Sipnayan sa Tambakan: Mathematical Ethnomodels Through the Lens of the Scrap Merchants

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DOI: https://dx.doi.org/10.47772/IJRISS.2025.909000323

Received: 19 July 2025; Accepted: 26 July 2025; Published: 09 October 2025

ABSTRACT

Contextualization is a key strategy in engaging students by making lessons relevant to their lives, particularly by linking students' real-world experiences to the mathematical concepts taught in school. This study investigates how junior high school mathematical concepts can be applied to the activities of scrap merchants to create meaningful and relevant educational modules. Specifically, the reverché focuses on integrating trigonometric ratios, spatial reasoning, and arithmetic and geometric sequences into practical tasks such as sorting and optimizing scrap materials. The study employs a design ethnography approach, with participants including scrap merchants and educators who implement these contextualized approaches. By mathematizing and organizing the findings into teaching and learning ressourcées based on ethnomodels from scrap-merchant communities, the research aims to bridge the gap between theoretical knowledge and practical application. Data were collected through interviews and analyzed using thematic coding to identify how contextualized learning enhances students' understanding and problem-solving skills. The findings underscore the effectiveness of incorporating real-world practices into mathematics education, emphasizing the importance of making lessons engaging and applicable to students' everyday lives. Recommendations for future research include using mixed approaches, exploring additional ethnomodels, and developing and testing specific educational modules in collaboration with industry professionals.

Keywords : Contextualization, Mathematics Education, Ethnomodels, Scrap Merchants, Educational Module, Bataan Peninsula State University

INTRODUCTION

The majority of today's learners would question the relevance of their actions. To make their lives trendy, they adopt new social media trends or anything else that makes meaning of their existence. This is also where they implement such a desire for relevance to how they view mathematics and other subjects in school. Taking these factors into account, it is necessary to grasp the culture of the people in need, in this case, the learners, to comprehend the demand for relevance. The teaching and learning of mathematics should reflect and embrasé the cultural diversity found in mathematics classrooms and in a world that is becoming increasingly interconnected (Koskinen & Pitkäniemi, 2022).

Students' learning experiences are meaningful and culturally pertinent Shen they comprehend the purpose of formal mathematics instruction and how it relates to their community (Herrera & Palomo, 2022). Furthermore, Bernardo et al. (2022) advocated extending beyond curricular and instructional factors, as social and psychological aspects of students' school experiences are significant indicators of low-performing students. By studying and incorporating these practices into the curriculum, teachers and learners can not only broaden their understanding of mathematics but also promote cultural diversity and inclusivity.

As a result, teachers must be adept at contextualizing and localizing lessons. If the students are engaged, participatory, and able to share examples based on their own experiences, the implementation is going well (Lorbis, 2019). This will only be effective if students recognize the relevance of the concepts to the realities of their lives. Additionally, contextualized teachings with multiple dimensions contributed to the development of 21st - century skills. These skills include presentation skills that help students confidently share their ideas, math skills, critical thinking skills that help them solve problems through thorough and precise analysis, synthesis, and evaluation of ideas, social skills that help them appreciate how unique each person is and bringing the culture and environment into the classroom made students more aware of and appreciative of their backgrounds and identities (Pescuela & Goyena, 2020).

This is also the reason why most teachers contextualize mathematics by utilizing available resources, such as indigenous materials in the locality and curriculum materials provided by the Department of Education (DepEd) and book publishers (Diago & Dillo, 2022), which are sometimes generalized and not culturally familiar for a particular area.

A useful strategy for making mathematics instruction and resources culturally appropriate is ethnomathematics. The material of the mathematics curriculum is presented in a way that is pertinent to the students' cultural backgrounds while also advancing their grasp of the topic since ethnomathematics explores the cultural components of mathematics (Acharya et al., 2020). Teachers must, however, get to know the community where they live and work to do this. By tying together existing knowledge with the new material, it is more important to comprehend the learners' lives and use their contexts while delivering the new lesson (Reyes et al., 2019).

To be able to translate it into contextualized teaching-learning materials, teachers must be exposed to the mathematizing practices of the majority of their students' environment. Contextualized problems can be more engaging than traditional mathematics problems (Buan et al., 2021).

In the year 2016, through the provision of Department of Education (DepEd) Order No. 35, teachers were encouraged to conduct various professional development strategies to improve the teaching and learning process. Curriculum contextualization, localization, and indigenization are a few examples. The department acknowledged that expanding curriculum contextualization through indigenization is critical for populations with cultural traditions that differ from the majority of people in the same area.

Regarding the composition of context-based teaching and learning materials, teachers' understanding of cultural practices is limited to a superficial level (Mercado, 2021); otherwise, they would engage in a double effort. This is the motivation for this research. In an area where scraps are the primary source of income for most households, there are only a small number of context-based teaching and learning materials available. And many of these materials were only incorporated into recycling and waste management.

In Olongapo City, the two (2) barangays namely Brgy. New Kalalake and Brgy. Pag-asa scoped by the vicinity of Kalalake National High School (KNHS), have many scrap merchants who are classified in variety of ways such as “mangangalakal ng basura”, “magbobote”, and junk shop owners. These occupations are also the primary sources of income for many of the families of the students enrolled in the aforementioned school. This is why the researcher would like to delve deeper into the potential mathematical concepts embedded in the activities of scrap merchants' communities and seek cultural artifacts. The ethnomathematics methodology will be utilized to conduct this study and identify ethnomodels effectively. To make mathematics instruction and pedagogy culturally pertinent, these ethnomodels will serve as a foundation for designing context-based teaching-learning materials. To also prove that mathematics and culture cannot be separated. Math is culture (Kang, 2022).

METHODOLOGY

This qualitative research study employed an ethnographic approach to explore the mathematical practices of scrap merchants in Brgy. New Kalalake and Brgy. Pag-asa, Olongapo City. Through direct observation, the researcher identified mathematized activities within the merchants' daily routines, providing insights into how these practices can inform contextualized mathematics instruction for junior high school students.

The study was grounded in symbolic interactionism, a theoretical framework rooted in constructivist epistemology. Constructivism posits that knowledge acquisition is an adaptive process where individuals

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue IX September 2025

organize their experiential worlds rather than uncovering an external reality independent of the knower (O'Donovan, 2021). This perspective aligns with the notion that authentic comprehension arises from prior experience and foundational knowledge, with individuals constructing understanding by integrating preexisting beliefs with new concepts and tasks (Saleem et al., 2021).

