

Supporting Students' Transition from Mathematical Literacy to Pure Mathematics through Embedded Remedial Tutorial Intervention

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Research Article

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Abstract

The transition from Mathematical Literacy to Pure Mathematics in higher education presents significant challenges due to differences in conceptual demands, mathematical reasoning, and symbolic representation. This study investigated the impact of embedded remedial tutorial interventions in supporting students' transition from Mathematical Literacy to Pure Mathematics and improving academic performance. Guided by Vygotsky's Sociocultural Theory of Learning, particularly the concepts of the Zone of Proximal Development and scaffolding, alongside Constructivist Learning Theory, the study examined how structured academic support facilitates mathematical knowledge development. A quasi-experimental mixed-methods research design was adopted within a pragmatic paradigm. Quantitative data consisted of students' mathematics achievement scores collected across the 2025 and 2026 academic years, analysed through descriptive statistics and the Wilcoxon Signed-Rank Test. Qualitative insights were obtained through observations of student attendance, participation, engagement, and problem-solving challenges. The embedded remedial tutorials were integrated into Pure Mathematics lectures and focused on strengthening prerequisite knowledge, algebraic fluency, symbolic manipulation, conceptual understanding, and mathematical problem-solving through guided practice and immediate feedback. The findings revealed varied performance patterns across student cohorts. While some groups demonstrated statistically significant improvements following participation in the intervention, others experienced declines associated with contextual factors such as inconsistent attendance, limited engagement, and inadequate independent practice. These findings suggest that the effectiveness of remedial support depends on both the quality of instructional scaffolding and students' active involvement in the learning process. The study concludes that embedded remedial tutorials provide an effective pedagogical mechanism for bridging the gap between Mathematical Literacy and Pure Mathematics by offering timely, integrated, and context-specific academic support. The findings highlight the importance of responsive mathematics support models that recognise diverse student backgrounds, strengthen mathematical competence, and promote equitable participation and success in higher education mathematics.

Introduction

Mathematical proficiency is essential for success in higher education, particularly in disciplines requiring analytical reasoning and quantitative skills. However, many students experience challenges when transitioning from Mathematical Literacy at secondary school level to Pure Mathematics at university level due to differences in curriculum focus, conceptual demands, and mathematical thinking (Bolstad, 2023). While Mathematical Literacy emphasises practical applications of mathematics in everyday contexts, Pure Mathematics requires abstract reasoning, symbolic manipulation, algebraic proficiency, and advanced problem-solving skills (Kappassova et al., 2025). For students who completed Mathematical Literacy in Grade 12, this transition often presents significant academic difficulties. The shift from contextual mathematical applications to abstract mathematical concepts requires students to develop new ways of reasoning and engage with unfamiliar mathematical representations. Limited exposure to formal mathematical processes may contribute to challenges such as conceptual

misunderstandings, weak problem-solving strategies, reduced confidence, and difficulties adapting to the cognitive demands of Pure Mathematics (Ncube & Luneta, 2025).

To address these challenges, higher education institutions have implemented various academic support initiatives, including remedial tutorial programmes aimed at strengthening students' mathematical foundations. While conventional tutorials are often offered separately from lectures, embedded remedial tutorial interventions integrated within lectures provide immediate and contextually relevant support (Ahmadfard, 2026). Such interventions enable students to revisit foundational concepts, practise mathematical procedures, receive feedback, and develop confidence while engaging with course content. This study investigates the effectiveness of lecture-integrated remedial support in assisting students transitioning from Mathematical Literacy to Pure Mathematics. The study focuses on students who completed Mathematical Literacy at school and participated in a preparatory first-term programme before engaging with Pure Mathematics in the second term. Despite this preparation, many students experienced difficulties related to algebraic fluency, abstract reasoning, and mathematical problem-solving.

The embedded remedial tutorial intervention was introduced to provide additional scaffolding, strengthen conceptual understanding, and support students' adaptation to the demands of Pure Mathematics. The intervention provided opportunities for guided practice, clarification of misconceptions, and reinforcement of mathematical concepts. However, the impact of such interventions is influenced by factors such as attendance, participation, and students' commitment to independent practice. Improvements in performance may therefore be associated with active engagement in remedial support, while declines may reflect inconsistent attendance and limited opportunities for practice.

The study contributes to mathematics education research by examining how structured pedagogical support can bridge the transition between different forms of mathematical knowledge. Rather than viewing students' difficulties as individual deficits, the study positions the transition as a learning challenge requiring appropriate scaffolding and responsive teaching strategies. By analysing student performance patterns before and after the implementation of remedial tutorials, the study provides insights into the potential of embedded academic support models to enhance mathematical readiness, improve student success, and promote equitable participation in mathematically demanding higher education programmes.

Background of the Study

Mathematical competence is essential for academic success and participation in fields requiring analytical and quantitative reasoning. However, higher education institutions continue to face challenges related to students' diverse mathematical backgrounds and levels of preparedness. A significant challenge is the transition from Mathematical Literacy at school level to Pure Mathematics at university level, as these subjects differ in their learning objectives, conceptual demands, and approaches to

mathematical reasoning (Hwang & Ham, 2021). In the South African context, Mathematical Literacy focuses on the practical application and interpretation of mathematical information, whereas Pure Mathematics requires abstract reasoning, symbolic manipulation, algebraic proficiency, and advanced problem-solving skills (North, 2024). Consequently, students transitioning from Mathematical Literacy often experience difficulties adapting to the cognitive demands of Pure Mathematics, particularly in areas such as conceptual understanding, mathematical notation, and formal problem-solving (Kappassova et al., 2025).

These transition challenges may negatively influence students' academic performance, confidence, and persistence in mathematics-related courses. As higher education institutions expand access to students from diverse educational backgrounds, there is an increasing need for effective academic support strategies that address differences in prior mathematical preparation. Remedial tutorial interventions have emerged as an important mechanism for strengthening students' mathematical foundations and addressing conceptual gaps. Embedded remedial tutorials integrated within lectures provide immediate and contextualised support by allowing students to clarify misconceptions, practise mathematical procedures, and receive guided assistance while engaging with course content (Mailizar, Johar & Hidayat, 2025). Such interventions serve as a form of pedagogical scaffolding that supports students' gradual development of mathematical competence.

This study examines the impact of embedded remedial tutorial interventions on students transitioning from Mathematical Literacy to Pure Mathematics. Although students received preparatory support before engaging with Pure Mathematics, many continued to experience challenges related to abstract reasoning, algebraic fluency, and problem-solving. The intervention was therefore designed to strengthen foundational knowledge, enhance conceptual understanding, and improve students' ability to cope with the demands of Pure Mathematics. The effectiveness of remedial support is influenced by factors such as attendance, participation, and opportunities for independent practice. While active engagement with tutorials may contribute to improved performance, inconsistent attendance and limited practice may constrain learning gains. Therefore, analysing performance patterns before and after intervention implementation provides valuable insights into the role of embedded remedial tutorials in supporting mathematical transitions.

The study contributes to mathematics education by exploring how targeted academic support can bridge the gap between Mathematical Literacy and Pure Mathematics. It highlights the importance of inclusive pedagogical approaches that recognise students' prior learning experiences while providing structured pathways towards mathematical success in higher education.

Research Problem

Despite increasing efforts to widen access to higher education, many students continue to enter university with insufficient mathematical preparedness (Sekonyela, 2021). A critical transition challenge occurs among students who completed Mathematical Literacy at Grade 12 level and subsequently enrol

in programmes requiring Pure Mathematics. The differences between these forms of mathematical knowledge create a significant learning discontinuity. While Mathematical Literacy emphasises contextual interpretation and practical applications, Pure Mathematics requires abstract reasoning, symbolic representation, algebraic manipulation, and formal problem-solving skills. Consequently, many students experience difficulties when engaging with the conceptual and cognitive demands of university mathematics (Ncube & Luneta, 2025). These challenges include weak algebraic fluency, limited conceptual understanding, difficulties interpreting mathematical notation, ineffective problem-solving strategies, and reduced confidence in mathematical engagement.

Higher education institutions have introduced various academic support initiatives, including remedial tutorials, to address these challenges. However, traditional tutorial models offered separately from lectures may not always provide timely and context-specific support for students' immediate learning needs (Ukwandu et al., 2025). Limited empirical evidence exists regarding the effectiveness of embedded remedial tutorials integrated within regular teaching activities as a strategy for supporting the transition from Mathematical Literacy to Pure Mathematics (Byiringiro, 2024). Although embedded interventions may provide continuous scaffolding, reinforce foundational concepts, and address misconceptions during learning, their effectiveness may depend on factors such as student attendance, participation, engagement, and opportunities for independent practice.

The research problem addressed by this study is the persistent gap between students' prior Mathematical Literacy preparation and the conceptual demands of university-level Pure Mathematics, despite existing preparatory programmes and academic support initiatives. The study investigates whether embedded remedial tutorial interventions provide an effective pedagogical approach for bridging this gap by strengthening mathematical foundations, improving academic performance, and supporting successful transition into Pure Mathematics. By analysing students' performance patterns before and after exposure to embedded remedial tutorials, the study aims to generate evidence on the role of integrated academic support in addressing mathematical preparedness challenges. The findings may contribute to inclusive mathematics education practices that recognise diverse entry pathways while providing structured opportunities for students to develop the mathematical competencies required for success in higher education.

