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The Knowledge of Indigenous West Papuan Pre-service Teachers about Primary School Mathematical Contents: Strengths and Weaknesses

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Abstract: Teachers' knowledge about mathematical content affects students' mathematics learning outcomes. This study aimed to identify the knowledge of pre-service primary school teachers about mathematical contents. Within a quantitative methodological approach, 150 respondents (58 Papuans and 92 non-Papuans) were involved in this study. An evaluation was developed to measure their knowledge of mathematics topics at the primary level, particularly the content area of number. Furthermore, strengths and weaknesses within each basic arithmetic operation for Papuan pre-service teachers were also identified. It comprised 30 items that covered fundamental numeracy and problem-solving. This study found that the pre-service teachers' knowledge of mathematical content was low—not exceeding 50 on the scale. Mixed operations and division were challenging for all Indigenous West Papuan pre-service teachers. The teaching department could assist Indigenous pre-service teachers in increasing their capability of mathematical content knowledge. Historical and cultural factors should be considered when designing teaching programs.

Keywords: Indigenous; pre-service teachers; mathematical content knowledge

INTRODUCTION

Data collected from multiple assessment sources indicates low mathematics performance of West Papuan students at all educational levels. There are a variety of tools available for assessing mathematics outcomes, including small-class size, large-scale observational studies, National Examinations, and internationally representative tests, e.g., PISA and TIMSS (Dirhantoro & Paramita, 2014; Manibuy et al., 2014; Ministry of Education, 2019; Sianturi et al., 2018; The Indonesian

Bureau of Statistics, 2019). Despite the diversity of methodologies and frameworks used, there is a close review with resounding consensus that West Papuans perform very poorly and differ greatly from their peers.

The continued low performance of students in recent years has prompted a growing interest in exploring how teachers' commitment, content knowledge, and beliefs might play a role in this low performance (Sianturi et al., 2018; Werang et al., 2017). On the other hand, the proficiency of teachers in West Papua is worrying. This is reinforced by a report from the Office Head of the Study on the Papua Province Education Quality Assurance which revealed that the quality of teachers in Papua Province was poor (Costa, 2018). The latest teacher competency test report in 2017 described 2,401 of 2,564 teacher applicants (94%) did not pass the assessment, as their content knowledge acquisition was below the standard (Costa, 2018). Provinces of Papua and West Papua are the two provinces with the highest ranking for teachers who did not pass the teacher efficacy assessment (Costa, 2018). In fact, a focal point across this literature is a high concentration of teachers to come to the field with little understanding of the fundamental principles of mathematics. Although local Papuan governments organise teacher professional development programs to improve in-service teachers' mathematic skills (Ismail & Imawan, 2021; Weking, 2025), more relevant programs in teacher education are needed to prepare the prospective mathematics teachers.

Here, we investigated one particular aspect of teacher quality, i.e., mathematical content knowledge, specifically knowledge about the primary school mathematics curriculum. Accordingly, a research question for this study was designed to understand Indigenous West Papuan pre-service teachers' knowledge of primary school mathematics curricula. The research questions guiding this study include:

1. What is the level of Indigenous West Papuan pre-service primary teachers' knowledge of basic mathematical content?
2. Which mathematical content areas are the strongest and weakest for Indigenous West Papuan pre-service teachers?

We intend to investigate these research questions to develop a conceptual model of mathematics teacher development, which might serve as a guide to our existing policy analysis. These investigations could provide empirical evidence that supports or disproves assumptions currently used in explaining how teacher preparation programs are conducted, accreditation requirements for such programs, and teacher professional development initiatives.

In Indonesia, teacher candidates begin developing their mathematical content knowledge through a developmental education program in the teacher education department. To prepare pre-service teachers to have sufficient competence upon completing their teaching program, the Faculty of Education and Teacher Training develop courses relevant to their qualifications. Regarding mathematical content knowledge, especially for students majoring in primary school teacher education, the faculty members ensure that the mathematical courses cover all the mathematical domains at the primary school level. Moreover, to scaffold the mathematical content knowledge of pre-service

teachers, mentor teachers play a crucial role in providing them with guidance and offering feedback.