Symbolic interactionism further emphasizes that meanings are constructed through social interactions and are subjectively interpreted by individuals (Mardon et al., 2021; Conerly et al., 2021). This approach underscores the importance of immersing oneself in the community to gain a deeper understanding of their practices. Consequently, the researcher adopted design ethnography, a method that generates knowledge through praxis by observing actions and behaviors (Muller, 2020). Design ethnography involves active interaction with individuals in the field, extending beyond mere observation to establish meaningful relationships and comprehend the world from participants' perspectives (Xue & Desmet, 2019; Malpe, 2021). Setting is a critical aspect of ethnographic research, as understanding people and their behaviors requires context-specific investigation (Adhikari, 2023). To strengthen data credibility, the researcher-maintained field notes, capturing rich, detailed information (Howitt, 2019, as cited in Arth, 2020).

The study's population comprised six scrap merchants from Brgy. New Kalalake and Brgy. Pag-asa, selected through purposive sampling. Inclusion criteria included: (a) extensive knowledge of scrap merchandising; (b) being at least 23 years old and a resident of either barangay for at least five years; and (c) having a minimum of five consecutive years of experience as a scrap merchant.

Exclusion criteria encompassed participants who: (a) resided in the same household as another participant; or (b) engaged in scrap merchandising on a part-time basis while holding other regular employment.The participants' profiles are as follows:

Table 1 :List of participants in pseudo names

No.	Pseudo Name	Sex	Age	Years Of Experience As A Scrap Merchant	Barangay They Reside In
1	Jo	Female	35	5	Pag-asa
2	Ado	Male	39	6	Pag-asa
3	Ana	Female	37	11	Pag-asa
4	Ramil	Male	55	20	New Kalalake
5	Letty	Female	48	8	Pag-asa
6	Cecil	Female	63	32	New Kalalake

Data collection involved participant observation, field notes, ethnographic interviews (both formal and informal), and examination of cultural artifacts or tools utilized by the merchants. Informants participated in interviews guided by a protocol developed from initial surveys conducted in the target barangays.

Purposive sampling, defined as selective or subjective sampling, was employed to include individuals deemed most appropriate for answering the research questions (Nyimbili & Nyimbili, 2024). Data collection continued until saturation was reached, meaning no new insights or themes emerged (Rahimi & Khatooni, 2024). This approach ensured that the sample size was adequate to cover all relevant aspects of the research questions without redundancy.

The researcher-initiated data collection by obtaining necessary permissions from the barangays, with approval granted by the third week of June. Consent forms were distributed to participants, and profiling was completed within three days of authorization. Data collection involved visits to six junk shops, with interviews and observations scheduled based on participant availability. Each visit ranged from 20 minutes to 5.5 hours, conducted between 6:00 a.m. and 6:00 p.m., excluding Sundays. Observations evolved from descriptive to focused and then to selective, utilizing checklists to highlight specific aspects of interest.

The researcher employed technology, such as recording devices, to facilitate accurate and detailed data collection, particularly when documenting tools and devices used by the scrap merchants, which were integrated into mathematical concepts like shapes and geometric figures (Lau & Bratby, 2023).

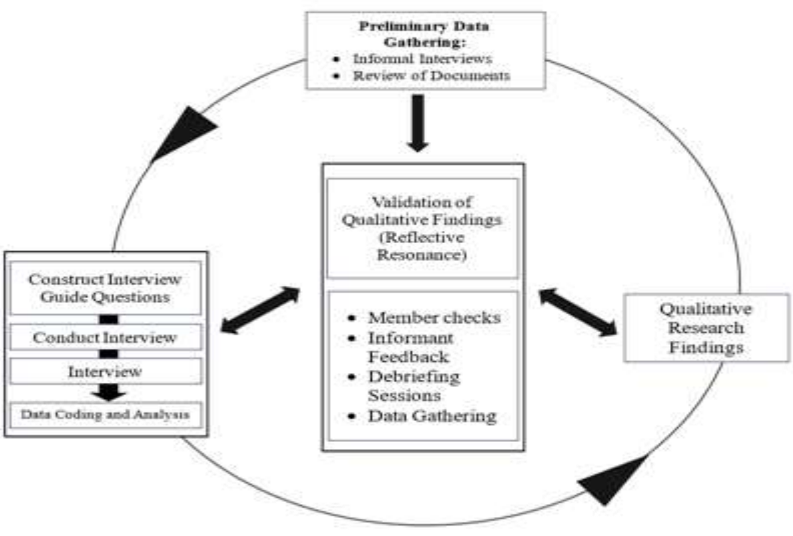
Interviews served as evidence of the assumptions made between participants. Semi-structured interviews, using pre-formulated open-ended questions, were conducted to gain comprehensive insights into participants' viewpoints and experiences (Mashuri et al., 2022). Questions were designed to explore daily routines, tools and materials used, strategies for weighing and valuing materials, and methods for improving sales. These inquiries were informed by Vygotsky's Zone of Proximal Development (ZPD), Kolb's Experiential Learning Theory, and Bandura's Social Cognitive Theory, each providing a lens through which to understand the learning processes of the scrap merchants.

Ethical considerations were paramount throughout the study. Consent forms outlined the study's goals, expectations, voluntary participation, and confidentiality assurances. All participant responses were digitally recorded and transcribed, with pseudonyms assigned to maintain anonymity. Data were securely stored and will be destroyed after three years. The study's findings, when published, will not include identifying information.

Data analysis followed LeCompte's (2000) three stages: item level, pattern level, and structure level analysis. NVivo software was utilized to identify and interpret key themes from the data. The software's autocoding feature facilitated the identification of relevant sections of text, which were then reviewed and refined by the researcher to ensure accuracy and context. Geometrical shapes and patterns were also identified to study cultural artifacts, especially physical objects.

To establish trustworthiness and rigor, the study employed triangulation through ethnographic interviews, participant observation, field notes, and cultural artifacts (María, 2020). This approach allowed for cross-verification of information from different perspectives. The researcher applied Lincoln and Guba's (1985) criteria—credibility, transferability, dependability, and confirmability—to evaluate the quality of the research. Credibility was ensured through a well-structured research method, early community engagement, and member-checking. Transferability was addressed by providing detailed descriptions to allow for replication in different contexts. Dependability was maintained through overlapping approaches and detailed methodological descriptions. Confirmability was achieved by ensuring findings were based on data collected and not influenced by the researcher's biases. Below is a graphic illustrating the data collection method used to ensure the quality and rigor of the research.

