MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2026, 22(9), em2899
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/19123

Fostering arithmetic problem-solving in primary education through didactic sequences with ethnomathematical connections using chontaduro commercialization

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Received 08 January 2026 ▪ Accepted 23 February 2026

Abstract
The literature shows that primary, secondary, and higher education students have difficulty solving problems involving arithmetic operations. The research goal was to implement a teaching sequence based on the ethnomathematical connections identified in the marketing of chontaduro in Santander de Quilichao, Cauca, Colombia, to promote the resolution of additive and multiplicative problems in primary school children. The research was based on the extended theory of connections, the typology of additive and multiplicative problems according to semantic structure, and universal activities. This is a qualitative-exploratory research with an ethnographic approach developed in two large stages. In the first, the daily practices of chontaduro marketing were analyzed. The merchant was selected and interviewed, and then the data were analyzed to identify ethnomathematical knowledge. The second stage included three moments: selection of volunteer students from a public institution in Santander de Quilichao; design of a didactic-ethnomathematical sequence based on the practice of chontaduro marketing and additive and multiplicative structures; and development of the seminar-workshop with the students to analyze problem-solving. The results showed that, in the sale of chontaduro in different units (bags, segments, and bundles) and in the counting processes, arithmetic operations with money are fundamental for solving and understanding additive problems (change, combination, comparison, and equalization) and multiplicative problems (multiplying factor, repeated addition, ratio, or proportion). This type of ethnomathematical teaching sequence has allowed students to consistently solve problems that involve everyday practices in their immediate sociocultural context.

Keywords: problem-solving, primary school, ethnomathematical connections, didactic sequence

INTRODUCTION

In the teaching and learning of mathematics at all school levels, problem-solving is essential, since it allows the development of mathematical knowledge considering the skills of quantitative reasoning, communication, argumentation, critical reading, creative thinking, etc. (Basri et al., 2025; Cai & Rott, 2024; Krawitz et al., 2025; Ministry of National Education [MNE], 2006; National Council of Teachers of Mathematics [NCTM], 2000; Rodríguez-Nieto et al., 2023b; Verschaffel et al., 2020; Wren et al., 2025) and

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Contribution to the literature

- The article uses a portion of the extended theory of connections (ETC), demonstrating the functionality of ethnomathematical connections in everyday practices and their relationship to the sale of chontaduro fruit.
- It proposes a two-stage qualitative-ethnographic design that allows for the identification of implicit ethnomathematical knowledge in everyday practices and its transformation into a contextualized didactic sequence for primary school children.
- It demonstrates that the use of chontaduro sales promotes the understanding and consistent resolution of arithmetic problems in school contexts.

requires the establishment of mathematical connections involved in the step-by-step process activated by the person at the time of solving (Font & Rodríguez-Nieto, 2024; Rodríguez-Nieto et al., 2025b). MNE (2016) mentions that additive problem-solving is present in several curricular materials, such as the basic learning rights (BLR) (MNE, 2016), which include problems based on additive structures and their resolution processes.

Problem-solving deepens mathematical understanding and fosters critical thinking and adaptability, essential skills beyond the academic realm. Particularly when working with additive structures, students gain a solid foundation for tackling more complex concepts and understanding how mathematical principles apply to real-world situations (Ekdahl et al., 2024; Ufer et al., 2024). Arithmetic word problems (AWP), especially additive ones, enhance the ability to solve daily problems with basic operations and initiate algebraic thinking (Livaque, 2018). Nesher (1999) and Socas and Bueno (1997) classify them into change, combination, comparison, and equalization. Nesher (1999) also identifies four recognition levels: level 1 (counting), level 2 (change), level 3 (part-whole), and level 4 (directional relationships). Polya and Zugazagoitia's (1965) methodology understanding, planning, executing, and reviewing is central to problem-solving. Difficulties with additive and multiplicative operations often stem from interpreting problems in verbal, numerical, or graphical forms and from poor data comprehension. Castro et al. (1995) note that many challenges in additive or subtractive problems arise from limited understanding of arithmetic calculation, where addition and subtraction are taught simplistically, without addressing deeper properties, which undermines mathematical learning.

The literature has identified various investigations on additive word problems. Rodríguez-Nieto et al. (2019) note that the most common difficulties involve comparison and equating structures, arising from errors in different solution phases. Factors such as data order, sentence structure, and unknown placement are crucial. Livaque (2018), Rodríguez-Nieto et al. (2019, 2023b), and Pacheco (2019) emphasize that implementing additive problems in the classroom enhances teaching and learning. Pacheco (2019) stresses the relevance of didactic strategies and technological tools to motivate students. Pinzón-Pérez and González-Palacio (2022) argue for linking additive problems to real-life contexts to foster understanding, connecting daily life and arithmetic. Ayala-Altamirano et al. (2022) highlight that word problems help transfer abstract thinking to concrete situations, supporting algebraic thinking. Rojas and Sotelo (2022) identify common errors such as misinterpreting statements and difficulty translating them into arithmetic language. Students struggle with comprehension, literal translation, and incorrect algorithm application. Ekdahl et al. (2024) note that young students lack effective strategies for subtraction problems, even within 1-20. They also lack adequate heuristics and reasoned justifications. Rum and Juandi (2022) affirm that challenges include both arithmetic calculations and statement interpretation. At advanced levels, difficulties persist in interpretation, mathematical modeling, and reasoning explanation.

From the ethnomathematics approach, several studies have addressed arithmetic involving addition and subtraction. Aroca (2015) proposed that addition equals subtraction, exploring algorithms, visual language, gestural numerical communication, and mental calculation in the bus calibrator activity in Colombian cities and large municipalities. Other works identified arithmetic operations in the calculation system of the Marosok trade tradition of the Minangkabau Tribe in West Sumatra (Nurjanah et al., 2021), and in the tong tong galitong ji game, whose five stages include addition, subtraction, multiplication, arithmetic operations modulo 6 and modulo 3, arithmetic sequences, and, in stage five, probability (Susanti, 2020). However, research on ethnomathematical connections has given limited attention to arithmetic aspects, focusing more on geometric ones, such as the shapes and materials used to structure artifacts (Breda et al., 2023; Olivero-Acuña et al., 2025; Rodríguez-Nieto, 2021; Rodríguez-Nieto & Escobar-Ramírez, 2022; Rodríguez-Nieto et al., 2023a, 2025a; Sudirman et al., 2024)

Now, research has been carried out on chontaduro regarding the production of flavored beverages (Segovia, 2015), on the production of beer by the Wamani Community, Archidona Canton (Calapucha-Licuy, 2019), and on the effectiveness of the seed in removing turbidity (Mendoza & Rodríguez, 2024) with a scientific and commercial perspective. Ibarra and Ayala