Theoretical Framework

This study is guided by Vygotsky's (1978) Sociocultural Theory of Learning, particularly the concepts of the Zone of Proximal Development (ZPD) and scaffolding, complemented by Constructivist Learning Theory. These theoretical perspectives provide a framework for understanding how students develop mathematical competence when transitioning from Mathematical Literacy to Pure Mathematics and how structured pedagogical interventions support this process. The transition involves more than acquiring additional content knowledge; it requires a transformation from contextual and practical mathematical applications towards abstract reasoning, symbolic representation, algebraic manipulation, and formal problem-solving. Vygotsky's Sociocultural Theory views learning as a socially mediated

process in which knowledge develops through interaction with more knowledgeable others, including lecturers, tutors, and peers. The ZPD represents the difference between what learners can achieve independently and what they can accomplish with appropriate guidance. In this study, students transitioning from Mathematical Literacy possess valuable prior mathematical experiences but may require additional support to develop the conceptual understanding, procedural fluency, and reasoning skills expected in Pure Mathematics. The gap between their existing capabilities and the demands of university mathematics represents their ZPD.

Embedded remedial tutorials are conceptualised as scaffolding mechanisms operating within this zone. By integrating academic support directly into lectures, students receive immediate guidance, feedback, and opportunities to practise mathematical procedures while engaging with challenging concepts. This support assists students in addressing misconceptions, strengthening algebraic skills, developing mathematical reasoning, and gradually increasing confidence and independence in problem-solving. Scaffolding is therefore viewed as temporary instructional support that enables students to progress from assisted performance towards autonomous mathematical competence. The study is further informed by Constructivist Learning Theory, which views learners as active participants in knowledge construction. From this perspective, students enter Pure Mathematics with existing mathematical knowledge that can be extended and reorganised through meaningful learning experiences. However, the shift from practical Mathematical Literacy contexts to formal mathematical structures requires students to reconstruct their understanding and develop new ways of representing and reasoning about mathematical ideas. Embedded remedial tutorials facilitate this process by providing guided opportunities for students to connect prior knowledge with new mathematical concepts, challenge misconceptions, and develop deeper conceptual understanding.

Overall, the theoretical framework positions embedded remedial tutorials as a bridge between students' existing mathematical knowledge and the advanced cognitive demands of Pure Mathematics. It emphasises that transition challenges should not be viewed as individual deficiencies but as learning gaps that can be addressed through appropriate scaffolding, social interaction, and responsive pedagogical support.

Conceptualisation of the Theoretical Framework

Figure 1 presents the conceptual framework underpinning this study, illustrating the theoretical process through which students transition from a Mathematical Literacy background to successful performance in university-level Pure Mathematics. The framework is grounded in Social Constructivist Theory, particularly Vygotsky's concept of the Zone of Proximal Development (ZPD), which posits that learning occurs most effectively when learners receive appropriate instructional support to bridge the gap between their current level of understanding and the desired level of competence. The framework begins with students' prior mathematical knowledge, represented by their Mathematical Literacy background. While Mathematical Literacy equips students with practical numeracy and contextual problem-solving skills, it often provides limited preparation for the abstract, symbolic, and procedural demands of Pure

Mathematics. Consequently, students encounter several transition challenges, including limited algebraic fluency, difficulties with abstract mathematical reasoning, weak symbolic manipulation skills, and challenges in applying formal mathematical problem-solving procedures.

To address these challenges, the framework positions the embedded remedial tutorial intervention as the central pedagogical mechanism facilitating successful transition. Drawing on the principles of scaffolding within the Zone of Proximal Development, the intervention provides structured academic support through guided mathematical practice, immediate feedback, clarification of difficult concepts, tutor and peer interaction, and repeated opportunities for reinforcement. These instructional strategies enable students to progressively construct new mathematical understanding while reducing misconceptions and strengthening foundational knowledge. As students engage with the remedial intervention, they develop higher levels of mathematical competence, characterised by improved conceptual understanding, enhanced mathematical reasoning, increased confidence in engaging with mathematical tasks, and greater independence in solving complex problems. These competencies represent the intermediate learning outcomes that mediate the relationship between the remedial intervention and academic achievement.

Ultimately, the framework proposes that the development of mathematical competence contributes to improved academic performance in Pure Mathematics. The framework therefore conceptualises embedded remedial tutorials as a scaffolded instructional approach that transforms students' existing mathematical knowledge into the conceptual and procedural competencies required for success in higher education mathematics. It further suggests that continuous feedback and reinforcement throughout the intervention strengthen learning, promote sustained conceptual growth, and improve long-term academic outcomes.

Purpose of the Study

The purpose of this study is to investigate the impact of embedded remedial tutorial interventions on students' transition from Mathematical Literacy to Pure Mathematics and their academic performance in higher education. The study examines how lecture-integrated remedial support assists students in overcoming conceptual, symbolic, and cognitive challenges associated with moving from a practically oriented mathematical background to the abstract demands of university-level Pure Mathematics. Specifically, the study explores how scaffolded remedial tutorials enhance foundational mathematical competencies, including algebraic fluency, conceptual understanding, mathematical reasoning, and problem-solving skills. By analysing students' performance patterns before and after the intervention, the study aims to determine the effectiveness of embedded remedial support in facilitating mathematical knowledge transformation and improving academic outcomes. It also considers the influence of student engagement factors, including attendance, participation, and independent mathematical practice, on achievement trajectories. The study recognises that transition challenges are shaped not only by individual factors but also by differences in prior mathematical experiences, curriculum exposure, and access to structured learning support. Therefore, it seeks to contribute to the development of inclusive

and evidence-based mathematics support strategies that accommodate diverse student backgrounds and promote success in mathematically demanding higher education programmes.

The study specifically aims to:

1. Examine the challenges experienced by students transitioning from Mathematical Literacy to Pure Mathematics, particularly difficulties related to algebraic fluency, abstract reasoning, symbolic representation, and problem-solving.
2. Evaluate the impact of embedded remedial tutorials on academic performance by analysing changes in students' mathematical achievement before and after the intervention.
3. Identify factors influencing achievement outcomes following the intervention, including attendance, participation, engagement with tutorial activities, and opportunities for independent practice.

Through these objectives, the study aims to provide empirical insights into the role of embedded remedial interventions as a mechanism for bridging mathematical knowledge gaps and supporting successful transition into Pure Mathematics at higher education level.

Methodology

Research Design

This study adopted a quasi-experimental mixed-methods research design to investigate the impact of embedded remedial tutorial interventions on students' transition from Mathematical Literacy to Pure Mathematics and their subsequent academic performance in higher education. The adoption of a quasi-experimental design was appropriate because the study examined the effects of an educational intervention implemented within an existing teaching and learning environment where participants could not be randomly assigned to experimental and control groups. This design enabled the researcher to investigate changes in students' mathematical achievement following exposure to structured remedial support while maintaining the authenticity of the educational context. The quantitative component of the study employed a longitudinal pre-post comparative design to analyse changes in students' mathematics performance before and after participation in embedded remedial tutorials. Student achievement patterns were examined across two academic years (2025 and 2026) and across different academic terms to determine whether participation in the intervention was associated with measurable changes in academic outcomes. The comparative analysis focused on identifying performance trajectories as students progressed from a preparatory Mathematical Literacy phase towards engagement with the more abstract requirements of Pure Mathematics.

The qualitative interpretive component complemented the quantitative analysis by providing contextual insights into students' experiences during this transition. Attention was given to the challenges students encountered when moving from Mathematical Literacy to Pure Mathematics, including difficulties related to algebraic reasoning, symbolic manipulation, conceptual understanding, and mathematical problem-solving. The qualitative component further explored contextual factors that contributed to

variations in achievement outcomes, including attendance, participation, engagement with remedial activities, and opportunities for independent mathematical practice. The methodological approach was informed by Vygotsky's Sociocultural Theory of Learning and Constructivist Learning Theory. Within this theoretical orientation, the embedded remedial tutorial intervention was conceptualised as a scaffolded learning mechanism designed to support students within their Zone of Proximal Development. The intervention provided structured guidance, opportunities for mathematical practice, immediate feedback, and collaborative engagement aimed at facilitating the gradual development of mathematical competence.

Research Context and Setting

The study was conducted within a higher education mathematics support environment involving students enrolled in programmes requiring engagement with Pure Mathematics. The participants were students who had completed Mathematical Literacy at Grade 12 level rather than Pure Mathematics during their secondary schooling. Students entering higher education from a Mathematical Literacy background possessed mathematical knowledge primarily developed through practical applications, interpretation of quantitative information, and contextual problem-solving. However, university-level Pure Mathematics required engagement with a different form of mathematical thinking characterised by abstraction, symbolic representation, formal reasoning, and systematic problem-solving.

The transition therefore required students to develop competencies in areas such as:

- Algebraic manipulation and procedural fluency;
- Interpretation and use of symbolic mathematical notation;
- Abstract mathematical reasoning;
- Formal problem-solving strategies;
- Conceptual understanding of mathematical relationships and structures.

Before engaging formally with Pure Mathematics, students participated in a first-term preparatory programme designed to strengthen foundational mathematical knowledge and improve readiness for subsequent mathematical learning. Despite this preparation, many students continued to experience difficulties during the transition into Pure Mathematics in the second term. These challenges highlighted the need for additional academic support and informed the implementation of embedded remedial tutorial interventions.

