

Perceptions and Challenges of Indigenous Papuan Students in Learning Elementary Linear Algebra

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Abstract

The transition from secondary school to university mathematics presents substantial academic challenges, particularly for students entering higher education from geographically remote and educationally disadvantaged contexts. While previous studies have extensively examined students' conceptual difficulties in learning linear algebra, limited attention has been given to how Indigenous students experience this transition within regional scholarship programmes designed to expand educational access. This study explored the perceptions, learning challenges, and learning experiences of Indigenous Papuan students participating in the Seribu Sarjana scholarship programme while learning Elementary Linear Algebra at Universitas Musamus. A qualitative descriptive design was employed involving thirteen first-year Indigenous Papuan students from Mappi Regency, South Papua. Data were collected through classroom observations, semi-structured interviews, students' written work, reflective field notes, and post-test responses during an eight-session remedial programme. The data were analysed using thematic analysis supported by methodological triangulation. The findings revealed three major themes. First, participants entered university mathematics with uncertain academic identities, negative perceptions of mathematics, and limited mathematical self-confidence. Second, their learning challenges extended beyond procedural difficulties and included fragile foundational mathematical knowledge, difficulties in abstract symbolic reasoning, mathematics anxiety, and dependence on guided instructional support. Third, participants' learning experiences changed progressively throughout the remedial programme, as evidenced by increased classroom engagement, improved conceptual understanding through multiple representations, and growing mathematical confidence and willingness to participate. This study contributes to mathematics education by demonstrating that students' transition to university mathematics is shaped by interactions between prior educational experiences, affective factors, and instructional support. The findings further suggest that expanding higher education access through regional scholarship programmes should be accompanied by structured academic transition support that addresses both cognitive and affective dimensions of learning.

Keywords: indigenous students, linear algebra, remedial teaching, mathematics education, student perception

Linear algebra is one of the fundamental subjects in undergraduate mathematics education and serves as a conceptual foundation for advanced studies in mathematics as well as applications across science, engineering, computer science, artificial intelligence, and data science. Despite its central role in university curricula, teaching and learning linear algebra have remained a major focus of mathematics education research for more than three decades because students consistently experience substantial conceptual difficulties when transitioning from procedural mathematics to abstract mathematical reasoning. Recent reviews indicate that research in linear algebra education has increasingly shifted from identifying students' misconceptions toward developing instructional approaches that foster conceptual understanding, mathematical reasoning, and meaningful engagement with abstract concepts (Carlson et al., [1993](#); Dorier, [2000](#); Stewart et al., [2019](#); Stewart & Troup, [2025](#)). Consequently, improving students'

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learning experiences in linear algebra continues to be regarded as an important research priority in contemporary mathematics education.

Although linear algebra is a core component of university mathematics curricula, it remains one of the most challenging subjects for undergraduate students. Unlike elementary mathematics, learning linear algebra requires students to transition from procedural computation to structural and abstract mathematical reasoning, while simultaneously coordinating multiple symbolic, graphical, and algebraic representations. Numerous studies have shown that students often experience persistent difficulties in constructing conceptual understanding of vectors, matrices, systems of linear equations, and other fundamental concepts because they rely primarily on procedural knowledge rather than relational understanding (Dorier, [2000](#); Stewart et al., [2019](#)). Recent syntheses further suggest that these difficulties are not merely conceptual but also involve cognitive, affective, and instructional dimensions, emphasizing the need for pedagogical approaches that promote conceptual reasoning, meaningful learning experiences, and active student engagement rather than procedural mastery alone (Stewart & Troup, [2025](#)).

The challenges of learning linear algebra become even more pronounced among students who enter higher education with limited academic preparation. Research on the transition from secondary school to university consistently shows that many first-year students struggle not only because of the increasing cognitive demands of university mathematics but also because of differences in prior educational experiences, learning opportunities, and academic support (Di Martino et al., [2023a](#)). For Indigenous students, learning experiences in higher education may also be shaped by cultural and linguistic differences between students' backgrounds and institutional teaching and assessment practices (Steele et al., [2024](#)). These circumstances highlight the importance of learning environments that acknowledge students' prior educational and cultural experiences and provide appropriate academic support during the transition to university study (Di Martino et al., [2023b](#); Matindike & Ramdhany, [2025](#)).

In Indonesia, expanding equitable access to higher education has become an important strategy for reducing educational disparities, particularly for students from geographically remote and historically underserved regions. Besides national initiatives, several local governments have introduced scholarship programmes to increase university participation among Indigenous students. One such initiative is the Seribu Sarjana (One Thousand Graduates) Programme established by the Government of Mappi Regency, South Papua, to expand higher education opportunities and strengthen the development of local human resources (Pemerintah Kabupaten Mappi, [2025a](#), [2025b](#)). The programme is also situated within the broader regional policy framework for educational assistance established by the Government of Mappi Regency (Pemerintah Kabupaten Mappi, [2023](#)).

The participants in this study represent one cohort of Indigenous Papuan students who entered a Mathematics Education undergraduate program through an affirmative higher education pathway. The cohort consisted of thirteen students from Mappi Regency, South Papua, students who entered university through the Seribu Sarjana (One Thousand Graduates) Programme, a regional scholarship initiative established by the Government of Mappi Regency to expand higher education opportunities for Indigenous Papuan youth. Unlike typical entrants to mathematics education programmes, these students came from highly diverse educational backgrounds, including vocational schools, religious-based schools, and general senior high schools with limited emphasis on advanced mathematics. In addition, many had experienced a gap of two to four years between completing secondary education and entering university. Such diversity in educational experiences and prior mathematical exposure created substantial

variation in academic preparedness, particularly for courses requiring abstract mathematical reasoning such as elementary linear algebra.

