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A PRAGMATIC WORLDVIEW TO MEANINGFUL MATHEMATICS LEARNING AMONG INDIGENOUS PEOPLES' STUDENTS: A SCALE DEVELOPMENT AND VALIDATION

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Abstract:
The academic performance of Indigenous Peoples (IP) students in mathematics often lags due to the lack of culturally responsive teaching approaches and curriculum designs, highlighting a significant research gap. This study aimed to develop and validate a measurement model of meaningful mathematics learning for Indigenous senior high school students, focusing on factors contributing to culturally relevant and effective mathematics education. Using a mixed-methods research design, the study involved Manobo senior high school students from the Davao Region. Data were gathered through surveys and interviews and analyzed through thematic analysis, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). The findings revealed four key dimensions of meaningful mathematics learning: Teaching Methods and Understanding, Learning Through Activities and Games, Real-Life Application of Mathematics, and Practice and Mastery. The final model demonstrated strong statistical reliability and validity and was within acceptable thresholds of model fit indices. These dimensions reflect the importance of culturally responsive and student-centered teaching approaches that connect mathematics to real-life contexts and Indigenous cultural practices. The study concludes that meaningful mathematics learning for Indigenous students can be enhanced by integrating cultural relevance, interactive teaching methods, and practical applications into the curriculum.

Keywords: scale development, indigenous students, mathematics, meaningful learning

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1. Introduction

Students in Indigenous societies worldwide often show a lack of enthusiasm for traditional educational experiences. This disengagement is not due to a deficiency in intelligence, creativity, or problem-solving abilities but rather stems from a misalignment between school culture and Indigenous students' sociocultural realities (Edaño, 2019; Jin, 2021). In mathematics education, Indigenous learners consistently underperform compared to their non-Indigenous peers, as seen in numerous national and international assessments (Burgin, 2023). This performance gap is especially alarming in the Philippine context, where systemic inequities in education continue to hinder the country's ability to meet global development benchmarks, including the Sustainable Development Goals (Moodie *et al.*, 2021; Rutherford *et al.*, 2019). Indigenous students in the Philippines often encounter multiple barriers in mathematics learning, including limited access to quality instruction, language difficulties, and a lack of culturally responsive pedagogy. These challenges result in lower engagement, reduced confidence, and diminished academic and career advancement opportunities. Despite growing recognition of these issues, there remains a critical gap in research: no existing scale has been developed to measure meaningful learning in mathematics, specifically among Indigenous students. This study seeks to address that gap by developing a culturally contextualized measurement tool grounded in theory and empirical evidence.

The PISA 2018 National Report for the Philippines revealed that Filipino students scored significantly below the Organization for Economic Co-operation and Development (OECD) average in reading, mathematics, and science, highlighting the urgent need for educational reform and improved inclusive education programs tailored to Indigenous communities (DepEd, 2019). The 2022 PISA results reflected similar trends, with only marginal gains: Filipino students scored an average of 355 in mathematics (compared to the OECD average of 472), 347 in reading (OECD average of 476), and 356 in science (OECD average of 485) (OECD, 2022).

In assessment programs for numeracy, Indigenous students remain the group with the highest educational disadvantage in mathematics education, with competence two years behind non-Indigenous students (MEECDYA, 2008). Compared to non-Indigenous students, who finish school in Year 12 at a rate of 46%, only 23% of Indigenous students aged 15 and over do the same (Lamb, 2009). Young Indigenous students also enroll at the lowest rates in post-compulsory education. It is clear from the study of PISA data that Indigenous students are neglected at higher competence levels in mathematical literacy but are significantly represented at the bottom end of the scale. In particular, the data shows that only 2% of Indigenous students outperformed their non-Indigenous counterparts in arithmetic literacy, as opposed to 15% of them.

Low mathematics literacy scores also show a considerable difference between Indigenous and non-Indigenous children, with 50% of Indigenous students falling into this category. These results emphasize the negative consequences on Indigenous children of having weak mathematical abilities. For example, their inability to satisfy the minimal math requirements for apprenticeships and traineeships in vocational education training (VET) severely restricts their capacity to take advantage of successful social, financial, and educational prospects. These restrictions significantly negatively affect their prospects for the future (O'Connor & Bronwyn, 2020; Jorgensen, 2020; Sianturi *et al.*, 2022).

Mathematics is a cornerstone for scientific, technological, and economic advancement, transcending its role in academic qualifications to equip individuals with essential skills for diverse professions (Maass *et al.*, 2019; Pumwa & Mohamed, 2020). Mathematics proficiency is critical for academic success and a driver of career aspirations and societal development (Siregar *et al.*, 2023; Freeman *et al.*, 2019). However, addressing disparities in education remains a pressing challenge, particularly for students from diverse and Indigenous backgrounds. Teachers often lack adequate training and resources to support these learners effectively (Long & Wendt, 2019; Ghani *et al.*, 2023). Enhancing teacher preparation programs and fostering inclusive pedagogical strategies are essential to overcoming these barriers.

Engaging and contextual teaching methods significantly enhance mathematics education. Connecting mathematical concepts to real-life contexts has improved comprehension, conceptual knowledge, and student motivation (Nyathi, 2020; Subramaniam, 2022). Fostering a positive and inclusive learning environment is vital to enabling students to engage meaningfully with mathematics (Brijlall & Ivasen, 2022). According to the National Council of Teachers of Mathematics (2014), one of the primary goals of teaching mathematics is to foster meaningful learning. They emphasize that an effective mathematics curriculum involves engaging students in meaningful learning through personalized and collaborative experiences, thereby developing their ability to understand and reason mathematically (p. 5). Ausubel's Meaningful Learning Theory is employed to achieve this important objective, as it emphasizes the learner's existing knowledge as the critical factor in the learning process. Meaningful learning occurs when students comprehend, connect, and integrate new information with what they already know, enabling them to apply this knowledge to solve unfamiliar problems.

In this context, the role of the teacher is that of a facilitator, supporting students in their exploration and assimilation of new concepts (Ausubel, 2000). Furthermore, due to the abstract nature of mathematics, teaching the subject can be challenging. Ausubel's learning theory is particularly suitable for teaching abstract concepts, as it encourages students to adopt a meaningful learning orientation. This orientation holds significant potential in student learning materials, as it enables students to actively seek connections between their prior knowledge and new information by modifying classroom activities to promote engagement in meaningful learning (Adhikari, 2020).

Principals and other school administrators may make all the difference in supporting teachers and encouraging achievement for Indigenous kids by emphasizing early learning. School systems can support the efforts of teachers and principals. High-quality Early Childhood Education and Care for Indigenous children puts them on a fast track to success. Students' lives are interconnected, with events in one area impacting others. Due to these factors, success for Indigenous children needs to be determined holistically, considering each student's entire being, along with their family and communities, by promoting success, involvement, engagement, and well-being are all essential components of helping Indigenous students succeed (OECD, 2017).

Effective school leadership is critical to improving education since school leaders can affect teaching and learning. The notion that leadership determines a school's success is widely accepted in many other types of organizations in addition to the educational sector (Watson, 2005). Strong and effective leadership may establish a school's culture and transform its dysfunctional parts into functional elements, promoting increased school attendance, setting high standards, and fostering a sense of pride in a child for being an Indigenous student (Schein, 2004; Sarra, 2003).

Excellent leadership is one of the critical components of exceptional schools (Reynolds, 1991). The relationship between school leadership and student results has been the subject of reviews of empirical studies (e.g., Bell *et al.*, 2003; Leithwood *et al.*, 2004; Marzano *et al.*, 2005; Leithwood *et al.*, 2006). These include how leaders actively participate in the development and implementation of curricula, support and advocate for effective teaching and assessment methods, and modify their leadership style to consider the needs of educators, students, and other stakeholders (Waters *et al.*, 2003).

This study adopts a pragmatic approach by integrating qualitative and quantitative methods, making it the most effective strategy for understanding meaningful mathematical learning among Indigenous students. By employing a mixed-methods research design, the study captures the rich, lived experiences of Indigenous learners through qualitative exploration while ensuring empirical validation of key learning factors using quantitative techniques such as Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (Suhr, 2006). This combination allows for a comprehensive and multidimensional understanding of how Indigenous students engage with mathematical concepts in culturally relevant ways (Long & Wendt, 2019). The qualitative phase provides contextual depth, ensuring that the findings are rooted in students' sociocultural realities, while the quantitative phase enhances scientific rigor by developing and validating a measurement model of meaningful learning (Ausubel, 2000). This dual-method approach is the best way to bridge the gap between theory and practice, as it enables researchers to identify, measure, and interpret the factors that contribute to meaningful mathematics learning (Brijlall & Ivasen, 2022). By aligning contextual insights with statistical validation, this study creates a holistic and evidence-based framework for designing inclusive, culturally responsive educational strategies that empower Indigenous learners to succeed in mathematics (Ghani *et al.*, 2023).

As theorized by David Ausubel, meaningful learning underscores the critical role of connecting new information to prior knowledge to foster deep, lasting understanding. According to Ausubel (1963), learning becomes meaningful when learners actively engage with content, integrate it with their existing cognitive structures, and organize it coherently. Unlike rote memorization, which leads to poor retention and limited transferability, meaningful learning enhances comprehension, critical thinking, and knowledge application by forming interconnected networks of concepts. Novak (1964), building on Ausubel's work, introduced concept mapping as a strategy to visually link prior and new knowledge, while Jonassen and Marra (2012) emphasized using technology to facilitate understanding. These principles guided the formulation of dimensions for assessing meaningful mathematical learning experiences, particularly relevant for Indigenous students who must apply mathematical. Mathematical knowledge is interconnected and supports strategic teaching approaches tailored to learners' needs.

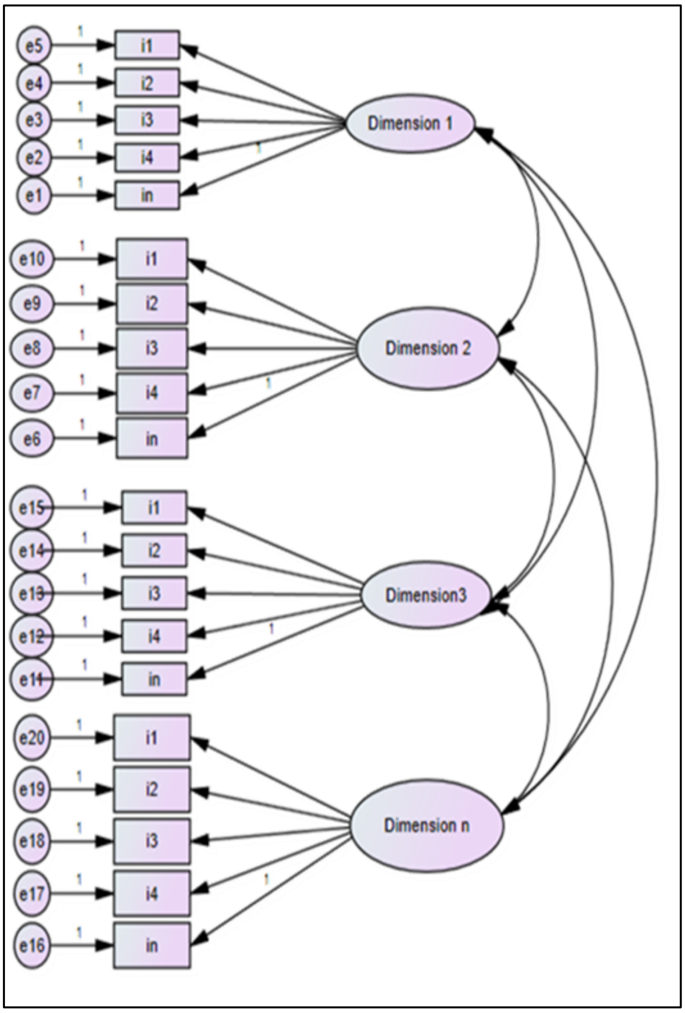

Figure 1: Hypothetical Observed Factors that Measure the Latent Dimensions of the Meaningful Learning Experiences

Figure 1 illustrates a hypothetical model representing these meaningful learning experiences, showing latent dimensions (D1, D2, D3, … Dn) measured by observed variables derived from participant responses. Confirmatory Factor Analysis (CFA), as Suhr (2006) explained, was employed to test hypothesized relationships between observed indicators and their latent constructs. In this model, error terms (e1, e2, … en) account for unexplained variances, one-headed arrows indicate factor loadings (beta coefficients), and two-headed arrows show the interrelationships among latent variables, all of which help validate the theoretical structure of meaningful mathematical learning experiences.