LITERATURE REVIEW

Teachers' Mathematical content knowledge

Across the international literature on mathematics teacher education, there is a consensus that the most basic requirement for teaching mathematics is to have a complete mastery of the content knowledge needed to teach mathematics (Bowie et al., 2019). Mathematics knowledge is required for teachers to teach math to primary students (Livy et al., 2019). A teacher who is proficient in teaching school mathematics has a comprehensive and profound understanding of school mathematics, such as an understanding of whole ideas, proper methods for introducing students to new mathematical concepts, and engaging ways to create a sense of wonder that students will take away from the experience (Llinares & Chapman, 2019).

"Content knowledge (CK) is the teacher's understanding of the material" (Suharta & Parwati, 2020, p. 293). In teaching mathematics, Ball et al., (2008, p. 399) define mathematical knowledge as mathematical knowledge "entailed by teaching"—in other words, mathematical knowledge needed to perform the recurrent tasks of teaching mathematics to students. There is a link between the measure of teachers' mathematical content knowledge (MCK) and students' mathematics outcomes (Browning et al., 2014). A previous empirical study discovered a positive relationship between teachers' content knowledge and student mathematics learning achievement in Indonesia (Suharta & Parwati, 2020). There is an assumption if a student's mathematical ability is low, it might be influenced by the teacher's understanding of mathematics (Suharta & Parwati, 2020).

The effect of this content knowledge on a teacher's competence is considered critical. The need for solid content knowledge as a key indicator of the four teachers' core competencies has resulted in its inclusion in Indonesian governmental legislation, such as Law Number 20 of 2003 (2003) and Law Number 14 of 2005 (2005), Government Regulation Number 19 of 2005 (2005), Government Regulation Number 74 of 2008 (2008), and Government Regulation Number 16 of 2007 (2007). The four teachers' competencies include pedagogical, personal, professional, and social competencies. *Pedagogical competency* relates to teachers' ability to manage learning effectively. *Personal competency* concerns stability, integrity, and exemplary character. *Social competency* emphasizes effective communication and collaboration with students. Among these, *professional competency* which consists of the mastery of subject matter and continuous professional development, directly reflects teachers' content knowledge, serving as the foundation for effective teaching. Therefore, according to these legislations, teachers must hold a standard academic qualification in which they have excellent content knowledge competence to teach in the classroom.

Research on teaching mathematics indicates the importance of supporting pre-service teachers' MCK to enhance their mathematics and teaching (Kula Ünver, 2018). Ball et al., (2008, p. 399-402) introduced five domains of mathematical knowledge, including common content knowledge

(CCK), specialised content knowledge (SCK), knowledge of content and students (KCS), and knowledge of content and teaching (KCT). Ball et al.'s (2008) framework of mathematical knowledge for teaching offers a clear and structured understanding of the different kinds of knowledge required for effective mathematics instruction. The distinction between CCK and SCK emphasises that teaching mathematics involves more than just solving problems—it requires a deep understanding of mathematical concepts in ways that support student learning. SCK, for instance, includes the ability to interpret various models of operations like subtraction or division, which may not be necessary in other professions but are crucial for clarifying student misconceptions. This nuanced approach elevates the professional nature of teaching and highlights the unique intellectual demands it places on educators.

However, the boundaries between the domains—especially between KCS and KCT—can be difficult to distinguish in practice. Teaching is inherently dynamic, and a teacher's response to a student's misunderstanding often draws simultaneously on knowledge of mathematics, student thinking, and instructional strategies. Furthermore, while the framework effectively captures cognitive aspects of teaching, it under-represents the affective and cultural dimensions, such as building student confidence or addressing equity in mathematics classrooms. As such, while Ball et al.'s model is a valuable tool for teacher education and research, its practical application requires adaptation to diverse teaching contexts and a broader consideration of the socio-emotional realities of the classroom.

Bognar et al. (2024) present a model of professional development (PD) that strongly aligns with Ball et al.'s framework (2008), particularly in its emphasis on enhancing pedagogical content knowledge (PCK) through structured interventions, coaching, and the integration of technology. Their findings support the idea that improving PCK—especially KCS and KCT—has a greater impact on student outcomes than CK alone, reinforcing the view that teaching demands more than procedural fluency. However, the near absence of general pedagogical knowledge in these PD programs raises concerns about a potentially narrow focus. While specialised knowledge is critical, effective teaching also relies on classroom management, student motivation, and differentiated instruction—areas typically covered under pedagogical knowledge. Therefore, a more balanced PD approach that integrates mathematical knowledge for teaching with foundational pedagogical skills may better support teachers in diverse educational contexts.