Prior to the formal data collection, the first author conducted preliminary classroom observations during the initial meetings of the remedial programme to identify students' initial mathematical readiness and determine the focus of subsequent instructional support. These observations revealed considerable variation in students' prior mathematical knowledge. Many students experienced substantial difficulties with basic arithmetic operations and elementary algebraic manipulation, including solving simple linear equations, factorising quadratic expressions, and interpreting algebraic symbols. In contrast, students appeared to respond more positively to topics involving vectors and matrices when these concepts were introduced through visual representations and contextual examples. These initial observations indicated that students' learning difficulties extended beyond specific mathematical topics and reflected broader issues related to conceptual understanding, prior learning experiences, and academic preparedness. Consequently, they provided the empirical basis for investigating students' perceptions, learning challenges, and conceptual development during the remedial learning programme.

Previous studies have substantially advanced understanding of students' learning difficulties in linear algebra, particularly regarding conceptual understanding, mathematical reasoning, and common misconceptions associated with abstract mathematical concepts (Dorier, [2000](#); Stewart et al., [2019](#); Stewart & Troup, [2025](#)). Other studies have highlighted the importance of culturally responsive pedagogy and equitable learning environments for students from diverse educational and sociocultural backgrounds (Luzano, [2025](#); Prahmana et al., [2026](#)). However, these strands of research have largely developed independently. Limited attention has been given to how students from affirmative higher education pathways, particularly Indigenous students from geographically remote regions, experience learning university mathematics after entering higher education. Furthermore, little is known about how their prior educational experiences, perceptions of mathematics, and conceptual development interact during the learning of abstract mathematical subjects such as elementary linear algebra. This lack of evidence represents an important gap in the mathematics education literature, particularly in countries where widening participation policies have successfully increased access to higher education but where questions concerning academic readiness and learning support remain insufficiently understood.

Against this background, this study seeks to explore the learning experiences of Indigenous Papuan students enrolled in an undergraduate Mathematics Education programme while participating in a structured remedial class in elementary linear algebra. Rather than focusing solely on learning outcomes, this study examines students' perceptions of learning mathematics, the cognitive and affective challenges they encounter, and the changes in their mathematical understanding throughout the remedial learning programme. Specifically, the study addresses the following research questions:

- RQ1. How do Indigenous Papuan students perceive learning elementary linear algebra?
- RQ2. What cognitive, affective, and educational challenges do they experience while learning elementary linear algebra?
- RQ3. How do students' learning experiences and mathematical understanding change during participation in a structured remedial learning programme?

This study contributes to the mathematics education literature in three important ways. First, it extends current research on university mathematics by examining the learning experiences of Indigenous Papuan students who participate in the Seribu Sarjana programme, a regional scholarship initiative established by the Government of Mappi Regency to expand higher education opportunities for Indigenous youth. While previous studies have predominantly examined either conceptual difficulties in

learning linear algebra or educational equity separately, this study integrates these perspectives to provide a contextual understanding of students' experiences in learning an abstract university mathematics course. Second, this study moves beyond describing students' learning difficulties by examining how their perceptions, learning challenges, and mathematical understanding evolve throughout a structured remedial learning programme. This approach offers a richer explanation of the learning process than studies focusing solely on learning outcomes or conceptual errors. Third, the findings provide empirical evidence that can inform the design of inclusive instructional support for Indigenous students entering university through regional scholarship programmes. Rather than evaluating the scholarship policy itself, this study demonstrates how expanded access to higher education should be accompanied by appropriate academic support to facilitate students' transition into university mathematics.

METHODS

Research Design

This study employed a qualitative descriptive design to explore the perceptions, learning experiences, and challenges encountered by Indigenous Papuan students while learning Elementary Linear Algebra through a structured remedial programme. A qualitative descriptive approach was considered appropriate because the purpose of the study was to obtain a rich and contextual understanding of how students perceived the learning process, responded to instructional activities, and experienced academic challenges during the transition to university mathematics. Rather than testing a hypothesis or evaluating the effectiveness of an intervention, this study sought to describe and interpret students' experiences within their natural learning environment. The qualitative approach enabled the researchers to capture students' voices, classroom interactions, and contextual factors that shaped their engagement with mathematical learning (Creswell, [2014](#); Merriam & Tisdell, [2016](#)). A descriptive orientation was adopted to systematically document observable learning behaviours and participants' experiences without manipulating the instructional setting (Gay, Mills, & Airasian, [2011](#)).

Research Context

The study was conducted during the first semester of the 2024/2025 academic year at the Mathematics Education Study Program, Universitas Musamus, Indonesia. The participants were recipients of the Seribu Sarjana (One Thousand Graduates) Programme, a regional scholarship initiative established by the Government of Mappi Regency, South Papua. The programme was designed to expand access to higher education for Indigenous Papuan students by providing financial support to pursue undergraduate studies at selected universities. Within this context, a structured remedial programme was organized to support students who experienced difficulties in adapting to university mathematics, particularly in the Elementary Linear Algebra course.

The remedial programme was conducted outside the regular class schedule over eight instructional sessions. Each session lasted approximately 90 minutes and was facilitated by the first author, who also served as the course lecturer. Participation was voluntary but strongly encouraged because the programme aimed to provide additional academic support rather than formal assessment. The instructional activities emphasized conceptual understanding through guided practice, classroom discussion, visual representations, contextual examples, and continuous formative feedback. Besides supporting students academically, the remedial programme also provided opportunities for the

researchers to observe students' learning behaviours, classroom interactions, and evolving responses to mathematical tasks within an authentic instructional setting.

Participants

The participants consisted of thirteen first-year Indigenous Papuan students from Mappi Regency, South Papua, who were enrolled in the Mathematics Education Study Program at Universitas Musamus through the Seribu Sarjana scholarship programme implemented by the Government of Mappi Regency. Although all participants shared the same scholarship scheme, they came from diverse educational backgrounds, including general senior high schools, vocational schools, and religious-based schools. Several students had also experienced a gap of two to four years between completing secondary education and entering university, resulting in heterogeneous levels of mathematical preparedness at the beginning of the study.