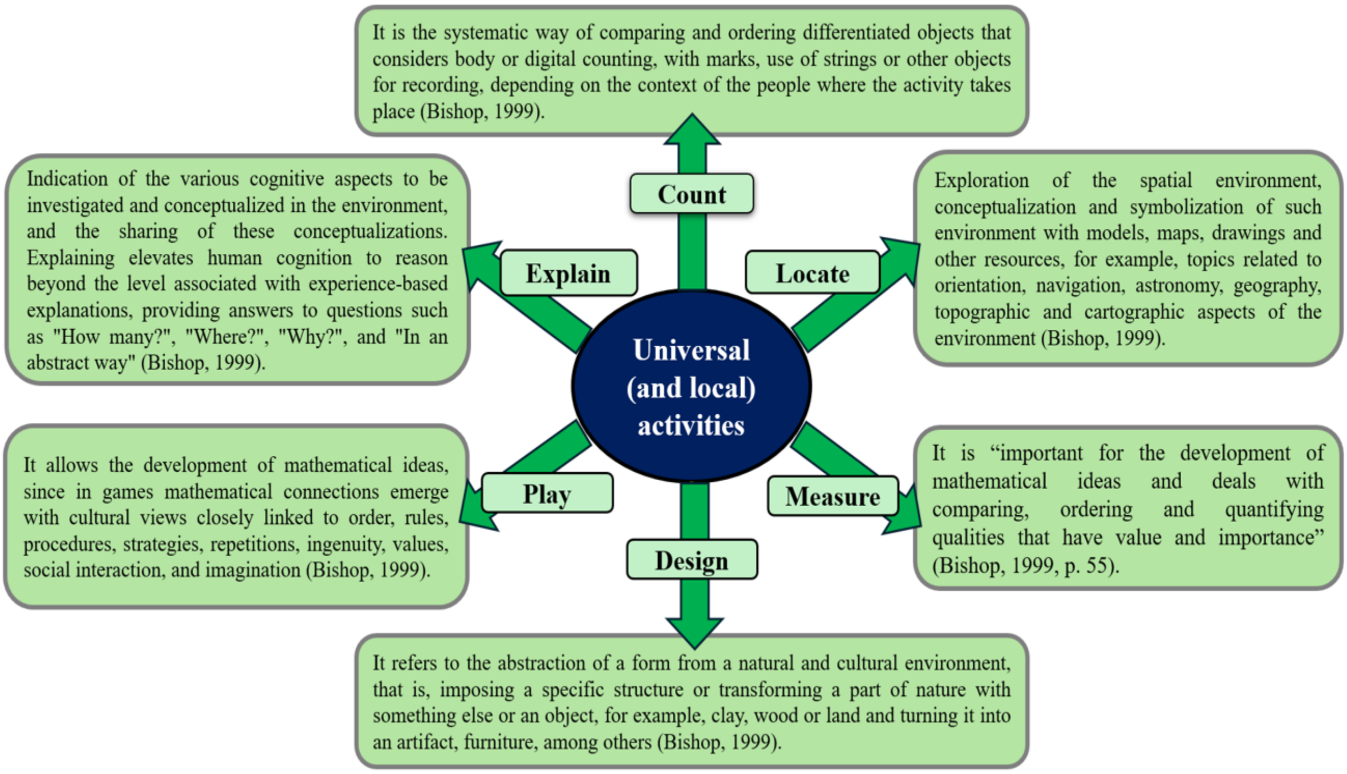


Figure 1. Universal and local activities proposed by Bishop (1999) (Source: Authors' own elaboration)

(2022) addressed the factors that influence the consumption of chontaduro through a strategy to innovate and strengthen marketing. However, there is no research on chontaduro that investigates the mathematical knowledge involved in planting and sales, which would promote the teaching and learning of mathematics from a sociocultural perspective.

Studies on additive problems confirm that students’ difficulties often stem from an incorrect use of operations and a limited understanding of the statement, influenced by semantic and syntactic variables (Capone et al., 2021; Kullberg et al., 2024; Riley & Greeno, 1988). It is also essential to identify students’ level of arithmetic knowledge and the mathematical processes they employ when solving these problems, analyzing both successes and errors (Doz et al., 2023; Rojas & Sotelo, 2022; Verschaffel et al., 2020). In fact, the lack of richness in the situational context of additive problems is an aspect that would be substantially improved through assessments of everyday practice explored from the perspective of ethnomathematical connections, which have been important in other problem-solving contexts (Rodríguez-Nieto et al., 2023a). Considering this problem, the following research question arises:

How to implement a teaching sequence based on emerging ethnomathematical connections from the commercialization of chontaduro and its links with curricular materials to promote the resolution of additive and multiplicative problems in primary school children?

THEORETICAL FOUNDATION OF THE RESEARCH

Ethnomathematics

Ethnomathematics studies how indigenous or urban communities, children, and adults, practice and use mathematics through their own traditions and goals (D’Ambrosio, 2001). This discipline explores the ways in which elements are counted, measured, played, classified, and ordered in diverse cultures and is closely related to Mathematics Education, analyzing the cultural influence on mathematics teaching (Gerdes, 2013). It is emphasized that universal and local activities such as counting, measuring, and designing, present in the daily lives of all cultures, contribute to mathematical knowledge (Bishop, 1999).

Universal Activities

Bishop (1999) proposed that, regardless of culture or context, there are certain universal mathematical activities that humans practice to understand and organize the world (see **Figure 1**).

Ethnomathematical Connections

This research uses a part of the ETC, since it does not consider intra-mathematical and extra-mathematical connections, but only ethnomathematical connections. In this context, considering sociocultural aspects of mathematics education, the ethnomathematical connection is the relationship between the mathematical

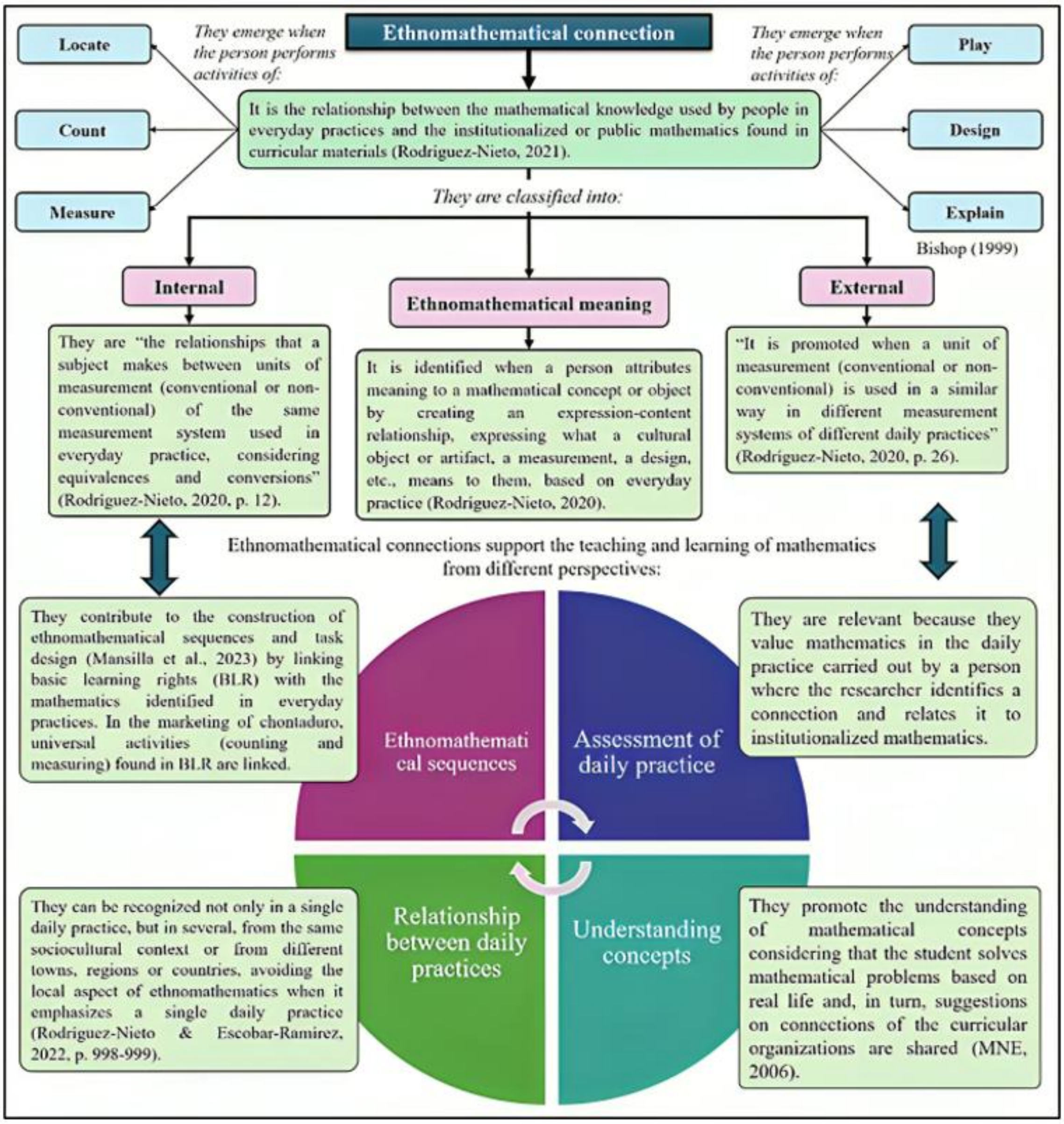


Figure 2. Ethnomathematical connections and main aspects (Source: Authors' own elaboration)

knowledge that people apply in their daily activities and the formal or institutional mathematics found in textbooks (Rodríguez-Nieto, 2021). These connections are divided into three types: internal, external, and those with ethnomathematical meaning (Rodríguez-Nieto, 2020; Rodríguez-Nieto et al., 2023a); see **Figure 2**.