Figure 1: The process of collecting data to ensure the trustworthiness and rigor of the study



ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue IX September 2025

Observations in the study transitioned from being descriptive to focused and selective, with the use of checklists becoming more prevalent. This methodological shift allowed the researcher to systematically document and analyze specific aspects of the scrap merchants' activities, particularly those relevant to mathematical practices. The use of technology for recording observations helped maintain a high level of accuracy and detail, providing a clear and comprehensive view of the practices being studied. Triangulation in this study played a crucial role in ensuring the robustness of the findings by combining various data collection techniques, applying trustworthiness criteria, and systematically analyzing the convergence of information from multiple sources. This approach not only enhanced the validity of the study but also provided a deeper understanding of the cultural and mathematical dimensions of the scrap merchants' practices in Olongapo City.

RESULTS AND DISCUSSION

The thematic diagram below provides a comprehensive view of the practical, sorting, and economic aspects of scrap merchant operations. It highlights how scrap merchants apply measurement and pricing strategies, employ sorting techniques, and navigate economic and logistical challenges. The analysis offers valuable insights into the real-world applications of mathematical and economic concepts and underscores the complexities of managing a scrap business.

Figure 2: Generated themes based on the participants' responses.

The following sections present the ethnomodels derived from the mathematical activities observed among the scrap merchants.

Table 2 : Summary of key themes and related ethnomodels

Key Themes	Related Ethnomodels
Theme 1: Practical Application of Measurement and Pricing	**Arithmetic and Geometric Sequences in Scrap Prices and Exchange Rates** Arithmetic and geometric sequences describe how scrap prices and exchange rates fluctuate over time. Arithmetic sequences reflect regular price increases or decreases, while geometric sequences account for exponential growth or decay, highlighting the economic patterns in the scrap trade.
	Number Sense and Exactness in Weighing Scraps Using Measuring Devices

	In scrap operations, merchants use precise measurements, often referred to as "guhit" (a line on mechanical scales), to measure weight. The researcher found that each "guhit" on scales corresponds to specific weights (e.g., 50 grams or 1 kilogram), demonstrating the need for exactitude and calibration in the weighing process.
Theme 2: Sorting and Categorization Techniques	**Squares and Rectangles in "magaang bakal" or transformer metal E-I laminations** Sorting scrap materials such as E-I laminations for transformers involves creating geometric shapes. The E and I laminations are arranged to form rectangles, and square patterns are created by organizing the laminations in a grid. This process shows how sorting methods are influenced by geometric principles.
Theme 3: Economic and Logistical Considerations in Operations	**Trigonometric Ratios in "pick-up" or "hakot"** Hakot, or the transfer of scrap materials to open trucks, involves the use of trigonometric principles. A ladder or ramp is used to load materials onto trucks, optimizing space and weight distribution using slanted angles, demonstrating the practical application of trigonometry in maximizing truck capacity.

Table 2 connects key themes in the operations of scrap merchants with related ethnomodels that illustrate how mathematical principles are applied in their daily practices. Theme 1, "Practical Application of Measurement and Pricing," is linked to the use of arithmetic and geometric sequences to track fluctuations in scrap prices and exchange rates, as well as the precise measurement of scrap weight through "guhit" on mechanical scales, emphasizing the importance of accuracy. Theme 2, "Sorting and Categorization Techniques," is associated with the use of geometric principles in sorting scrap materials, particularly how E-I laminations for transformers are arranged into squares and rectangles. Finally, Theme 3, "Economic and Logistical Considerations in Operations," highlights the application of trigonometric ratios in the process of hakot, or transferring scrap materials onto trucks, where slanted angles optimize the loading process, demonstrating the integration of geometry in logistics.

Arithmetic and Geometric Sequences in Scrap Prices and Exchange Rates

Arithmetic sequences involve a constant difference between consecutive terms. In the context of scraps' prices or exchange rates, this could reflect regular increases or decreases over fixed periods. While geometric sequences involve a constant ratio between consecutive terms. In the context of scraps' prices or exchange rates, this could represent exponential growth or decay.

The informants described the sorting process and how certain materials are handled differently based on their value. For example, paper is accepted only in specific conditions, such as clean white paper, and is priced between 2 to 3 pesos per kilogram. In contrast, different types of metal scraps, like brass and copper, are sold at higher prices but are less frequently available. The informants highlighted that pricing varies not only by material but also by local practices and market demand, underscoring the importance of sorting and correctly identifying materials to maximize profit in the recycling business.

The table below presents the price ranges for each scrap material based on the summarized statements provided by the informants.

Table 3 : Scrap prices and exchange rates

ScrapMaterial	Price Range/ Exchange Rate
Class A Plastic (Sibak)	₱6 per kilo
Class B Plastic (Dark)	₱6 per kilo
Class C Plastic (Blackout)	₱5 per kilo

Steel/Bakal	₱14-15 per kilo
Tin/Yero	₱9 per kilo
Aluminum	₱50 per kilo
Softdrink Cans (In-can)	₱43-45 per kilo
Copper/Tanso	₱430-460 per kilo
Brass (Yellow/ Yellow Brass Pipe Fittings)	₱240-250 per kilo
Plastic Bottles (1.5-liter Softdrinks)	₱1.50 per piece
Long Neck Bottles (e.g., Emperador)	₱1 per piece
Gin Bottles (Bilog)	₱0.50 per piece
Ketchup Bottles	3 bottles for ₱1
Paper (White)	₱2-3 per kilo
CDs	₱24-25 per kilo
Small Cans (e.g., Milk, Canned Goods)	₱9 per kilo

An informant, Jo, told how they categorize scrap prices:

“Sa sibak, class A ‘yang matingkad, itong dark, class B, ‘yang itim na itim, wala sa dalawa… ‘yan ang pinakamura. Nabili kami ng assortir naganyan, sais per kilo. Bakal e 14 per kilo, lata, nuebe, sa yero gano’n din. ‘Yung mga aluminum, sinkwenta ‘yon. Sa in-can naman o ‘yong mga coke in can, forty-five kada kilo. ‘Yang tanso ang pinakamahal e nasa 430 kilo ‘yan.”