While various studies have documented the educational disadvantages experienced by Indigenous learners, particularly in mathematics, there remains a lack of empirical research that explores their meaningful learning experiences within the Philippine context. Existing literature often emphasizes theoretical perspectives or national-level performance data without capturing Indigenous students' lived realities and sociocultural contexts. Moreover, there is a scarcity of validated tools specifically designed to measure the dimensions of meaningful learning in mathematics among Indigenous learners. The role of school administrators in promoting such learning has also been insufficiently addressed, leaving a gap in understanding how leadership practices can support culturally responsive and inclusive education. This study addresses these gaps by integrating qualitative insights and quantitative validation to develop a comprehensive model of meaningful mathematics learning tailored to Indigenous students in Region XI.

The study focuses on the meaningful learning experiences of Indigenous students in Region XI. The study specifically examines the role of school administrators in promoting and supporting the meaningful learning of Indigenous students. The study involves mixed-methods research methodologies to gather comprehensive data on Indigenous students' experiences, perspectives, and needs in Region XI. The study includes Indigenous students from Manobo tribes or cultural backgrounds in Davao Occidental and Davao del Sur. Studies that solely rely on theoretical or conceptual frameworks without empirical data related to the experiences of Indigenous students. Studies that primarily focus on quantitative analysis or statistical modeling without providing qualitative insights into the meaningful learning experiences of Indigenous students.

The study's researchers are interested in developing a model of meaningful mathematics learning among Indigenous students using a pragmatic approach. Specifically, it will answer to the following objectives:

1) To explore Indigenous students' views on meaningful mathematics learning.
2) To determine the factors of meaningful learning in Mathematics using Exploratory Factor Analysis.
3) To develop a scale that will measure meaningful learning in mathematics among indigenous students in the Davao Region.

The study hypothesized that Meaningful Mathematical Learning could be explained by active, meaningful learning, constructive, meaningful learning, cooperative, meaningful learning, authentic, meaningful learning, and intentional, meaningful learning.

Understanding and prioritizing the meaningful learning of Indigenous students is essential for school administrators, as Indigenous learners bring unique cultural perspectives, histories, and knowledge systems that enrich the educational environment. School leaders can enhance students' academic performance, social-emotional well-being, and pride in their heritage by fostering inclusive and equitable learning spaces that honor and integrate Indigenous identities. This study is significant as it provides a culturally contextualized framework for assessing meaningful mathematics learning among Indigenous students. It offers practical tools for educators and administrators to improve engagement and achievement. Furthermore, the study contributes to the realization of Sustainable Development Goal 4 (SDG 4) on Quality Education, particularly SDG 4.5, which aims to eliminate disparities in education and ensure equal access for Indigenous learners. By promoting culturally responsive practices, this research supports reconciliation, intercultural understanding, and creating educational systems that empower all learners to thrive.

2. Method

2.1 Study Participants

The study participants were the Manobo senior high school students in the Davao Region. To be eligible for participation in the study, participants had to fulfill specific criteria. These criteria included identifying as members of an indigenous group, specifically the Manobo tribe, being senior high school students, expressing voluntary willingness to participate in the study, and providing legal documentation that grants informed permission and consent. Further, students are allowed to ask questions and clarify the study before they consent. Whether they participate in the study will not affect their academic standing, grades, or any other aspect of their relationship with the school or the researcher. The study focused on students in grades eleven and twelve during the 2023-2024 academic year. Excluded from the study were individuals who were not students at this school, not senior high school, and not part of the Manobo community.

The researchers used two types of sampling techniques: non-probability and probability sampling. In the qualitative phase, the researcher utilized the purposive sampling technique, which is non-probability sampling. It ensures that the researcher will interview the targeted participants, who are Manobo and senior high school students. In the quantitative phase, the researcher used simple random sampling to satisfy the Exploratory Factor Analysis and Confirmatory Factor Analysis assumptions. A simple random sampling method was employed to ensure a fair representation of the population. This method guarantees that every member of the population has an equal opportunity to be included in the sample (Ghauri & Gronhaug, 2005).

In the qualitative phase, the researchers interviewed 12 senior high school students. This number of participants was sufficient to achieve data saturation, ensuring meaningful learning in Mathematics, as saturation is often reached when no new themes emerge in qualitative research (Majid *et al.*, 2018). In the quantitative part of the study, the researchers surveyed 300 Manobo students since the EFA requires a minimum of 100-200 participants for stable results (MacCallum *et al.*, 1999). Some researchers recommend a minimum of 300 participants for more reliable factor structures, mainly when factor loadings are lower (Willmer *et al.*, 2019). However, when factor loadings are high (≥0.6), a smaller sample size of 150-200 may be sufficient (Michael *et al.*, 1988). For CFA, which requires a larger sample due to its complexity, a widely used guideline suggests at least 5-10 participants per estimated parameter, with a minimum of 200 participants to ensure statistical power (Jackson, 2001). Thus, the researcher surveyed 300 Manobo students.

2.2 Materials and Instrument

The researcher utilized two types of research instruments. For the qualitative phase, the researcher utilized the interview guide questionnaire. The interview guide questionnaire was created based on the assumption of meaningful learning of Ausubel.

For the quantitative phase, the researcher utilized a custom survey questionnaire created based on the findings of in-depth interviews, relevant scholarly literature, and appropriate sources aligned with the goals of the investigation. The questionnaire focused explicitly on the study's variables, encompassing the various factors defining students' attitudes toward learning mathematics. The questionnaire is designed to elicit responses from participants using a 5-point Likert scale, enabling them to swiftly indicate their level of agreement on various statements.

The survey questionnaire utilized a 5-point Likert scale to allow respondents to indicate their level of agreement quickly and effectively. The Likert scale consisted of five points with corresponding descriptions: 1-Never - The attitude toward learning mathematics must be evident. 2-Rarely - The attribute of attitude toward learning mathematics is rarely manifested; 3- Occasionally - The attribute of attitude toward learning mathematics is occasionally manifested, 4-Sometimes - The attribute of attitude toward learning mathematics is frequently manifested, and 5-Always - The attribute of attitude toward learning mathematics is always manifested.

2.3 Design and Procedure

This study implemented a mixed method design to capture the meaningful learning experiences of Indigenous students of the quantitative. It is a pragmatic approach combining quantitative and qualitative techniques using student interviews and survey questionnaires (Bonds & Raacke, 2014). As shown in Figure 2, the researcher started with the literature readings and interviewed the students on their views of meaningful learning in Mathematics. Significant statements will be used to create a survey questionnaire. The researcher employed the Content Validity Ratio (CVR) method to ensure the questionnaire's validity. A panel of ten experts will be carefully chosen to evaluate the custom questionnaire. Only item statements surpassing the predetermined cutoff value of 0.80 were retained in the survey questionnaire, while those falling below the threshold were excluded.

Moreover, factor analysis, specifically exploratory factor analysis (EFA), operates on the principle that measurable variables can be condensed into more minor latent variables. These latent variables share a common variance and are not directly observable, a process known as reducing dimensionality (Bartholomew, Knott, & Moustaki, 2011). Similarly, EFA is commonly used to investigate the potential underlying factor structure of a set of measured variables without imposing any predetermined structure on the results (Child, 1990). Unlike discriminating between independent and dependent variables, EFA is an interdependence technique that does not require formal hypotheses. It allows researchers to identify a dataset's underlying dimensions or factors (Hooper, 2012). For this study, EFA is the most suitable method to explore the various factors influencing students' attitudes toward learning mathematics subject.

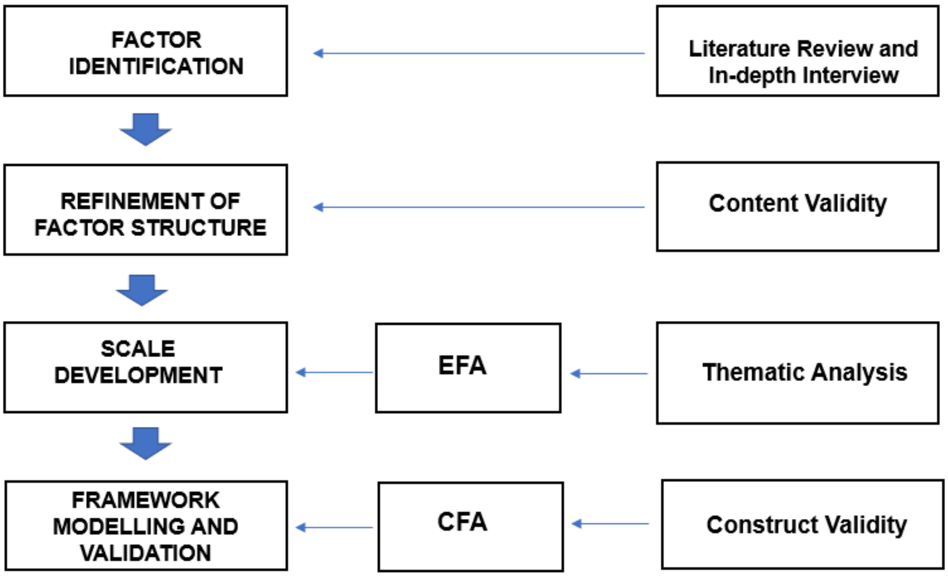

Figure 2: Research Process Flow

The survey questionnaire employed in this study was meticulously crafted by incorporating valuable insights from in-depth interviews and an extensive literature review encompassing various relevant studies. Before commencing data collection, the researcher diligently sought feedback and revisions from qualified validators, who thoroughly examined the finalized questionnaire. Furthermore, an independent third-party validator provided their expert evaluation, which resulted in an impressive rating of four, signifying a remarkably high level of quality.

Subsequently, the researcher submitted all necessary documentation to UMERC (University Research Ethics Review Committee) to obtain their endorsement and the requisite certificate for data collection. In addition, a formal request letter seeking permission to conduct the study was delivered to the department heads and administrative officers, accompanied by endorsements from the Department officials of the school's division office and secondary schools. Once the divisional officials authorized data collection, the researcher commenced the data-gathering process.