Although all participants belonged to the same admission cohort, they exhibited considerable diversity in their educational backgrounds and prior mathematical preparation. They graduated from different types of secondary schools, including general senior high schools (SMA), vocational high schools (SMK), and religious-based schools (SMART). Furthermore, several students experienced a gap of two to four years between completing secondary education and entering university. These differences contributed to heterogeneous levels of mathematical readiness at the beginning of the programme, making the cohort particularly suitable for exploring students' perceptions, learning experiences, and learning challenges during the remedial programme. To protect participants' confidentiality, pseudonyms (P1–P13) were used throughout the study.

Tabel 1. Participant Characteristics

Characteristic	Description
Number of participants	13
Admission pathway	Higher Education Affirmation Programme (ADik)
Ethnicity	Indigenous Papuan students
Place of origin	Mappi Regency, South Papua
University	Universitas Musamus
Study programme	Mathematics Education
Academic level	First-year undergraduate students
Types of previous schools	SMA, SMK, SMART
Gap between graduation and university entry	Approximately 2–4 years
Sampling technique	Purposive sampling

Structure of the Remedial Programme

The remedial programme was designed to strengthen students' foundational understanding of Elementary Linear Algebra through structured learning activities conducted over eight sessions. Rather than repeating regular classroom instruction, each session focused on addressing students' conceptual difficulties identified during preliminary classroom observations. The instructional design emphasized guided learning, classroom discussion, visual representations, contextual examples, collaborative problem solving, and continuous formative feedback. Throughout the programme, students were encouraged to explain their reasoning, discuss alternative solution strategies, and reflect on their learning experiences. These instructional activities also provided opportunities for the researchers to observe students' cognitive development, classroom participation, and responses to different learning approaches.

Tabel 2. Structure of the Remedial Programme

Session	Main Topic	Learning Activities	Research Data Collected
1	Diagnostic activities and prerequisite concepts	Initial observation, discussion, diagnostic exercises	Observation notes
2	Linear equations	Guided practice, lecturer explanation, discussion	Observation, field notes
3	Quadratic equations	Collaborative problem solving	Observation
4	Inequalities / prerequisite algebra	Scaffolding, reflection	Observation, reflection
5	Vectors	Visual representations, contextual examples	Observation
6	Matrices	Guided exercises, peer discussion	Observation
7	Integrated practice	Independent and collaborative problem solving	Observation, field notes
8	Review, post-test, and interview	Post-test, semi-structured interviews	Test results, interview transcripts

Data Collection

Multiple sources of qualitative data were collected to obtain a comprehensive understanding of students' learning experiences during the remedial programme. Data triangulation was employed by combining classroom observations, semi-structured interviews, reflective field notes, students' written work, and post-test results. Using multiple data sources enabled the researchers to capture students' perceptions, learning behaviours, conceptual difficulties, and changes in mathematical understanding from complementary perspectives. The combination of these data sources also strengthened the credibility of the findings through methodological triangulation (Creswell & Poth, [2018](#)).

Tabel 3. Data Collection Procedures

Data Source	Purpose	Time of Collection	Output
Preliminary classroom observation	Identify students' initial mathematical readiness	Before remedial programme	Observation notes
Classroom observations	Document learning behaviours, participation, and conceptual difficulties	Throughout eight sessions	Field notes
Students' written work	Examine mathematical understanding and problem-solving strategies	Every learning session	Student worksheets
Reflective field notes	Record contextual events and researcher reflections	Every session	Reflective journal
Post-test	Examine students' mathematical understanding after remedial learning	Final session	Written responses
Semi-structured interviews	Explore students' perceptions and learning experiences	After post-test	Interview transcripts

Semi-structured interviews were conducted after the completion of the remedial programme to explore students' perceptions of learning Elementary Linear Algebra, the challenges they experienced, and their reflections on the remedial learning process. An interview protocol consisting of open-ended questions was developed to encourage participants to describe their experiences freely while allowing the interviewer to probe emerging issues in greater depth. Each interview lasted approximately 25–40 minutes and was audio-recorded with participants' consent before being transcribed verbatim for analysis.

Non-participant classroom observations were conducted throughout the remedial programme using an observation protocol designed to document students' classroom participation, interactions with peers and the lecturer, problem-solving strategies, and responses to different instructional approaches. Observation data were recorded as descriptive field notes immediately after each learning session to preserve contextual details.

Data Analysis

The qualitative data were analysed using Braun and Clarke's ([2006](#); [2021](#)) six-phase thematic analysis. This approach was selected because it provides a systematic procedure for identifying, analysing, and interpreting patterns of meaning across qualitative data. Interview transcripts, classroom observation notes, reflective field notes, and students' written responses were analysed iteratively to generate themes that represented students' perceptions, learning challenges, and learning experiences during the remedial programme.

Tabel 4. Thematic Analysis Procedure

Phase	Description
Familiarisation	Reading interview transcripts, field notes, and students' written work repeatedly
Initial coding	Generating initial codes representing meaningful learning experiences
Searching for themes	Grouping similar codes into broader categories
Reviewing themes	Comparing themes across different data sources
Defining and naming themes	Refining themes and developing thematic descriptions
Writing the report	Integrating themes with supporting quotations and literature

Post-test responses were not analysed quantitatively but were used as supporting evidence to complement the qualitative findings. Students' written responses were examined to identify patterns of mathematical understanding and were triangulated with interview and observation data to strengthen the interpretation of students' learning experiences.

Trustworthiness

To enhance the trustworthiness of the findings, several strategies were employed. Credibility was established through methodological triangulation by comparing data obtained from classroom observations, interviews, students' written work, and post-test responses. Member checking was conducted by confirming interview interpretations with several participants to ensure that their views were accurately represented. Peer debriefing among the research team was used to discuss coding decisions and thematic interpretations, while an audit trail documenting data collection and analysis procedures was maintained to enhance dependability and confirmability (Lincoln & Guba, [1985](#)).

Ethical Considerations

Prior to data collection, all participants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any stage without academic consequences. Written informed consent was obtained from all participants. To protect confidentiality, pseudonyms (P1–P13) were used in all transcripts and research reports. All research data were stored securely and used exclusively for academic purposes.