The Urgency of Indigenous Teacher Professional Development for the Future and Well-Being of Indigenous Students

Indigenous educators can foster valuable community and cultural knowledge of educational delivery services that can contribute to the empowerment of marginalized Indigenous populations, which is noteworthy for such communities as a whole (Thornton et al., 2011). Research has indicated that Indigenous students require a more culturally appropriate learning environment, and Indigenous teachers can create such learning environments (Emekauw, 2004; O'Connor, 2010; Sianturi et al., 2018; Yen et al., 2013). Since Indigenous teachers must demonstrate cultural sensitivity to the needs of their students and understand Indigenous protocols to teach their students

effectively, their roles are considered crucial within this context because those teachers have a profound knowledge of the context of their Indigenous students.

It was evident throughout the lesson that an Indigenous educator in Thornton et al.'s (2011) study was confident in her ability to teach mathematics and to find a way to perform well. Indeed, when she taught small groups earlier in her career, she frequently paused to ask the mentor teacher to elaborate on relatively simple mathematical concepts. Over time, making a connection between symbols, places, and words was an easy task for her. She could bridge the gap between the children's lived experiences and the resources they were familiar with by creating that connection and using ways they preferred. No wonder the children had a general sense of involvement with the lesson, as they scrambled to match cards, joined in the race, called answers out, and enthusiastically drew their representations of what was happening.

According to Sianturi et al. (2018), having an Indigenous West Papuan teacher in the classroom who was willing to infuse Indigenous knowledge and stories in his teaching generated a new nuance to the classroom in which students were incredibly enthusiastic about engaging with his teaching approach. The teacher's belief in mastering mathematics material in accordance with the applicable curriculum by integrating the material with Indigenous cultural content knowledge not only prompted the improvement of Indigenous students' mathematics learning achievement but also for himself, it sparked strong enthusiasm that he could become a role model for his community.

Developing this type of confidence can be challenging as part of any pre-service teacher education program within a remote community (Thornton et al., 2011). The problem manifests even more acutely when we consider the harsh challenges of remote Indigenous culture. Refuting any unwritten regulations regarding who should be in charge in the classroom will be tough. However, there are a number of supporting factors in this case: the support provided by the mentor teacher, the university lecturer, the school-based coordinator, and the peers in the education program (Thornton et al., 2011).

Systematic Inequality in Education in West Papua

The development of Indigenous teachers in West Papua must be understood within a broader context of historical and structural marginalisation. Educational inequities in the region are not merely technical issues of access or quality but are deeply embedded in colonial legacies, state policies, and sociopolitical hierarchies that continue to shape educational outcomes for Indigenous Papuans (Kudiai, 2015; Sianturi & Hurit, 2024; Sianturi et al., 2018; 2023). These systemic forces have not only limited the opportunities for Indigenous communities to access quality education but have also impeded the development of culturally grounded and confident Indigenous teachers. Understanding the intersecting impacts of these structural barriers is essential in order to challenge deficit narratives and work toward a more just and culturally responsive teacher education system in West Papua.

The long history of colonialism, educational system, cultural background, sociopolitical and socio-economic factors indirectly contribute to the mathematical content knowledge of Indigenous West Papuan pre-service teachers. Most Indigenous West Papuan pre-service teachers have undergone systematic inequality in education.

Scholars have argued that the existence of political legacy, violence, and international influences under Indonesian state colonial rules (Kudiai, 2015; Sugandi, 2008; Upton, 2009; Webb-gannon, 2020). Such organic developments, prejudice against the low quality of Papuan students and stereotypes that label them with primitiveness have indirectly hindered numerous possibilities for the Papuan students to leverage their potential (Macleod, 2011; Sianturi et al., 2022a). People from outside Papua have transmigrated and dominated customary Papuan lands (Upton, 2009; Widjojo et al., 2010). Now they are a minority in their land, and Javanese have become predominant in those lands (Siadari, 2017; Wardana, 2017).

More than 200 Indigenous Papuan tribes, which are scattered in coastal and highland areas, inhabit the West Papuan region. The geographical condition of this region is another factor that is also an obstacle to the limited access and education services (Kristiansen, 2006). Therefore, this condition causes the learning experience of Indigenous students to differ geographically.