(“For plastics, Class A is the bright-colored ones, Class B is dark, and the rest are the cheapest. We buy assorted plastics at six pesos per kilo. Metal is 14 pesos per kilo, cans are nine pesos, and sheet metal is the same. Aluminum is fifty pesos, Coke cans are forty-five pesos per kilo, and brass is the most expensive at 430 pesos per kilo.”)

Informant, Ado elaborated more other materials.

“Halimbawa sa tanso nga, sa amin 460 ‘yan. Ewan ko lang sa iba kung mas mataas o mas mababa ang benta nila. ‘Yan ang pinakamahal. ‘Yong dilaw naman a tinatawag nila ay nasa 240 pesos ‘yon. Kaunti lang din nagbebenta kasi parang parts ‘yon ng tubo e. Sa timbang naman ng lata, otso pesos ‘yon. ‘Yong CD na bihira naman din ang nagbebenta, nasa 24 ang kilo no’n sa amin. Sa per piraso naman, piso sa 1.5 na boteng plastik. ‘Yan naman ang pinakamadalas na ibenta dito.”

(“For example, copper is 460 here. I don’t know if others sell it higher or lower. That’s the most expensive. The yellow type, which they call brass, is 240 pesos. Few sell it because it’s like tube parts. For cans, it’s 8 pesos per kilo. CDs, which are rarely sold, are 24 pesos per kilo here. For each piece, it’s 1 peso for 1.5-liter plastic bottles. This is the most frequently sold here.”)

Recent studies have utilized statistical methods to analyze historical data on scrap prices and exchange rates. These include time series analysis, regression models, and econometric techniques to identify patterns, trends, and relationships (Petropoulos et al., 2022). Advances in machine learning algorithms have enabled researchers to develop predictive models for scrap prices and exchange rates. Techniques such as neural networks and deep learning are used to capture complex patterns in large datasets (Sarker, 2021).

Studies explore arbitrage opportunities and pricing discrepancies based on mathematical principles (Cui et al., 2019). Mathematical models play a crucial role in risk management strategies related to scrap prices and exchange rates. This includes the valuation of financial derivatives, hedging techniques, and portfolio optimization based on mathematical finance theories (Marzban et al., 2021).

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue IX September 2025

Table 4: Sample mathematical problems involving sequences using the data in Table 3

Mathematical Problem	Formula	Solution
A junk shop purchases Class A plastic (*sibak*) at ₱6 per kilo. Each month, the price of Class A plastic increases by ₱0.50. What will be the price of Class A plastic in the 6th month if the initial price is ₱6?	Finding the nth term of an arithmetic sequence $$\boldsymbol{a_n = a_1 + (n-1)d}$$ where: $\boldsymbol{a_n}$ is the price in the nth month $\boldsymbol{a_1}$ is the initial price $\boldsymbol{d}$ is the common difference (monthly increase) **n** is the number of months	Plugging in the values: $$a_6 = 6 + (6-1)0.50$$ $$\boldsymbol{a_6 = ₱\,8.50}$$ The price of Class A plastic in the 6th month will be ₱ 8.50.
A junkshop receives a special offer for plastic bottles (1.5-liter soft drinks) where the price decreases by 20% each month. If the initial price is ₱1.50 per piece, what will be the price of a plastic bottle in the 4th month?	Finding the nth term of a geometric sequence $$\boldsymbol{a_n = a_1 \cdot r^{n-1}}$$ where: $\boldsymbol{a_n}$ is the price in the nth month $\boldsymbol{a_1}$ is the initial price $\boldsymbol{r}$ is the common ratio (percentage decrease) **n** is the number of months	Plugging in the values: $$a_4 = 1.50 \cdot 0.80^{4-1}$$ $$\boldsymbol{a_4 = ₱\,0.768}$$ The price of a plastic bottle in the 4th month will be approximately ₱0.77.

Mathematical models are applied to assess the environmental impact of scrap metal recycling and its economic implications. Studies analyze the cost-effectiveness of recycling programs and regulatory policies using mathematical frameworks (Asare et al., 2022). Additionally, governments and policymakers use mathematical modeling to evaluate the effects of monetary policies, trade agreements, and environmental regulations on scrap prices and exchange rates. This informs strategic decisions and policy interventions (Deep, 2023).

Furthermore, academic and industry collaborations provide case studies on how mathematical models are implemented in scrap metal trading firms and financial institutions. These studies highlight best practices and real-world applications of mathematical theories (Singh, 2020). Also, mathematical models enable stakeholders to conduct scenario analysis and forecast future trends in scrap prices and exchange rates. This aids in strategic planning, budgeting, and risk assessment across different economic scenarios (Latysheva & Chupryna, 2023).

Number Sense and Exactness in Weighing Scraps Using Measuring Devices

Scrap merchants do not use convenient measures of length and weight using body parts or objects. They only use measurements under the metric system. Their unique way of weighing is when they replace gram with guhit. Guhit is the literal line found in a mechanical weighing scale.

The informants explained that while weights are measured in kilos, "guhit" denotes additional grams. Letty demonstrated that each "guhit" represents 100 grams and showed how it affects pricing, using a calculator to determine costs.

“Tapos ayon nga ‘yong guhit. Alam mo ba ‘yong ibig kong sabihin? Tingnan mo itong pang 20-kilo. Sample-an kita. O ayan ‘di ba? May 3 kilos at ilang guhit ‘yan? O edi kung tatlong kilo at tatlong guhit, 3 kilos and 300 grams ang ibig sabihin. O ito ang table calculator. Alam mo naman siguro ito noh? Halimbawa sa sibak, o singko pesos kada kilo ‘yon. Itatype ko 3.3 times 5. Ayon na ang ibabayad ko.”

("And here are the marks. Do you know what I mean? Look at this 20-kilo weighing scale. I'll show you. See? There are 3 kilos and a few marks. So if there are three kilos and three marks, it means 3 kilos and 300 grams. Here's the table calculator. You probably know how to use this, right? For example, with plastics, which are five pesos per kilo. I'll type in 3.3 times 5. That's how much I'll need to pay.")

Upon examining various mechanical weighing scales, the researcher discovered that the term "guhit" does not solely denote additional grams. Specifically, on a 20-kilogram scale, each "guhit" corresponds to 50 grams, rather than the previously assumed 100 grams. Furthermore, on scales with capacities of 100 kilograms or more, "guhit" may also indicate additional kilograms. This variability in the measurement of "guhit" underscores the need for careful calibration and interpretation depending on the scale's capacity and type.

