students form the majority, with 8,996 males and 6,945 females.

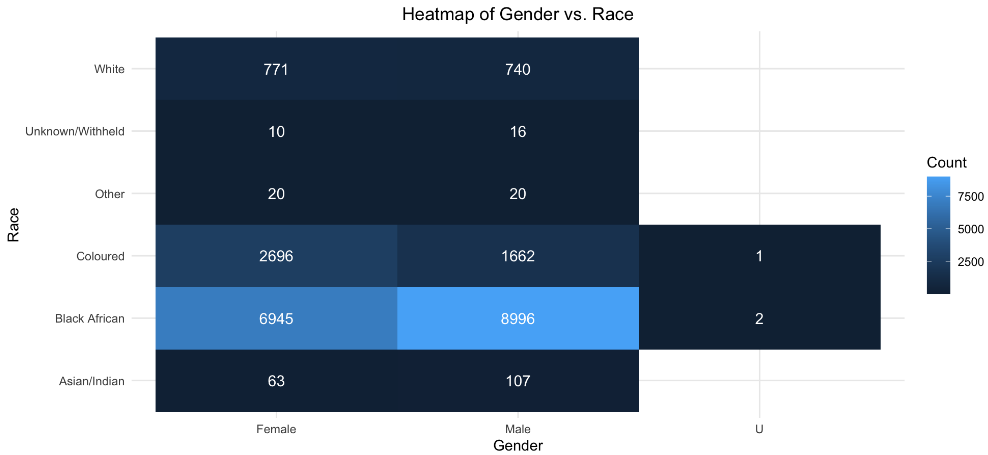

Figure 4.2: Heatmap of Gender vs. Race distribution. The numbers on the tiles correspond to actual counts.

Coloured students are the second-largest group, with a comparatively higher number of females (2,696) than males (1,662). Smaller racial groups—White, Asian/Indian, Other, Unknown/Withheld—comprise the remaining portions. These data confirm the importance of considering both Race and Gender when examining access to mathematical sciences.

4.1.3 Enrollment by Broad Discipline Over Five Years

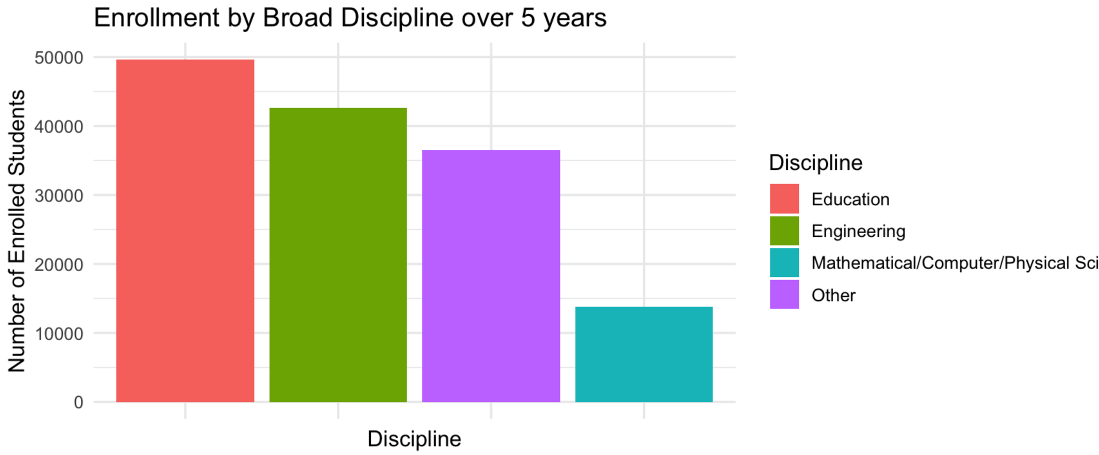

Figure 4.3: Enrollment by Broad Discipline Over Five Years

Figure 4.3 shows aggregate enrollments across four South African universities, categorized into *Education*, *Engineering*, *Mathematical/Computer/Physical Sciences*, and *Other*. *Education* exhibits the highest overall enrollment, suggesting a sustained demand for teacher training. *Engineering* is second-largest, aligning with national STEM initiatives. *Mathematical/Computer/Physical Sciences* accounts for a smaller share, underscoring a potential gap in specialised STEM areas.