Participants and Sampling

The study population consisted of students transitioning from Mathematical Literacy to Pure Mathematics across three academic cohorts: Logistics, Transportation, and Public Relations. A purposive sampling strategy was employed because participants were selected based on specific characteristics directly aligned with the purpose of the study.

The inclusion criteria required that participants:

- Had completed Mathematical Literacy at secondary school level;
- Participated in the preparatory mathematical transition programme;
- Were enrolled in academic programmes requiring Pure Mathematics;
- Were exposed to the embedded remedial tutorial intervention.

The sample distribution across the two academic years is presented in Table 1 below:

Table 1 Sample distribution across the two academic years		
Cohort	2025 Sample	2026 Sample
Logistics	36	37
Transportation	19	21
Public Relations	61	60

The inclusion of multiple cohorts across two academic years enabled comparison of performance trajectories and provided a broader understanding of the relationship between embedded remedial support and student achievement.

Description of the Embedded Remedial Tutorial Intervention

The intervention implemented in this study consisted of an embedded remedial tutorial programme integrated directly into scheduled Pure Mathematics lectures. Unlike conventional tutorial approaches that provide support through separate supplementary sessions, the embedded model incorporated remedial activities within the normal teaching process. This enabled students to receive immediate assistance while engaging with mathematical concepts, positioning academic support as an integral component of instruction rather than an additional intervention. The primary aim of the intervention was to address conceptual and procedural gaps experienced by students transitioning from Mathematical Literacy to Pure Mathematics. While Mathematical Literacy emphasises contextual applications, interpretation of information, and practical problem-solving, Pure Mathematics requires greater proficiency in abstract reasoning, symbolic manipulation, algebraic fluency, logical deduction, and formal mathematical processes. The intervention therefore focused on bridging this transition by strengthening the foundational competencies required for successful participation in university mathematics.

Tutorial activities included revision of prerequisite concepts, development of algebraic skills, practice with mathematical notation and symbolic manipulation, clarification of abstract concepts, guided problem-solving, correction of misconceptions, and provision of immediate formative feedback. These activities enabled students to consolidate prior knowledge while gradually developing the higher-order reasoning skills expected in Pure Mathematics. The intervention was informed by Vygotsky’s concept of

scaffolding within the Zone of Proximal Development. Initially, students received structured support through lecturer explanations, worked examples, guided exercises, peer interaction, and tutor assistance. Mathematical problems were broken into manageable steps to support conceptual understanding and procedural development. As students gained confidence and competence, instructional support was gradually reduced to encourage independent problem-solving.

A key feature of the intervention was its integration within the lecture environment, allowing lecturers and tutors to identify and address misconceptions as they occurred. Students were provided with opportunities to ask questions, receive feedback, engage in discussions, and practise mathematical skills within the context of learning. This immediate and contextualised support strengthened the connection between teaching, remediation, and students' mathematical development. The intervention also promoted active engagement through collaborative problem-solving activities, guided practice, and reflection. Rather than passively receiving information, students actively reconstructed their prior Mathematical Literacy knowledge into the more formal and abstract reasoning required in Pure Mathematics. Overall, the embedded remedial tutorial intervention functioned as a scaffolded pedagogical strategy aimed at reducing mathematical knowledge gaps, improving conceptual understanding, strengthening algebraic fluency, and enhancing students' confidence and independence in mathematical problem-solving.

Data Collection

Quantitative Data Collection

The primary source of quantitative data for this study consisted of students' mathematics assessment scores collected during Term 1 and Term 2 of the 2025 and 2026 academic years. The purpose of collecting these achievement data was to examine changes in students' mathematical performance as they transitioned from a Mathematical Literacy preparation phase into the more conceptually demanding environment of Pure Mathematics, particularly following exposure to the embedded remedial tutorial intervention. The quantitative dataset comprised both individual student achievement records and aggregated performance indicators. Individual assessment scores were collected to enable analysis of student-level performance changes, while aggregated indicators were used to identify broader patterns and trends across different cohorts and academic periods. The collected data included students' assessment marks, mean achievement scores, standard deviation values, and minimum and maximum performance scores. Mean achievement scores were used to determine overall levels of academic performance within each cohort and academic period, while standard deviation values provided insight into the extent of variation among students' achievement outcomes. The inclusion of minimum and maximum scores further enabled examination of performance ranges and identification of differences in achievement levels among students within each cohort. Collectively, these quantitative indicators provided a comprehensive basis for evaluating changes in mathematical performance and assessing the potential influence of embedded remedial tutorial support. The collected performance data enabled systematic examination of achievement patterns across different transition points. Since students

initially engaged with a preparatory Mathematical Literacy programme before progressing to Pure Mathematics, comparisons were structured to capture changes associated with this transition process.

Within-Year Performance Comparisons

The study conducted within-year comparisons to examine changes in student performance as learners progressed through the academic cycle. Two primary comparisons were undertaken:

- 2025 Term 1 compared with 2025 Term 2; and
- 2026 Term 1 compared with 2026 Term 2.

These comparisons provided insight into how students' mathematical achievement changed as they moved from the initial preparatory phase into formal engagement with Pure Mathematics. Term 1 represented the period during which students received foundational mathematical preparation aimed at strengthening prerequisite knowledge and addressing potential gaps arising from their Mathematical Literacy background. Term 2 represented a period of increased engagement with Pure Mathematics concepts requiring higher levels of abstraction, symbolic reasoning, algebraic manipulation, and formal problem-solving.

By analysing performance differences between the two terms within each academic year, the study examined whether students demonstrated improvement, stability, or decline in achievement following the transition into Pure Mathematics and participation in the embedded remedial tutorial intervention.

Across-Year Performance Comparisons

In addition to within-year comparisons, the study conducted across-year analyses to examine whether performance patterns differed between cohorts exposed to the intervention during different academic years. The following comparisons were undertaken:

- 2025 Term 1 compared with 2026 Term 1; and
- 2025 Term 2 compared with 2026 Term 2.

These comparisons enabled examination of whether students' performance trajectories varied across implementation periods and whether differences existed between cohorts experiencing the embedded remedial intervention in different academic years. The analysis provided insight into the consistency of intervention effects and the extent to which improvements or challenges observed in one cohort were reflected in subsequent cohorts. The longitudinal comparison across two academic years strengthened the study by allowing examination of recurring performance trends rather than relying on a single cohort. This approach supported a more comprehensive evaluation of the embedded remedial tutorial intervention by considering both immediate changes in student achievement and broader patterns of mathematical transition over time.

Overall, the quantitative data collection strategy provided an empirical foundation for evaluating the effectiveness of embedded remedial tutorials in supporting students transitioning from Mathematical

Literacy to Pure Mathematics. Through systematic analysis of achievement patterns within and across academic years, the study was able to investigate whether structured remedial support contributed to improved mathematical readiness, enhanced academic performance, and a more successful transition into university-level mathematics.

Qualitative Data Sources

Although the primary evidence base of this study consisted of quantitative achievement data, qualitative interpretation was incorporated to provide deeper insights into the contextual factors influencing students' mathematical development and performance trajectories. This inclusion was important because changes in academic achievement cannot be fully explained through numerical outcomes alone. Students' performance is influenced by multiple factors, including engagement with instructional support, participation in learning activities, attendance patterns, and challenges encountered during the transition to university-level Pure Mathematics. Qualitative data were obtained through contextual observations of students within the embedded remedial tutorial environment. These observations focused on students' participation, attendance, engagement with mathematical tasks, interactions with tutors and peers, and difficulties experienced during problem-solving activities. The purpose was to provide explanatory insights into the achievement patterns identified through quantitative analysis.

Student engagement was examined through their willingness to participate in discussions, seek clarification, attempt mathematical exercises, and apply feedback during guided learning activities. Attendance patterns were also considered, as consistent participation provided sustained opportunities for students to practise mathematical procedures, address misconceptions, and strengthen conceptual understanding. The study further explored students' involvement in guided exercises, collaborative activities, and independent practice, as these processes were essential for transforming prior Mathematical Literacy knowledge into the abstract reasoning and symbolic practices required in Pure Mathematics. Observations also identified specific transition challenges, including difficulties with algebraic manipulation, mathematical notation, procedural application, and abstract reasoning. The qualitative component therefore complemented the quantitative findings by explaining variations in student performance outcomes. While statistical analysis demonstrated changes in achievement patterns, qualitative observations provided insights into how engagement, participation, and learning experiences influenced the effectiveness of the embedded remedial intervention. This integration enabled a more comprehensive understanding of the conditions under which remedial support facilitated successful mathematical transition.

Data Analysis

The data analysis process was designed to examine the extent to which embedded remedial tutorial interventions influenced students' transition from Mathematical Literacy to Pure Mathematics and their subsequent academic performance. Both descriptive and inferential statistical analyses were employed to identify performance patterns, determine statistically significant changes, and interpret the role of the intervention within the broader context of students' mathematical development.

Descriptive Statistical Analysis

Descriptive statistical analysis was conducted to establish overall achievement patterns across different cohorts, academic years, and instructional periods. This analysis provided an initial understanding of students' performance trajectories before and after exposure to the embedded remedial tutorial intervention.

The descriptive analysis included the calculation and interpretation of mean scores, standard deviations, and minimum and maximum performance values.

Mean Scores

Mean scores were calculated to determine the average level of student achievement within each cohort and academic period. These measures provided an overview of general performance trends and enabled comparisons of students' achievement before and after the transition from Mathematical Literacy preparation to Pure Mathematics. Changes in mean performance were examined to determine whether students demonstrated improvement, stability, or decline following participation in the embedded remedial tutorial intervention.