It should be noted that these types of ethnomathematical connections and different points of view are not the only ones that exist, but that others may emerge as the literature progresses.

Problem-Solving in Mathematics Education

Before referring to problem-solving, it is important to highlight that a problem is a challenging situation (numerical, written, or verbal) that contains data, an unknown quantity, where the subject must establish relationships to respond to the challenge or question, which in most cases the solution is not immediate (Rizo & Campistrous, 1997). In this research, an arithmetic problem in its statement:

> They present data in the form of quantities and establish quantitative relationships between them, whose questions refer to the determination of one or several quantities or their relationships, and which require the performance of arithmetic operations for their resolution (Echenique, 2006, p. 30).

This implies that arithmetic problems are classified as additive and multiplicative and in most curricular organizations, problem-solving is presented as a competence based on the individual autonomously solving challenging mathematical problems (Common Core State Standards Initiative [CCSSI], 2018; Vergnaud, 1991).

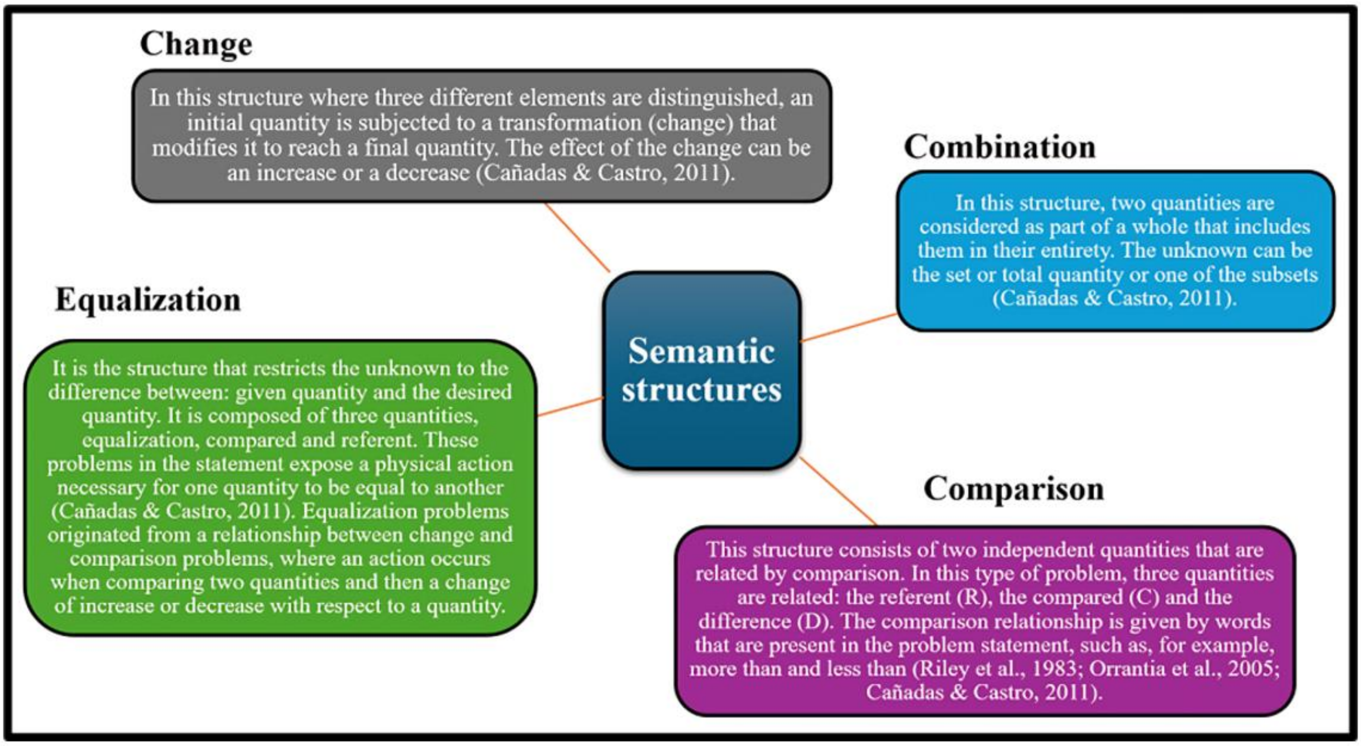


Figure 3. Semantic structure categories in additive problem-solving (Source: Authors' own elaboration)

Arithmetic Word Problems (Additives) and Semantic Structure

A typology of AWP additive is presented. Their resolution is based on the semantic structure, which includes the meanings of the words, symbols, and relationships involved in the problem (Orrantia et al., 2005; Van Dijk & Kintsch, 1983). Rodríguez-Nieto et al. (2019) points out that the degree of difficulty of the problems depends on their consistency. Consistent problems involve a direct model, such as "win" or "more than," which facilitates their understanding. Inconsistent problems, on the other hand, are more difficult, since they require reconstructing both the semantic structure and the meaning. Additive problems are classified according to their semantic structure into four categories (**Figure 3**): change, combination, comparison, and equalization, which constitute a useful framework for solving verbally stated problems.

It is worth noting that change and equalization problems are considered dynamic, while combination and comparison problems are static (Cañadas & Castro, 2011). The syntactic component refers to the order and relationships between the data, words, and symbols contained in the problem statement, as well as the place occupied by the unknown quantity (Cañadas & Castro, 2011; Orrantia et al., 2005; Rodríguez-Nieto et al., 2019). See **Table 1** for examples.

Table 1. Classification of additive problems according to semantic and syntactic structure

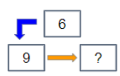
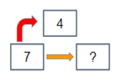
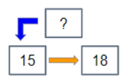
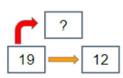
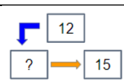
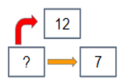
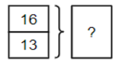
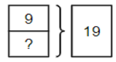
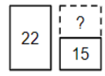
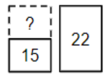
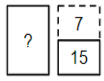
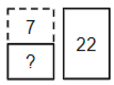
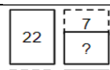
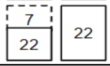
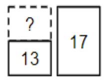
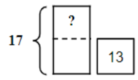
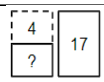
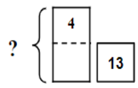
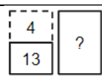
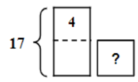
Semantic structures		AWP additive	Scheme
Unknown in the final quantity	Change 1 (increase)	Pedro has 9 apples and was given another 6 apples. How many apples does he have now?	
	Change 2 (decrease)	Pedro has 7 apples and gave away 4. How many apples did he have left?	
Unknown in the quantity of change	Change 3 (increase)	Felipe had 15 apples. He was given some apples. Now he has 18 apples. How many apples did he receive?	
	Change 4 (decrease)	Felipe had 19 apples. After giving away some apples, he has 12 left. How many apples did he give away?	
Unknown in the initial quantity	Change 5 (increase)	Antonio had some apples and was given 12 apples. If he now has 15 apples, how many apples did he have at the beginning?	
	Change 6 (decrease)	Antonio had some apples and gives away 12. If he now has 7 apples, how many apples did he have at the beginning?	

Table 1 (Continued).