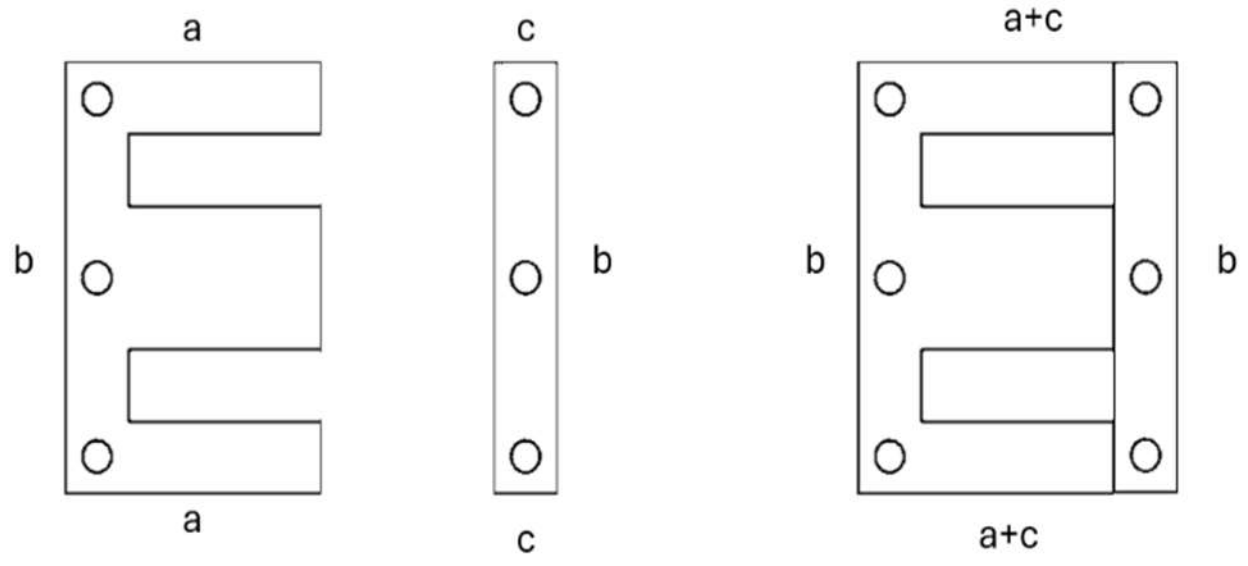
Number sense refers to a person's intuitive understanding of numbers and their relationships, which is essential for accurate measurements in industrial settings such as scrap metal yards (Tsao & Lin, n.d.). Workers need to interpret numerical data from weighing devices to ensure they accurately assess the quantity of scraps, which impacts pricing and processing.

Squares and Rectangles in *"magaang bakal"* or transformer metal E-I laminations

Transformer metal E laminations are thin, stacked sheets of electrical steel used to form the core of transformers. These laminations are typically shaped like the letter "E", with slots and holes designed to minimize energy losses due to eddy currents and maximize magnetic flux efficiency. Transformer metal E laminations are rectangular in shape individually, with precise dimensions specified to fit within the transformer core assembly. These rectangles are stacked and assembled to form the complete core structure. These rectangular laminations can be arranged and stacked in configurations that approximate squares.

As represented using graphics, a more comprehensive geometrical relationship has been found between transformer meatal E laminations and squares and rectangles. This explains that advances in educational technology have influenced how spatial reasoning skills are taught. Virtual manipulatives and digital platforms are increasingly used to engage students in interactive activities involving geometric shapes (Walkington et al., 2021). Such tools facilitate exploration and understanding of how shapes fit together to form specific configurations.

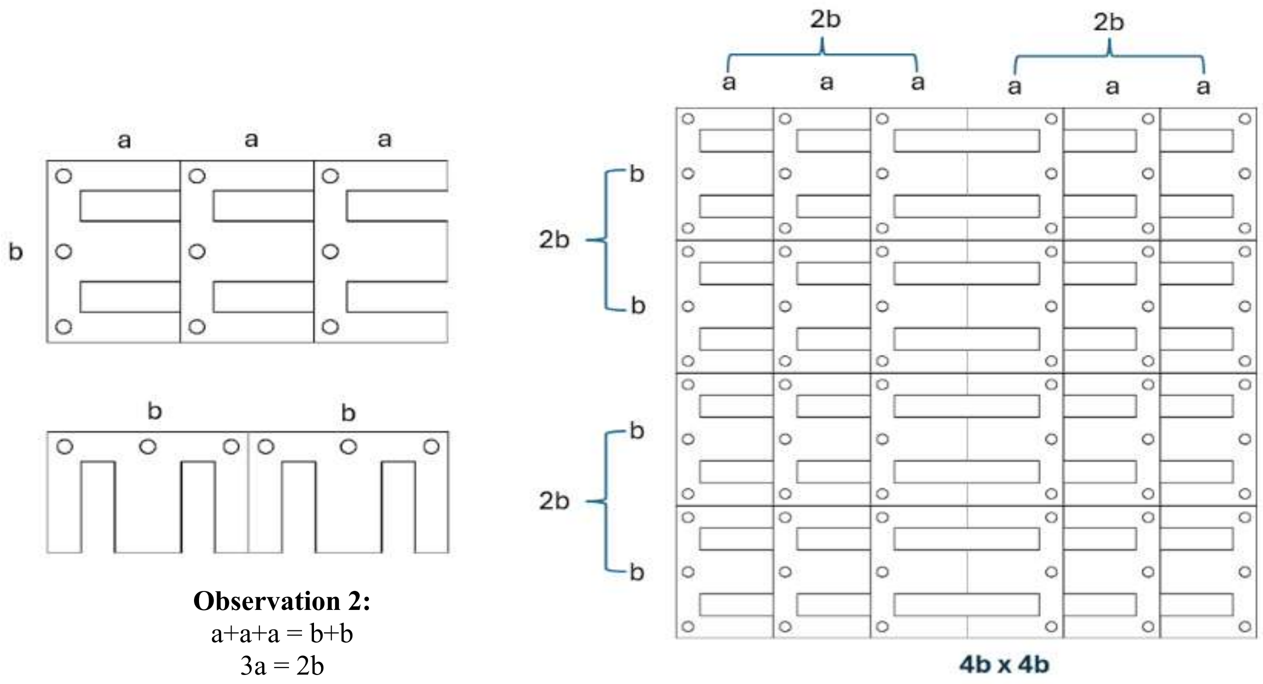
Figure 3: Observation 1 - Geometric representations of *"magaang bakal"* as a rectangle



Observation 1:
Sum of the lengths of all sides = (a+c) + (a+c)+b+b
Sum of the lengths of all sides = 2(a+c)+2b
Sum of the lengths of all sides = Perimeter

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue IX September 2025

Figure 4 : Observation 2 - Geometric representations of *"magaang bakal"* as a square



The researcher discovered that E-I mono-phase materials were the lamination samples she collected as a model. She utilized E and I laminations to make rectangles. She completed the shape by combining E laminations in one orientation with I laminations. This will assist in demonstrating how rectangles are generated with varying lengths and widths. For the square, she organized the E laminations in a grid pattern to create squares.