Standard Deviations

Standard deviation values were analysed to determine the degree of variation in students' performance scores within each cohort. These measures provided insight into the consistency of achievement outcomes and assisted in determining whether the intervention contributed to reducing performance disparities among students. A smaller standard deviation indicated more consistent achievement patterns, whereas larger values reflected greater variation in students' mathematical performance and levels of adaptation to Pure Mathematics.

Minimum and Maximum Scores

Minimum and maximum performance scores were examined to identify the range of achievement outcomes within each cohort. These measures assisted in understanding the extent of individual differences among students and highlighted variations in students' ability to cope with the transition from Mathematical Literacy to the more abstract demands of Pure Mathematics. Analysis of performance ranges also provided evidence of whether the intervention supported students across different achievement levels.

Inferential Statistical Analysis

To determine whether observed differences in student performance were statistically significant, inferential statistical analysis was conducted. Since the dataset consisted of paired observations obtained from the same participants across different academic periods, and the assumption of normal distribution could not consistently be established, the study employed the Wilcoxon Signed-Rank Test as the primary inferential statistical procedure.

The Wilcoxon Signed-Rank Test was considered appropriate because it is a non-parametric statistical technique used to analyse differences between related samples. This test enabled examination of whether students' mathematics performance changed significantly across different transition points and intervention periods.

The inferential analysis focused on identifying significant differences in student achievement:

- Before and after the transition from Mathematical Literacy preparation into Pure Mathematics;
- Before and after exposure to embedded remedial tutorial interventions;
- Across different academic years to determine whether performance patterns varied between cohorts.

The statistical hypotheses guiding the analysis were formulated as follows:

Null Hypothesis (H_0)

There is no statistically significant difference between students' mathematics performance before and after participation in embedded remedial tutorial interventions.

Alternative Hypothesis (H_1)

There is a statistically significant difference between students' mathematics performance before and after participation in embedded remedial tutorial interventions.

The level of statistical significance was established at $p < 0.05$. Therefore, when the calculated probability value was below this threshold, the null hypothesis was rejected, indicating that a statistically significant difference existed between the paired observations. Conversely, when the probability value exceeded 0.05, the null hypothesis was retained, suggesting that the observed differences were not statistically significant.

Interpretation of Intervention Effects

The interpretation of statistical findings considered both positive and negative performance trends to provide a balanced understanding of the influence of embedded remedial tutorials. Improvements in student achievement following participation in the intervention were interpreted as potential evidence that structured academic support contributed to the development of mathematical competence, particularly by strengthening foundational knowledge, improving problem-solving ability, and supporting adaptation to the cognitive demands of Pure Mathematics.

However, declines in student performance were not interpreted solely as evidence that the intervention was ineffective. Instead, performance decreases were examined within the broader learning context in which the intervention occurred. The study recognised that the effectiveness of remedial support is influenced by the interaction between instructional provision and students' active engagement with learning opportunities.

Factors considered in interpreting declining performance patterns included:

- Poor attendance and reduced exposure to remedial support activities;
- Limited participation during tutorial sessions;
- Insufficient opportunities for independent mathematical practice;
- Difficulties maintaining engagement with abstract mathematical concepts associated with Pure Mathematics.

This interpretive approach acknowledges that remedial interventions function as a form of pedagogical scaffolding, but the extent to which students benefit depends on their sustained participation, willingness to practise mathematical processes, and ability to progressively develop independent mathematical reasoning.

Ethical Considerations

Ethical principles governing educational research were maintained throughout all stages of the study. Student achievement records were treated as confidential research data and were analysed anonymously to protect participant identities and ensure privacy. Participation in the embedded remedial tutorial intervention formed part of the institution's academic support structure and was not linked to students' assessment results or academic progression decisions. The intervention was implemented as a supportive learning mechanism intended to enhance students' mathematical preparedness and success. The collected data were used exclusively for research purposes, and all findings were reported at cohort level rather than at individual participant level. This approach ensured confidentiality, minimised risks associated with identification of participants and maintained ethical standards in educational research. Overall, the data analysis procedures provided a systematic approach for examining the effectiveness of embedded remedial tutorial interventions. By combining descriptive statistical analysis, non-parametric inferential testing, and contextual interpretation, the study was able to investigate not only whether students' performance changed, but also how and why the intervention contributed to students' transition from Mathematical Literacy to Pure Mathematics.

Quantitative Findings: Transition from Mathematical Literacy to Pure Mathematics and the Influence of Remedial Tutorial Interventions on Academic Performance

The transition from Mathematical Literacy at secondary school level to Pure Mathematics at university level presents significant academic challenges due to differences in curriculum orientation, mathematical language, conceptual abstraction, and problem-solving expectations. Students in this study predominantly entered higher education with Mathematical Literacy backgrounds, which emphasise practical applications, interpretation of quantitative information, and contextual problem-solving. However, university-level Pure Mathematics requires engagement with abstract concepts, symbolic manipulation, algebraic reasoning, logical argumentation, and procedural fluency. This shift created a substantial cognitive gap that influenced students' preparedness and academic performance.

During the first academic term, students participated in a preparatory Mathematical Literacy phase aimed at strengthening foundational competencies required for Pure Mathematics. This phase addressed areas such as algebraic manipulation, numerical reasoning, mathematical notation, and problem-solving strategies. Despite this preparation, many students experienced difficulties when transitioning to Pure Mathematics in the second term. Limited exposure to formal algebra, functions, symbolic reasoning, and abstract mathematical processes constrained students' ability to adapt to the demands of university mathematics.

To address these challenges, embedded remedial tutorial interventions were integrated into scheduled Pure Mathematics lectures. Unlike traditional support models offered separately from formal teaching, the embedded approach provided immediate and context-specific assistance within the learning environment. The intervention focused on revising prerequisite concepts, strengthening algebraic fluency, developing conceptual understanding, providing guided problem-solving practice, and correcting misconceptions through immediate feedback. This approach functioned as a bridge between students' existing Mathematical Literacy knowledge and the advanced mathematical practices required in Pure Mathematics.

The performance patterns across cohorts demonstrate varied responses to the intervention (see Table 2). In Logistics, students achieved relatively strong Term 1 mean scores in both 2025 (77.5%) and 2026 (77.1%), reflecting the benefits of foundational preparation and structured support. However, performance declined in Term 2, with mean scores of 69.8% in 2025 and 68.7% in 2026, indicating difficulties associated with increased abstraction and conceptual complexity in Pure Mathematics. Transportation students demonstrated improvement during Term 1 of 2026, achieving a mean score of 76.1% compared with 67.8% in Term 1 of 2025. This improvement suggests that enhanced remedial support contributed to stronger mathematical preparedness. However, Term 2 performance declined in both years, suggesting that initial gains required continued engagement, independent practice, and sustained participation to be maintained. The Public Relations cohort demonstrated the most sustained improvement, increasing from 65.4% in Term 1 of 2025 to 72.6% in Term 1 of 2026 and 75.8% in Term 2 of 2026. The reduced standard deviations in 2026 also indicate greater consistency in student performance. These outcomes suggest that students who actively engaged with embedded tutorials were better able to overcome transition challenges and develop the competencies required for Pure Mathematics.

The findings further indicate that achievement outcomes were influenced not only by instructional support but also by attendance, participation, and opportunities for independent mathematical practice. Students who engaged consistently with tutorials were better positioned to consolidate conceptual understanding and develop mathematical confidence, whereas inconsistent participation contributed to persistent learning gaps. Overall, the findings demonstrate that transitioning from Mathematical Literacy to Pure Mathematics requires deliberate pedagogical support. Embedded remedial tutorials provide an effective mechanism for reducing mathematical knowledge gaps by integrating scaffolding directly into

lectures. However, sustainable improvement depends on the interaction between quality instructional design, student engagement, and the development of self-regulated learning practices.

Table 2
Comparative Summary of Logistics, Transportation, and Public Relations Performance Scores (2025–2026)

Service Area	Year	Term	n	Mean (%)	SD	Minimum (%)	Maximum (%)
Logistics	2025	Term 1	36	77.5	8.4	60	93
	2025	Term 2	36	69.8	14.1	0	95
	2026	Term 1	37	77.1	11.9	50	97
	2026	Term 2	37	68.7	12.1	37	92
Transportation	2025	Term 1	19	67.8	12.3	50	90
	2025	Term 2	19	60.6	15.2	43	92
	2026	Term 1	21	76.1	11.1	54	94
	2026	Term 2	21	63.0	14.6	18	93
Public Relations	2025	Term 1	61	65.4	18.6	0	92
	2025	Term 2	61	65.7	17.0	5	87
	2026	Term 1	60	72.6	10.8	38	94
	2026	Term 2	60	75.8	11.8	0	100

Table 3 presents descriptive statistics for the Logistics Department, illustrating changes in students’ mathematics performance across different academic periods and transition points. The analysis examines achievement patterns within and across academic years to understand how students responded to the transition from Mathematical Literacy preparation to Pure Mathematics and the implementation of embedded remedial tutorial support.