A thematic analysis was conducted to explore the students' views on meaningful learning in mathematics. Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were used to determine the factors of meaningful learning in Mathematics and the best-fit model. These techniques facilitated the identification and determination of the underlying factors that characterized students' attitudes toward learning mathematics. The EFA enabled comprehensive data exploration, revealing patterns, relationships, and latent constructs contributing to students' perspectives on the subject. In addition, CFA was used to develop a model based on different parameters such as Chi-square, TLI, and RMSEA.

The study's researcher followed ethical considerations throughout the study. Participation was entirely voluntary. Not all research participants were obliged to participate in the interview. They were free to decline participation in the study, which had no impact on their academic status, grades, or relationships with the school or researcher. Respondents' personal information, such as name, age, and program, was confidential. Informed consent was obtained from all participants. The study posed no high-risk concerns, such as physical, psychological, or socioeconomic harm. This research was original and did not involve plagiarism or data fabrication.

Furthermore, the research paper established transparent provisions on authorship, delineating qualifications that attributed credit solely to substantial contributions—such as conception and design, data acquisition, analysis and interpretation, drafting or critical revision, and final approval of the published version. It ensured accountability and recognition for those who significantly contributed to the research process, which was in line with the principles of scholarly integrity. There was no conflict of interest, as the researchers' school was not included in the study. The responsible disposal of data was diligently carried out, ensuring strict adherence to the Data Privacy Law. The researcher safeguarded sensitive information by securely deleting electronic files and shredding physical documents as per legal requirements. By following the guidelines outlined in the Data Privacy Law, the researcher maintained the confidentiality and integrity of the data collected, including using codes to protect participants' identities.

School administrators and teachers served as the primary recruitment agents for this study. Having established relationships with the target population of Manobo senior high school students, they played a pivotal role in participant recruitment. They were given orientation about the study to ensure they could effectively communicate its details to potential participants. These school personnel provided information about the research, ensuring students understood its aims, potential benefits, and associated risks. Participating school administrators and teachers also played a crucial role in explaining the informed consent process to students. This process included clearly outlining how participants could voluntarily withdraw from the study at any time without repercussions. It was emphasized that students had complete autonomy in deciding whether to participate, with no pressure or obligation. This approach adhered to ethical guidelines designed to uphold the rights and welfare of participants throughout the study.

The researcher also considered the potential risks associated with students' participation, including physical, psychological, social, and economic dimensions. For instance, participants may have experienced discomfort or distress when discussing sensitive topics related to their mathematics learning experiences. The risk of disclosing personal information was also acknowledged, as it could have had potential social or economic repercussions.

To safeguard participants' well-being, the researcher developed comprehensive measures to mitigate these risks. Stringent protocols were followed to protect the confidentiality and privacy of participant data. Participants were informed of their right to withdraw from the study at any point without consequence if they felt uncomfortable. During the qualitative phase of the study, the researcher was accompanied by the school guidance counselor to help mitigate any psychological distress. The researcher remained committed to offering immediate support and appropriate follow-up to ensure participants' safety and comfort. These actions were in accordance with ethical guidelines and upheld the integrity of the study.

Finally, the study findings were communicated to the students, along with an explanation of how their responses contributed to the formulation of the scale. Additionally, the research adviser served as the co-author of this study during its publication and presentation.

3. Results and Discussion

3.1 Views of Meaningful Learning in Mathematics

Presented in Table 1 is the thematic analysis of meaningful learning in Mathematics. The study's researcher utilized the Qualitative Interpretation Technique using the 6 Phases of Thematic Analysis by Braun and Clark (2006). The views of meaningful learning in Mathematics are *Facilitating Learning on Problem-Solving, Emphasizing Practical Applications of Mathematics, Using Student-Centered Strategies, Connecting Lessons to Students' Personal Lives, Integrating Fun in Learning Task Design, Enabling Student Self-paced Learning, Using Communicative Instructional Approach Ensuring Organized Implementation of Lessons, Building up Mastery of Mathematical Knowledge, Connecting Prior Knowledge to New Knowledge, Experiencing Authentic Application of Math Lessons,* and *Using Conceptual Tools to Build Mental Models*.

Table 1: Thematic Analysis of the Views of Meaningful Learning in Mathematics

Themes	Significant Statements
Facilitating Learning on Problem Solving	He enjoys learning math, especially when he gets the answer correctly. (ID1) It should teach us step-by-step how to understand things better. (ID2) Enjoys it when one can answer a difficult problem. (ID6) When one can answer the questions in Math. (ID12) Enjoying solving activities is a reason for one not forgetting lessons. (ID1) I really enjoy solving math, for it helps me when the (proper)time comes. (ID7) Teachers should do step-by-step solving in order for students to understand well. (ID4) Students have to discover the solutions. (ID8) Teachers should give problems to be solved at home for mastery purposes. (ID5) Formulating questions for students helps develop critical thinking. (ID8)
Emphasizing	Math lessons are useful when applied to one's life. (ID7)

Practical Applications of Mathematics	Apply learning to real-life scenarios. (ID10) Help students apply what they learn to their lives. (ID4) teachings applied in real scenarios make it more interesting. (ID1) I learned a lot that I can use in daily living. (ID2) Lessons in algebra, integers, and polynomials help in daily encounters in life. (ID3) I applied learning in statistics to my practical research subject. (ID8) applied it to my real-life situations like computations or estimations. (ID1) teach students how to apply what they learn in school to other places. (ID12) Requiring projects that deal with math application. (ID11) Learning math is a great help in doing other subjects easily. (ID9) What I learned in math was useful in other subjects. (ID10) Applied learning in Math in English lessons. (ID12)
Using Student-Centered Strategies	Using differentiated activities can build students' interest. (ID9) Initiates a series of activities that increase students' interest. (ID7) The teacher knows how to work with students. (ID3) Teachers should have connections to student life. (ID5) Gradually loved math because of my teacher. (ID7) Initiating easier activities for students to have a guided idea of the concept. (ID10) Focusing on child-centered activities. (ID8) Sharing ideas in grouping activities helps students learn a lot. (ID9) Allowing students to read factsheets and explain the concept. (ID6)
Connecting Lessons to Students' Personal Lives	lessons that relate to student experiences is the reason for learning better. (ID4) Having real-life activities helps students easily understand the concept. (ID10) When teachers relate topics to real scenarios. (ID2) Organize lessons aligned to real-life situations to which everyone can relate. (ID11) Localize lessons, and these should be based on actual experience. (ID7) Using relatable situations in life encourages a willingness to learn. (ID3) initiating activities that students can connect to their actual experiences. (ID12) Giving activities that invite students' participation. (ID8) Emphasizing lessons through localization ensures the transfer of learning. (ID9)
Integrating Fun in Learning Task Design	Students enjoy a lesson if there is a game integrated into it. (ID5) providing games to make learning more effective. (ID9) Teachers initiate games that are aligned with real scenarios. (ID10) The teacher uses interactive games for fun and better learning. (ID3) Incorporating games in math lessons. (ID4) Integrating games makes lessons interesting & easily achieves learning. (ID2)
Enabling Student Self-paced Learning	Students need to review and practice at home. (ID5) Students really have to discover the solutions. (ID8) The teacher allows students to discover answers on their own. (ID5) Enjoys memorizing the multiplication table. (ID12) Recall my learning and practice for mastery to do better in the next lesson. (ID4) When teachers gave us activities, we did them on our own. (ID11)
Using a Communicative Instructional Approach	The teacher translates the lesson into dialect with a step-by-step process. (ID3) Translating the lesson into dialect. (ID6) Learning is meaningful when teachers translate difficult lessons into dialects. (ID4) Learning is easily achieved when teachers do not explain fast. (ID2) Explained the topic well, and students understood the activities given. (ID10) Explained clearly the concept, and activities were understandable. (ID9) Learning is not strengthened when the teacher does not explain well. (ID6) Teachers keep repeating the lesson until students master it. (ID5)

Ensuring Organized Implementation of Lessons	The teacher organizes the topic. (ID3) Good to have difficult topics first before the easy ones. (ID6) The teacher gives simple activities that lead to higher topics. (ID11) Teachers should organize lessons and create activities. (ID4) use activities that invite students' participation and are useful to their experiences. (ID8) Planned and organized lessons for students to better understand. (ID12)
Building up Mastery of Mathematical Knowledge	Help students recall previous lessons before proceeding to new lessons. (ID3) Teacher reviews before a new lesson. (ID12) Helpful to one's learning when the teacher repeats instruction. (ID5) Teachers ought to use drills and reviews. (ID8) The teacher uses pictures and drills in teaching. (ID11) Should give more drills for students to understand well. (ID10) Should give more drills for students to learn easily. (ID12)
Connecting Prior Knowledge to New Knowledge	When lessons are clearly connected, it helps one understand better. (ID3) Connecting new lessons to previous lessons really helps. (ID5) Connecting the previous lesson with a new lesson. (ID2) Connecting is difficult when previous lessons are not well understood. (ID1) Difficult lessons should be emphasized and given connections. (ID7) Learning is meaningful when previous learning is connected to new lessons. (ID8)
Experiencing Authentic Application of Math Lessons	A lot of lessons are valuable to the daily grinds of life. (ID8) Things learned at home are clarified and strengthened in school. (ID2) Remembering parent's technique in computing boardfeet. (ID5) Very useful to my mother's debt management. (ID8) I was asked to buy it and explain the total expense I got. (ID12) Applied topics in measurements at home, like measuring lengths and diameters. (ID11) The topics of problem-solving and interest help me in selling. (ID7)
Using Conceptual Tools to Build Mental Models	It is better to use charts and diagrams at the start of new lessons. (ID8) Being guided by diagrams when doing one's assignment. (ID10) When the teacher gave a video clip, it gave us an advanced idea. (ID12) To give more factsheets to students. (ID6) The teacher uses pictures in teaching. (ID11) The teacher uses a picture to introduce the concept of a new lesson. (ID10) Giving fact sheets to students gives them time to study at home. (ID7) Using pens to underline, similar to highlighting, can help one not to forget. (ID1) Diagrams/charts are a big help for us in learning. (ID3) using concept maps and diagrams helps me not to forget. (ID4) Using diagrams helps one to easily learn and remember lessons. (ID5)

A. Facilitating Learning on Problem Solving

The findings reveal that students value solving mathematical problems, mainly when they arrive at correct answers. They emphasized the importance of step-by-step instruction provided by teachers to enhance comprehension and mastery. Students enjoyed solving difficult problems and highlighted the significance of self-discovery in learning solutions. Assignments and problem-solving tasks at home were also noted to improve critical thinking and ensure mastery. Students further stressed that discovering solutions independently helps them build confidence and prepares them for real-life applications. Problem-solving activities were identified as essential tools in developing analytical and critical thinking skills that extend beyond the classroom.

Facilitating problem-solving builds mathematical skills, critical thinking, and self-confidence. This aligns with constructivist learning theories, where learners actively face challenges to construct knowledge (Carvalho, 2023). Teachers play a pivotal role in guiding students through structured problem-solving processes that promote understanding and mastery (Papadopoulos & Rott, 2019). By fostering self-discovery and providing opportunities for independent practice, teachers empower students to become resilient learners (Firmansyah & Syarifah, 2023). Assigning complex, real-world problems can prepare students for future challenges while reinforcing their knowledge (Olivares *et al.*, 2020). This approach also helps students appreciate the practical value of mathematics in everyday life (Ormonoy, 2022).