Another cause is the lack of teachers' commitment and quality. A study conducted in the southern region of Papua stated that one of the biggest educational problems is the low commitment and quality of primary school teachers (Werang et al., 2017). Interviews with the Education and Teaching Office of Southern Papua (2017) found that the highest teacher absenteeism rates occurred in the outskirts of southern Papua, especially among primary school teachers. Some teachers often do not come to class, so learning stops, and students do not obtain educational services like other students. Meanwhile, due to school age, Indigenous students are forced to be promoted to the next grade, even though they have not mastered the material in previous grades. Moreover, the low quality of teachers causes students' learning experiences to be less than optimal. As mentioned earlier, most teachers in Papua cannot achieve the standard of teacher quality (Costa, 2018).

Another problem found to be a cause of systematic inequality in education in West Papua is the design and implementation of a curriculum that is irrelevant to Papuan children. The curriculum currently implemented, namely the 2013 national curriculum, is seen as not relevant to the educational needs of Papuan children (Sianturi et al., 2018; 2022a). There is a separation between children's life experiences and cultural context with the material presented and the presentation of the material does not consider Indigenous ways of knowing (Sianturi et al., 2025). In mainstream education, learning emphasises western mindsets and measures learning outcomes in a standard way (Rigney et al., 2020; Sianturi et al., 2024). Though international and local literature has demonstrated that Indigenous people have a learning system that is different from western patterns, and learning will be more fun for Indigenous children through a cultural approach (e.g., a Harris, 1984; Matang & Owens, 2014; Owens, 2012; Yunkaporta, 2009). That is why students often have difficulty understanding learning.

Apart from the government and policymakers who have the authority to reform curriculum, this is also inseparable from the responsibility of tertiary institutions, which have a role to play in preparing prospective teachers. Prospective teachers must be equipped with knowledge and skills to incorporate the Papuan cultural context into learning. However, this is absent in the structure of the courses at tertiary institutions across West Papua.

The Context of the Study

The level of understanding of mathematics material affects a prospective teacher's readiness and confidence to teach mathematics material. Several prospective teachers do not master the mathematics material, and mistakes often occur in solving math problems (Sumartini, 2020). The mistakes occur due to pre-service teachers' lack of mathematical concepts (Sumartini, 2020). Prospective teachers with inadequate mastery of mathematics will think they are not good enough to teach mathematics (Sumartini, 2020).

Pre-service primary school teachers in Papua often experience the same thing. A lack of understanding of the material often causes anxiety in entering a teaching internship program. We limited our study to investigating the level of knowledge of prospective primary school teachers about mathematics material in primary schools. Mathematics topics taught at the primary level comprise five content areas: number, shape and space, measurement, data handling, and algebra. In this study, we focused on the content area of "number" which covers whole numbers, fractions, decimals, percentages, and basic arithmetic operations. Moreover, strengths and weaknesses within each basic arithmetic operation for Papuan pre-service teachers were also explored. Since this was a preliminary study in this region for the tertiary level, the results provided an overview of areas of improvement for teacher education programs. Our next project would be conducted qualitatively to discover the causes and strategies (including historical and sociocultural factors) that could be conducted both from the perspectives of pre-service teachers and instructors at the teaching department and supported by higher education curriculum analysis.

METHOD

We identified the mathematical abilities of pre-service primary school teachers. Participants were given a mathematical test. Computational fluency and mathematical interpretation and modeling skills were highlighted in the test. To accomplish this investigation, this study employed a quantitative methodological approach (Creswell, 2009). Ethical clearance was obtained from the Human Research Committee at a local university, and all participants provided us with informed consent.

Research Participants

This study involved 150 pre-service teachers in years 1, 2, and 3. The demography of the respondents is provided in Table 1. The participants came from diverse tribal backgrounds (58 Papuans and 92 non-Papuans). For the convenience of the report, we grouped some tribes based on the

similarity of regional origin. Ambonese, Kei, and Tanimbar tribes were grouped into Maluku, as they were originally from Maluku Island. Makassar, Bugis and Toraja tribes were grouped into Makassar as they were originally from Sulawesi Island. Meanwhile, the ethnic groups of NTT, Batak, NTB, and other ethnic groups were grouped into others. The number of respondents from the Javanese tribe was dominant.