4.1.4 Programme Analysis Over Five Years

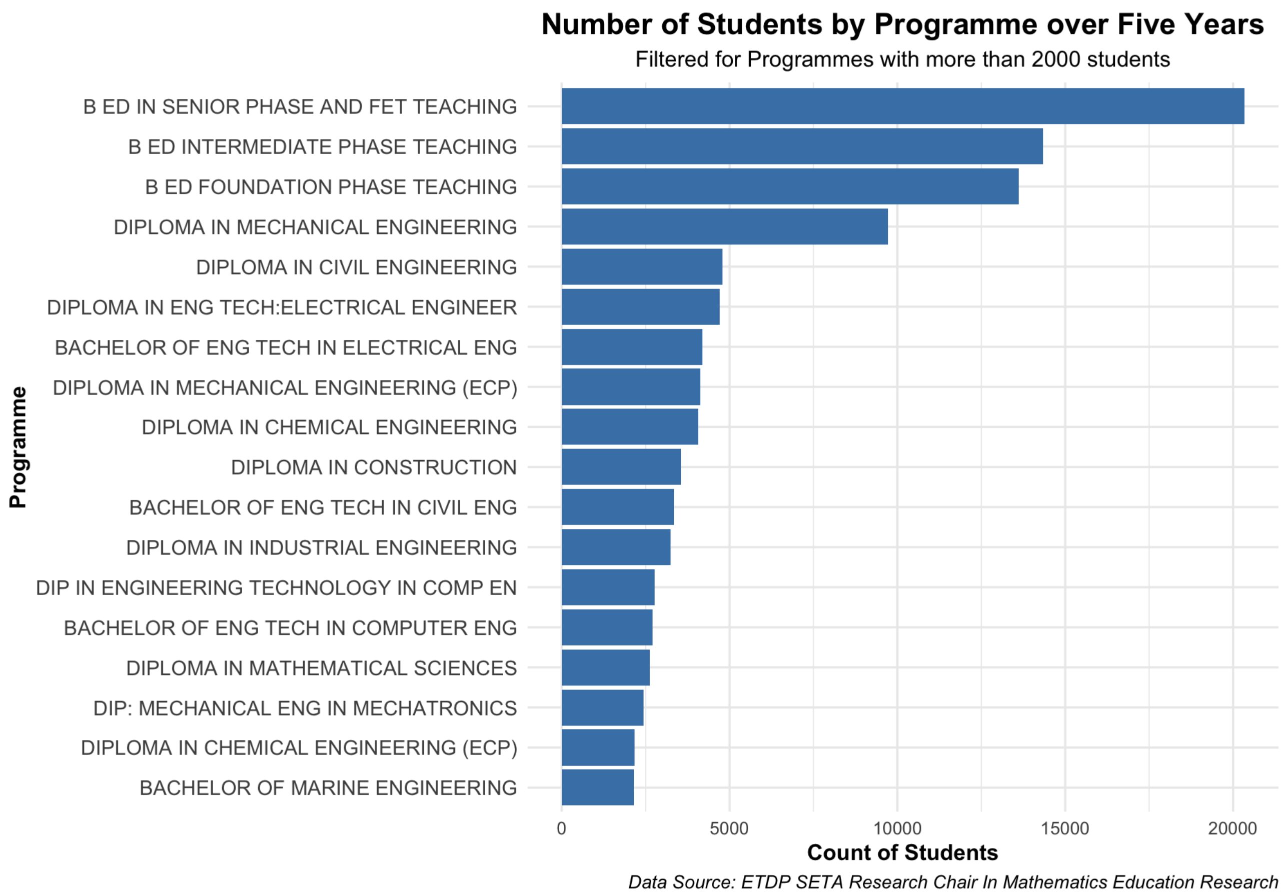

Figure 4.4: Distribution of Enrolment across Various Programmes Over Five Years

Figure 4.4 extends the enrollment perspective to a more detailed programme level, indicating that while certain streams (e.g., Education or Engineering) draw larger cohorts, smaller or specialised programmes also contribute meaningfully to the diversity of offerings. Notably, support or foundational programmes register significant enrollments, indicating the need for academic support to address underpreparedness in mathematics.

4.1.5 Key Insights from the Descriptive Analysis

- **Race-Quintile Distribution:** Lower quintile schools—often predominantly Black African and Coloured—lack resources, influencing the level of mathematics preparedness.

- **Intersection of Race and Gender:** Male students slightly outnumber females in some groups, though Coloured females surpass Coloured males, suggesting nuanced gender dynamics.
- **Enrollment Trends:** Education and Engineering dominate, while Mathematical/ Computer/Physical Sciences remain smaller, potentially hindering the pipeline of skilled STEM graduates.
- **Support Programmes:** High enrollment in support courses underscores the persistent gap between high school and university readiness, especially for students from historically disadvantaged backgrounds.

5 Inferential Results

5.1 Results

This section presents the empirical findings from two complementary studies that investigated the predictive power of Grade 12 Mathematics (Matric Mathematics) in shaping academic performance in mathematics-intensive programmes at South African universities. The first study used a structural equation modelling (SEM) framework to analyse sequential module outcomes, whereas the second study adopted a Bayesian hierarchical approach to explore multi-year performance across various STEM fields.

5.1.1 Approach 1: Structural Equation Modelling (SEM)

Model Fit and Overall Significance. The SEM model evaluated relationships among Matric Mathematics marks, credits passed, support programme participation, and performance in three mathematics modules (MATM1534, MATM1622, MATM1644). Goodness-of-fit indices indicated an excellent model fit:

- $\chi^2(6) = 6.028,\ p = 0.420$
- CFI = 1.000, TLI = 1.000, RMSEA = 0.004

Table 5.1: Key SEM Path Coefficients Predicting Sequential Module Performance

Predictor	**MATM1534**	**MATM1622**	**MATM1644**	**Significance**
Matric Math	0.48	0.18	0.09	*** / n.s.
Credits Passed	0.01	0.42	0.43	n.s. / ***
Gender (Male)	0.32	-0.33	0.12	** / n.s.
SES (Quintile 5)	0.52	9.13	6.19	** / ** / n.s.
Bridge Programme	0.26	0.29	0.14	* / * / n.s.