The comparison between 2025 Term 1 and Term 2, involving 36 students, revealed a decline in mean performance from 78.03% to 67.64%, while the median decreased from 77.50% to 66.00%. This reduction suggests that students experienced difficulties when progressing from the preparatory Mathematical Literacy phase into the more abstract and conceptually demanding Pure Mathematics environment. Although students possessed foundational knowledge, the increased emphasis on algebraic manipulation, symbolic reasoning, formal mathematical procedures, and advanced problem-solving appeared to influence their achievement outcomes. A similar pattern was observed in 2026, where 37 students demonstrated a decrease in mean performance from 76.30% in Term 1 to 68.35% in Term 2. The median score also declined from 77.00% to 67.00%. The recurrence of this trend across both academic years indicates that the transition into Pure Mathematics remained a significant challenge for students with Mathematical Literacy backgrounds. While embedded remedial tutorials

provided structured support, students’ success depended on sustained participation, regular attendance, and opportunities for independent mathematical practice.

Cross-year comparisons showed relatively stable performance patterns. The comparison between 2025 Term 1 and 2026 Term 1 revealed only a slight decrease in mean performance from 78.03% to 76.42%, with the median remaining constant at 77.50%. This suggests that both cohorts entered the programme with comparable levels of mathematical preparedness and received similar benefits from the preparatory support structures. The comparison between 2025 Term 2 and 2026 Term 2 indicated a slight improvement in the later cohort, with the mean increasing from 67.64% to 68.58% and the median from 66.00% to 67.00%. Although modest, this improvement may reflect refinements in the embedded remedial approach, improved alignment of tutorial activities with students’ learning needs, and increased awareness of transition challenges.

Overall, the findings demonstrate that students experienced a consistent decline when moving from Mathematical Literacy preparation to Pure Mathematics, highlighting the cognitive shift required to engage with abstract mathematical concepts. However, stable cross-year outcomes and slight improvement in 2026 suggest that embedded remedial tutorials provided valuable scaffolding. The intervention supported students in developing mathematical reasoning, symbolic understanding, and problem-solving skills required for successful participation in university-level Pure Mathematics.

Table 3
Descriptive Statistics: Logistics Department

Comparison	N	Mean (Before)	Mean (After)	Median (Before)	Median (After)
2025 Term 1 vs Term 2	36	78.03	67.64	77.50	66.00
2026 Term 1 vs Term 2	37	76.30	68.35	77.00	67.00
2025 Term 1 vs 2026 Term 1	36	78.03	76.42	77.50	77.50
2025 Term 2 vs 2026 Term 2	36	67.64	68.58	66.00	67.00

Table 4 presents the results of the Wilcoxon Signed-Rank Test conducted for the Logistics Department to determine whether statistically significant differences existed in students’ mathematics performance across different academic periods. The analysis examined within-year changes associated with the transition from Mathematical Literacy preparation to Pure Mathematics, as well as cross-year comparisons between cohorts exposed to the embedded remedial tutorial intervention.

The comparison between 2025 Term 1 and Term 2 produced a Wilcoxon test statistic of $W = 108.50$ with $p = 0.001$. Since the p-value was below the significance level of 0.05, the null hypothesis was rejected, indicating a statistically significant difference in student performance between the two terms. The decline observed in achievement suggests that students experienced difficulties when transitioning from Mathematical Literacy preparation to the more abstract demands of Pure Mathematics. The increased

emphasis on symbolic manipulation, algebraic reasoning, and formal problem-solving created additional cognitive challenges despite the availability of remedial support.

Similarly, the comparison between 2026 Term 1 and Term 2 revealed a statistically significant difference ($W = 67.50, p < 0.001$). This confirms that the transition into Pure Mathematics remained a significant challenge across both academic years. Although embedded remedial tutorials provided scaffolding and opportunities for guided practice, students’ ability to maintain performance was influenced by additional factors, including attendance, participation, and independent mathematical engagement.

The comparison between 2025 Term 1 and 2026 Term 1 showed no statistically significant difference ($W = 213.00, p = 0.340$). The null hypothesis was therefore retained, indicating that both cohorts entered the programme with comparable levels of mathematical preparedness. Similarly, the comparison between 2025 Term 2 and 2026 Term 2 revealed no statistically significant difference ($W = 313.50, p = 0.759$), suggesting that students across both cohorts experienced similar achievement patterns after transitioning into Pure Mathematics.

Overall, the findings reveal two key patterns. First, significant within-year differences demonstrate that the transition from Mathematical Literacy to Pure Mathematics represents a substantial academic challenge, primarily due to increased conceptual abstraction and reasoning demands. Second, the absence of significant cross-year differences suggests that the embedded remedial intervention provided a consistent support structure but did not fully eliminate the underlying challenges associated with mathematical transition.

These findings highlight that embedded remedial tutorials should be viewed as a continuous scaffolding mechanism rather than a short-term intervention. While such support strengthens foundational competencies, successful transition requires sustained student engagement, regular attendance, and continued opportunities for mathematical practice.

Table 4
Wilcoxon Signed-Rank Test Results: Logistics Department

Comparison	Wilcoxon W Statistic	p-value	Decision
2025 Term 1 vs Term 2	108.50	0.001	Reject H_0
2026 Term 1 vs Term 2	67.50	< 0.001	Reject H_0
2025 Term 1 vs 2026 Term 1	213.00	0.340	Fail to reject H_0
2025 Term 2 vs 2026 Term 2	313.50	0.759	Fail to reject H_0

Table 5 presents descriptive statistics for the Transportation Department, illustrating changes in students’ mathematics performance across academic periods and cohorts. The analysis examines achievement patterns within and across academic years to evaluate students’ transition from Mathematical Literacy preparation to Pure Mathematics and the influence of embedded remedial tutorial support on their mathematical development.

The comparison between 2025 Term 1 and Term 2, involving 19 students, revealed a decline in performance. The mean score decreased from 68.47% to 61.32%, while the median declined from 70.00% to 55.00%. The reduction in both measures suggests that students experienced challenges when transitioning into Pure Mathematics. The decline in median performance indicates that reduced achievement occurred across a substantial proportion of the cohort rather than among isolated individuals. This pattern reflects difficulties associated with increased abstraction, symbolic representation, algebraic reasoning, and formal problem-solving requirements.

A similar trend was observed for the 2026 cohort, where mean performance declined from 76.76% in Term 1 to 62.52% in Term 2, and the median decreased from 77.00% to 63.00%. Although students demonstrated stronger initial performance compared with the previous cohort, the decline during Term 2 indicates that the conceptual demands of Pure Mathematics continued to present significant challenges. This suggests that while improved preparation and embedded remedial support enhanced readiness, they did not completely remove the difficulties associated with mathematical transition.

Cross-year comparisons showed evidence of improvement among the 2026 cohort. The comparison between Term 1 results revealed an increase in mean performance from 68.47% in 2025 to 76.00% in 2026, with the median increasing from 70.00% to 76.00%. This improvement suggests that students entered the programme with stronger preparation or benefited from refinements in the preparatory and remedial support structures.

The comparison between 2025 Term 2 and 2026 Term 2 also showed slight improvement, with mean performance increasing from 61.32% to 62.37% and median performance improving from 55.00% to 63.00%. Although the mean difference was modest, the improved median indicates that more students achieved higher performance levels in the later cohort.

Overall, the findings demonstrate that the transition from Mathematical Literacy to Pure Mathematics remains challenging, particularly due to the shift from contextual mathematical applications to abstract reasoning and symbolic manipulation. However, improvements across cohorts suggest that embedded remedial tutorials provided meaningful scaffolding by strengthening foundational knowledge and supporting mathematical adaptation. Nevertheless, sustained attendance, active participation, and continuous practice remain essential for students to successfully navigate this transition.

Table 5
Descriptive Statistics: Transportation Department

Comparison	N	Mean (Before)	Mean (After)	Median (Before)	Median (After)
2025 Term 1 vs Term 2	19	68.47	61.32	70.00	55.00
2026 Term 1 vs Term 2	21	76.76	62.52	77.00	63.00
2025 Term 1 vs 2026 Term 1	19	68.47	76.00	70.00	76.00
2025 Term 2 vs 2026 Term 2	19	61.32	62.37	55.00	63.00

Table 6 presents the results of the Wilcoxon Signed-Rank Test conducted for the Transportation Department to examine whether statistically significant differences existed in students' mathematics performance across different academic periods. The analysis focused on within-year transitions from Mathematical Literacy preparation to Pure Mathematics and cross-year comparisons to determine whether performance patterns differed between cohorts exposed to embedded remedial tutorial interventions.

The comparison between 2025 Term 1 and Term 2 produced a Wilcoxon test statistic of $W = 43.50$ and a p-value of 0.067. Since the p-value exceeded the significance level of $p < 0.05$, the null hypothesis was retained, indicating that the observed decline in performance was not statistically significant. Although students' mean and median scores decreased, the change may reflect normal cohort variation rather than a meaningful deterioration in achievement. However, the decline suggests that some students experienced difficulties adjusting to the conceptual and cognitive demands of Pure Mathematics.

The 2026 Term 1 and Term 2 comparison revealed a statistically significant difference ($W = 16.00$, $p < 0.001$), resulting in rejection of the null hypothesis. This indicates a significant change in student performance between the two terms. The decline suggests that students continued to encounter challenges when transitioning to more abstract mathematical processes, including formal reasoning, symbolic manipulation, and advanced problem-solving.

The comparison between 2025 Term 1 and 2026 Term 1 yielded $W = 52.50$ with $p = 0.087$, indicating no statistically significant difference between the two cohorts. Although the 2026 cohort showed improved descriptive performance, the difference was insufficient to confirm significant improvement. Similarly, the comparison between 2025 Term 2 and 2026 Term 2 produced $W = 82.50$ and $p = 0.896$, confirming no statistically significant difference between cohorts after the transition into Pure Mathematics.