RESULTS AND DISCUSSION

Negotiating an Unfamiliar Academic Identity

Thematic analysis of the interview data revealed that participants entered the Mathematics Education programme with predominantly uncertain and negative perceptions toward learning mathematics at the university level. These perceptions were shaped not by a single factor but by the interaction of previous educational experiences, programme placement through the Seribu Sarjana scholarship programme, limited mathematical preparation, and students' expectations about higher education. Four interrelated themes emerged from the analysis: (1) entering mathematics through an unintended academic pathway, (2) negative perceptions toward mathematics, (3) low mathematical self-confidence, and (4) changing perceptions through supportive learning experiences.

Entering Mathematics Through an Unintended Academic Pathway

The first theme highlights that many participants entered the Mathematics Education programme through an academic pathway that they had not intentionally chosen. Rather than selecting Mathematics Education based on personal interest or career aspirations, participants were assigned to the programme as part of the Seribu Sarjana scholarship placement process administered by the Government of Mappi Regency. Although the scholarship provided valuable opportunities for higher education, several students explained that they initially experienced uncertainty and hesitation because the assigned programme did not match their educational expectations.

"I never imagined studying mathematics. I was told to accept it because of the scholarship," said one participant. "I graduated from a farming vocational school, and we didn't really study math just basic calculations."

These narratives indicate that students' initial engagement with mathematics was influenced not only by their previous learning experiences but also by limited autonomy in choosing their academic programme. For several participants, entering Mathematics Education represented an unexpected educational transition rather than a personally planned academic pathway. This condition appeared to shape their early expectations, motivation, and confidence toward learning university mathematics.

This finding is consistent with previous studies suggesting that limited autonomy in academic programme selection may reduce students' sense of belonging, disciplinary identity, and intrinsic motivation during the transition to higher education (Thomas & Quinn, [2007](#)). Similar observations have also been reported in research on students' transition to university mathematics, where prior expectations and educational experiences substantially influence students' engagement with challenging mathematical content (Di Martino et al., [2023b](#)). However, unlike previous studies, the present findings demonstrate that programme placement through a regional government scholarship initiative introduces an additional contextual dimension that shapes students' early learning experiences in university mathematics.

Developing Negative Expectations Toward University Mathematics

Beyond the issue of programme placement, participants consistently described mathematics as an intimidating and emotionally demanding subject. Their previous learning experiences had shaped expectations that university mathematics would be even more difficult than mathematics encountered in secondary school. Consequently, many participants approached the Elementary Linear Algebra course with feelings of anxiety, uncertainty, and fear of failure before formal learning had even begun.

"When I see equations with letters, I panic and don't know where to start."

The interview data suggest that students' perceptions were not merely expressions of dislike toward mathematics but reflected anticipatory anxiety formed through previous unsuccessful learning experiences. Participants tended to associate symbolic mathematical expressions with inevitable failure, resulting in avoidance behaviours and reduced confidence when confronting unfamiliar mathematical tasks.

These findings support previous research indicating that mathematics anxiety often develops before students engage with new mathematical content and substantially influences their willingness to participate in learning activities (Tapia & Marsh, [2004](#); Hannula, [2006](#)). However, unlike previous studies focusing primarily on mathematics anxiety among general undergraduate populations, the present study suggests that anticipatory anxiety was also shaped by participants' educational transition through the Seribu Sarjana programme, their heterogeneous educational backgrounds, and limited previous exposure to advanced mathematics.

Limited Mathematical Self-Confidence

Participants' lack of confidence became evident not only during interviews but also throughout classroom observations. Several students hesitated to answer even simple numerical questions and frequently relied on finger counting or mental representations when performing basic arithmetic operations. Such behaviours reflected more than limited procedural fluency; they also illustrated students' uncertainty regarding their own mathematical competence.

"I count on my fingers or use sticks in my head. I can't do it fast like others," explained one student during practice."

The interview narratives indicate that participants' reliance on finger counting should not be interpreted solely as evidence of weak computational skills. Rather, it reflected a broader lack of confidence in their mathematical abilities. Even when participants possessed the procedural knowledge required to solve simple numerical problems, they frequently doubted the accuracy of their own reasoning and therefore depended on concrete strategies to minimise perceived errors. Classroom observations further showed that this uncertainty often led students to hesitate before answering questions, avoid volunteering responses, or wait for confirmation from the lecturer before proceeding with problem-solving activities. These findings suggest that limited mathematical self-confidence acted as an important affective barrier, reducing students' willingness to engage actively with abstract mathematical tasks despite having the potential to develop their understanding through appropriate instructional support.

The present findings support previous studies demonstrating that mathematical self-confidence plays a crucial role in students' engagement with university mathematics. Research has consistently shown that students with low mathematical self-confidence tend to avoid challenging tasks, hesitate to express mathematical reasoning, and rely heavily on external validation before attempting problem solving. Such behaviours may limit opportunities to construct conceptual understanding, particularly in abstract subjects such as linear algebra (Hannula, [2006](#); Stewart et al., [2019](#)).

From a transition perspective, these findings also align with Di Martino et al. (2023a), who argued that students entering university mathematics often experience a "crisis of confidence" as they adjust to new academic expectations and increasingly abstract forms of mathematical thinking. However, the present study extends this literature by showing that limited mathematical self-confidence was shaped not only by the cognitive demands of university mathematics but also by participants' educational backgrounds and their transition into higher education through the Seribu Sarjana programme. Consequently, confidence should be understood as a context-dependent construct that develops through

interactions between prior learning experiences, institutional support, and students' opportunities to participate successfully in mathematical learning.

Overall, this theme demonstrates that participants' learning difficulties were not solely attributable to insufficient mathematical knowledge. Their hesitation to engage with mathematical tasks was closely related to fragile mathematical self-confidence, suggesting that strengthening students' confidence is as important as improving procedural competence in supporting successful transitions to university mathematics.