Criteria	Category	Frequency (*n*)
Year of study	Year 1	30
	Year 2	46
	Year 3	84
Gender	Female	110
	Male	40
Tribe	Asmat	11
	Dani	2
	Muyu	16
	Mandobo	9
	Auyu	4
	Marind	13
	Serui	3
	Java	37
	Makasar	11
	Maluku	27
	Others	17

Table 1. The demography of participants

Instruments and Data Analysis

Data was collected through a survey sheet consisting of two parts, the first part was a mathematical test sheet, and the second part was respondents' information. The test given consisted of simple arithmetic operations (e.g., addition, subtraction, multiplication, division, and mixed operations) and problem-solving (e.g., word problems). Problem-solving questions were addressed to identify their analytical thinking. The test comprised 30 items (24 multiple-choice items and six essay items), in which 4 multiple-choice items and 1 essay question represented each topic of number content area. Table 2 provides some examples of test items. We analysed data quantitatively. This test was developed by adapting the basic mathematics questions distributed in the latest National Examination at the primary level and from textbooks used in primary schools across Papua. The rationale for this test construction choice was that most of the questions came from these two sources which are also often a scourge for pre-service primary school teachers.

Item number	Test items	English translation
8	$\frac{5}{4} - \frac{7}{9} = \ldots$ a. $\frac{2}{5}$ b. $\frac{1}{18}$ c. $\frac{12}{13}$ d. $\frac{17}{36}$ e. $\frac{35}{36}$	$\frac{5}{4} - \frac{7}{9} = \ldots$ a. $\frac{2}{5}$ b. $\frac{1}{18}$ c. $\frac{12}{13}$ d. $\frac{17}{36}$ e. $\frac{35}{36}$
15	Faktor Persekutuan Terbesar (FPB) dari 36, 48, dan 72 adalah.... a. 36 b. 24 c. 12 d. 8 e. 6	The Greatest Common Factor (GPA) of 36, 48, and 72 is.... a. 36 b. 24 c. 12 d. 8 e. 6
17	$135 - 27 \div 9 \times 25 = \ldots$ a. $\frac{108}{225}$ b. 60 c. 300 d. 2.700 e. 3.300	$135 - 27 \div 9 \times 25 = \ldots$ a. $\frac{108}{225}$ b. 60 c. 300 d. 2,700 e. 3,300
24	Bibi memiliki beras $1\frac{3}{4}$ kg. Kemudian Bibi membeli lagi $2\frac{1}{2}$ kg. Beras tersebut dimasak 0,2 kg. Sisa beras Bibi sekarang ...kg. a. $3\frac{3}{20}$ b. $3\frac{1}{20}$ c. $4\frac{1}{20}$ d. $3\frac{3}{20}$ e. $4\frac{9}{20}$	My auntie has $1\frac{3}{4}$ kg of rice. She buys again $2\frac{1}{2}$ kg of rice. Then she cooks 0.2 kg of rice. Her leftover rice now is ...kg. a. $3\frac{3}{20}$ b. $3\frac{1}{20}$ c. $4\frac{1}{20}$ d. $3\frac{3}{20}$ e. $4\frac{9}{20}$

Table 2. Examples of test items

Two experts validated this test to measure whether the test items represented each topic. The results gained from experts indicated that all items described each topic of the content area measured. The experts also provided corrections regarding word choices in the test items. After revising the test, we tested it on 113 pre-service teachers of years 1, 2, and 3 from the Indonesian language and literature department. The test reliability was measured by using Cronbach's alpha value. The value of Cronbach's alpha was 0.58. This means that the test was reliable. The data was analyzed using SPSS, employing descriptive analysis. The paper-pencil test was administered and completed in 90 minutes.

RESULTS

The results of this study comprised four parts, namely: (1) the overview of mathematical content knowledge of Papuan pre-service primary school teachers; (2) the strengths and weaknesses of Papuan pre-service primary school teachers in mastering mathematical knowledge for each topic. A normality test was measured to determine whether the data was normally distributed. The statistical results showed a significance value of 0.181 greater than 0.05 (Appendix A), which means that the data were normally distributed. Thus, statistical tests could be measured parametrically.