Overall, the findings demonstrate a mixed pattern of performance changes. While the 2026 Term 1 to Term 2 transition presented a significant decline, the remaining comparisons indicated relatively stable achievement patterns across cohorts. The results suggest that embedded remedial tutorials provided valuable transitional support but did not completely overcome the challenges associated with moving from Mathematical Literacy to the abstract demands of Pure Mathematics.

These findings emphasise the need for sustained academic support, active tutorial engagement, and opportunities for independent mathematical practice. Theoretically, the results align with Vygotsky’s concept of scaffolding within the Zone of Proximal Development, suggesting that continuous guided support is essential for developing the mathematical competencies required for successful engagement with Pure Mathematics.

Table 6
Wilcoxon Signed-Rank Test Results: Transportation Department

Comparison	Wilcoxon W Statistic	p-value	Decision
2025 Term 1 vs Term 2	43.50	0.067	Fail to reject H_0
2026 Term 1 vs Term 2	16.00	< 0.001	Reject H_0
2025 Term 1 vs 2026 Term 1	52.50	0.087	Fail to reject H_0
2025 Term 2 vs 2026 Term 2	82.50	0.896	Fail to reject H_0

Table 7 presents the descriptive statistics for the Public Relations Department, highlighting students’ mathematics performance patterns across different academic periods and cohorts. The analysis examines changes associated with the transition from Mathematical Literacy preparation to Pure Mathematics and the potential influence of embedded remedial tutorial interventions. Compared with the Logistics and Transportation cohorts, the Public Relations cohort demonstrates a more consistent improvement trajectory, suggesting stronger adaptation to the mathematical demands of Pure Mathematics. The comparison between 2025 Term 1 and Term 2, involving 60 students, revealed a relatively stable performance pattern. The mean score decreased slightly from 65.33% to 64.88%, while the median declined from 72.00% to 69.00%. Although a small reduction was observed, the limited change suggests that students maintained relatively consistent achievement during the transition. This stability may indicate that embedded remedial tutorials supported students through guided practice, misconception clarification, and reinforcement of foundational mathematical concepts.

In contrast, the 2026 Term 1 and Term 2 comparison showed improved achievement. The mean score increased from 71.85% to 74.08%, while the median increased from 73.00% to 77.00%. These improvements suggest that students became more confident and capable of engaging with Pure Mathematics requirements over time. The positive trend may be attributed to sustained participation in remedial tutorials, which strengthened mathematical competence and problem-solving abilities. Cross-year comparisons also demonstrated improved performance among the 2026 cohort. Between 2025 Term 1 and 2026 Term 1, the mean score increased from 65.73% to 71.85%, while the median improved from 72.00% to 73.00%. Similarly, the comparison between 2025 Term 2 and 2026 Term 2 showed a substantial increase in mean performance from 65.00% to 74.08%, with median scores improving from 70.00% to 77.00%. This represents the strongest positive shift and suggests that the 2026 cohort was better prepared to sustain performance after transitioning into Pure Mathematics.

Overall, the Public Relations cohort demonstrated a more positive performance trajectory, with the 2026 cohort showing consistent improvement across academic periods. The findings suggest that embedded remedial tutorials contributed to students’ mathematical development by enhancing algebraic fluency, conceptual understanding, and problem-solving skills. The results further support the importance of sustained scaffolding and active student engagement in facilitating the transition from Mathematical Literacy to Pure Mathematics. From a theoretical perspective, the findings align with Vygotsky’s Zone of Proximal Development, emphasising the role of guided support in enabling students to progress towards independent mathematical reasoning.

Table 7
Descriptive Statistics: Public Relations Department

Comparison	N	Mean (Before)	Mean (After)	Median (Before)	Median (After)
2025 Term 1 vs Term 2	60	65.33	64.88	72.00	69.00
2026 Term 1 vs Term 2	59	71.85	74.08	73.00	77.00
2025 Term 1 vs 2026 Term 1	59	65.73	71.85	72.00	73.00
2025 Term 2 vs 2026 Term 2	59	65.00	74.08	70.00	77.00

Table 8 presents the results of the Wilcoxon Signed-Rank Test for the Public Relations Department to determine whether statistically significant differences existed in students’ mathematics performance across different academic periods. The analysis examined within-year transitions from Mathematical Literacy preparation to Pure Mathematics and cross-year comparisons to evaluate differences between cohorts exposed to embedded remedial tutorial interventions.

The comparison between 2025 Term 1 and Term 2 produced a Wilcoxon test statistic of $W = 772.50$ with $p = 0.668$. Since the p-value exceeded 0.05, the null hypothesis was retained, indicating no statistically significant difference in student performance. Although descriptive statistics showed a slight decline in mean and median scores, the change was not statistically meaningful. This suggests that students maintained stable achievement levels during the transition, possibly due to the supportive role of embedded remedial tutorials in reinforcing foundational concepts and addressing mathematical challenges.

The comparison between 2026 Term 1 and Term 2 revealed a statistically significant difference ($W = 567.50$, $p = 0.026$), resulting in rejection of the null hypothesis. The improvement in mean and median scores indicates a positive performance shift, suggesting that students adapted more effectively to Pure Mathematics after continued exposure to remedial support. This improvement may be associated with increased familiarity with mathematical expectations, strengthened conceptual understanding, and opportunities for guided practice and feedback.

The comparison between 2025 Term 1 and 2026 Term 1 yielded $W = 618.50$ with $p = 0.143$, indicating no statistically significant difference between the two cohorts. Although the 2026 cohort demonstrated higher descriptive performance, the difference was not statistically significant, suggesting comparable initial levels of mathematical preparedness.

However, the comparison between 2025 Term 2 and 2026 Term 2 showed a statistically significant difference ($W = 477.00$, $p = 0.002$). The 2026 cohort achieved significantly higher performance, with mean scores increasing from 65.00% to 74.08% and median scores from 70.00% to 77.00%. This improvement suggests that the later cohort benefited from stronger transition support and more effective engagement with embedded remedial tutorials.

Overall, the findings demonstrate a more positive performance trajectory for the Public Relations cohort. While the 2025 cohort maintained stable achievement, the 2026 cohort showed significant improvement following sustained remedial intervention. The results highlight the value of continuous scaffolding, feedback, and guided mathematical practice in supporting the transition from Mathematical Literacy to Pure Mathematics. The findings align with Vygotsky’s Zone of Proximal Development, emphasising that structured support enables students to progressively develop independent mathematical reasoning and problem-solving abilities.

Table 8
Wilcoxon Signed-Rank Test Results: Public Relations Department

Comparison	Wilcoxon W Statistic	p-value	Decision
2025 Term 1 vs Term 2	772.50	0.668	Fail to reject H_0
2026 Term 1 vs Term 2	567.50	0.026	Reject H_0
2025 Term 1 vs 2026 Term 1	618.50	0.143	Fail to reject H_0
2025 Term 2 vs 2026 Term 2	477.00	0.002	Reject H_0

Table 9 provides a consolidated summary of the Wilcoxon Signed-Rank Test findings across the three departments, highlighting statistically significant performance changes following the transition from Mathematical Literacy preparation to Pure Mathematics and exposure to embedded remedial tutorial interventions. The results demonstrate that the impact of the intervention was not uniform across departments, with performance patterns influenced by cohort characteristics, prior mathematical preparedness, student engagement, and adaptation to the conceptual demands of Pure Mathematics.

The Logistics Department showed statistically significant differences in both the 2025 Term 1 to Term 2 and 2026 Term 1 to Term 2 comparisons, with both indicating significant declines in performance. These findings suggest that students experienced considerable challenges when transitioning into Pure Mathematics. The decline may be associated with the increased demands of university-level mathematics, including abstract reasoning, symbolic manipulation, algebraic processes, and formal problem-solving. Although remedial tutorials provided important scaffolding, the results indicate that

students required sustained support and continuous practice to successfully transfer foundational knowledge into a more abstract mathematical context.

The Transportation Department demonstrated a statistically significant change only in the 2026 Term 1 to Term 2 comparison, which also reflected a decline in performance. This suggests that although students initially demonstrated stronger achievement, challenges emerged as they encountered more advanced Pure Mathematics concepts. The finding highlights the need for remedial support to continue beyond initial preparation and to provide ongoing assistance in consolidating mathematical understanding.

In contrast, the Public Relations Department demonstrated a more positive trajectory, with significant improvements observed in the 2026 Term 1 to Term 2 and 2025 Term 2 to 2026 Term 2 comparisons. These results suggest that students benefited more effectively from embedded remedial tutorials, possibly due to stronger engagement, increased mathematical confidence, improved participation, and greater opportunities for guided practice.

Overall, the findings indicate that embedded remedial tutorial interventions have the potential to support students’ transition from Mathematical Literacy to Pure Mathematics; however, their effectiveness depends on contextual and learner-related factors. While the Public Relations cohort demonstrated the benefits of sustained academic support, the declines observed in Logistics and Transportation reveal the persistent difficulties students face when moving from practical mathematical applications to abstract mathematical reasoning.

From the perspective of Vygotsky’s Sociocultural Theory and Constructivist Learning Theory, the findings emphasise that mathematical development occurs through guided interaction and active knowledge reconstruction. Embedded remedial tutorials provide essential scaffolding that assists students in progressing from existing Mathematical Literacy knowledge towards the conceptual and reasoning demands of Pure Mathematics. However, the variation in outcomes highlights the need for adaptive interventions that address differences in student readiness, engagement, and learning trajectories.