Semantic structures		AWP additive	Scheme
Unknown in the whole	Combination 1	Camilo has 16 yellow crayons and 13 blue ones. How many does he have in total?	
Unknown in one part	Combination 2	Camilo has 19 crayons, some are white and others are blue, if 9 are white, how many are blue?	
Unknown in the difference	Comparison 1 (increase)	Marcela has 22 pencils and Camilo has 15. How many more pencils does Marcela have than Camilo?	
	Comparison 2 (decrease)	Camilo has 15 pencils and Marcela has 22. How many fewer pencils does Camilo have than Marcela?	
Unknown in the compared	Comparison 3 (increase)	Camilo has 15 pencils. Marcela has 7 more pencils than Camilo. How many pencils does Marcela have?	
	Comparison 4 (decrease)	Marcela has 22 pencils. Camilo has 7 fewer pencils than Marcela. How many pencils does Camilo have?	
Unknown in the referent	Comparison 5 (increase)	Marcela has 22 pencils, 7 more pencils than Camilo. How many pencils does Camilo have?	
	Comparison 6 (decrease)	Camilo has 15 pencils, 7 pencils less than Marcela. How many pencils does Marcela have?	
Unknown in the equalization	Equalization 1 (increase)	Felipe has 17 shirts and Julián has 13 shirts. How many shirts does Julián have to earn to have as many as Felipe?	
	Equalization 1 (decrease)	Felipe has 17 shirts and Julián has 13 shirts. How many shirts does Felipe have to give away to have as many as Julián?	
Unknown in the compared	Equalization 3 (increase)	Felipe has 17 shirts and Julián is given 4 shirts. How many shirts does Julián have to buy to have the same quantity as Felipe?	
	Equalization 4 (decrease)	Julian has 13 shirts. If Felipe gives away 4 shirts, he will have as many as Julian. How many shirts does Felipe have?	
Unknown in the referent	Equalization 5 (increase)	Julian has 13 shirts and needs to buy 4 more shirts to have as many as Felipe. How many shirts does Felipe have?	
	Equalization 6 (decrease)	Felipe has 17 shirts, and if he gives away 4 shirts, he'll have as many as Julian. How many shirts does Julian have?	

Note. Information adapted from the work of Cañadas and Castro (2011), Orrantia et al. (2005), and Rodríguez-Nieto et al. (2019) & blue refers to addition and red to subtraction

Multiplicative Problems

Multiplication is learned after addition and subtraction, and is related to concepts such as decimals, fractions, and proportions (Aguirre, 2011). To understand the multiplicative structure, it is necessary to understand the additive structure. Vergnaud (1991) studied the conceptual fields of these structures, defining them as sets of problems that allow for arithmetic operations and additive concepts. That is, multiplicative structures are conceived as the set of situations that require multiplication, division, or a combination of such operations. The first advantage of this approach through situations is that it allows for the generation of a classification based on the analysis of cognitive tasks and the procedures that can be implemented in each of them (Vergnaud, 2012).

Multiplicative structures are one of the most difficult topics in the classroom today, and even more so when we talk about the three fundamental types in the mathematics curriculum guide, as shown in the MEN (2006): groups of variables, combinations and comparisons. Vergnaud (2012) identify four types of multiplicative problems: multiplying factor (MF), repeated addition, ratio and Cartesian product. This work focuses on the first three:

1. **MF:** Multiplicative relationship between objects/events, expanding or reducing a magnitude with quantifiers.
2. **Repeated addition:** Multiplication as the repeated addition of equal quantities.
3. **Ratio or proportion:** Direct multiplication to find the total and inverse multiplication to find a single-digit value (Table 2).

Didactic Sequence

A didactic sequence is understood as:

Table 2. Classification of the multiplicative structure according to Vergnaud (2012)

Type of problems	Examples according to their classification
Multiplying factor	Direct multiplication: Amplification of a magnitude. Felipe has 25 balls, Marcela has 3 times more than Felipe. How many balls does Marcela have? Inverse multiplication: Finding quantifiers. Felipe has 20 balls and Marcela has 60 balls. How many times as many balls does Marcela have compared to Felipe? Inverse multiplication: Reducing magnitude. Marcela has 24 balls, 6 times more than Felipe. How many balls does Felipe have?
Repeated addition	If we combine 4 bags of candy with 7 units in each bag, we can achieve the same result by adding. Thus, 7 + 7 + 7 + 7 = 28 is equivalent to the multiplication equation 7 x 4 = 28.
Ratio or proportion	Direct multiplication: Finding the total. It takes 6 chontaduros to fill a pound bag. How many chontaduros are needed to fill 7 pound bags? Inverse multiplication (single digit). To fill a bag of chontaduros you need 6, with 72 chontaduros how many bags can be filled?

Table 3. Example of an indicative proposal for constructing a teaching sequence (data taken from Díaz-Barriga, 2013)

Section	Description/content
Subject	Mathematics
Thematic unit or location of the program within the general course	Functions and their applications in real-life contexts
General topic	Understanding and interpreting functions through graphical and algebraic representations
Contents	Concept of function; domain and range; linear and quadratic functions; interpretation of graphs; relationships between variables.
Duration of the sequence and number of sessions planned	3 weeks–6 sessions of 90 minutes each
Name of the teacher who created the sequence	Prof. [Name of the teacher]
Objectives	Promote understanding of the function concept, encourage reasoning about variable relationships, and apply functions to model real-world situations.
If the teacher deems it appropriate, choice of a problem, case or project	Design a small project in which students model a real situation (e.g., cost, revenue, or motion) using a linear or quadratic function.
General guidelines for evaluation	Evaluation is based on conceptual understanding, problem-solving, argumentation, and application in contextualized situations.
Structure and evaluation criteria for the evidence portfolio; guidelines for completing and using the exams	The portfolio includes activity records, problem solutions, and reflections on learning. Exams assess reasoning and the ability to connect representations.
Didactic sequences	They are designed to respond to the following principles: connecting content to reality; connecting content knowledge and student experience; using digital applications and resources; and accessing learning evidence.
Timeline of the teaching sequence	Opening activity: Exploration of real situations involving relationships between variables. Development activity: Construction and analysis of functions using digital tools (GeoGebra, Desmos). Closing activity: Presentation of the project or problem solution and reflection on learning.
Line of evidence for learning assessment	Conceptual understanding of functions, interpretation of graphs, and application to real contexts.
Evidence of learning (if applicable, evidence of a problem or project)	Project report, function model, presentation, and portfolio reflections.
Resources	Bibliographic: mathematics textbooks and academic articles. Newspaper and cybergraphic: online simulations, educational videos, and datasets.

> The result of establishing a series of learning activities that have an internal order between them, with this we start from the teaching intention of recovering those previous notions that students have about a fact, linking it to problematic situations and real contexts in order that the information that the student will access in the development of the sequence is significant, makes sense and can open a learning process, the sequence demands that the student do things, not routine and monotonous exercises, but actions that link their knowledge and previous experiences, with some question that comes from reality and with information about an object of knowledge (Díaz-Barriga, 2013, p. 19-20).

For the purposes of this mathematical research connected to the sociocultural context, the didactic-ethnomathematical sequence refers to a set of activities consisting of additive word problems related to real-life contexts, such as the everyday practice of chontaduro. A proposal for constructing the didactic-ethnomathematical sequence is shown below (**Table 3**).

Table 4. Personal information of chontaduro merchants

Participants	Age (years)	Education level	Years of experience in daily practice	Reasons why he became a chontaduro merchant
Cecilia (P1)	67	Up to 2nd year of primary school	42	Cecilia sold chontaduro to support herself and her family financially (daily practice).
Delfín Casanova (P2)	58	Up to 9th grade of secondary school	30	Delfín sells chontaduro because he likes it and it is a good source of income.