B. Emphasizing Practical Applications of Mathematics

Students appreciated mathematics when its application to real-life situations was emphasized. They noted that lessons in algebra, statistics, and other topics became meaningful when connected to daily tasks, research, and academic work. They emphasized the importance of applying mathematical concepts in personal and practical scenarios, such as budgeting or solving everyday problems. Students found lessons more engaging when projects and activities involved real-world applications. The ability to connect mathematics to practical situations motivated them to learn and enhanced their understanding of its relevance.

Practical application bridges the gap between theoretical concepts and real-world utility, aligning with experiential learning theories. When students see the relevance of mathematics in their lives, their motivation and engagement increase significantly (Dorimana *et al.*, 2022; Rodley & Bailey, 2021). By integrating real-world tasks, such as creating budgets, analyzing data, or solving everyday problems, educators make learning more tangible and meaningful. This approach also fosters interdisciplinary learning by connecting mathematics to other subjects and contexts (Nugraheni, 2021). Ultimately, the focus on practical applications helps students recognize the value of mathematics in addressing real-life challenges.

C. Using Student-Centered Strategies

Students highlighted the effectiveness of student-centered activities, such as group work, differentiated instruction, and peer collaboration. They reported that activities tailored to their needs and interests increased engagement and enjoyment. Students also noted that positive teacher-student relationships and personalized attention motivated them to learn better. Collaborative activities allowed them to share ideas and learn from their peers, which enhanced their understanding of mathematical concepts. Additionally, differentiated instruction provided them with the opportunity to approach learning in ways that suited their individual strengths and preferences.

Student-centered strategies focus on actively engaging students in the learning process by tailoring activities to their individual needs and learning styles. This approach aligns with learner-centered education principles, which emphasize the importance of participation, collaboration, and personal relevance in learning. Teachers who build positive relationships with students foster an environment of trust and motivation, which is essential for effective learning (Firmansyah & Syarifah, 2023; McCarthy-Curvin *et al.*, 2021). Collaborative activities encourage peer learning and improve problem-solving skills. Differentiated instruction ensures inclusivity by addressing the diverse needs of students, allowing them to succeed at their own pace.

D. Connecting Lessons to Students' Personal Lives

Students found learning more meaningful when lessons were tied to their personal experiences. Activities that localized and contextualized mathematical concepts enhanced understanding and participation. They reported that lessons grounded in real-life situations encouraged deeper engagement and better retention. Students appreciated when teachers used examples and activities that reflected their daily lives, such as budgeting or managing personal expenses. They also noted that culturally relevant teaching made abstract concepts more relatable and understandable.

Connecting lessons to students' personal lives makes learning more relevant and engaging. This approach reflects culturally responsive teaching, which values the integration of students' experiences and cultural backgrounds into lessons. When mathematical concepts are tied to familiar contexts, students can better relate to and understand abstract ideas (Carvalho, 2023; Olivares *et al.*, 2020). This strategy also fosters intrinsic motivation as students see the relevance of mathematics in their daily lives. By contextualizing lessons, teachers can bridge the gap between theoretical knowledge and real-world applications, promoting meaningful and lasting learning.

E. Integrating Fun in Learning Task Design

Incorporating games and interactive activities into lessons increased students' enjoyment and motivation to learn. Gamified learning helped simplify abstract concepts and created a positive, engaging learning environment. Students noted that games reduced stress, fostered collaboration, and made lessons more interesting. They appreciated activities that combined fun with meaningful learning, such as problem-solving games aligned with real-life scenarios. Teachers who used interactive and enjoyable activities were reported to increase students' willingness to engage with challenging topics.

Gamification in education transforms learning into an enjoyable experience, boosting student engagement and reducing anxiety. Interactive activities and games make learning fun and foster critical thinking, problem-solving, and teamwork. By aligning games with lesson objectives and real-world scenarios, teachers can enhance the relevance of mathematical concepts (Piriyasurawong & Ruangvanich, 2019; Suryani *et al.*, 2020). This approach helps students overcome negative attitudes toward mathematics, building a more positive and open mindset.

F. Enabling Student Self-Paced Learning

Students valued opportunities to discover solutions independently and practice at their own pace. They highlighted the importance of reviewing lessons at home and engaging in self-directed activities to reinforce learning. Students noted that independent problem-solving allowed them to develop mastery over time. They appreciated when teachers encouraged exploration and provided activities that fostered autonomy. Self-paced learning also gave students the confidence to tackle challenges on their own, enhancing their ability to apply knowledge effectively.

Self-paced learning fosters autonomy, responsibility, and self-regulation among students. It aligns with self-regulated learning theories, which emphasize the importance of practice, reflection, and independent problem-solving. By allowing students to learn at their own pace, teachers enable them to build confidence and develop a deeper understanding of concepts (Dewi *et al.*, 2021; Nisa *et al.*, 2023). Encouraging self-paced learning also prepares students for lifelong learning as they learn to take initiative and manage their progress.

Using a Communicative Instructional Approach. Students appreciated when teachers used local dialects to explain complex mathematical concepts. Translating lessons into a familiar language made them easier to understand and more relatable. Clear and repeated explanations were highlighted as critical to comprehension and mastery. Students noted that their understanding improved significantly when teachers broke down complex topics into smaller, digestible parts. Additionally, repetition and consistent review helped reinforce learning and clarified misconceptions.

The communicative instructional approach promotes inclusivity by addressing language barriers that may hinder understanding. Translating lessons into students' native languages ensures equitable access to education and fosters deeper comprehension. Clear and repeated explanations align with scaffolding practices, enabling students to gradually grasp challenging concepts (Moreira-Párraga & Alcívar-Castro, 2022; Zhang *et al.*, 2021).

G. Ensuring Organized Implementation of Lessons

Students stressed the importance of well-organized lessons, starting with simpler topics before progressing to more complex ones. Structured activities that built upon each other helped them understand and retain information better. Teachers who planned lessons systematically and connected them to students' experiences were seen as more effective. Students also appreciated when lessons followed a logical flow, ensuring they were prepared for advanced topics. Organized teaching allowed them to build confidence and avoid confusion.

Structured lesson planning is vital for scaffolding learning and ensuring a logical progression of topics. This approach aligns with instructional design principles, which emphasize clarity, coherence, and sequencing. Teachers who organize lessons systematically help students build a solid foundation of knowledge before introducing more advanced concepts. By connecting lessons to students' experiences, educators make learning relevant and engaging (Nugraheni, 2021; Siswono *et al.*, 2018).

H. Building Up Mastery of Mathematical Knowledge

Students emphasized the importance of drills, reviews, and repeated instructions in mastering mathematical concepts. Visual aids, such as pictures and diagrams, were also noted to support their understanding. They appreciated teachers who provided frequent reviews before introducing new topics, as this reinforced their prior knowledge. Students highlighted that repeated practice allowed them to grasp challenging concepts more effectively. They also found that visual representations simplified abstract ideas and made lessons more engaging.

Repetition and practice are fundamental to mastering skills, particularly in mathematics. This approach aligns with behaviorist learning theories, which emphasize reinforcement and repetition in skill acquisition. Teachers who use drills, reviews, and visual aids provide multiple opportunities for students to internalize concepts. Visual representations, such as diagrams and charts, enhance cognitive processing by breaking down complex information into manageable parts (Kusumah *et al.*, 2020; Rodley & Bailey, 2021). By focusing on mastery, educators ensure that students build a strong foundation of knowledge and confidence in their abilities.

I. Connecting Prior Knowledge to New Knowledge

Students emphasized the importance of linking new lessons to previous ones. They reported that understanding new topics was challenging when prior knowledge was insufficient. Lessons that built upon previous learning were noted to enhance comprehension and retention. Students appreciated teachers who made explicit connections between topics, helping them see the continuity in mathematical concepts. They also highlighted that bridging prior and new knowledge encouraged a deeper understanding of the subject.

Connecting prior knowledge to new concepts is essential for meaningful learning, as it builds on students' existing cognitive frameworks. This approach aligns with constructivist theories, which emphasize the integration of prior experiences into new learning. Teachers who make explicit connections help students develop a cohesive understanding of mathematical concepts, reducing confusion and enhancing retention (Carvalho, 2023; Olivares *et al.*, 2020).

J. Experiencing Authentic Application of Math Lessons

Students valued opportunities to apply mathematical concepts in authentic settings, such as managing finances or solving real-world problems. They noted that practical applications made learning more meaningful and reinforced their understanding. Students appreciated activities connecting lessons to real-life scenarios, such as measurements, budgeting, or data analysis. They reported that such experiences not only improved their mathematical skills but also showed the relevance of the subject in everyday life.

Authentic learning experiences bridge the gap between theoretical knowledge and real-world applications. This approach aligns with situated learning theories, emphasizing learning in contexts that reflect actual practice. By integrating real-life scenarios into lessons, teachers make mathematics more tangible and relevant to students (Dorimana *et al.*, 2022; Asfar *et al.*, 2019). Authentic applications also foster critical thinking and problem-solving skills as students learn to navigate challenges in meaningful ways.

K. Using Conceptual Tools to Build Mental Models

Students highlighted the usefulness of diagrams, charts, and fact sheets in understanding and retaining lessons. Visual tools helped them organize information, simplify abstract concepts, and create mental models. They appreciated teachers who used visual aids to introduce new topics, providing a clear learning framework. Students also noted that concept maps and diagrams allowed them to better understand relationships between ideas. Additionally, fact sheets were seen as valuable resources for reviewing and reinforcing knowledge at home.

Conceptual tools like diagrams and charts enhance learning by organizing information into clear and meaningful structures. This aligns with cognitive theories, which emphasize the role of visual representation in simplifying complex ideas. By using these tools, teachers provide students with a framework for understanding abstract concepts and connecting related ideas (Dewi *et al.*, 2021; Rodley & Bailey, 2021). Visual aids also support retention and recall, making them an effective resource for both instruction and independent study. Encouraging students to use conceptual tools fosters deeper comprehension and equips them with strategies for organizing and applying knowledge.

3.2 Item Pool and Expert Opinion

The determination of the factors of meaningful learning started with the formulation of the item statements through the readings of the review of related studies and in-depth interviews with the research participants. The dissertation adviser and ten experts analyzed the Item Pool of Statements (IPS) content. The ten experts who rated the items have finished their doctoral degrees. These experts were chosen for their wide range of experience in test development, teaching mathematics, textual analysis and psychology, and counseling.

The experts were asked to rate the items using Lawshe's (1975) criteria (essential, useful but not essential, not necessary). From the expertise of the content validators, the achievement of the content validity of the items depends on the agreement of the validators. As required by Lawshe, the ten panel of experts should agree on the validity of an item at least 0.80. Those items that did not pass the minimum validity will be subjected to revision or elimination.

There are 55 items retained, none deleted, with all the items with a coefficient above 0.80. Specifically, the table presents indicators related to various aspects of teaching and learning, each measured by a specific number of items. *Interest and Engagement in Learning* is measured through 6 items (1, 2, 3, 4, 5, and 6), focusing on how much students are interested and actively engaged in their learning process. *Teaching Methods and Understanding* is assessed using eight items (7, 8, 9, 10, 11, 12, 13, and 14), which capture the effectiveness and clarity of teaching methods as perceived by students. *Real-life application of Math* is evaluated through 8 items (15, 16, 17, 18, 19, 20, 21, and 22), highlighting the connection of mathematical concepts to real-life situations.