The Overview of Pre-service Teachers' Mathematical Content Knowledge

Table 3 describes pre-service primary school teachers' knowledge about mathematics topics. None of the pre-service teachers answered all the questions correctly. The highest score was 19, and the lowest score was 1. Overall, their performance was 43.17 on a scale of 100. That is, their capability to master fundamental mathematical knowledge did not even exceed 50%. The tribes with the lowest average scores were Asmat pre-service primary school teachers, and the highest was Javanese pre-service primary school teachers. For the Papuan tribe itself, the Serui and Auyu tribes had higher performance than other Papuan tribes.

Tribe	N	Minimum	Maximum	Mean	%
Asmat	11	4	11	5.82	24.25
Dani	2	6	7	6.50	27.08
Muyu	16	1	17	7.31	30.46
Mandobo	9	3	12	6.33	26.38
Auyu	4	8	16	10.50	43.75
Marind	13	1	18	8.46	35.25
Serui	3	9	15	12.33	51.38
Jawa	37	1	19	13.35	55.63
Makassar	11	2	19	12.19	50.79
Maluku	27	1	16	10.16	42.33
Others	17	7	19	12.41	51.71
Total	150	1	19	10.36	43.17

Table 3. The pre-service primary school teachers' knowledge about mathematics topics

The Strengths and Weaknesses of Indigenous Papuan Pre-Service Teachers in Mastering Mathematical Content for Each Topic

Asmat and Mandobo pre-service primary school teachers did not master 50% of any operation (Table 4). For the Dani tribe itself, none of them could solve mathematical word problems. On the other hand, Muyu and Marind pre-service primary school teachers performed better in completing mathematical word problems, obtaining the highest correct percentage. Mixed counting and division operations were complex operations for all Papuan tribes. Meanwhile, the Dani, Muyu, and Mandobo tribes experienced difficulties in subtraction operations. The addition operation was a relative operation that almost all Papuan pre-service primary school teachers could solve.

Arithmetic Operation	Asmat		Dani		Muyu		Mandobo		Auyu		Marind		Serui	
	Mean	%	Mean	%	Mean	%	Mean	%	Mean	%	Mean	%	Mean	%
Addition	1.55	38.75	2.00	50.00	1.63	40.75	1.78	44.50	2.75	68.75	1.62	40.5	2.33	58.25
Subtraction	1.00	25.00	1.00	25.00	0.75	18.75	0.78	19.50	1.50	37.50	1.15	28.75	3.00	75.00
Multiplication	1.00	25.00	2.00	50.00	1.31	32.75	1.44	36.00	2.25	56.25	1.38	34.50	2.00	50.00
Division	0.64	16.00	0.50	12.50	1.13	28.25	0.78	19.50	1.00	25.00	1.69	42.25	2.00	50.00
Mixed operations	0.36	9.00	1.00	25.00	0.50	12.50	0.67	16.75	1.00	25.00	0.54	13.50	1.00	25.00
Word problems	1.27	31.75	0.00	0.00	2.00	50.00	0.89	22.25	2.00	50.00	2.08	58.00	2.00	50.00

Table 4. Pre-service teachers' mathematical content knowledge by Papuan ethnicity

DISCUSSION

Results revealed that pre-service primary school teachers' overall knowledge of primary school mathematics materials was deficient. This implies that most of them struggled to master mathematical materials at the primary school level. Some of them completed fundamental mathematical courses in years 2 and 3 of their study, including multiplication, division, and word problems.

This result was a little worrying for the future generation of Papuan children. How will Papuan education improve if the quality of pre-service primary school teachers, especially Indigenous Papuan pre-service teachers, does not meet the expected standards? Remarkably for such marginalised communities, the literature describes Indigenous educators as having the potential to foster meaningful community and cultural knowledge of educational delivery services (Thornton et al., 2011). Several researchers have recommended that teachers shift the learning environment for Indigenous students to be more culturally relevant (Emekauw, 2004; O'Connor, 2010; Sianturi et al., 2018; Yen et al., 2013). Since teaching Indigenous students requires cultural sensitivity to their multiple and diverse needs and an understanding of Indigenous protocols, Indigenous teachers'