Table 5. Types of questions in the interview protocol (adapted from Rodríguez-Nieto & Escobar-Ramírez, 2022)

Type of questions	Description
General questions: These are short-answer questions used to build relationships between researchers and participants.	What is your name?, How old are you and how long have you been doing this work?, What is your educational level?, What motivated you to sell chontaduro?
Questions for exemplification: These are those that lead to a discussion on the topic being studied.	Over time in this work, have you developed any kind of strategy for purchasing and marketing chontaduro?, Where can you buy chontaduro?, And how do you buy it?
Structural questions: These focus on opening discussions about the main topics of the research.	What does buying and selling chontaduro involve?, Where is it packaged?, How is it sold?, What is the price?
Contrast questions: Allow participants to determine their final positions on the main issues.	How is the best way to sell chontaduro?, Is there a classification for chontaduro?, In the different bags you see in the market, according to capacity, how many chontaduros can each bag hold?

METHODOLOGY

This qualitative exploratory research with an ethnographic approach was developed in two main stages. The first stage analyzed daily practice of chontaduro marketing, encompassing three phases: selection of participating merchants; conducting semi-structured interviews to collect data; and analyzing these data to identify the ethnomathematical knowledge used by the merchants. The second stage included three moments (m): m1: selection of participating elementary school students from a public institution; m2: design of an ethnomathematical teaching sequence based on chontaduro marketing practices and additive and multiplicative problems; and m3: development of a seminar-workshop with elementary school students where the ethnomathematical teaching sequence was applied.

Stage 1. Based on Ethnography

The selected participants (from stage 1) are chontaduro merchants from the Municipality of Santander de Quilichao who work daily and are recognized in their community (described in **Table 4**). They voluntarily participated in semi-structured interviews. Cecilia, 67 years old, is a native of La Capilla and has 42 years of experience in chontaduro farming and marketing. Although she only completed part of primary school, she has worked in agriculture for most of her life, focusing on natural products from Cauca. Delfín, 58 years old, has 30 years of experience and studied through basic secondary school. He became interested in marketing chontaduro from a young age due to its high demand and economic importance. Both are well-versed in the benefits of chontaduro, as well as the conditions for its distribution and marketing.

Figure 4. Third grade primary school students (Source: Field study)

To collect information in the ethnographic stage (phase 2), questions were posed to apply the semi-structured interviews (**Table 5**), however, during the course of the dialogue other questions emerged to delve deeper into the topic in question (Restrepo, 2016).

During fieldwork, audio recordings, interviews, and photographs were used to record data. In one of the interviews, relevant data were collected and used to answer the questions, which contains the traders' personal information. Data analysis was carried out considering the ethnomathematical connections presented in the theoretical foundation.

Stage 2. Ethnomathematical Connections and Problem-Solving in the Classroom

This stage was developed in three moments: at *moment 1*, 10 students (P3, …, P12) from the third grade of primary education at the Dominguillo Technical Agricultural Educational Institution, La Capilla headquarters, aged between 7 and 8 years, participated voluntarily (see students in **Figure 4**).

At *moment 2*, a didactic-ethnomathematics sequence was designed based on the practice of marketing

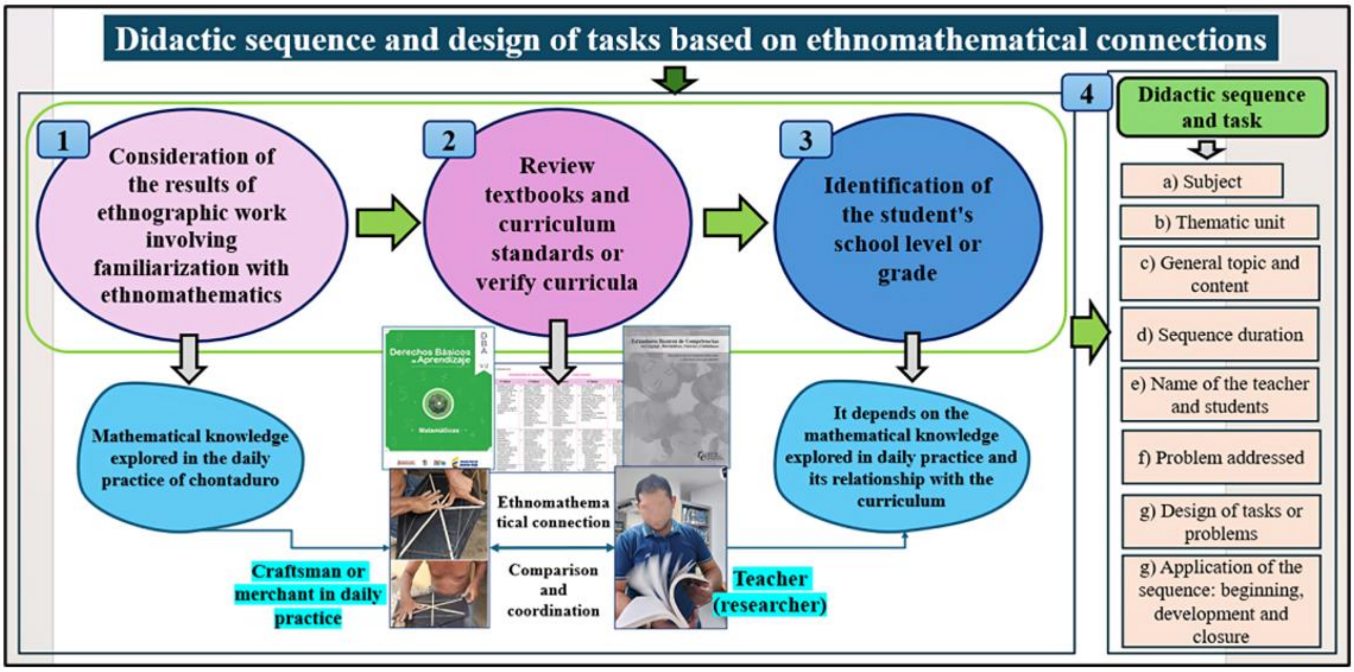


Figure 3. Model for the design of a didactic-ethnomathematical sequence (Source: Authors' own elaboration)

chontaduro, taking into account the difficulties in additive and multiplicative structures to contextualize mathematical knowledge in problem-solving (AWP additives) and multiplicative, based on the models of Mansilla et al. (2023), Rodríguez-Nieto and Castro (2023), and Díaz-Barriga (2013). The model for creating the sequence comprises four phases: Consideration of ethnographic results and familiarization with ethnomathematics; review of textbooks and competency standards as ethnocurricular dialogue to establish ethnomathematics connections; selection of the school grade to be consistent with the students' school level; and design and implementation of the didactic sequence together with the tasks or problems, following three activities: opening, development, and closing activities (**Figure 5**).

At *moment 3*, a seminar-workshop was held with third-grade students, who were given audiovisual recordings for their research project. This research focused on the ethnomathematics teaching sequence, which addresses problem-solving associated with contextualized additive and multiplicative AWP (ethnomathematics). Data analysis was based on the theoretical foundation of additive problems and ethnomathematical connections.

RESULTS

Stage 1 Results

In the third phase of the first stage of this research, the ethnomathematical knowledge in the daily practice of two chontaduro traders is reported and ethnomathematical connections with the curriculum and the BLR are established.

Ethnomathematical connections in the commercialization of chontaduro

In this daily practice, merchants constantly use units of measurement, counting processes with money, explanations according to their sociocultural context and decision making (universal activity of playing). Specifically, the analysis identified some initial codes (Cd), as shown in **Table 6**.

Table 6. Examples of codes according to universal activities

Codes	Description	Universal activity identified
Cd1	There are three types: red, green, and yellow chontaduro; the red one is the most common in Cauca.	In Cd1 and Cd2, the universal activities of counting and explaining were identified, because P2 mentioned the typology of chontaduros and their characteristics.
Cd2	Chontaduros are classified into male and female.	
Cd3	Chontaduro is sold by bunch or individually (gestures with his hands to show the chontaduro)	In Cd3, the universal activity of measuring was recognized because the clusters and the unit refer to the unit of measurement, which, in fact, is a counting process by repeating the unit or cluster.

Table 6 (Continued).