Learning Through Activities and Games is represented by seven items (23, 24, 25, 26, 27, 28, and 29), emphasizing the role of interactive and engaging activities in learning. *Relating Lessons to Student Experiences* includes six items (30, 31, 32, 33, 34, and 35), assessing lessons' relevance to students' personal experiences. *Practice and Mastery* are measured with six items (36, 37, 38, 39, 40, and 41), focusing on the importance of practice and achieving mastery. *Language and Clarity in Teaching* is captured by five items (42, 43, 44, 45, and 46), which evaluate the clarity and comprehensibility of the language used in teaching. *Lesson Organization and Structure* is assessed through 5 items (47, 48, 49, 50, and 51), focusing on the logical sequencing and organization of lessons. Finally, *Self-Efficacy and Motivation* are measured using four items (52, 53, 54, and 55), examining students' belief in their ability to succeed and their intrinsic motivation to learn. Each indicator is thoughtfully structured to represent key dimensions of the educational process.

Table 2 shows the number of items in the subscale of Meaningful Mathematical Learning in the three-phase item development. In phase 1, items were generated from the literature reviews and in-depth interviews with the research participants. With the help of the item writer, who is an expert in measurement and evaluation, 55 item statements were formulated. This phase ensures the coherence, validity, and accuracy of each factor of meaningful learning in Mathematics. In phase two, the items were checked by the research adviser to ensure the content validity and objectivity of the items. None of the items were deleted. The last phase is the experts' validation.

Table 2: Tentative Number of Items of the Subscale of Meaningful Mathematical Learning in the Three-Phase Item Development

Sub-scale	Number of Items		
	Phase 1 (Literature Analysis and In-depth Interview)	**Phase 2 (Adviser's Revisions)**	**Phase 3 (Experts Validation)**
1. Interest and Engagement in Learning	6	6	6
2. Teaching Methods and Understanding	8	8	8
3. Real-Life Application of Math	8	8	8
4. Learning Through Activities and Games	7	7	7
5. Relating Lessons to Students to Student Experiences	6	6	6
6. Practice and Mastery	6	6	6
7. Language and Clarity in Teaching	5	5	5
8. Lessons Organization and Structure	5	5	5
9. Self-Efficacy and Motivation	4	4	4

3.3 Construct Validity

3.3.1 Sampling Adequacy and Suitability Test Results

Table 3 presents the results of the exploratory factor analysis of active, meaningful learning. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO=0.908) was used to measure the adequacy and suitability of the exploratory factor analysis involving 300 respondents. The findings show that the data is suitable for exploratory factor analysis since it surpassed the minimum requirement of 0.5. The finding also tells us that the data is enough to have a distinct factor (Kaiser, 1974).

Bartlett's Test of Sphericity shows that the R-matrix is not an identity matrix. It also shows that we have patterned relationships amongst the variables ($p<0.001$).

Table 3: Sampling Adequacy and Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.908
Bartlett's Test of Sphericity	**Approx. Chi-Square**	5546.288
	df	1035
	Sig.	0.00

Table 4 shows the latent roots criterion of the extracted factors, depicting the percentage of variance. The factor analysis results show that Factor 1 is the most significant, with an eigenvalue of 12.783, accounting for 27.79% of the total variance. This means it represents the strongest underlying theme or construct in the data. Factor 2 follows, contributing 5.234% of the variance with an eigenvalue of 2.408, which is still meaningful but far less influential than Factor 1. Factor 3 explains 4.279% of the variance with an eigenvalue of 1.968, indicating a moderate but important contribution. Factors 4 and 5 explain 3.632% and 3.468% of the variance, with eigenvalues of 1.671 and 1.595, respectively, showing smaller but still notable influences. Factor 6 adds another 3.308% of the variance with an eigenvalue of 1.522, while Factor 7 accounts for 2.965% with an eigenvalue of 1.364. Factors 8 and 9 explain 2.857% and 2.537% of the variance, with eigenvalues of 1.314 and 1.167, respectively. Similarly, Factors 10, 11, and 12 each contribute between 2.248% and 2.495% of the variance, with eigenvalues just over 1.

Table 4: Latent Roots Criterion of the Extracted Factors Depicting the Percentage of Variance

Factor	Eigenvalue	% of Variance	Cumulative %
1	12.783	27.79	27.79
2	2.408	5.234	33.024
3	1.968	4.279	37.303
4	1.671	3.632	40.935
5	1.595	3.468	44.403
6	1.522	3.308	47.711
7	1.364	2.965	50.676
8	1.314	2.857	53.533
9	1.167	2.537	56.07
10	1.148	2.495	58.565
11	1.077	2.342	60.907
12	1.034	2.248	63.154

Figure 3 depicts the scree plot derived from the secondary Exploratory Factor Analysis (EFA) undertaken within this investigation. As delineated by Cattell (1966), the scree plot employs eigenvalues extracted from either the input or condensed correlation matrix. The plot manifests as a visual representation where eigenvalues are charted on the vertical axis while factors are delineated along the horizontal axis. Through visual examination of the plot, analysts can identify the juncture at which there is a notable decline in eigenvalue magnitude, often termed the "elbow" of the plot. The scree plot is valuable for discerning the number of significant factors derived from the data and the variance explicated by each factor. Specifically, analysts seek the point on the plot where the trajectory of the line connecting the plotted eigenvalues changes abruptly, indicating a marked reduction in eigenvalue magnitude.

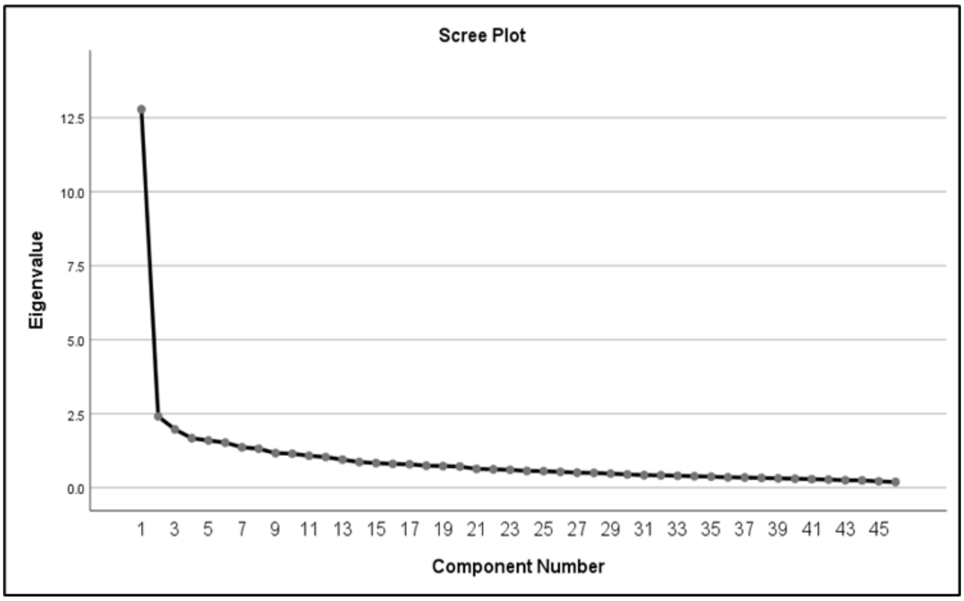

Figure 3: Scree Plot of Meaningful Learning in Mathematics

This juncture indicates the number of factors deemed meaningful for further analysis. In the context of the presented scree plot, it is evident that the instrument under scrutiny exhibits a multidimensional framework—the conspicuous decline in the plotted line after the third factor substantiates this observation. Gorsuch (1997) emphasized that the screen test's efficacy depends on specific conditions, particularly a sizable sample size and well-defined underlying factors within the data.

In Table 5, the researchers present the factor loading and thematic analysis findings concerning meaningful learning in Mathematics. Following the exploratory factor analysis, the researchers identified a set of 47 items, which were then grouped into twelve distinct factors or dimensions reflecting the different dimensions of learning Mathematics. To ensure the reliability of our analysis, we systematically removed any items with factor loadings below 0.4, consistent with the rigorous criteria established by previous studies (Costello & Osborne, 2005; Fuentes & Gono, 2023; Gono, 2024; Gono & Abalos, n.d.; Gono & Pacoy, 2021; Gono & Sales, 2024; Romero & Gono, 2021).

Additionally, the researchers eliminated any factors with fewer than three-item statements (MacCallum *et al.*, 1999; Raubenheimer, 2004). As a result, the researchers identified seven distinct factors with 38 items that characterize the strategies utilized in learning mathematics.

Table 5: Factor Loading of Meaningful Learning in Mathematics

Item Number	Factor Loading											
	1	2	3	4	5	6	7	8	9	10	11	12
I8	0.715											
I7	0.708											
I15	0.579											
I4	0.573											
I6	0.494											
I14	0.493											
I5	0.462											
I9	0.447											
I10	0.425											
I29		0.652										
I30		0.633										
I32		0.631										
I27		0.616										
I28		0.587										
I26		0.527										
I23		0.519										
I24		0.425										
I21			0.729									
I20			0.601									
I22			0.529									
I13			0.511									
I11			0.497									
I19				0.706								
I17				0.558								
I18				0.555								
I12												
I1					0.689							
I2					0.607							
I3					0.455							
I36						0.808						
I37						0.771						
I34							0.593					
I33							0.53					
I25							0.496					
I31							0.409					
I39								0.834				
I40								0.765				
I38								0.55				
I16									0.715			
I35									0.438			
I46										0.816		
I45										0.814		
I42											0.73	
I41											0.608	
I43												0.758
I44												0.717

Table 6 in the research findings presents a comprehensive thematic analysis of the item statements of meaningful learning in Mathematics derived from the exploratory factor analysis. Before the thematic analysis, the researcher deleted item statements that were not part of the factors. For Factor 1, the researcher deleted item number 15; for Factor 2, the researcher deleted item numbers 30 and 32; for Factor 3, the researcher deleted item numbers 11 and 13; and for Factor 6, the researcher deleted item number 25. The first factor, identified as "Teaching Methods and Understanding," encompasses a total of 8 item statements (4, 5, 6, 7, 8, 9, 10, and 14).

Table 6. Factor 1- Teaching Methods and Understanding

Item Number	Item Statements	Factor Loading
I8	Teachers should explain math concepts using practical examples	0.715
I7	The teacher should teach us step-by-step to help us understand math concepts better	0.708
I4	Solving math challenges makes me more interested in the subject.	0.573
I6	Math challenges encourage me to engage more with the subject	0.494
I14	Teachers should give problems to solve at home for mastery	0.493
I5	I feel a sense of accomplishment when I understand complex math topics.	0.462
I9	The teacher should provide more examples when explaining difficult math concepts.	0.447
I10	I understand math better when the teacher breaks down complex ideas into smaller steps.	0.425

The selected items reflect the factor *of Teaching Methods and Understanding*, as they highlight how teaching strategies impact students' ability to grasp and engage with mathematical concepts. For instance, statements like "Teachers should explain math concepts using practical examples" and "The teacher should teach us step-by-step to help us understand math concepts better" emphasize the importance of using clear and relatable approaches that make complex ideas easier to understand. Similarly, items such as "Solving math challenges makes me more interested in the subject" and "Math challenges encourage me to engage more with the subject" point to the role of interactive and problem-solving activities in sparking interest and promoting deeper involvement in learning.