roles are crucial because they have a profound knowledge of their Indigenous context. Sianturi et al. (2018) found that the presence of an Indigenous West Papuan teacher who committed to adopting Indigenous knowledge and stories in his teaching created a new nuance to his classroom, in which students were incredibly enthusiastic about learning with his approach. The results of this study, which was a little discouraging, provided a picture of the quality of the developmental education program in the teaching and education department. Therefore, the teaching and education department must consider how to increase Indigenous Papuan pre-service teachers. It was essential for the government and the Faculty of Education and Teacher Training to give more attention to Indigenous Papuan pre-service teachers. In order to understand the kind of attention most beneficial to these tribes, the faculty first needed to give them a voice. The strategy conducted has not addressed this challenge because they were completely silent on how these voices were considered. For example, a comprehensive bill, the Teacher Law, aimed at raising the quality of teachers through teacher certification was passed by the government in 2005 in an effort to improve education quality; however, the teacher certification has not improved student learning outcomes nor increased the competencies of teachers (The World Bank, 2014). A commitment to provide teachers with training related to the content knowledge will increase their teaching practices (Habiyaremye et al., 2022).

The strategy should be more related to the historical and cultural factors, and our findings provided a discussion that can be helpful. The results also described that five Indigenous West Papuan tribes performed differently in each topic of mathematics materials. Asmat and Mandobo pre-service teachers encountered difficulties in mastering all basic mathematical knowledge, including addition, subtraction, multiplication, division, mixed operations, and problem-solving. Auyu tribe is a tribe that originally came from the same region or adjacent to where Mandobo, Asmat, Muyu, and Marind tribes came from. However, the Auyu tribe seemed to perform better than them. For Muyu and Marind students, solving math problems was the most effortless operation. Based on history, the Muyu tribe had always known the barter system with *ot* (seashell) and *mindit* (animal teeth), which remain in use today (Jerat Papua, 2014; Mei, 2016). Additionally, the Muyu tribe is also known for having good arithmetic and social skills (Mei, 2016). This is why their capability to complete mathematical problem-solving operations was much better than other operations. Future research could usefully explore the impact of stereotype threat on mathematical achievement across Indigenous groups to better understand sociocultural dimensions of performance disparities.

The results revealed notable weaknesses in the understanding of mixed operations and division, which were the most challenging for Indigenous Papuan pre-service teachers. These areas showed high error rates and a lack of procedural fluency and conceptual clarity. Pre-service teachers often struggle with conceptual understanding of elementary number theory, showing a tendency towards procedural approaches (Zazkis & Campbell, 1996). For instance, in our study, many respondents struggled to apply the correct order of operations in word problems or made errors in multi-step division problems. Research on pre-service teachers' mathematical understanding also indicates significant challenges in understanding division concepts (Simon, 1993), including difficulties with division by zero (Crespo & Nicol, 2006). Furthermore, recent research highlights difficulties in identifying errors and comprehending content in mathematical word

problems, with pre-service teachers often focusing on solutions rather than critically evaluating problem statements (Abdullah et al., 2024). These studies consistently demonstrate gaps in conceptual understanding, particularly in connecting mathematical concepts to real-world contexts. Common themes include challenges in explaining mathematical reasoning, limited depth of understanding in seemingly basic operations, and difficulties in applying mathematical knowledge to diverse situations. These findings underscore the need for enhanced teacher education programs that emphasize conceptual understanding and critical thinking in mathematics.

Other research has also found that Indigenous people's way of learning tends to apply a whole pattern rather than a sequence form (Harris, 1984; Hughes & More, 1997; Yunkaporta, 2009). This resulted in Indigenous students encountering difficulties in completing sequence arithmetic operations like mixed arithmetic operations and division (Hughes & More, 1997). Therefore, when deciding programs for teaching department, taking cultural factors into consideration enables educational authorities to provide a transformed learning experience (Sianturi et al., 2018). Contextual mathematics should be made more visible to Indigenous students, including the incorporation of cultural attributes into mathematics (Bishop, 2002; Showalter, 2013; Yao, 2014).

The observed weaknesses in mathematical knowledge cannot be fully understood without considering the cultural and historical context of Indigenous education in West Papua. Indigenous students often come from families and communities with limited access to quality primary and secondary mathematics education due to systemic inequities, under-resourced schools, and language barriers. International literature indicates an essential issue of the role of culture in our (mis)understanding of "mathematical ability" itself (Antone, 2012; Forgarty & Schwab, 2012). The mathematical ability of Indigenous people is developed within their cultural context (Owens, 2012). Therefore, assessing a mathematical ability through a standardised test might not be a good choice (Rigney et al., 2020; Sianturi et al., 2024). Our study used a standardised test, which might influence Papuan pre-service teachers to understand the test. A study by Sianturi et al. (2025) revealed that when a test was modified from a standardised form into an item that incorporated Indigenous cultural context, Papuan students (junior and high school levels) completed the test easier and faster. Knowing this might help the government and the Faculty of Education and Teacher Training design effective strategies for effective learning, designing professional teacher programs and assessing teachers' mathematical ability.