These are the approaches made by the researcher :

Observation 1: Perimeter Calculation

In analyzing the geometric properties of a specific shape, the perimeter is calculated by summing the lengths of all sides. Consider a polygon with sides denoted as a, b, c arranged in a pattern where the sides a and c are repeated twice, and the side b are also repeated twice.

Sum of Side Lengths: The total length of all sides can be expressed as:

$$(a+c)+(a+c)+b+b$$

Here, each side length a and c is counted twice, and each side length b is also counted twice.

Simplification: By combining like terms, the expression simplifies to:

$$2(a+c)+2b$$

This result shows that the sum of the side lengths is twice the sum of a and c, plus twice b.

Perimeter Definition: The perimeter P of a polygon is defined as the sum of the lengths of all its sides. Hence, the formula:

$$P= 2(a+c)+2b$$

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue IX September 2025

accurately represents the perimeter of the polygon in question. This observation confirms that the perimeter is consistently calculated as the aggregate of all side lengths.

Observation 2: Ratio and Proportions

In this observation, the proportional relationship between the lengths a and b was analyzed based on a given equality:

1. Equality of Sides: The equation provided is:

a+a+a = b+b

which simplifies to: **3a=2b**

This equation indicates that the combined length of three sides of length a is equal to the combined length of two sides of length b.

2. Solving for a: To express a in terms of b, rearrange the equation:

$$a = \frac{2}{3}b$$

This indicates that each side of length a is $\frac{2}{3}$ the length of each side b.

3. Application to Square Formation:

In the context of forming a square, each side of the square must be equal in length. To analyze how the lengths a and b can be used to form a square, we utilize the proportional relationship:

$$a = \frac{2}{3}b$$

Suppose we want to determine how many units of length a are needed to match a given number of units of length b to form a square. We analyze a hypothetical situation where six units of length a are required to form a geometric shape, and we need to confirm if this configuration satisfies the condition of forming a square:

Substituting $a = \frac{2}{3}b$ into the equation 6a= 4b yields:

$$6\left(\frac{2}{3}\right)b = 4b$$

Simplify this equation:

$$4b = 4b$$

This confirms that the proportional relationship holds, and that the configuration of sides satisfies the condition.

Research explores how spatial reasoning and geometric understanding contribute to problem-solving in fields like engineering and computer science (Munoz-Rubke et al., 2021). Understanding how to stack shapes effectively to optimize space or solve design problems is part of this discourse.

Educational frameworks, such as learning trajectories, continue to guide curriculum design in mathematics education. These frameworks emphasize the progression of spatial skills development, including tasks like stacking blocks or tiles to form geometric shapes (Clements & Sarama, 2020). Despite technological advancements, hands-on learning experiences with physical manipulatives remain effective for teaching geometric concepts. Recent studies highlight the benefits of tactile engagement in learning tasks involving geometric shapes and spatial relationships (National Council of Teachers of Mathematics, 2020).

Trigonometric Ratios in "pick-up" or "hakot"

Hakot or transferring of scrap materials to open trucks is one of the mathematical activities of the scrap merchants involved in transporting. The traditional "paghahakot" uses ladder slanted from the ground to the firm side of the truck or lowered wide ramp at the back-opening of the truck. These materials ease the weight of the scraps to logically fill in the truck, maximizing its space.

Informant, Ana, explained :

"Nakikita mo 'yong parang magkadugtong sa likod, rampa 'yon na naibaba para itutulak na lang 'yong mga iaakyat na sako o kaya 'yong mga loose na kalakal, ibig sabihin itong mga plastic na tungtungan, parang ganito."

("You see the part that's connected at the back? That's a ramp that's lowered so you can just push up the sacks or loose materials, meaning those plastic things used as supports, like this.")

Informant, Ramil, alsoadded :

"Ito? Hindi 'yan pinto. Isinasandig ito sa truck para diyan na ipadulas o daus-os 'yong mabigat na kalakal. Siyempre, mataas 'yong 'di ba? Mas madali kung may rampa."

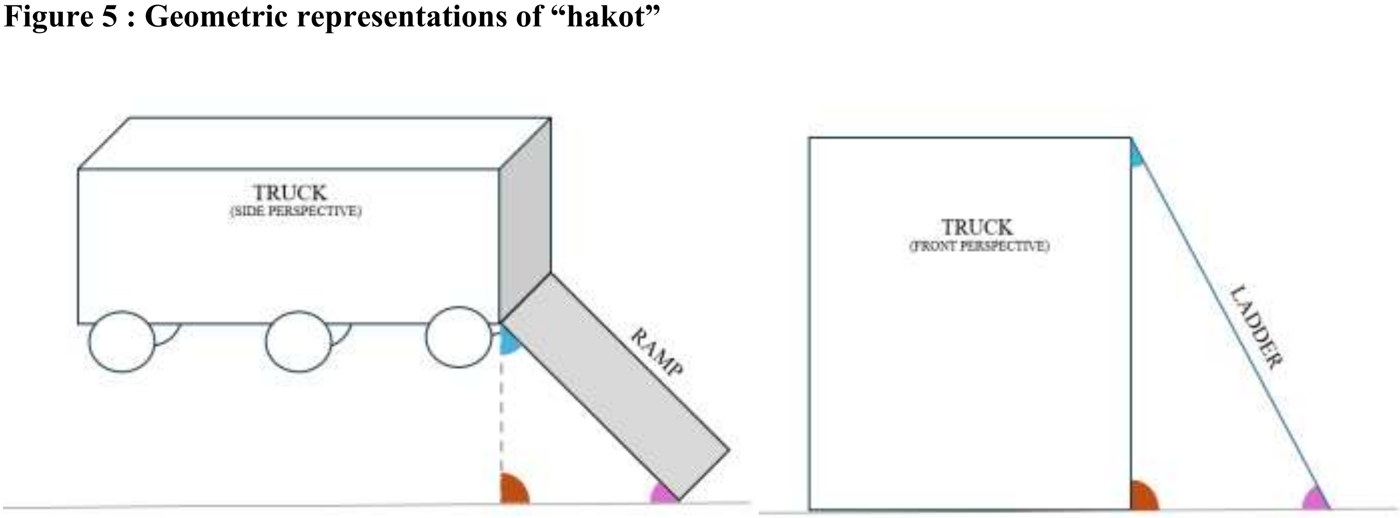
("This? That's not a door. It's propped up against the truck to slide or push the heavy materials. Of course, it's high up, right? It's easier if there's a ramp.")