The item "Teachers should give problems to solve at home for mastery" highlights how reinforcement through practice outside the classroom helps solidify what students learn. Additionally, "I feel a sense of accomplishment when I understand complex math topics" reflects how effective teaching can lead to confidence and satisfaction when students overcome difficult challenges. Items such as "The teacher should provide more examples when explaining difficult math concepts" and "I understand math better when the teacher breaks down complex ideas into smaller steps" underline the value of clear explanations, the use of examples, and breaking down information to ensure comprehension.

Table 7: Factor 2- Learning Through Activities and Games

Item Number	Item Statements	Factor Loading
I29	I enjoy math activities where I can work with classmates to solve problems.	0.652
I30	relating math lessons to real-life experiences helps me learn better.	0.633
I32	I understand math better when the lessons are connected to things I experience daily.	0.631
I27	Teachers should incorporate math games that help reinforce the lessons.	0.616
I28	I feel that I learn better when teachers use interactive activities during math lessons.	0.587
I26	Math games make learning fun and engaging.	0.527
I23	Differentiated activities increase my interest in math.	0.519
I24	Group activities help me understand math concepts better.	0.425

For Factor 2, these items represent the factor *of Learning Through Activities and Games* because they highlight how interactive and collaborative approaches make learning math more effective and enjoyable. For example, the statement "I enjoy math activities where I can work with classmates to solve problems" points to the value of teamwork, where students can learn from one another while tackling problems together. Similarly, "Relating math lessons to real-life experiences helps me learn better" and "I understand math better when the lessons are connected to things I experience daily" emphasize the importance of connecting math concepts to everyday situations, making them more relatable and easier to grasp.

The items "Teachers should incorporate math games that help reinforce the lessons" and "Math games make learning fun and engaging" reflect how games can make learning feel less like a chore and more like an enjoyable challenge. When teachers use interactive games, students are often more motivated to participate and absorb the material. Additionally, "I feel that I learn better when teachers use interactive activities during math lessons" and "Differentiated activities increase my interest in math" highlight the importance of using a variety of engaging methods that cater to different learning preferences, keeping students interested and involved in the lessons. Lastly, "Group activities help me understand math concepts better" emphasizes how working with peers can deepen understanding through the exchange of ideas and shared problem-solving experiences.

Factors 3 and 4 are the *Real-Life Application of Math*, which focuses on how connecting mathematical concepts to practical, real-world scenarios enhances students' understanding and interest. For instance, when teachers explain how math is used in different careers, it helps students see its relevance to their future and understand its practical value beyond the classroom. Similarly, relating math to other subjects, like science or economics, demonstrates how it plays a crucial role across disciplines, making it more engaging and meaningful. Students often find math more interesting when they can apply it to real-life situations, as it allows them to see its usefulness in solving everyday problems or achieving personal goals. These items highlight the importance of showing how math connects to the real world, making the subject more relatable and inspiring greater enthusiasm for learning.

Table 8: Factor 3 and 4- Real-Life Application of Math

Item Number	Item Statements	Factor Loading
Factor 3- Real-Life Application of Math		
I21	Teachers should explain how math concepts can be used in different careers.	0.729
I20	I find math more useful when I can apply it to other subjects like science or economics.	0.601
I22	I am more interested in math when I can apply it to real-life situations.	0.529
Factor 4- Real-Life Application of Math		
I19	Math lessons that relate to personal finances or budgeting make me more interested in learning.	0.706
I17	I understand math better when the teacher relates it to real-world problems.	0.558
I18	Applying math to practical scenarios helps me remember the concepts better.	0.555

Factor 5 reflects the factor *of Interest and Engagement in Learning Math* by emphasizing how positive experiences with math can inspire motivation and confidence. For instance, the enjoyment of learning math, especially when arriving at the correct answer, highlights the satisfaction and excitement that come from success in problem-solving. Similarly, solving math problems is linked to a boost in confidence, as each correct solution reinforces a student's belief in their abilities. Feeling motivated when solving a challenging problem independently underscores the sense of accomplishment and pride that comes from overcoming difficulties, which fosters a deeper connection to the subjects.

Table 9: Factor 5- Interest and Engagement in Learning Math

Item Number	Item Statements	Factor Loading
I1	I enjoy learning math, especially when I get the correct answer.	0.689
I2	Solving math problems boosts my confidence in learning.	0.607
I3	I feel motivated when I can solve a difficult math problem by myself.	0.455

Factor 6 reflects the *Relating Lessons to Student Experiences* by emphasizing how connecting math concepts to students' real-world contexts enhances learning. When lessons are tied to students' personal experiences, they become more relatable and meaningful, helping learners see the practical relevance of what they are studying. Similarly, when teachers incorporate real-world scenarios into math lessons, students tend to understand and process information more quickly, as these scenarios provide familiar and concrete examples. Using everyday life as a basis for explaining math concepts helps bridge the gap between abstract ideas and practical application, making learning more engaging and easier to grasp. By aligning math lessons with students' lived experiences, these items highlight the importance of making education both relevant and impactful.

Table 10: Factor 6- Relating Lessons to Student Experiences

Item Number	Item Statements	Factor Loading
I34	Lessons connected to student experiences make learning math more meaningful.	0.593
I33	When the teachers relate math lessons to real-world scenarios, I learn faster.	0.53
I31	Teachers should use examples from everyday life to explain math concepts.	0.409

Factor 7 is *Practice and Mastery*, which highlights the importance of individual practice and reinforcement in mathematics. The statement *"I prefer practicing math problems on my own after the teacher demonstrates them"* emphasizes the value of applying learned concepts independently, which strengthens understanding and builds confidence. Similarly, *"I enjoy discovering solutions on my own after the teacher explains the basics"* reflects the importance of exploration and self-guided problem-solving in achieving a deeper grasp of mathematical ideas. Lastly, *"Practice drills help me retain math concepts better"* underscores the role of repetition in reinforcing and retaining knowledge. Together, these items capture how practicing independently, solving problems through exploration, and engaging in drills contribute to mastering math skills and concepts effectively.

Table 11: Factor 7- Practice and Mastery

Item Number	Item Statements	Factor Loading
I39	I prefer practicing math problems on my own after the teacher demonstrates them.	0.834
I40	I enjoy discovering solutions on my own after the teacher explains the basics.	0.765
I38	Practice drills help me retain math concepts better.	0.550

3.3.2 Measurement Model of Meaningful Learning in Mathematics

Confirmatory Factor Analysis (CFA) is to test whether the measurement model is consistent with the Exploratory Factor Analysis that was run in the previous section. Typically, CFA is used in a deductive mode to test a hypothesis regarding unmeasured sources of variability responsible for the commonality among test scores in terms of relationships of the constructs. The number of factors and pattern of loading were hypothesized before the analysis, and there were numerous restrictions on the solution (Hoyle, 2000). If constraints imposed on the model are inconsistent with the sample date, the results of the statistical model fit will indicate a poor fit, and the model will be rejected.

Table 12: Model Fit Indices

	X^2	X^2/df	GFI	CFI	TLI	RMSEA	PCLOSE
Initial Results	740	1.373	0.883	0.846	0.82	0.035	1.00
1. Modification 1 Deleted Factor 3	382.692	1.549	0.910	0.850	0.85	0.043	0.922
2. Modification 2 Deleted Factor 5	316.3	1.412	0.92	0.87	0.86	0.037	0.991
3. Modification 3 e10-e17; e10-e11; e11-e16; e1-e4; e1-e9, e2-e50	282.31	1.289	0.929	0.912	0.90	0.031	1.00
Acceptable Values	<3.00		0.90	0.90	0.90	<0.08	>0.05
Good Fit Values	p<0.05		0.95	0.95	0.95	<0.08	>0.05

Before conducting a Confirmatory Factor Analysis (CFA), researchers consider several critical assumptions. First, regarding sample size, a minimum N of 400 is often preferred as larger sample sizes help achieve accurate parameter estimates and enhance model stability (Goretzko *et al.*, 2023). Second, for distribution properties, CFA assumes multivariate normality; however, robust methods like diagonally weighted least squares (DWLS) can handle ordinal data and modest violations of normality effectively (Cheng-Hsien Li, 2016). Third, on measurement scales, commonly used maximum likelihood estimators require data measured on a continuous scale, while DWLS is suitable for ordinal or Likert-scale data (Goretzko *et al.*, 2023). Lastly, in terms of the type of indicator, CFA assumes that indicators reflect latent factors, with their relationships determined by covariation patterns. Modern practices recommend careful assessment of model fit using indices like RMSEA, CFI, and TLI to validate these assumptions (Pristianti, 2022).

Figure 4 shows the Model Fit Indices of Meaningful Mathematical Learning (Seven Factor Rotation). Using AMOS 20 software, the obtained values were $\chi 2/pdf = 1.373$, GFI = 0.883, CFI=0.846, TLI = 0.82, and RMSEA= 0.035. Since some of the measures of good fit do not satisfy the requirement, the researcher checks different requirements for the measurement model.

The researcher comes up with different trials to come up with the best-fit model of meaningful learning. The relevance of determining the best-fit model in terms of fitting the observed data collected ensures that the model is an exact reflection of meaningful learning among indigenous peoples'students. The researcher is guided by the different model fit indices, such as the goodness of fit index (GFI) and the Root Mean Square Error of Approximation (RMSEA). GFI ranges from 0 to 1.0 and indexes the relative amount of the observed variance and covariance accounted for by the model; values greater than 0.9 are viewed as indicative of a good fit (Tanaka, 1993). RMSEA indexes the degree of discrepancy between the observed and implied covariance matrices per degree of freedom. The minimum value of RMSEA is zero; Browne and Cudeck (1983) propose 0.05 as a value indicative of close fit, 0.08 as indicative of marginal fit, and 0.10 as indicative of poor fit of a model, taking into account the degrees of freedom of the model.

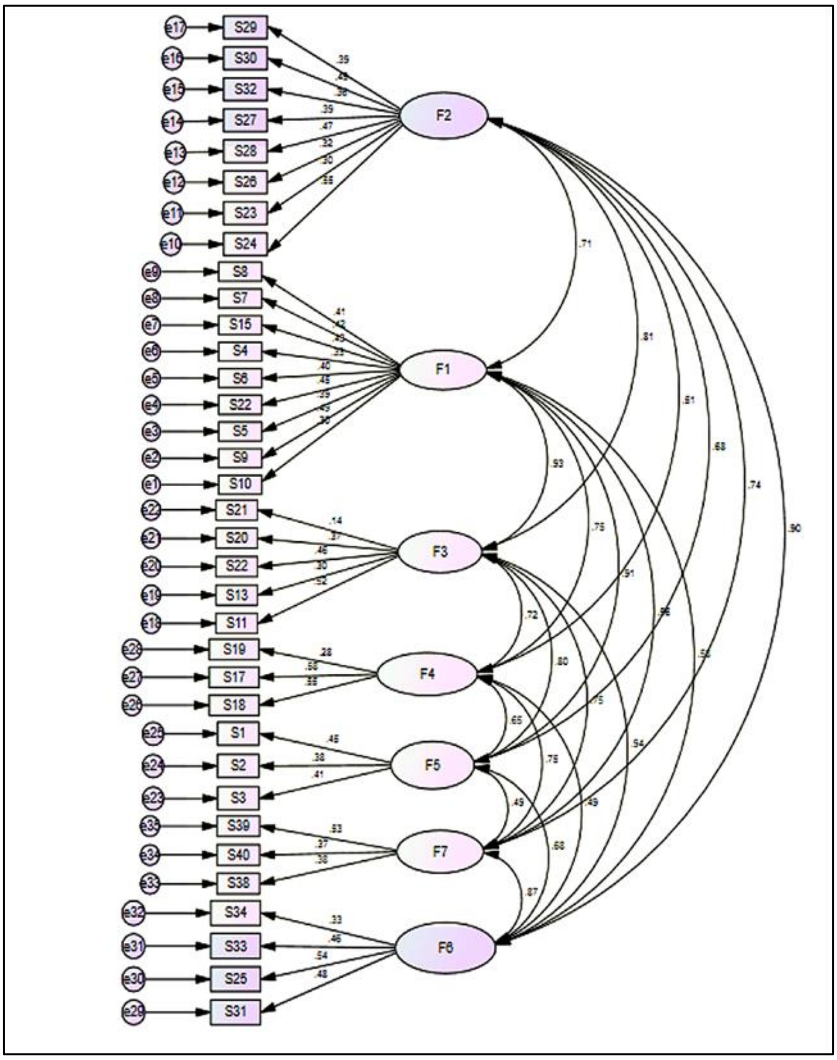

Figure 4: Model fit indices of meaningful mathematical learning (7 factors first-order)