Our study presented pre-service teachers' knowledge of mathematics materials in primary schools, but we recommend readers not interpret these results for political or other non-research purposes. The study has several limitations that must be acknowledged. First, the focus on number content excludes other mathematical domains such as geometry, algebra, or measurement, which may have revealed different strengths and weaknesses. Second, the sample is limited to pre-service teachers in one province, which may not represent all Indigenous Papuan groups. Therefore, future researchers can consider a larger sample size. Third, the study relies on quantitative test results, which—while useful—do not fully capture the cultural reasoning or informal mathematical strat-

egies employed by participants. Lastly, the study does not explore in depth the pedagogical approaches used in the teacher education programs, which may have influenced the outcomes. Further research is required to determine the impact of history and culture on their pre-service teachers' mathematical ability, particularly Indigenous Papuan pre-service teachers. In addition, it is also necessary to investigate qualitatively the strengths and weaknesses of Indigenous Papuan pre-service teachers that affect their mastery of mathematical content knowledge. As we mentioned earlier, we intended to conduct our following research qualitatively to identify the causes and strategies (including historical and sociocultural lenses) from the perspectives of pre-service teachers and instructors of the teaching department and complemented by a curriculum analysis of higher education. Future research may also adopt mixed-methods designs, combining standardised assessments with interviews or classroom observations, to better understand the cognitive and contextual processes behind correct and incorrect responses. In doing so, researchers can move beyond test scores to grasp the full picture of mathematical learning among Indigenous populations. While our study highlighted structural and historical factors that might influence Indigenous Papuan pre-service teachers' mathematical content knowledge, it did not extensively explore these factors and other potential contributors such as pedagogical approaches, curriculum design, or disparities in access to educational resources, which represent limitations to the current analysis. Future research may investigate these potential contributors specifically.

CONCLUSION

The mathematical content knowledge of pre-service teachers at the primary school teacher education department is one indicator of core competencies for a teacher. Our study reveals that the competence of mathematical content knowledge of such teacher candidates is low. The average level has not exceeded 50 on the scale, which is below the standard. Asmat pre-service teachers have the lowest performance among other pre-service teachers. Mixed operations and division are challenging for all Indigenous West Papuan pre-service teachers.

This present study provides some recommendations. The Faculty of Teacher Education and Training might provide more assistance in equipping their Indigenous West Papuan pre-service teachers. In the first semester, matriculation in fundamental mathematics might be given to increase their mathematical knowledge. The most critical factor that the faculty should consider is historical and sociocultural factors. In designing teaching programs for Indigenous Papuan pre-service teachers, the faculty should incorporate cultural backgrounds into their curricula and teaching practices. It is also worth considering providing Indigenous West Papuan pre-service teachers with a space to share their insights and inspirations on how the program and Indigenous culture-based instruction can be developed to better support them.

The findings of this study have also direct implications for teacher education policies and curriculum design. First, mathematics education courses for pre-service teachers in Papua should include diagnostic assessments to identify specific content gaps early in the program. Second, targeted interventions—such as bridging courses focused on number concepts and problem-solving—

should be integrated into the curriculum. Third, teacher education programs should adopt culturally relevant pedagogies that contextualise mathematical concepts within Indigenous students' lived experiences, supporting both understanding and retention.

Furthermore, policymakers should consider the systemic challenges Indigenous students face and implement affirmative support mechanisms, such as mentorship, additional academic tutoring, and community-based learning strategies. These would help ensure that Indigenous pre-service teachers not only improve their MCK but are also empowered to become effective educators in their own communities.

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APPENDIX

Appendix A. Analysis of normal distribution test

N		150
Normal Parameters[b]	Mean	10.3600
	Std. Deviation	4.61145
Most Extreme Differences	Absolute	0.090
	Positive	0.087
	Negative	-0.090
Kolmogorov-Smirnov Z		1.096
Asymp. Sig. (2-tailed)		0.181

[b] *Normal distribution is assumed*