A passage from the observation guide notes:

In the process of loading scrap materials onto trucks using ladders or ramps, angles of elevation and depression are crucial mathematical concepts. The angle of elevation refers to the angle between the horizontal ground and the line of sight to an object above the ground (in this case, the ladder or ramp leaning against the truck). Conversely, the angle of depression is the angle between the horizontal ground and the line of sight to an object below the ground (e.g., viewing the base of the ladder from the top of the truck).

Drawing from the informants' insights, the researcher explores the significance of angles of elevation and depression in the loading of scrap materials onto trucks. The angle of elevation aids in understanding the relationship between the ladder or ramp and the truck, while the angle of depression provides perspective from various heights. By applying trigonometric ratios such as sine, cosine, and tangent, they could enhance the loading process, facilitating accurate calculations of distances and heights. This strategy could ultimately improve safety and efficiency, ensuring optimal utilization of truck space.

Figure 5 : Geometric representations of "hakot"



ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue IX September 2025

Thus, the researcher suggests the following mathematical problems associated with the significance of angles observed in truck loading using ramps and ladders.

Table 5 : Samplemathematicalproblemsinvolving trigonometric ratios using geometric representations of *"hakot"*

MathematicalProblem	Formula	Solution
A loading dock uses a ramp to facilitate the loading and unloading of scraps onto trucks. The ramp is inclined at an angle of 15° with respect to the horizontal ground. A truck is positioned at the top of the ramp, and the length of the ramp is known to be 10 meters. Find the vertical height (h) of the ramp from the ground to the top of the truck.	**Finding the Vertical Height (h):** To find the vertical height h, we use the sine function, which relates the angle of elevation, the length of the ramp, and the height: $sin\theta = \frac{h}{length\ of\ ramp}$ $\boldsymbol{h = length\ of\ ramp \cdot sin\theta}$	Plugging in the values: $h = 10m \cdot sin15°$ $\boldsymbol{h \approx 2.588\ meters}$
A junkshop worker is using a ladder to load goods onto a truck. The ladder is positioned against the side of the truck and forms an angle 30° with the ground. The length of the ladder is 12 meters. The junkshop worker needs to determine how high up the side of the truck the ladder reaches and how far the base of the ladder is from the truck.	**Finding the Vertical Height (h):** To find the vertical height h, we use the sine function, which relates the angle of elevation, the length of the ramp, and the height: $sin\theta = \frac{h}{length\ of\ ramp}$ $\boldsymbol{h = length\ of\ ramp \cdot sin\theta}$	Plugging in the values: $h = 12m \cdot sin30°$ $\boldsymbol{h \approx 10.392\ meters}$

The use of angles of elevation and depression in "paghahakot" illustrates the practical application of mathematics in everyday tasks. It demonstrates how mathematical concepts learned in classrooms, such as trigonometry, are directly applicable to real-world scenarios, enhancing students' understanding and appreciation of mathematics (Spangenberg, 2021). Loading scrap materials onto trucks requires spatial awareness to estimate distances, visualize the loading process, and ensure the materials are evenly distributed. This activity fosters problem-solving skills as scrap merchants calculate angles and distances to efficiently utilize truck space while maintaining safety standards (Raabe et al., 2022). Such strategies cater to diverse learning styles and enhance students' engagement and understanding of mathematical principles (Cardino & Ortega-Dela Cruz, 2020).

Ethnomodelsderivedfrom the practices of scrap-merchant communities can be effectively incorporated into educational modules to create contextualized and practical learning experiences. Modules such as "Hakot" use trigonometric ratios to teach spatial management in truck loading, while "Magaang Bakal" applies geometric principles using E-I laminations to explore shape analysis and organization. Another module, "On Kilos and Guhit," uses real scrap pricing data to teach arithmetic and geometric sequences, enhancing students' understanding of market dynamics and financial literacy. These modules ground mathematical concepts in real-world scenarios, making them more meaningful and engaging for learners. Collaboration with scrap-merchant communities ensures the authenticity of the content, helping educators design resources that reflect actual tools, measurements, and challenges faced in these contexts.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue IX September 2025

Figure 6 : Context-based activity modules developed using the ethnomodels from scrap merchants

CONCLUSIONS AND RECOMMENDATIONS

While scrap merchants engage in essential activities such as sorting and categorizing materials, using various tools to handle different types of scrap, and optimizing pricing through effective measurement, some practices can be enhanced by integrating junior high school mathematical concepts. These activities, including loading scrap materials onto trucks, sorting transformer metal laminations, and analyzing pricing trends, can be better understood and optimized using trigonometric ratios, spatial reasoning, and arithmetic and geometric sequences. By incorporating these mathematical principles into educational modules, such as those focusing on truck loading (Hakot), geometric construction with E-I laminations (Magaang Bakal), and pricing analysis (On Kilos and Guhit), students can gain practical insights into how mathematics applies in real-world scenarios. The integration of ethnomodels from scrap-merchant communities into these teaching resources not only contextualizes mathematical concepts but also makes learning more relevant and impactful. This approach highlights the importance of bridging theoretical knowledge with practical application, ensuring that educational content resonates with students and enhances their problem-solving skills.