The first attempt of the researcher is to delete factors with interrelationship of more than 0.85. A value of more than 0.85 means the factor has an issue of multicollinearity (Hoyle, 2000). Thus, the research, one by one, deleted those latent factors more than 0.85. The first modification was the deletion of factor 3. The obtained values were $\chi 2/df = 1.549$, GFI = 0.910, CFI=0.85, TLI = 0.85 and RMSEA= 0.043. Still, there are some parameters that do not reach the threshold. In modification 2, the researcher deleted factor 5 with an interrelationship coefficient of more than 0.85. This resulted to the following values $\chi 2/df = 1.412$, GFI = 0.920, CFI=0.87, TLI = 0.89 and RMSEA= 0.031.

It can be observed in the final model that the interrelationships between latent factors passed the threshold of 0.5 - 0.85. This implies that the factors in terms of discriminant validity measure the same direction as the other latent variables. Further, it shows the extent to which factors of meaningful learning are distinct and uncorrelated. The rule is that variables should relate more strongly to their own factor than to another factor (Hoyle, 2000).

The researcher correlated the error terms of the same dimension as provided by the modifications index. Confirmatory Factor Analysis involves some manner of respecification, which, in the typical instance, involves either freeing fixed parameters or, less commonly, fixing free parameters in the initially specified model (Bollen & Long, 1993). Further, the researcher deleted item number 28, which the researcher believes does not measure that factor and increases its validity.

Figure 4 shows the model fit indices of meaningful mathematical learning (4 factors third-order). The obtained values were $\chi 2/df = 1.289$, GFI = 0.929, CFI=0.912, TLI = 0.90 and RMSEA= 0.031. All of the coefficients are fitted to the level of acceptance. Thus, the model is fit.

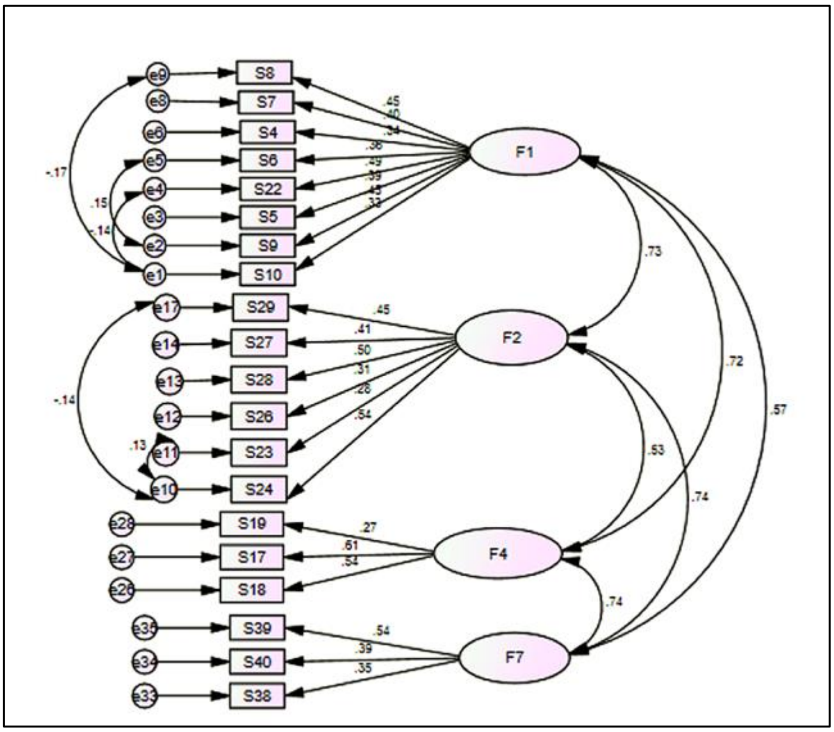

Figure 5: Model fit indices of meaningful mathematical learning (4 factors 3rd-order)

In the four factors third-order model, factor 1- Teaching Methods and Understanding had eight-item statements (8, 7, 4, 6, 22, 5, 9, and 10); learning through activities and games had six-item statements (29, 27, 28, 26, 23, 24); Real Life Application of Math obtained three-item statements (19, 17, and 18); and Practice and Mastery had three-item statements (139, 38, 40).

It can be observed in the final model that the interrelationships between latent factors passed the threshold of 0.5 - 0.85. This implies that the factors in terms of discriminant validity measure the same direction as the other latent variables. Further, it shows the extent to which factors of meaningful learning are distinct and uncorrelated. The rule is that variables should relate more strongly to their own factor than to another factor (Hoyle, 2000).

The Confirmatory Factor Analysis helps us analyze the convergent validity of each construct. The results, outlined in Table 13, revealed that all item statements significantly contribute to different factors, as indicated by a p-value < 0.05. This implies that each item serves as an excellent measure of its corresponding indicator of meaningful learning in Mathematics.

Table 13: Results of convergent validity testing

			Estimate	S.E.	C.R.	P
S9	<---	F1	1.326	.315	4.213	***
S5	<---	F1	1.097	.281	3.897	***
S14	<---	F1	1.396	.337	4.148	***
S6	<---	F1	1.095	.283	3.864	***
S4	<---	F1	1.027	.275	3.730	***
S7	<---	F1	1.463	.360	4.065	***
S8	<---	F1	1.408	.360	3.915	***
S10	<---	F1	1.000			
S24	<---	F2	1.000			
S29	<---	F2	.726	.143	5.081	***
S23	<---	F2	.569	.144	3.958	***
S26	<---	F2	.578	.136	4.255	***
S28	<---	F2	.934	.158	5.914	***
S27	<---	F2	.796	.152	5.235	***
S18	<---	F4	1.000			
S17	<---	F4	1.123	.191	5.884	***
S19	<---	F4	.469	.139	3.372	***
S38	<---	F7	1.000			
S40	<---	F7	1.349	.365	3.693	***
S39	<---	F7	1.647	.391	4.217	***

To ascertain convergent validity, the researcher meticulously examined all factors involved in the study. As depicted in Table 14, each latent construct, including Teaching Methods and Understanding, Learning through Activities and Games, Real Life Application of Math, and Practice and Mastery, demonstrated statistical significance. This implies that the measures selected by the researcher effectively converge upon the intended aspects of Meaningful Learning in Mathematics. Convergent validity, in this context, refers to the degree to which different measures theoretically expected to be related indeed exhibit significant associations. The researcher's meticulous examination confirms that multiple indicators within each construct align and converge on common ground, substantiating the validity of the measurement model. Further, this compelling outcome indicates that our study has a robust and satisfactory level of convergent validity (Gerbing & Anderson, 1988). The significance of these latent constructs affirms that our chosen measures effectively converge upon the intended aspects of meaningful learning in Mathematics. This alignment is crucial as it demonstrates that multiple indicators within each construct are converging on a common conceptual space, supporting the overall validity of our measurement model.

Table 14: Convergent and Discriminant Validity

			Estimate	S.E.	C.R.	P
F1	<-->	F2	0.73	.009	4.025	***
F1	<-->	F4	0.72	.010	3.906	***
F1	<-->	F7	0.57	.006	3.029	.002
F2	<-->	F4	0.53	.011	3.994	***
F2	<-->	F7	0.74	.010	3.854	***
F4	<-->	F7	0.74	.012	3.711	***

3.3.3 Reliability Tests for Derived Dimensions

Thompson and Levitov in Matlock-Hetzel (2010) proposed that the quality of a test can be evaluated by computing its reliability, which refers to the consistency of results when administered to the same groups under the same conditions. Reliability is defined as the degree to which an assessment consistently measures what it is intended to measure (Airasian & Russell, 2001). Table 15 highlights the level of reliability of meaningful learning and its dimensions, with coefficients ranging from 0.639 to 0.855 and an overall reliability of 0.88. According to standards in educational assessments, a reliability value above 0.70 is indicative of a very good test (Annavajjhala, Dargel, Kuwahara, & Raza, 2010).

Table 15: Reliability Coefficients of Meaningful Learning and its Dimensions

Sub-scale	Number of Items	Cronbach's Alpha
1. Teaching Methods and Understanding	8	0.855
2. Learning Through Activities and Games	6	0.822
3. Real-Life Application of Math	3	0.728
4. Practice and Mastery	3	0.639
Total Scale	**20**	**0.888**

Reliability is a cornerstone of psychometric evaluation, ensuring that test scores remain consistent across replications. Gitomer *et al.*, (2021) emphasized that reliability serves as a foundation for validity and is critical when assessments are used to make high-stakes decisions. Reliability can be influenced by various factors, such as the test format, the homogeneity of the group, and the clarity of items. Similarly, Frisbie (1988) noted that teacher-made tests typically have lower reliability (around 0.50) compared to standardized tests (around 0.90), underscoring the importance of robust test design.

Internal consistency measures, such as Cronbach's alpha, are widely used to evaluate reliability. Ferketich (1990) highlighted that high internal consistency indicates that test items measure a cohesive construct, enhancing the utility of the test. Furthermore, Garg and Lee (2015) demonstrated that mixed-format assessments in higher education often achieve reliability levels comparable to standardized tests, reinforcing the notion that a well-structured test can maintain reliability across diverse formats.

Practical strategies to enhance reliability include increasing test length, refining item clarity, and using consistent scoring methods. Pipia (2014) stressed the importance of reducing measurement errors to ensure reliability and validity. These principles are evident in Table 9, where reliability scores demonstrate that the dimensions of meaningful learning assessments are robust and capable of providing accurate and consistent measures for educational evaluation. This integration underscores that reliability is not merely a technical concept but a critical component of effective educational assessments, ensuring fairness and accuracy in measurement.

3.3.3 Meaningful Learning in Mathematics among Indigenous Students

A. Teaching Methods and Understanding

Effective teaching methods tailored to Indigenous cultures create an inclusive learning environment by integrating cultural knowledge into pedagogy. Storytelling and traditional practices are particularly effective in connecting abstract mathematical ideas to students' cultural backgrounds. For example, integrating Indigenous legends into mathematics lessons contextualizes learning in ways that resonate with students, making complex concepts more relatable (Golafshani, 2022; Naidoo, 2021). These methods enhance understanding and retention by bridging the gap between abstract theories and lived experiences.