Table 9
Overall Findings Summary

Department	Significant Findings	Direction of Change
Logistics	2025 T1–T2 and 2026 T1–T2 significant	Significant decline each year
Transportation	2026 T1–T2 significant	Significant decline
Public Relations	2026 T1–T2 and 2025 T2–2026 T2 significant	Significant improvement

Qualitative Findings: Students’ Experiences of Transitioning from Mathematical Literacy to Pure Mathematics and the Influence of Embedded Remedial Tutorial Interventions

The qualitative findings provided deeper insight into students’ experiences of transitioning from Mathematical Literacy to Pure Mathematics and their perceptions of the embedded remedial tutorial

intervention. While the quantitative findings demonstrated variations in academic performance trajectories across cohorts, the qualitative evidence explained the underlying factors influencing these outcomes. Thematic analysis of students' learning experiences revealed four major themes: (1) the conceptual gap between Mathematical Literacy and Pure Mathematics, (2) the role of embedded tutorials as a scaffolding mechanism, (3) the development of mathematical confidence and independent problem-solving, and (4) the influence of student engagement and attendance on intervention effectiveness.

The findings indicated that students did not perceive their difficulties as resulting from an inability to learn mathematics, but rather from differences in mathematical experiences, curriculum expectations, and exposure to formal mathematical reasoning. The embedded remedial tutorials were viewed as an important transitional mechanism that assisted students in reconstructing their mathematical understanding and adapting to the demands of university-level Pure Mathematics.

Theme 1: Experiencing the Conceptual Gap between Mathematical Literacy and Pure Mathematics

A dominant theme emerging from the qualitative data was the significant conceptual discontinuity experienced by students when transitioning from Mathematical Literacy to Pure Mathematics. Participants indicated that although Mathematical Literacy provided them with foundational mathematical skills, the nature of mathematical thinking required in Pure Mathematics was substantially different. Students particularly identified challenges related to algebraic manipulation, symbolic notation, abstract reasoning, and interpreting mathematical procedures. Participants explained that Mathematical Literacy had primarily focused on applying mathematical concepts to practical situations, whereas Pure Mathematics required them to understand underlying mathematical structures and relationships. This difference created uncertainty and anxiety during the initial stages of the transition.

One participant explained:

In Mathematical Literacy, we were mostly solving problems based on real-life situations, but in Pure Mathematics you must understand the meaning behind the symbols and formulas. At first, I did not know how to approach those types of questions.

Another participant stated:

The biggest challenge was algebra. We knew how to calculate answers, but we did not have enough practice with changing equations, working with variables, and understanding why certain steps are followed.

These experiences reflect the theoretical assumption that students entered Pure Mathematics with existing mathematical knowledge but required additional support to transform this knowledge into the

abstract mathematical practices expected at university level. From a Vygotskian perspective, students were operating within a Zone of Proximal Development where appropriate scaffolding was necessary to support movement from familiar mathematical practices towards more advanced forms of mathematical reasoning. Participants also highlighted difficulties with mathematical language and notation. The symbolic nature of Pure Mathematics represented a new form of communication that required students to develop mathematical literacy beyond everyday interpretation.

One student commented:

“The symbols looked unfamiliar. Sometimes I understood the idea, but I struggled to understand what the notation was asking me to do.”

This finding suggests that the transition involved not only acquiring new mathematical procedures but also developing fluency in the language and representations of formal mathematics.

Theme 2: Embedded Remedial Tutorials as a Form of Mathematical Scaffolding

The second major theme concerned the role of embedded remedial tutorials in supporting students' transition into Pure Mathematics. Participants consistently described the intervention as a valuable support structure because it helped at the point where mathematical difficulties emerged. Unlike traditional support programmes offered outside lectures, students perceived the embedded approach as more accessible because remediation occurred alongside the introduction of new mathematical concepts.

A participant explained:

The tutorial helped because when we struggled during the lecture, we could immediately get clarification. We did not have to wait until another session to ask questions.

Another student stated:

The tutor explained the same concepts differently. Sometimes the lecturer would introduce the theory, and then the tutorial helped us understand how to apply it step by step.

These findings demonstrate the importance of immediate feedback and guided practice as components of effective scaffolding. The intervention created opportunities for students to interact with tutors, discuss mathematical ideas, and gradually develop greater independence.

Participants particularly valued worked examples and guided problem-solving activities.

One participant commented:

Before the tutorials, I would look at a mathematics problem and not know where to start. The examples showed us the process, and eventually I could attempt similar questions on my own.

This reflects Vygotsky's (1978) argument that learning occurs through social interaction and guided participation. The tutor acted as a more knowledgeable other who supported students in completing mathematical tasks that they could not initially perform independently.

Theme 3: Development of Mathematical Confidence and Independent Problem-Solving

A third theme related to the development of students' mathematical confidence. Participants indicated that their initial experiences with Pure Mathematics were characterised by uncertainty and fear of failure. However, continuous engagement with embedded tutorials gradually improved their confidence and willingness to participate.

Students explained that the intervention changed their perceptions of mathematics from being an intimidating subject to one that could be understood through practice and persistence.

One participant reflected:

At the beginning, I thought Pure Mathematics was only for students who did Mathematics at school. After attending the tutorials, I realised that I could improve if I practised more.

Another participant stated:

The tutorials gave me confidence because I could make mistakes and learn from them without feeling embarrassed.

The findings suggest that the intervention contributed not only to mathematical competence but also to students' mathematical identities. Through repeated opportunities for practice, feedback, and correction of misconceptions, students developed greater self-efficacy in engaging with mathematical problems.

Participants also described a gradual movement from dependence on tutors towards independent problem-solving.

A student explained:

Initially, I needed the tutor to guide every step, but later I started trying questions myself before asking for help.

This progression reflects the gradual withdrawal of scaffolding described within sociocultural learning theory. As students developed competence, responsibility for mathematical reasoning shifted increasingly towards the learner.

Theme 4: Student Engagement, Attendance, and Commitment as Factors Influencing Intervention Effectiveness

Although students generally viewed the embedded remedial tutorials positively, participants emphasised that the benefits of the intervention depended strongly on attendance, participation, and personal commitment. Students who attended regularly and actively engaged with tutorial activities reported greater improvements in understanding and confidence.

A participant explained:

The students who attended the tutorials regularly improved because they had more opportunities to practise. Mathematics needs continuous practice.

Another student noted:

Sometimes students missed tutorials because they thought they could study later, but when the work became more difficult, they struggled to catch up.

These findings provide insight into the variations observed in the quantitative performance results. While the intervention created opportunities for mathematical development, participation determined the extent to which students benefited from available support.

Participants also highlighted the importance of independent practice outside formal instructional sessions.

One student stated:

The tutorials helped us understand the concepts, but you still have to practise on your own. Mathematics cannot only be learned during class.

This finding reinforces the constructivist perspective that students actively construct mathematical knowledge through engagement, reflection, and application. The intervention provided the necessary learning environment, but students' active participation remained essential for successful transition.

Theme 5: Transitioning from Dependency to Mathematical Independence

A final theme emerging from the qualitative findings was the gradual transition from reliance on external support towards independent mathematical learning. Participants described how the embedded tutorials initially served as a source of guidance but gradually encouraged them to take greater responsibility for their learning.

One participant explained:

At first, I depended on the tutor because Pure Mathematics was new to me. Later, I started solving problems before checking with the tutor.

Another participant stated:

The tutorials taught us strategies for thinking about problems, not only how to get answers.

This finding demonstrates that the intervention supported deeper mathematical development by encouraging students to internalise problem-solving strategies. The role of the tutorial therefore extended beyond remediation of content gaps and contributed to the development of mathematical thinking practices required for university success.

The qualitative findings demonstrate that students' transition from Mathematical Literacy to Pure Mathematics involved significant cognitive, conceptual, and emotional adjustments. Students experienced difficulties primarily because of differences between practical mathematical applications and the abstract reasoning demands of university mathematics. However, embedded remedial tutorials provided an effective scaffolding mechanism by creating opportunities for immediate feedback, guided practice, misconception correction, and collaborative mathematical engagement. The findings further indicate that the effectiveness of the intervention was influenced by student participation, attendance, and commitment to independent practice. Students who actively engaged with tutorial activities developed stronger mathematical confidence, improved problem-solving strategies, and greater independence in mathematical reasoning.

Overall, the qualitative evidence supports the theoretical proposition that mathematical transition is not simply a process of correcting student deficiencies, but rather a developmental process requiring structured support, meaningful interaction, and opportunities for students to reconstruct their mathematical understanding. The embedded remedial tutorial intervention functioned as a bridge between students' existing Mathematical Literacy knowledge and the abstract mathematical practices required for successful engagement with Pure Mathematics in higher education.