Recognising the Value of a Supportive Learning Environment

Although participants initially expressed uncertainty and anxiety toward mathematics, their perceptions gradually changed as they engaged in the remedial learning programme. Interview data and classroom observations indicated that students began to appreciate learning environments characterized by patience, repeated explanations, guided practice, and opportunities to ask questions without fear of making mistakes. Rather than perceiving mathematics solely as a difficult subject, participants increasingly viewed learning as a process that became manageable when appropriate instructional support was available.

"I haven't studied anything since I finished school four years ago. My brain was not used to this anymore," said another participant.

The participant's account illustrates an important shift in how mathematics learning was perceived during the remedial programme. The positive response was not simply associated with the mathematical content becoming easier; rather, it reflected a change in the conditions under which participants engaged with that content. Explanations delivered incrementally, opportunities to revisit concepts, and the lecturer's willingness to respond to difficulties reduced the pressure participants initially associated with mathematical tasks. Classroom observations similarly indicated that participants became increasingly willing to ask questions, attempt solutions, and remain engaged with problems even when their first attempts were unsuccessful. Thus, the emerging positive perception of mathematics appeared to develop alongside participants' growing sense that difficulties and mistakes could be addressed as part of the learning process rather than interpreted as evidence that they were incapable of learning mathematics.

This finding is particularly important when considered alongside the negative expectations and limited mathematical self-confidence identified in the preceding themes. Participants entered the programme carrying previous experiences that had contributed to anxiety, hesitation, and doubts about their mathematical competence. The remedial environment provided an alternative learning experience in which those expectations could gradually be reconsidered. From this perspective, supportive instruction functioned not only as a means of addressing gaps in mathematical knowledge but also as a mechanism through which participants could reconstruct their perceptions of themselves as learners of mathematics.

This interpretation is consistent with research emphasising that students' experiences in mathematics are shaped by the interaction between cognitive, affective, and instructional dimensions rather than by mathematical ability alone. Hannula (2006) demonstrated that motivation and emotions in mathematics learning develop dynamically through students' interactions with learning situations, while Stewart et al. (2019) highlighted the importance of instructional approaches that support conceptual engagement in linear algebra rather than relying predominantly on procedural manipulation. More recent work emphasising student perspectives in mathematics education similarly suggests that understanding

how learners experience instructional environments can reveal dimensions of learning that achievement measures alone may not capture (Svensson Källberg & Roos, [2025](#)).

The present findings extend these perspectives by demonstrating how such supportive conditions operated within a distinctive educational transition experienced by Indigenous Papuan participants entering university through the Seribu Sarjana programme. For these participants, academic support was particularly consequential because they were simultaneously adapting to university-level mathematics, negotiating unfamiliar academic expectations, and addressing differences in prior mathematical preparation. The findings therefore suggest that expanding access to higher education through regional scholarship initiatives needs to be accompanied by learning environments capable of responding to the academic and affective dimensions of students' transition into university study.

Overall, the fourth theme demonstrates that participants' initial perceptions of mathematics were neither permanent nor resistant to change. Their experiences during the remedial programme indicate that supportive instructional environments can create conditions in which negative expectations begin to shift toward greater willingness to engage with mathematics. This change provides an important transition from the participants' initial perceptions examined in RQ1 to the cognitive and affective learning challenges explored in RQ2 and, subsequently, to the changes in learning experiences examined in RQ3.

Navigating Cognitive and Affective Challenges in Learning Elementary Linear Algebra

Fragile Foundational Mathematical Knowledge

While the previous section examined participants' initial perceptions toward learning university mathematics, this section focuses on the cognitive and affective challenges that emerged during their engagement with Elementary Linear Algebra. Analysis of classroom observations, students' written work, interviews, and reflective field notes identified four interconnected themes describing how participants experienced mathematical learning throughout the remedial programme: (1) fragile foundational mathematical knowledge, (2) difficulties in abstract symbolic reasoning, (3) mathematics anxiety and fear of failure, and (4) dependence on guided instruction. Together, these themes demonstrate that participants' learning challenges extended beyond procedural errors and reflected broader interactions between prior educational experiences, affective responses, and instructional support.

Classroom observations and students' written work consistently revealed that participants entered university with fragile foundational mathematical knowledge. Before encountering formal concepts in Elementary Linear Algebra, many participants experienced difficulty performing basic arithmetic operations, manipulating algebraic expressions, and solving simple linear equations. These limitations frequently interrupted subsequent learning because participants were required to divide their attention between recalling prerequisite knowledge and understanding newly introduced concepts.

From the first remedial sessions, classroom observations revealed that even basic arithmetic operations posed challenges for many students. Several participants were unable to perform simple addition, subtraction, multiplication, and division without counting on their fingers or relying on mental aids.

“I count on my fingers or use sticks in my head. I can't do it fast like others.”

“I haven't studied anything since I finished school four years ago. My brain was not used to this anymore”.

The classroom observations and interview data indicate that participants' mathematical difficulties were rooted in insufficient mastery of prerequisite mathematical knowledge rather than solely in the complexity of Elementary Linear Algebra. Their reliance on finger counting, hesitation when performing

basic calculations, and difficulties recalling previously learned concepts suggest that fundamental numeracy skills had not yet become automatic. Furthermore, the prolonged gap between secondary education and university entry appeared to weaken students' retention of previously acquired knowledge, forcing them to reconstruct basic mathematical concepts while simultaneously learning more advanced topics. Consequently, participants experienced a double cognitive burden, as they were required to revisit foundational concepts while adapting to the abstract demands of university mathematics.

These findings are consistent with previous research emphasising that prerequisite mathematical knowledge is one of the strongest predictors of success in university mathematics. Dorier (2000) argued that students' difficulties in linear algebra frequently originate from weaknesses in elementary algebra rather than from linear algebra itself. Similarly, Stewart et al. (2019) reported that inadequate mastery of prerequisite concepts limits students' ability to construct conceptual understanding of more advanced mathematical structures. Di Martino et al. (2023b) further explained that students entering university mathematics often experience discontinuities between secondary and tertiary mathematics, particularly when prior learning opportunities have been limited.