Codes	Description	Universal activity identified
Cd4	A bunch can cost between 60 thousand and 70 thousand dollars or more, depending on the quality and size of the bunch.	In Cd4 and Cd5, the activity of counting is evident, as well as the use of mathematical justifications related to the size of the bunch. Furthermore, in Cd5 P1 makes the decision about the price of chontaduro, which invites us to reflect on the activity of playing.
Cd5	Chontaduro is sold at one or two thousand pesos per unit; three units cost 3,000 pesos, five units cost 5,000 pesos, and so on. It depends on the customer's choice of quantity. Chontaduro is topped with honey and salt to make it more delicious.	

Figure 6. Counts at the chontaduro sale (Source: Field study)

Figure 7. Prices in the marketing of chontaduro (Source: Field study)

Table 6 summarizes the identification of ethnomathematics in chontaduro marketing. In addition, P1 details other ethnomathematical knowledge related to universal activities. For example, P1 assigns a value of $1,000 per unit of chontaduro, $7,000 per kilo when it is at a good price, and $78,000 per bunch, depending on size, with a bunch that can have 120 units. Bags of chontaduro at the market cost between $3,000 and $5,000. These data allow for situations of change, combination, comparison, and equalization, and multiplicative structure depending on the quantity of chontaduro purchased and the basic operation involved (see **Figure 6** and transcript excerpt).

Figure 6 shows the counts made by Ms. Cecilia during the initial interview, which will be used as input for the second stage of the research. **Figure 7** and **Figure 8** show the arithmetic calculations made by the merchant.

In the interview with merchant P1, the following key data were obtained:

Unit price: One unit of chontaduro costs $1,000.

Bag prices: Bags of chontaduro are priced at $3,000, $4,000, and $5,000.

Figure 8. Chontaduros packaged by ½ pound, kilos and per unit (Source: Field study)

Bunch price: A bunch of chontaduro sells for $78,000.

Price per kilo: A kilo of chontaduro recently sold for $7,000 but can vary between $4,000 and $6,000 depending on the merchant.

Amount in a kilo: One kilo of chontaduro contains between 29 and 32 chontaduros, and 4 kilos are equivalent to 116 to 128 chontaduros, with a value of $28,000 (see interview excerpt).

> (Interviewer 1) E1: How much does a chontaduro cost per unit?
>
> P1: If sold individually, they would be 1,000 pesos; two units would be 2,000 pesos … five units cost 5,000, and so on. That depends on the customer's quantity …
>
> P1: 1 finger is 1 chontaduro, two fingers are 2 chontaduros, 3 fingers are 3 chontaduros, (…) 5 fingers are 5 chontaduros, 6 fingers are 6 chontaduros in a bag, and so on … (counts fingers to indicate the unit).
>
> E1: How much do bags cost?
>
> P1: Bags cost 3,000, 4,000, 5,000 pesos. When they order a bunch of chontaduro, it sells for 78,000 pesos and up.
>
> E1: How much does a kilo of chontaduro cost?
>
> P1: I sold it about 15 days ago for seven thousand pesos (7,000 pesos). It's a good price, because when the price drops, a kilo sells for 4,000 pesos, other merchants can sell it for 6,000 pesos. That depends on the person; each one has their own prices.
>
> E1: And how many units does a kilo contain?

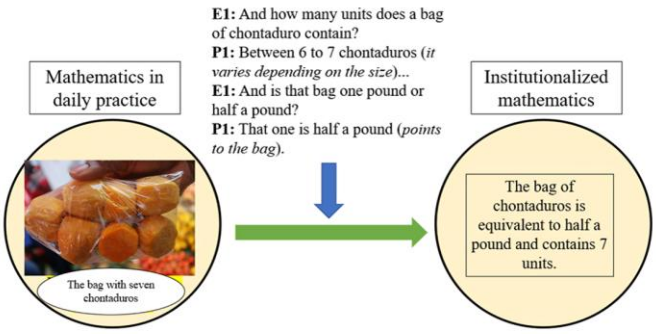


Figure 9. Ethnomathematical connection between the bag and the half pound (Source: Authors' own elaboration)

> P1: A kilo of chontaduro would contain between 29 and 32 chontaduros in different sizes. If you buy 4 kilos, that would be 116 or 128 chontaduros, and they would cost 28,000 pesos.
>
> E1: And how do you sell them? In bags, in bunches, or how do you deliver them?
>
> P1: If it's sold individually, it costs one thousand pesos and is packaged in transparent bags (moves hands to show the bags).
>
> E1: And how many units does a bag of chontaduro contain?
>
> P1: Between 6 and 7 chontaduros (varies depending on the size) ...
>
> E2: How many chontaduros are in a 1-pound bag?
>
> P2: They have to be weighed, but they can hold between 10 and 15 chontaduros. However, if they're not too big, chontaduros of all colors and sizes are added when packing. If you ask me to sell you a bag of 10 chontaduros mixed together, then you put it on the scale and whatever it says is what you charge ... there can be large sales of like a million; when we talk about a ton, it's six million.

Figure 11. Classification of chontaduros according to color (Source: Field study)

As merchants explain, chontaduro is sold in half-pound bags, one-pound bags, in kilos, or individually. These can be packaged already peeled or unpeeled (uncooked). This demonstrates the functionality of the ethnomathematical connection (see **Figure 9** and **Figure 10**) that links the unconventional unit of measurement of the bag with the (institutionalized) half-pound, which contains 6 to 7 units of chontaduro, depending on the size.

On the other hand, in the market the chontaduro has a classification, that is to say that there is the male and female chontaduro and their colors are red, green and yellow, but people consume the red chontaduro more (see **Figure 11** and the extract of the interview).

> E2: Which chontaduro sells the most, which one do people like the most, or do they all sell equally?
>
> P2: There are three types: red, green, and yellow chontaduro; the red is the most common in Cauca, but all types are sold, but the most bought is the red one, or if they say give me some of the yellow and the red one, then they add a sprig (referring to a twig) of yellow and another of the red one,

Figure 10. Variety of chontaduros and their respective prices that can be delivered (Source: Field study)

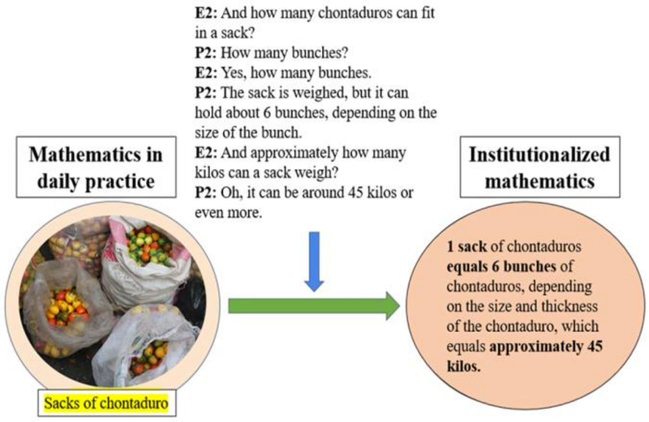


Figure 12. Ethnomathematical connections between the chontaduro bundle and kilo (Source: Authors' own elaboration)

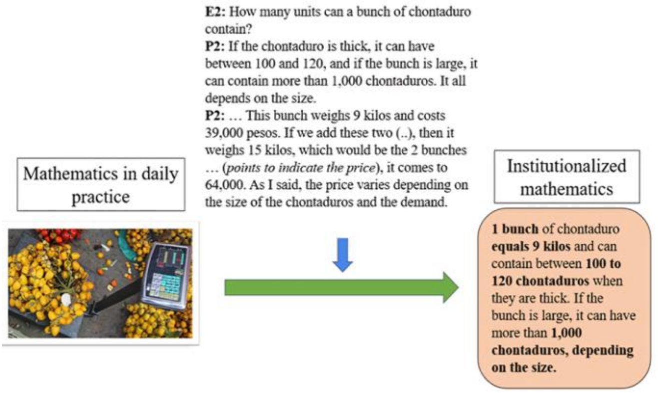


Figure 13. Non-conventional measurement of connected bunch with its weight in kilograms (Source: Authors' own elaboration)

although the yellow one is better, but they have more of the red one.