Discussion

The findings of this study contribute to research on mathematical transitions in higher education by demonstrating that movement from Mathematical Literacy to Pure Mathematics involves a transformation in mathematical thinking rather than merely the acquisition of additional content knowledge. Consistent with Bolstad (2023), the study confirms that Mathematical Literacy emphasises contextual interpretation and practical application, whereas Pure Mathematics requires abstraction, symbolic reasoning, algebraic manipulation, and formal problem-solving. This transition therefore presents conceptual challenges for students whose prior mathematical experiences differ from university expectations. The difficulties identified in algebraic fluency, symbolic manipulation, and

abstract reasoning support previous research showing that mathematical readiness is shaped by learners' exposure to mathematical practices, instructional opportunities, and learning contexts (Hwang & Ham, 2021; Kappassova et al., 2025). Students transitioning from context-based Mathematical Literacy are required to reconstruct their mathematical understanding within a more formal and symbolic environment. This highlights the importance of pedagogical approaches that connect existing knowledge with the demands of Pure Mathematics.

The improvements observed among some cohorts following embedded remedial tutorials provide evidence of the value of structured academic support. These findings align with Vygotsky's (1978) Sociocultural Theory, particularly the concepts of the Zone of Proximal Development and scaffolding, which emphasise learning through guided interaction and appropriate support. The tutorials created opportunities for immediate feedback, misconception correction, guided practice, and progressive development of mathematical competence. This supports constructivist perspectives that view learning as an active process of connecting new experiences with existing knowledge (Fosnot, 2013). The findings further support research on integrated remedial approaches. Ahmadfard (2026) and Mailizar et al. (2025) highlight the importance of targeted, learner-centred interventions in addressing conceptual gaps and improving mathematical outcomes. Extending this work, the present study demonstrates that embedding remedial support within Pure Mathematics lectures strengthens alignment between instruction and intervention by allowing learning difficulties to be addressed within the immediate classroom context.

However, the results also indicate that remedial interventions do not produce uniform outcomes. While some cohorts demonstrated significant improvement, others experienced limited progress or declines. This suggests that intervention effectiveness depends on factors such as attendance, motivation, participation, and opportunities for independent practice. The findings therefore reinforce the view that mathematical learning requires active student engagement alongside effective instructional support. The study also challenges deficit perspectives that portray Mathematical Literacy students as lacking mathematical ability. Instead, the findings suggest that these students possess valuable mathematical knowledge developed through different educational experiences. The primary challenge lies in transitioning between different forms of mathematical reasoning and representation. This supports inclusive approaches that recognise diverse learning pathways while providing opportunities to develop advanced mathematical competencies. From an institutional perspective, the findings suggest that embedded remedial models may be more effective than separate support programmes because they provide continuous scaffolding, timely feedback, and closer alignment with students' learning needs. Methodologically, the study demonstrates the value of mixed methods approaches, where quantitative evidence of achievement changes is complemented by contextual explanations of learner experiences.

Overall, the study confirms that successful mathematical transitions require sustained pedagogical support and active learner participation. Embedded remedial tutorials within Pure Mathematics lectures offer a promising approach for bridging the gap between Mathematical Literacy and university-level

mathematics. Future research should explore adaptive technologies, peer-assisted learning, and personalised support pathways to further enhance students' mathematical development and success.

Conclusion

This study examined the impact of embedded remedial tutorial interventions in supporting students' transition from Mathematical Literacy to Pure Mathematics in higher education. The findings demonstrate that this transition requires students to move beyond practical mathematical applications towards abstract reasoning, symbolic representation, algebraic manipulation, and formal problem-solving. Effective pedagogical support is therefore essential in developing the mathematical competencies required for university success. The study shows that embedded remedial tutorials provide a valuable strategy for bridging mathematical knowledge gaps by integrating targeted support within regular teaching activities. Through scaffolded instruction, guided practice, immediate feedback, and conceptual reinforcement, students developed stronger mathematical understanding and confidence. These findings align with Vygotsky's Sociocultural Theory and Constructivist Learning Theory, which emphasise the role of guided participation and structured support in developing independent competence.

However, achievement patterns varied across cohorts, with some groups demonstrating significant improvement while others experienced limited progress or declines. This suggests that intervention effectiveness depends not only on instructional support but also on student-related factors such as attendance, engagement, participation, and independent practice. The study challenges deficit views of Mathematical Literacy students by recognising their existing mathematical knowledge as a foundation for developing more advanced competencies. From an institutional perspective, the findings highlight the importance of integrating mathematics support within mainstream teaching structures. Effective interventions should combine conceptual development, procedural practice, formative assessment, collaborative learning, and continuous monitoring of student engagement.

In conclusion, embedded remedial tutorials represent a promising approach for facilitating the transition from Mathematical Literacy to Pure Mathematics. By providing timely and scaffolded support, these interventions can strengthen mathematical competence, increase student confidence, and promote equitable participation in university mathematics. Future research should investigate long-term outcomes and explore technology-enhanced approaches for further supporting mathematical development.

Declarations

Ethics and Guidelines

Ethical approval for this study (Reference No. SEM1-2026-186) was obtained from the Faculty of Education Research Ethics Committee at the University of Johannesburg prior to data collection. All participants provided written informed consent before participating in the study. Participation was

voluntary, and participants were informed of their right to withdraw at any stage without penalty. Confidentiality and anonymity were maintained throughout the research process.

The study was conducted in accordance with the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) Statement guidelines. These guidelines informed the planning, implementation, analysis, and reporting of the nonrandomized intervention, thereby ensuring transparency, methodological rigor, and comprehensive reporting of the study design, participant recruitment, intervention procedures, outcome measures, and data analysis.

Consent for publication

Written informed consent for publication of anonymised data was obtained from all participants.

Availability of data and material

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SR conceived and designed the study, conducted the literature review, analysed and interpreted the data, and drafted the manuscript. SK contributed to the conceptualisation of the study, critically reviewed the manuscript, and provided intellectual input that strengthened the interpretation of the findings and the overall quality of the paper. Both authors read and approved the final manuscript.

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Figures

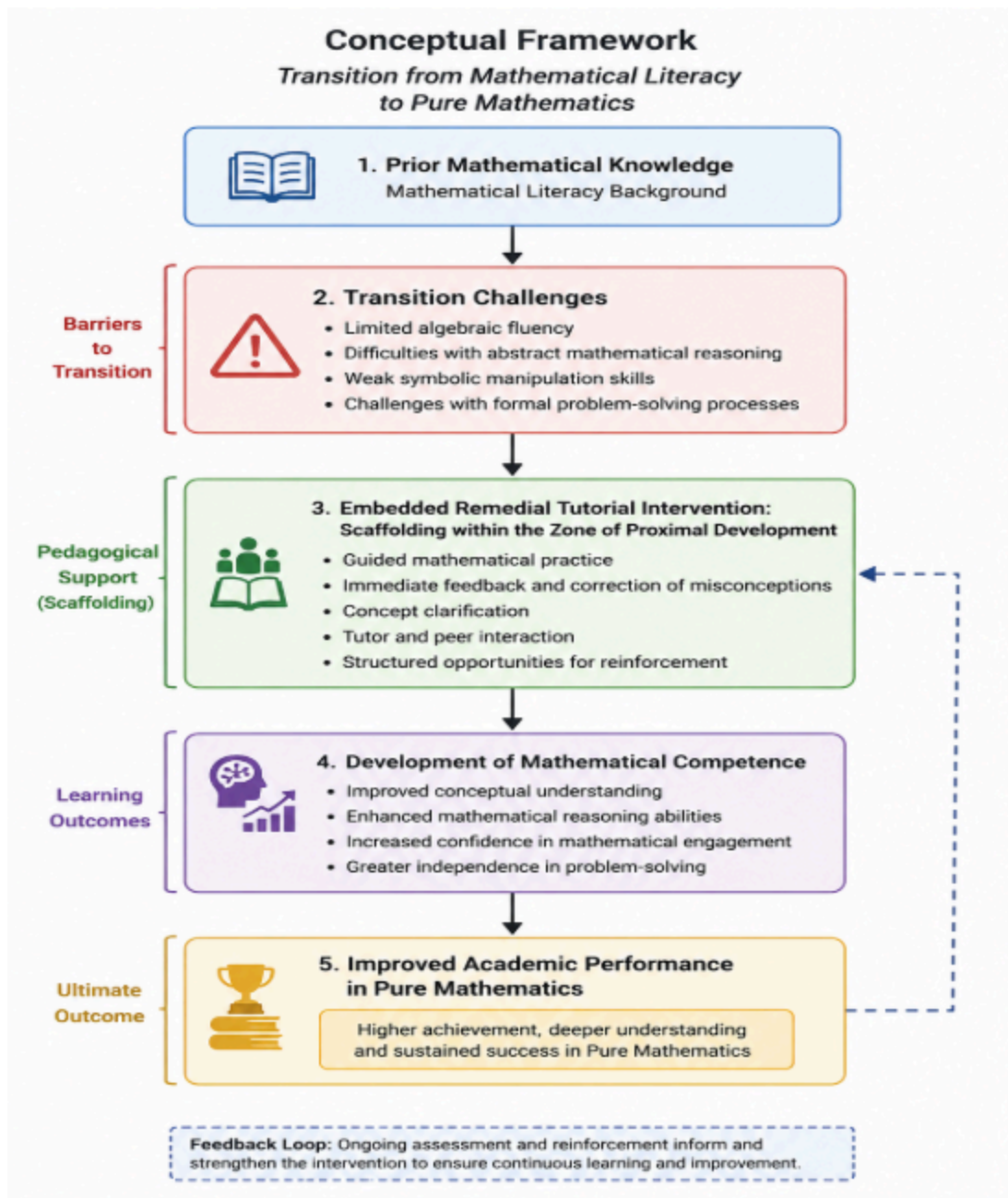


Figure 1

Conceptual Framework