The present study extends these findings by demonstrating that fragile foundational knowledge was shaped not only by previous mathematical learning but also by participants' educational trajectories. The diverse educational backgrounds of the participants, together with a two- to four-year interruption before entering university, created additional barriers to mathematical readiness. These contextual factors distinguish the present findings from previous studies and highlight the importance of considering educational history when designing instructional support for students entering higher education through regional scholarship programmes.

Overall, fragile foundational mathematical knowledge emerged as the initial cognitive challenge that influenced participants' subsequent learning experiences throughout the remedial programme. Strengthening prerequisite mathematical competencies should therefore become an integral component of remedial instruction designed for students entering university mathematics from diverse educational backgrounds.

Table 5. Student Performance on Post-Test by Topic

Topic	Correct	Partially Correct	Incorrect	Notes
Linear Equations (1 var)	6	–	7	1 student attempted factorization on linear problem
Quadratic Equations	4	2	7	Partial: incorrect factorization; most unable to proceed
Vectors (add, scalar mult.)	2	1	10	1 student miscalculated; others needed constant guidance
Matrices (add, mult.)	2	2	9	Some correct in addition, failed in matrix multiplication

Difficulties in Abstract Symbolic Reasoning

Beyond weaknesses in prerequisite mathematical knowledge, participants experienced substantial difficulty interpreting symbolic mathematical representations. Classroom observations and students' written work demonstrated that variables, algebraic expressions, and symbolic transformations were often perceived as disconnected procedures rather than meaningful mathematical representations.

These difficulties became increasingly apparent when participants were required to manipulate algebraic symbols independently while solving linear and quadratic equations.

The post-test results confirmed that participants continued to experience substantial difficulties across all mathematical topics assessed. Six participants correctly solved the one-variable linear equation, while four correctly completed the quadratic equation task. Performance was lower for vectors and matrices, with only two participants answering each topic correctly. These results indicate that participants' difficulties were not confined to symbolic equations but extended to the application of vector and matrix procedures. The equation-based responses nevertheless provided particularly visible evidence of difficulties in symbolic manipulation, including incorrect factorisation, inappropriate operations, and an inability to proceed when familiar procedures could not be applied.

Classroom observations further indicated that many participants attempted to manipulate symbols procedurally without understanding the relationships represented by the equations. Several students confused factorisation procedures, substituted inappropriate operations, or stopped working when encountering unfamiliar symbolic forms.

These findings indicate that participants' learning difficulties were not limited to procedural computation but reflected deeper challenges in interpreting mathematical symbols as meaningful representations. Rather than viewing equations as mathematical relationships, participants frequently approached them as sequences of disconnected procedures to be memorised. Consequently, when familiar procedures could no longer be applied, many students were unable to determine appropriate solution strategies independently. This pattern suggests that participants had not yet developed the representational flexibility required to transition from arithmetic reasoning to structural algebraic thinking.

These findings are consistent with Dorier (2000), who argued that one of the central difficulties in learning linear algebra lies in students' inability to move beyond procedural manipulation toward conceptual understanding of symbolic structures. Similarly, Trigueros and Oktaç (2005) reported that students often experience difficulties because symbolic representations are processed mechanically rather than interpreted as mathematical objects. Stewart et al. (2019) further emphasised that representational flexibility constitutes a fundamental component of successful learning in university linear algebra. The present study extends these findings by showing that such difficulties were further intensified by participants' heterogeneous educational backgrounds and interrupted learning experiences before entering university.

Mathematics Anxiety and Fear of Failure

In addition to cognitive challenges, participants demonstrated strong affective responses toward mathematics throughout the remedial programme. Classroom observations revealed that many participants hesitated before attempting mathematical tasks, avoided answering questions publicly, and frequently sought reassurance from the lecturer before writing their solutions. These behaviours reflected mathematics anxiety and fear of making mistakes rather than simple lack of mathematical knowledge.

During classroom activities, participants often remained silent until the lecturer provided additional guidance. Several students discontinued their work after making an initial error, while others preferred observing their peers rather than attempting independent solutions. Instructor reflections also noted that frustration increased when participants were asked to solve symbolic problems individually.

"When I see equations with letters, I panic and don't know where to start."

These observations suggest that participants' emotional responses substantially influenced their engagement with mathematical learning. Fear of making mistakes frequently prevented participants from

testing their own reasoning or exploring alternative solution strategies. Instead of actively constructing mathematical understanding, many preferred waiting for explicit confirmation from the lecturer before proceeding. Consequently, mathematics anxiety functioned as an affective barrier that limited productive participation in classroom learning.

These findings suggest that participants' learning performance depended strongly on the availability of instructional scaffolding. Rather than indicating an inability to learn mathematics, participants demonstrated that appropriate guidance enabled them to engage more confidently with unfamiliar concepts. Guided explanations, contextual representations, and continuous feedback appeared to reduce cognitive load while encouraging participants to participate more actively in classroom learning.

This finding supports previous research demonstrating that mathematics anxiety negatively affects students' confidence, persistence, and willingness to engage in mathematical reasoning (Hannula, [2006](#); Ma, [1999](#)). Tapia and Marsh ([2004](#)) further argued that negative emotional experiences in mathematics frequently reduce students' motivation to participate in subsequent learning activities. The present study contributes additional evidence by demonstrating that mathematics anxiety among participants was closely connected to their educational transition into university mathematics rather than merely to the complexity of mathematical content itself.

Dependence on Guided Instruction

Despite experiencing substantial learning difficulties, participants demonstrated noticeable improvement when instructional support was provided through guided explanations, contextual examples, repeated demonstrations, and continuous feedback. Throughout the remedial programme, classroom observations consistently showed that participants became more willing to attempt mathematical tasks after receiving structured guidance from the lecturer.

Instructor reflections indicated that one-to-one guidance was frequently required during classroom exercises, while peer collaboration helped reduce students' anxiety in several sessions. The use of real-life analogies, including market prices and direction vectors, also facilitated students' understanding of mathematical concepts. Furthermore, although most participants still experienced difficulties solving problems independently, greater classroom engagement was observed during vector and matrix activities after contextual explanations and guided practice were introduced, although post-test performance indicated that most participants still required substantial support to solve these tasks independently.