*** = $p < 0.001$, ** = $p < 0.01$, * = $p < 0.05$, n.s. = not significant.

Path Coefficients and Significance. Matric Mathematics showed its highest impact on the first module (MATM1534), with diminishing direct effects in subsequent modules. Credits Passed became more influential at higher levels of study. Gender differences were observed initially but not sustained. SES (quintile) and support status had moderate positive effects, especially early on.

5.1.2 Approach 2: Bayesian Hierarchical Modelling

Analytical Framework and Model Convergence. A Bayesian hierarchical model was fit to multi-year data from 630 STEM students. Convergence diagnostics were satisfactory, with Rhat$\approx$ 1.00 and stable MCMC trace plots.

Table 5.2: Bayesian Hierarchical Model Fixed Effects (Posterior Estimates)

Predictor	**Posterior Mean**	**95% Credible Interval**
Intercept	60.4	[57.1, 63.8]
Matric Math (per 1 pt)	2.13	[1.45, 2.82]
Progression Rate	7.66	[7.02, 8.30]
Admission Point	0.11	[-0.52, 0.74]
Gender (Male)	-0.84	[-1.94, 0.27]
Bridge Programme	1.90	[0.45, 3.45]

Fixed Effects Results. Matric Mathematics exhibited a substantial positive effect on average marks, but the largest driver of performance was "Progression Rate," indicating that consistent credit accumulation is crucial. The AP score was negligible, while gender effects were non-significant. support programme participants saw a modest uplift.

5.2 Combined Interpretation

Across these two investigations, Matric Mathematics predicts early success, but its importance diminishes as students progress and accumulate academic credits. Socioeconomic factors and bridging support can mitigate initial underperformance. The overarching implication is that while Matric Mathematics is a valuable admissions metric, it should be supplemented with targeted interventions and contextual considerations to ensure equitable and sustained achievement in mathematics-intensive domains.

6 Conclusion & Recommendations

This study consistently highlights the significant—but not sole—role Matric Mathematics plays in university success. SEM analysis showed that while strong Matric performance is a key predictor for introductory modules, continuous credit completion supersedes it at higher levels. Similarly, the Bayesian model indicates the substantial effect of Matric Mathematics on average marks, yet underscores that sustaining academic momentum (i.e., credit accumulation) is even more pivotal.

The grant enabled larger sample sizes, multi-institutional coverage, and advanced methods (SEM, Bayesian modelling). Interdisciplinary collaboration among mathematicians, education specialists, and statisticians enriched the analyses and boosted methodological rigour. The findings are thus more representative and robust, laying a basis for further inquiry into mathematics readiness and throughput.

The research team aims to leverage these results into more extensive longitudinal studies, potentially funded by the National Research Foundation (NRF) or additional ETDP–SETA grants. By exploring student trajectories from Grade 1 to university, we can illuminate how bridging and supportive interventions maintain long-term academic momentum. Such a study is critical because it would provide comprehensive insights into the cumulative impact of early educational experiences on later academic success, identify persistent gaps in learning, and inform data-driven policy recommendations to enhance educational outcomes across the entire schooling continuum.

6.1 Conclusion and Recommendations for ETDP–SETA

Matric Mathematics is a crucial filter for STEM access in South Africa but does not alone guarantee sustained university success. Both bridging initiatives and steady credit accumulation significantly influence outcomes. Socioeconomic and demographic factors further compound these results, suggesting that raw Matric scores should not be the sole admissions criterion.

Recommendations.

1. **Strengthen Secondary–Tertiary Alignment:** Promote dialogues between school educators and university lecturers to bridge curriculum gaps and align teaching methodologies.

2. **Expand and Refine Bridging Programmes:** Encourage pilot projects integrating

technology-based modules and problem-based learning to bolster foundational competence.

3. **Support Holistic Admissions Approaches:** Advocate for or fund context-sensitive admissions policies that weight school quintile or diagnostic assessments, not just raw exam marks.

4. **Foster Technology Integration in High Schools:** Provide resources and training so that learners, especially from underresourced schools, gain exposure to software tools early.

5. **Incentivise Data-Driven Monitoring:** Facilitate institutional partnerships to track student progress, allowing timely interventions for those at risk.

6. **Champion Gender-Responsive Strategies:** Offer mentorship and targeted support for female learners, focusing on bridging the subtle gaps that affect STEM participation.

By implementing these measures, ETDP–SETA can help ensure that more learners—regardless of socioeconomic background—have equitable opportunities to thrive in mathematics-related programmes. This, in turn, bolsters South Africa's broader developmental goals by expanding the pool of skilled STEM graduates.

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