E2: And how many chontaduros can fit in a bag?

P2: The bundle is heavy, but it can hold about 6 bunches, depending on the size of the bunch.

E2: How many kilos more or less can a package weigh?

P2: Oh! It can be about 45 kilos or even more.

E2: I have seen that other merchants bring the chontaduros in boxes (referring to baskets) Do you also sell them like this?

P2: When they bring it in boxes (baskets) it is so that the product is not damaged, that is, so that it does not spoil, that is why it is brought in boxes, but they are also weighed to sell them like that.

These units of measurement expressed by P2 in relation to boxes are externally connected to units of measurement used by Mexican farmers with the tare weight or box (Rodríguez-Nieto et al., 2022). The ethnomathematical connections between the bundle, the bunch, and the kilograms are presented below (see **Figure 12**).

On the other hand, other non-conventional units of measurement are explored, such as the bunch, which contains approximately 100 to 150 chontaduros and even up to 1,000 chontaduros (**Figure 13** and extract from the interview).

E2: How many chontaduros does a bunch of chontaduro have?

P2: If the chontaduro is thick it can have between 100, 120 and if the bunch is large it can have more than 1,000 chontaduros depending on the size.

E2: So how much does a bunch cost?

P2: It is weighed and that is what is charged, it depends on the size so the price varies.

E2: So if it is weighed and, for example, it weighs 4 kilos or more, how much is the bunch worth?

P2: Let's weigh this one (points to the bunch) this bunch weighs 9 kilos and costs 39,000 pesos, let's place these two (places two bunches to weigh them) (...) there you have 15 kilos which would be the 2 bunches, here it shows you the quantity and here it shows you the price at once (points to indicate the price) there they are 64,000 pesos, as I said the price varies depending on the size of the chontaduros and according to the demand.

When marketing chontaduro, it's clear that each merchant has their own way of selling the product. For example, in the case of Doña Cecilia, she states that green chontaduro may be cheaper because it's not widely sold. Furthermore, this color of chontaduro has the distinctive characteristic of being macho, meaning it doesn't contain a seed (see excerpt from the interview).

P1: The green chontaduro is rarely seen, and the unit of this chontaduro is a little more economical.

E1: What is the price?

P1: If they are not too large, the unit would be worth 900 pesos, and if the customer buys about 20, they would cost eighteen thousand pesos.

The analysis of stage 1 concludes that dialogue with merchants reveals the use of conventional and nonconventional mathematics and arithmetic calculations in the marketing of chontaduro. This led to progress to stage 2 of the research, which will integrate this conventional mathematics with institutionalized mathematics. The didactic-ethnomathematical sequence will focus on solving additive and multiplicative AWP, based on the competency standards and BRL for third grade.

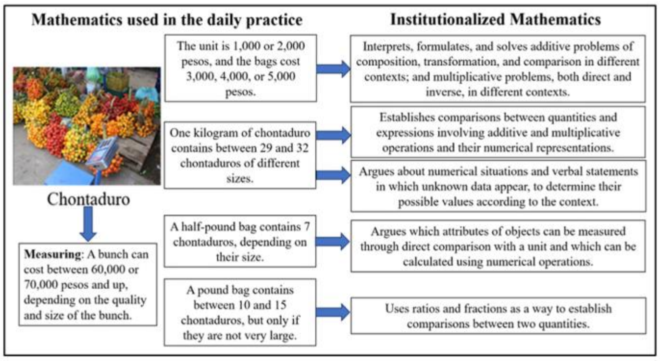


Figure 14. Measures in the commercialization of chontaduro and some of its ethnomathematical connections (Source: Authors' own elaboration)

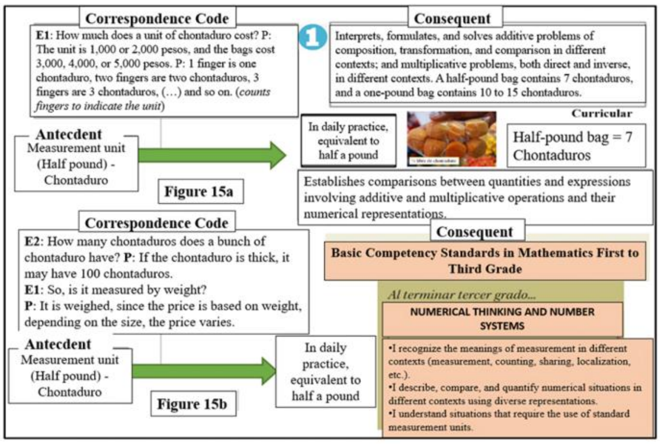


Figure 15. Correspondence code between the marketing of chontaduro and daily practice (Source: Authors' own elaboration)

Stage 2 Results

Design and implementation of a didactic-ethnomathematical sequence

The second stage of this research involved designing and implementing a didactic-ethnomathematical sequence based on the ethnomathematical knowledge identified in the results of stage 1 on the commercialization of chontaduro.

Familiarization with ethnomathematics: This section requires the researcher or professor to value the mathematics used by artisans, or in this case, chontaduro merchants. Specifically, mathematics related to universal activities was identified, such as units of measurement, counting processes with chontaduros, workstation locations, bag designs that connect with the unit of measurement of capacity, and decision-making related to sales, promotions, dialogue with customers, etc. All of this input, presented in stage 1 of ethnography, is essential for the development of stage 2.

Ethnocurricular dialogue and ethnomathematical connections: The ethnomathematical knowledge identified in the daily practice of chontaduro marketing is related to the contents of textbooks as well as the curricula or special documents published by the MNE (2006). In this case, the mathematical knowledge of the merchants is ethnomathematical knowledge and has been related to some BLR. There are ethnomathematical connections that link sales per unit, bags, segments and sacks with measurements and arithmetic operations, which adapts to the learning of mathematics in a real context. The objective is for the student to reason and create strategies to solve a problem and to have a better approach and understanding of addition, subtraction, and multiplication with basic operations that must be understood to avoid difficulties in higher grades.

Furthermore, Figure 14 represents the ethnomathematical connections that are linked to the basic competency standards in mathematics. While it is important to mention that these connections can be viewed from different perspectives, whether from a familiar context, as reflected in the marketing of chontaduro, they are simultaneously evident in the BLR and the MNE proposed to provide feedback for mathematics learning, where basic operations are algorithmically worked on.

Figure 15 shows other ethnomathematical connections from the everyday practice employed in the marketing of chontaduro, where ethnomathematical connections are embedded. This allows for the creation of contextualized problems taking into account different units of measurement (e.g., the unit, half a pound, the pound, or the kilo). In fact, the students' grade level is specified as third grade because it is consistent with the curriculum materials.

Design of the ethnomathematical sequence: Based on the model presented in Figure 5, the didactic-ethnomathematical sequence is structured. To do so, the subject, thematic unit, content, duration (time), names of the teacher and students, problem, task design, and implementation were taken into account (Table 7).

Table 7. Didactic sequence for solving additive and multiplicative AWP (data adapted from Díaz-Barriga, 2013)

Section	Description/content
Subject	Mathematics
Thematic unit or location of the program within the general course	Resolution of additive and multiplicative AWP
General topic	Additive and multiplicative problems according to their semantic structure
Contents	Semantic structure of additive problems (change, combination, comparison, and equalization) and multiplicative problems (multiplying factor, repeated addition, and ratio)

Table 7 (Continued).