These findings support research highlighting the importance of scaffolding, contextual instruction, and culturally responsive learning environments for students experiencing difficulties in mathematics (Gay, [2002](#); Luzano, [2025](#)). Visual and contextual representations can provide learners with alternative ways of accessing mathematical ideas, particularly when formal symbolic representations remain difficult to interpret (Duval, [2006](#); Stewart et al., [2019](#)). The present study extends this literature by demonstrating that instructional scaffolding is particularly valuable for Indigenous Papuan students participating in a regional scholarship programme, where educational diversity and interrupted learning histories require adaptive rather than standardised instructional approaches.

Transformation of Students' Learning Experiences During the Remedial Programme

While the previous section examined the cognitive and affective challenges experienced by participants, this section explores how their learning experiences evolved throughout the eight-session remedial programme. Analysis of classroom observations, students' written work, post-test results,

reflective field notes, and interview data indicated that participants' learning experiences changed progressively as they received structured instructional support. Three interrelated themes emerged from the analysis: (1) increasing engagement in classroom learning, (2) developing conceptual understanding through multiple representations, and (3) growing mathematical confidence and willingness to participate.

Increasing Engagement in Classroom Learning

At the beginning of the remedial programme, participants were generally passive during classroom activities and rarely volunteered answers or asked questions. However, repeated classroom observations indicated gradual increases in participation as the programme progressed. Students who initially remained silent began contributing to discussions, attempting problem-solving activities, and seeking clarification when encountering difficulties.

Classroom observations documented a gradual increase in students' participation throughout the eight-session remedial programme. During the first two meetings, most participants tended to remain silent, avoided eye contact with the lecturer, and were reluctant to respond when questions were posed to the class. Only a small number of students attempted to solve problems on the whiteboard, while the majority preferred waiting for the lecturer's explanation before beginning their work. Several students stopped working after making an initial mistake and frequently looked to their peers for confirmation before continuing their solutions.

As the remedial programme progressed, noticeable changes in classroom behaviour were observed. Participants began asking questions when they encountered unfamiliar concepts, engaged more actively in small-group discussions, and showed greater willingness to explain their reasoning to classmates. By the final sessions, several students voluntarily presented their solutions in front of the class, even when their answers were not entirely correct. Instructor reflection notes also indicated that participants became increasingly persistent when solving mathematical problems and required fewer prompts to initiate discussions or complete classroom exercises. Peer collaboration developed naturally, with students beginning to assist one another during guided practice activities, particularly when working on vector and matrix problems. These observations suggest that students' classroom engagement increased progressively alongside the implementation of supportive instructional strategies.

These observations suggest that instructional support influenced not only participants' mathematical understanding but also their classroom engagement. As participants experienced repeated opportunities to solve problems successfully within a supportive learning environment, they gradually became more willing to participate actively in classroom discussions. Increased engagement therefore appeared to represent an important indicator of students' adaptation to university mathematics learning.

The findings of this study reinforce previous research highlighting the importance of prerequisite mathematical knowledge in learning university mathematics. Dorier ([2000](#)) argued that many students' difficulties in linear algebra do not originate from the abstract nature of the subject itself but from weaknesses in elementary algebra that remain unresolved when students enter higher education. Similarly, Stewart et al. ([2019](#)) identified inadequate mastery of prerequisite concepts as one of the principal barriers preventing students from developing conceptual understanding in linear algebra. These studies suggest that university mathematics requires students to integrate previously acquired algebraic knowledge with increasingly abstract mathematical reasoning, making strong foundational knowledge an essential prerequisite for successful learning.

The present findings are also consistent with research on students' transition to university mathematics. Di Martino et al. ([2023a](#)) reported that many first-year university students experience

significant discontinuities between school mathematics and university mathematics because they enter higher education with uneven mathematical preparation. Such discontinuities often result in cognitive overload, as students must simultaneously recall prerequisite knowledge while attempting to understand unfamiliar mathematical concepts. Similar patterns were evident in the present study, where participants frequently struggled to perform basic algebraic operations before engaging with elementary linear algebra concepts. This pattern is consistent with recent research showing that student engagement in undergraduate mathematics is multidimensional and closely connected to students' participation, learning experiences, and academic outcomes (Papageorgiou et al., [2025](#)).

However, the present study extends previous research by demonstrating that fragile foundational mathematical knowledge cannot be understood solely as an individual cognitive deficit. Instead, participants' mathematical preparedness was closely associated with their educational trajectories. The participants came from diverse secondary school backgrounds, including general, vocational, and religious schools, and several had experienced interruptions of two to four years before entering university through the Seribu Sarjana programme. These educational experiences appeared to influence the retention of previously learned mathematical concepts and contributed to heterogeneous levels of readiness at the beginning of university study.

These findings suggest that strengthening prerequisite mathematical knowledge should become an essential component of transition programmes designed for students entering university mathematics through regional scholarship initiatives. Rather than assuming that all first-year students possess comparable mathematical foundations, universities should provide diagnostic assessment and targeted academic support that address differences in prior learning experiences. Such an approach may reduce cognitive overload during the transition to university mathematics and facilitate more equitable learning opportunities for students from diverse educational backgrounds.

Developing Conceptual Understanding Through Multiple Representations

Participants responded more actively when mathematical ideas were presented through visual representations, contextual examples, and guided explanations rather than through symbolic manipulation alone. During sessions on vectors and matrices, classroom observations indicated that diagrams, directional movements, familiar arrangements of objects, and step-by-step explanations encouraged participants to ask more questions, discuss mathematical ideas with their peers, and attempt tasks that they had previously approached hesitantly.

However, this increased engagement should not be interpreted as evidence of stronger procedural mastery of vectors and matrices. The post-test results showed that these remained the most difficult topics: only two participants correctly completed the vector tasks, while ten produced incorrect responses; similarly, only two participants correctly completed the matrix tasks, with two partially correct and nine incorrect responses. These results indicate that although visual and contextual representations appeared to make the concepts more accessible during classroom interaction, most participants had not yet developed sufficient procedural competence to solve vector and matrix problems independently by the end of the programme.