Explicit instruction, when paired with diagnostic feedback, is another critical method. Research shows that providing clear, step-by-step guidance alongside targeted feedback addresses the specific educational needs of Indigenous students, leading to better learning outcomes (O'Connor & Bronwyn, 2020). By focusing on areas where students struggle, teachers can ensure a more comprehensive understanding of mathematical concepts (Rosinansis *et al.*, 2022).

Cultural practices such as traditional measurement systems and spatial reasoning can also be incorporated into lessons. For example, Indigenous methods of navigation and pattern recognition provide authentic contexts for teaching geometry and algebra, fostering meaningful connections between curriculum content and cultural practices (Tangkur *et al.*, 2022; Borden, 2018).

Professional development for teachers is essential to implement these strategies effectively. Studies highlight the need for training that equips educators with knowledge of Indigenous traditions and their application in mathematics teaching (Kadonsi *et al.*, 2023; Moloi, 2022). This ensures that educators can create lesson plans that validate and incorporate students' cultural identities into the classroom.

B. Learning Through Activities and Games

Learning through culturally relevant activities and games makes mathematics engaging and accessible for Indigenous students. Games like "morabaraba" and other traditional activities incorporate mathematical reasoning into familiar contexts, promoting problem-solving skills and logical thinking (Moloi, 2022; Tangkur *et al.*, 2022). These activities transform abstract ideas into concrete experiences, which are more easily understood and retained.

Indigenous games also foster collaborative learning, as many are designed to be played in groups. This aspect encourages teamwork, communication, and the application of mathematical concepts in real-time problem-solving scenarios (Rosinansis *et al.*, 2022). Such interactions enhance students' social and cognitive skills while reinforcing their cultural identity.

Teachers play a pivotal role in integrating games into the curriculum. Research shows that educators who understand the cultural significance of these games and their mathematical components can design effective lesson plans that connect learning to students' lives (Moloi, 2022; Tang, 2021). Professional training in this area is essential to maximize the educational value of such activities.

Finally, games offer a platform for continuous assessment and feedback. Teachers can observe students' reasoning and problem-solving abilities during gameplay, providing opportunities for immediate intervention and support. This dynamic and interactive form of assessment enhances both engagement and learning outcomes (Kadonsi *et al.*, 2023; O'Connor & Bronwyn, 2020).

C. Real-Life Application of Mathematics

Real-life applications of mathematics, particularly through ethnomathematics, demonstrate the relevance of mathematical concepts in Indigenous students' lives. Ethnomathematics connects curriculum content with cultural artifacts, practices, and daily experiences, creating a sense of relevance and purpose in learning (Naidoo, 2021; Borden, 2018). For example, weaving patterns, traditional construction methods, and resource management activities serve as practical applications of geometry, arithmetic, and algebra.

Place-based mathematics education further enhances this connection by drawing on local environments and traditions. Studies reveal that using community-specific examples in teaching fosters a sense of pride and engagement among students as they see their cultural heritage reflected in their education (Kadonsi *et al.*, 2023; Rosinansis *et al.*, 2022). This approach also helps students appreciate the broader applications of mathematics beyond the classroom. Another significant benefit of real-life applications is their potential to address gender disparities in education. By linking mathematics to activities traditionally performed by women in Indigenous communities, such as cooking or textile work, educators can encourage broader participation and interest among female students (Moloi, 2022; Naidoo, 2021).

Finally, involving the community in education strengthens these real-life connections. Collaborative projects with elders or cultural practitioners bring authenticity to lessons, ensuring that mathematical concepts are taught in ways that align with cultural practices (Golafshani, 2022; Tang, 2021).

D. Practice and Mastery

Consistent practice in culturally relevant contexts is critical for mastery of mathematical concepts among Indigenous students. Ethnomathematics transforms abstract ideas into meaningful content by linking them to familiar cultural elements. For instance, traditional measurement systems and timekeeping practices offer accessible entry points for teaching mathematical principles (Rosinansis *et al.*, 2022; Tangkur *et al.*, 2022). Regular exposure to these culturally grounded methods reinforces understanding and aids retention. Studies in Indonesia have shown that consistent practice using ethnomathematical approaches improves both cognitive and practical skills as students integrate mathematical ideas into their everyday thinking (Rosinansis *et al.*, 2022; Naidoo, 2021). Additionally, culturally relevant practice fosters a growth mindset among students. By aligning mathematical concepts with their cultural identities, learners are more likely to view challenges as opportunities for growth rather than obstacles (Kadonsi *et al.*, 2023; Borden, 2018). This positive outlook enhances motivation and resilience in learning.

Finally, repetition and mastery in cultural contexts promote long-term academic success. Research indicates that students who regularly engage in practice activities rooted in their cultural heritage outperform peers in standardized assessments, demonstrating the lasting impact of culturally informed teaching methods (Golafshani, 2022; Tang, 2021).

4. Conclusion and Recommendation

The study comprehensively explored meaningful learning in mathematics among Indigenous senior high school students in the Davao Region. It successfully identified and validated the dimensions of meaningful learning, developed a reliable measurement scale, and proposed a best-fit model using rigorous methodological approaches, including Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). The results of CFA confirm the consistency of the measurement model with the EFA findings, reflecting a robust internal structure for measuring meaningful learning. The final model identified four key latent dimensions, as shown in Figure 6: Teaching Methods and Understanding, Learning Through Activities and Games, Real-Life Application of Mathematics, and Practice and Mastery. This model demonstrated strong model fit indices ($\chi2/df = 1.289$, GFI = 0.929, CFI = 0.912, TLI = 0.90, RMSEA = 0.031), validating the theoretical construct of meaningful learning in mathematics. The reliability coefficients for these dimensions ranged from 0.639 to 0.855, with an overall scale reliability of 0.888, signifying the scale's robustness and reliability.

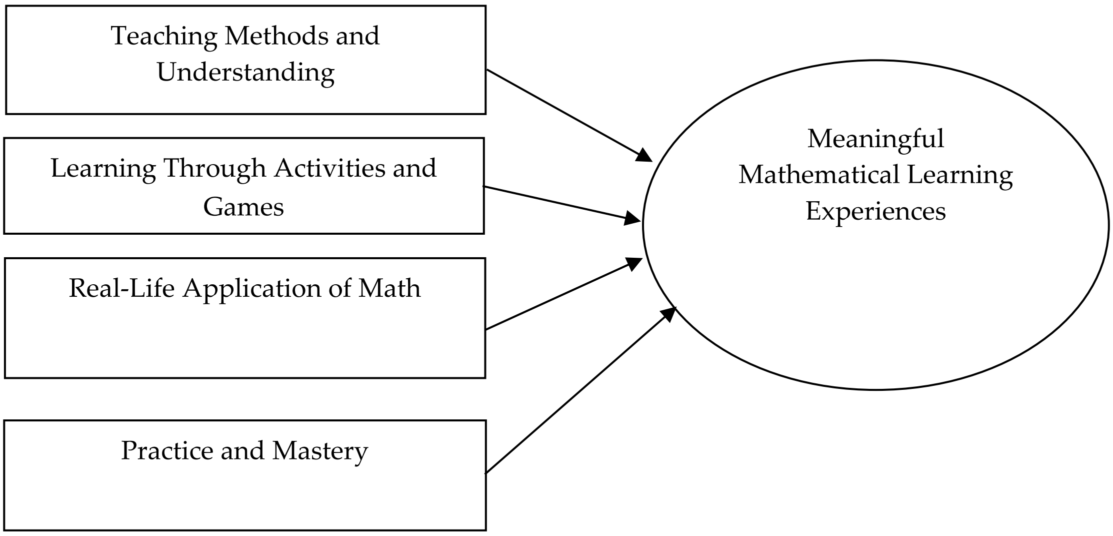

Figure 6: Measurement Model of Meaningful Learning in Mathematics

The study underscores the importance of culturally relevant and student-centered teaching approaches in promoting meaningful learning. The identified dimensions reflect the significance of effective teaching methods, interactive and gamified learning, contextualized real-life applications, and consistent practice tailored to the needs of Indigenous learners. These findings align with constructivist and experiential learning theories, which emphasize active engagement, cultural relevance, and practical applications as critical to learning success.

The research findings provide an evidence-based framework for enhancing mathematics education among Indigenous students. By integrating cultural and contextual elements, the proposed measurement model offers a valuable tool for assessing and improving educational strategies. Furthermore, the study highlights the potential of culturally responsive pedagogies to bridge educational gaps and empower Indigenous learners, fostering both academic success and cultural pride. The robust methodological foundation and significant outcomes of this study contribute to the growing body of knowledge on inclusive education. The validated measurement model serves as a guide for educators, school administrators, and policymakers in designing interventions that promote meaningful and equitable learning experiences for Indigenous students. These findings have broader implications for addressing educational disparities and enhancing the overall quality of mathematics education in diverse cultural contexts.

4.1 Recommendation

Based on the findings of the study, several actionable steps are proposed to enhance meaningful mathematics learning among Indigenous Peoples (IP) students.

Advocating for the integration of Indigenous knowledge, traditions, and practices into the mathematics curriculum strengthens cultural identity and educational relevance.

Elders and cultural bearers can contribute by participating in classroom activities, sharing traditional knowledge, and serving as mentors to students. Community-led workshops or storytelling sessions in schools may be organized to connect cultural practices with mathematical concepts. Collaborating with teachers and local education authorities creates a support system that encourages Indigenous students to see mathematics as valuable for both personal growth and community development.

Incorporating culturally relevant examples, such as local crafts, farming techniques, or community events, into math lessons helps connect abstract concepts to students' lived experiences. Teachers can engage in regular capacity-building programs focused on culturally responsive teaching strategies. Interactive and gamified learning activities, such as math-based storytelling, role-playing, or hands-on problem-solving tasks, can be introduced to boost student participation and critical thinking. Creating a welcoming classroom environment—where Indigenous identities are acknowledged and respected—promotes a stronger sense of belonging. Providing timely, consistent, and constructive feedback supports students in building confidence and improving conceptual understanding.

Embedding ethnomathematics into the curriculum ensures that learning is both meaningful and reflective of Indigenous culture. Contextualizing mathematics through real-life activities such as basket weaving, land measurement, or local trading introduces practical relevance. Developing localized learning modules that incorporate visuals, concept maps, and Indigenous languages enhances comprehension. A modular, flexible curriculum structure allows teachers to adapt materials to accommodate varying student learning styles, paces, and cultural backgrounds. Continuous collaboration with IP communities during curriculum development strengthens content authenticity and responsiveness.

Home-based support plays a vital role in reinforcing classroom learning. Tracking students' progress, offering help with homework, and creating opportunities for children to apply math in daily routines—such as household budgeting or farming schedules—make learning more engaging and practical. Attending school activities and communicating regularly with teachers fosters stronger home-school partnerships. Advocating for culturally relevant instruction and encouraging children to pursue education with pride in their cultural identity contributes to long-term academic motivation.

Exploring the long-term effects of culturally responsive mathematics education through longitudinal studies can provide deeper insights into student outcomes. Expanding the research scope to other subject areas and Indigenous groups across the Philippines ensures broader applicability. Studies involving technology integration, mobile applications, or gamification may identify innovative tools to enhance mathematics learning. Policy analysis focusing on the implementation and impact of education reforms related to Indigenous learners can inform more inclusive policymaking. Collaborating directly with Indigenous communities in designing and conducting research promotes mutual respect, empowerment, and relevance in future studies.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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