SUMMARY OF FINDINGS

Scrap merchants engage in a range of critical activities essential for the efficient operation of junk shops. Their work involves sorting and categorizing scrap materials, which is fundamental for accurate pricing and operational efficiency. This process includes using various tools such as magnets, hammers, cleavers, trolleys, and metal cutters to handle different types of materials, including metals, plastics, and paper. Effective organization and processing of these materials are crucial, as they directly influence the value of the scrap and the overall efficiency of the junk shop operations.

activities can be categorized and analyzed using junior high school mathematical concepts. For example, when loading scrap materials onto trucks, merchants apply trigonometric ratios and spatial awareness. The use of ramps and ladders involves calculating angles of elevation and depression to optimize the loading process, making efficient use of truck space. This application of trigonometry is essential for determining the most effective loading strategies. Additionally, spatial reasoning is required to manage and position ramps and ladders accurately, reflecting fundamental geometric skills.

In sorting specific scrap materials like transformer metal E-I laminations, junior high school geometry comes into play. These laminations, which are shaped like the letters "E" and "I," can be arranged to form rectangles and squares. This hands-on sorting activity provides practical examples of geometric principles such as perimeter calculation and proportional relationships. By arranging these laminations to optimize space, students can see how geometric concepts apply in real-world scenarios, enhancing their spatial reasoning skills.

Arithmetic and geometric sequences are also relevant in analyzing scrap prices and exchange rates. Arithmetic sequences help predict future prices by identifying consistent, linear changes, which is valuable for budgeting and forecasting. Geometric sequences model exponential growth or decay, aiding in long-term investment strategies and understanding market fluctuations. Accurate sorting and categorization of materials, such as metals and plastics, which have variable prices, are essential for maximizing profits and managing financial risks.

Ethnomodels from scrap-merchant communities can be integrated into educational modules to create contextualized teaching and learning resources. For instance, a module on optimizing truck loading (Hakot) could use trigonometric ratios to teach students about angles and space management. This module would provide practical exercises related to loading scrap materials, helping students apply trigonometric functions to real-life problems such as calculating the height of a truck bed based on ladder placement.

Another module, Magaang Bakal, could focus on geometric concepts by using E-I laminations to construct and analyze geometric shapes. This module would help students understand geometric properties and their applications in sorting and organizing materials. By physically handling these laminations, students would gain insight into spatial planning and packaging, reflecting real-world practices in junk shops.

The third module, On Kilos and Guhit, could explore arithmetic and geometric sequences through the analysis of scrap metal pricing and exchange rates. By using real-world data, students could investigate how these sequences model pricing trends and market conditions. This module would enhance students' understanding of financial analysis and risk management, making the learning experience more relevant to real-world scenarios.

Integrating these ethnomodels into educational curricula involves developing modules that reflect the specific practices and challenges faced by scrap merchants. Collaboration with scrap-merchant communities is essential to gather accurate data and insights, which can then be translated into teaching resources. For example, understanding the nuances of measurement terms like "guhit" and how they vary with scale capacity can help students grasp the importance of accurate calibration and interpretation in measurement practices.

By incorporating local knowledge and practical applications into mathematics education, these modules provide students with meaningful and engaging learning experiences. The practical examples drawn from scrap-merchant activities not only make mathematical concepts more relevant but also help students develop problem-solving skills applicable in real-world settings. This approach demonstrates the value of integrating ethnomodels into teaching to enhance the effectiveness of mathematics education.

Overall, the integration of ethnomodels into mathematics education offers a contextualized approach that bridges theoretical knowledge with practical application. By reflecting on the real-world practices of scrap merchants, educational modules can provide students with valuable insights into how mathematics is used in various professional settings, making learning more relevant and impactful.

CONCLUSION

The present study aimed to explore how the activities of scrap merchants can be effectively categorized and mathematized using junior high school mathematical concepts, and how ethnomodels from scrap-merchant communities can be utilized to create contextualized teaching resources. Based on the analysis of scrap merchants' activities and their practical applications, it was found that the integration of ethnomodels from scrap-merchant communities into educational modules offers a contextualized approach to teaching mathematics. Modules like Hakot, Magaang Bakal, and On Kilos and Guhit demonstrate how real-world practices can be translated into meaningful learning experiences. This approach not only makes mathematical concepts more relevant but also helps students develop practical problem-solving skills. This aligns with research on the benefits of contextualized and experiential learning in mathematics education (Pradhan, 2023; Alangui, 2017)

Integrating ethnomodels into mathematics education offers a valuable opportunity to connect classroom learning with professional practices. This approach not only enhances students' understanding of mathematical concepts but also prepares them to apply these skills in various real-life contexts, reflecting the broader significance of contextualized education.

RECOMMENDATIONS

The current research on integrating scrap merchants' activities into mathematics education through ethnomodels has provided valuable insights into how practical, context-based applications of mathematical concepts can enhance learning. However, to build on these findings and fully realize the potential of integrating ethnomodels into educational practices, several recommendations are proposed.

1. Future research would benefit from employing a mixed-methods approach, combining both quantitative and qualitative methodologies. This approach will allow for a more comprehensive analysis of the effectiveness of integrating ethnomodels into mathematics education. Quantitative data can provide statistical evidence of the impact on student learning outcomes, while qualitative insights can offer a deeper understanding of how these contextualized educational practices influence students' engagement and problem-solving skills.
2. It is recommended that subsequent studies address any limitations identified in the current research by exploring a broader range of ethnomodels from different professional communities beyond scrap merchants. Investigating various trades and industries could reveal additional opportunities for contextualized mathematics education. This broader exploration could enhance the relevance and applicability of mathematical concepts across diverse real-world scenarios.
3. It is suggested that researchers focus on developing and testing specific educational modules based on the ethnomodels studied. Pilot programs could be implemented in schools to assess the effectiveness of these modules in improving students' understanding of mathematical principles. Feedback from educators and students should be gathered to refine and enhance these modules, ensuring they meet educational objectives and resonate with students' experiences.
4. Educators and curriculum developers are encouraged to collaborate with professionals from various fields to design and implement contextualized teaching resources. Such collaboration can help create more dynamic and engaging learning materials that reflect real-world applications of mathematics. It is also important to continuously evaluate and update these resources based on evolving industry practices and educational needs.

The study highlights the potential benefits of integrating ethnomodels into mathematics education, particularly in bridging the gap between theoretical knowledge and practical application. By leveraging real-world examples and practices, educators can foster a more meaningful learning experience for students, preparing them to apply mathematical concepts effectively in various professional contexts.

Adopting a mixed-methods approach, expanding research to include diverse ethnomodels, developing and piloting specific educational modules, and fostering collaboration between educators and professionals are key recommendations. These steps will help enhance the integration of ethnomodels into mathematics education, ultimately providing students with valuable skills and insights applicable to real-world scenarios.

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