The combination of observational and post-test evidence therefore reveals an important distinction between emerging conceptual accessibility and demonstrated procedural performance. Participants became more willing to engage with vectors and matrices when these concepts were represented visually and contextually, but this increased accessibility did not immediately translate into successful independent problem solving. Rather than demonstrating complete conceptual understanding, the

observed changes suggest an early stage of conceptual development in which multiple representations provided cognitive entry points into otherwise abstract mathematical ideas.

This interpretation is consistent with Duval (2006), who argued that mathematical understanding involves coordinating different semiotic representations and that successful engagement with one representation does not necessarily imply mastery of formal symbolic procedures. Research in linear algebra education has similarly emphasised that students require sustained opportunities to connect visual, symbolic, and procedural representations before developing robust conceptual understanding (Dorier, 2000; Stewart et al., 2019). In the present study, multiple representations therefore functioned primarily as instructional bridges that increased accessibility and engagement, while the low post-test performance indicates that substantially more time and practice were required for participants to consolidate these emerging understandings into independent mathematical competence.

Overall, the findings suggest that multiple representations supported participants' initial conceptual engagement with abstract mathematical ideas, but the persistence of low post-test performance in vectors and matrices demonstrates that such support should be sustained beyond a short remedial programme before stronger claims about conceptual mastery can be made.

Growing Mathematical Confidence and Willingness to Participate

Beyond improvements in conceptual understanding, the remedial programme also contributed to noticeable changes in participants' mathematical confidence and classroom participation. Classroom observations, interview responses, and instructor reflections indicated that participants gradually became more willing to ask questions, express mathematical ideas, and attempt unfamiliar problems independently. Although feelings of uncertainty remained, students increasingly viewed mistakes as part of the learning process rather than as evidence of failure.

During the early stages of the remedial programme, participants rarely volunteered answers and generally waited for explicit guidance before attempting mathematical problems. Many students hesitated to present their work publicly and frequently sought confirmation from the lecturer before continuing their solutions. However, by the later sessions, classroom observations documented meaningful changes in students' participation. Participants began asking clarification questions more frequently, engaged actively in group discussions, volunteered to explain their reasoning, and demonstrated greater persistence when solving unfamiliar mathematical tasks. Instructor reflection notes further indicated that students required progressively fewer prompts to initiate discussions and became increasingly confident in completing classroom exercises independently. Interview responses also suggested that participants no longer perceived mathematics solely as a subject to be feared but increasingly regarded it as a discipline that could be understood through sustained practice and appropriate instructional support.

These findings suggest that mathematical confidence developed gradually through repeated experiences of successful participation rather than through improvements in procedural competence alone. As participants experienced supportive classroom interactions, constructive feedback, and opportunities to solve mathematical problems successfully, they became more willing to trust their own reasoning and participate actively in learning activities. The findings therefore indicate that confidence should be understood as a dynamic learning outcome that develops through positive educational experiences rather than as a fixed personal characteristic.

The findings support Bandura's (1997) theory of self-efficacy, which proposes that confidence develops primarily through mastery experiences and successful performance. As participants accumulated positive learning experiences during the remedial programme, they gradually strengthened

their beliefs in their own mathematical capabilities. Similarly, Hannula (2006) argued that students' emotions, motivation, and confidence evolve continuously through classroom interactions and significantly influence mathematical learning. Stewart et al. (2019) further emphasised that supportive instructional environments encourage students to engage more actively with challenging mathematical concepts by reducing fear of failure and promoting conceptual exploration.

The present study contributes additional evidence by demonstrating that the development of mathematical confidence among Indigenous Papuan students cannot be separated from the broader context of educational transition. For participants entering university through the Seribu Sarjana programme, confidence emerged not simply because they learned more mathematics, but because they experienced a learning environment that acknowledged their diverse educational backgrounds, encouraged active participation, and provided sustained instructional support. Consequently, confidence became both an affective outcome and an important mechanism facilitating students' successful transition into university mathematics.

CONCLUSION

This study explored the perceptions, learning challenges, and learning experiences of Indigenous Papuan students participating in the Seribu Sarjana programme while learning Elementary Linear Algebra at Universitas Musamus. The findings revealed that participants initially entered university mathematics with uncertain academic identities, negative expectations toward mathematics, and limited mathematical self-confidence. These initial perceptions were closely associated with diverse educational backgrounds, interrupted learning experiences, and limited prior exposure to advanced mathematical concepts.

The study further showed that participants' learning challenges extended beyond difficulties in understanding linear algebra itself. Fragile foundational mathematical knowledge, difficulties in interpreting abstract symbolic representations, mathematics anxiety, and dependence on guided instruction collectively shaped their learning experiences during the transition to university mathematics. These findings demonstrate that students' difficulties cannot be explained solely by cognitive factors but are closely intertwined with affective and educational experiences prior to entering higher education.

Despite these initial challenges, participants' learning experiences changed progressively throughout the structured remedial programme. Increased classroom engagement, the use of multiple mathematical representations, and sustained instructional support contributed to the development of conceptual understanding, greater mathematical confidence, and more active participation in learning. These findings indicate that appropriately designed remedial instruction can support both cognitive and affective dimensions of students' transition into university mathematics.

This study contributes to the mathematics education literature by providing empirical evidence on how students participating in a regional scholarship programme experience the transition to university mathematics. Rather than viewing learning difficulties as individual deficits, the findings highlight the importance of considering students' educational trajectories when designing instructional support. The study therefore suggests that expanding access to higher education through regional scholarship programmes should be accompanied by structured academic transition support, particularly for students entering mathematically demanding disciplines.

This study is limited to a single cohort of participants from one university and one regional scholarship programme. Future research could examine similar transition experiences across different

universities, scholarship schemes, and mathematical disciplines, while also investigating the long-term impact of remedial programmes on students' academic persistence and achievement.

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