Section	Description/content
Duration of the sequence and number of planned sessions	2 sessions, each lasting 1 hour and 40 minutes
Name of the professor who created the sequence	Authors of this article
Purposes	Analyze the resolution of additive and multiplicative problems by third-grade primary education students
If the teacher deems it appropriate, choice of a problem, case, or project	Difficulty solving additive problems with verbal statements and multiplicative structure (as described in the introduction)
Creation of tasks or problems	Semantic and syntactic structures are considered for designing AWP
Implementation of the didactic-ethnomathematical sequence	Solve additive and multiplicative AWP in the context of chontaduro commercialization
Trajectory of the didactic-ethnomathematical sequence	Opening: discussion on ethnomathematics and ethnomathematical connections in daily practice; development: Activities with additive word problems; & closing: activities with multiplicative structures (multiplying factor, repeated addition, ratio)
Resources	Bibliographic references, pencils, paper, erasers, markers, chontaduros, teaching sequence, and seminar-workshop

The following shows the steps from the design or creation of the tasks to the implementation of the didactic-ethnomathematical sequence.

Design of tasks based on the marketing of chontaduro: The tasks or problems were designed considering the context of the daily practice of chontaduro marketing (which involve the additive and multiplicative structure), which are presented in **Table 8** and **Table 9**.

Table 8. Classification of additive problems according to semantic and syntactic structure

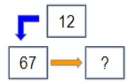
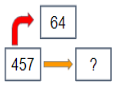
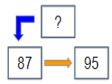
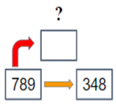
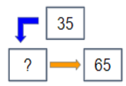
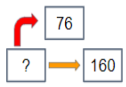
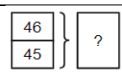
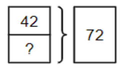
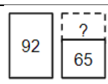
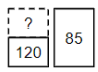
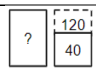
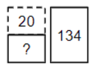
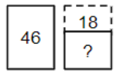
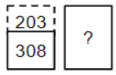
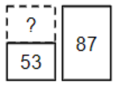
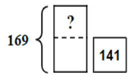
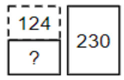
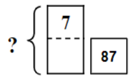
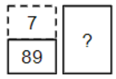
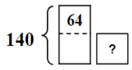
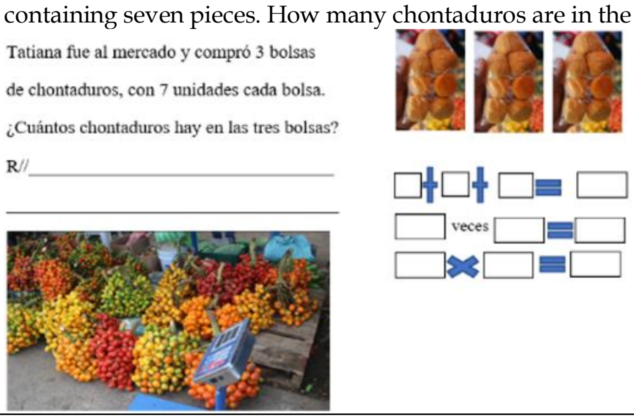
Semantic structures		AWP additive	Scheme
Unknown in the final quantity	Change 1 (increase)	Yeimy has 67 chontaduros and his aunt gave him 12 chontaduros. How many chontaduros does he have now?	
	Change 2 (decrease)	Yeimy has 457 chontaduros and gives 64 chontaduros to her brother. How many chontaduros did she have left?	
Unknown in the quantity of change	Change 3 (increase)	Yeimy had 87 chontaduros. She was given some chontaduros. Now she has 95 chontaduros. How many chontaduros has she been given?	
	Change 4 (decrease)	Tatiana had 789 chontaduros. After giving some chontaduros to her friend, she had 348 left. How many chontaduros did Tatiana give away?	
Unknown in the initial quantity	Change 5 (increase)	Tatiana had some chontaduros and her mother gave her 35. If she now has 65 chontaduros, how many chontaduros did she have at the beginning?	
	Change 6 (decrease)	Tatiana had some chontaduros and gave away 76 chontaduros. If she now has 160 chontaduros, how many chontaduros did she have at the beginning?	
Unknown in the whole	Combination 1	Camilo has 46 red chontaduros and 45 yellow chontaduros. How many chontaduros does he have in total	
Unknown in one part	Combination 2	Camilo has 72 chontaduros, some are green and others are red, if forty-two are green, how many are red?	
Unknown in the difference	Comparison 1 (increase)	Yeimy has 92 chontaduros and Camilo has 65 chontaduros. How many more chontaduros does Yeimy have than Camilo?	
	Comparison 2 (decrease)	Camilo has 120 chontaduros and Yeimy has 85 chontaduros. How many fewer chontaduros does Camilo have than Yeimy?	
Unknown in the compared	Comparison 3 (increase)	Camilo has forty chontaduros. Yeimy has 120 more chontaduros than Camilo. How many chontaduros does Yeimy have?	
	Comparison 4 (decrease)	Tatiana has 134 chontaduros. Camilo has 20 fewer chontaduros than Tatiana. How many chontaduros does Camilo have?	

Table 8 (Continued).

Semantic structures		AWP additive	Scheme
Unknown in the referent	Comparison 5 (increase)	Tatiana has 46 chontaduros, 18 chontaduros more than Camilo. How many chontaduros does Camilo have?	
	Comparison 6 (decrease)	Camilo has 308 chontaduros, 203 chontaduros less than Tatiana. How many chontaduros does Tatiana have?	
Unknown in the equalization	Equalization 1 (increase)	Yeimy has 87 chontaduros and Camilo has 53 chontaduros. How many chontaduros does Camilo have to buy to have as many as Yeimy?	
	Equalization 1 (decrease)	Tatiana has 169 chontaduros and Camilo has 141 chontaduros. How many chontaduros does Tatiana have to give away to have as many as Camilo?	
Unknown in the compared	Equalization 3 (increase)	Tatiana has 230 chontaduros. If Camilo buys 124 chontaduros, he will have the same number of chontaduros as Tatiana. How many chontaduros does Camilo have?	
	Equalization 4 (decrease)	Camilo has 87 chontaduros. If Tatiana sells 7 chontaduros, she will have as many as Camilo. How many chontaduros does Tatiana have?	
Unknown in the referent	Equalization 5 (increase)	Camilo has 89 chontaduros and needs to buy 7 more chontaduros to have as many as Tatiana. How many chontaduros does Tatiana have?	
	Equalization 6 (decrease)	Tatiana has 140 chontaduros and if she sells 64 chontaduros she will have as many as Camilo. How many chontaduros does Camilo have?	

Note. Information adapted from the work of Cañadas and Castro (2011), Orrantia et al. (2005), and Rodríguez-Nieto et al. (2019) & blue color refers to addition and the red to subtraction

Table 9. Tasks with multiplicative structure problems

Type of problems		Examples according to their classification
MF	Direct multiplication: Amplification of a magnitude.	(21) Camilo bought 25 chontaduros, Katherine has 3 times more than Camilo. How many chontaduros did Katherine buy? How much money did Katherine pay for the chontaduros if each one is worth $1,000?
	Inverse multiplication: Finding quantifiers.	(22) Camilo sold 12 chontaduros and Katherine 60 chontaduros. How many times more did Katherine sell in relation to Camilo?
	Inverse multiplicative: Reduction of magnitude.	(23) Katherine bought 24 chontaduros, 6 times more than Camilo. How many chontaduros did Camilo buy?
Repeated addition	If we combine 4 bags of candy with 7 units in each bag, we can achieve the same result by adding.	(24) Tatiana went to the market and bought three bags of chontaduros, each containing seven pieces. How many chontaduros are in the three bags? 
Ratio or proportion	Direct multiplication: finding the total	(25) Tatiana needs 7 chontaduros to fill a half-pound bag. How many chontaduros are needed to fill 12 half-pound bags?
	Inverse multiplication (single digit)	(26) A half-pound bag can hold 7 chontaduros. How many chontaduros will be needed to fill 14 bags? (27) To pack 77 chontaduros, 11 bags are required. How many chontaduros are needed to pack 5 bags? (28) If 14 chontaduros fit in 2 bags, how many bags are needed to pack 49 chontaduros?

Opening activities: For forty-five minutes, the students were explained some ethnomathematical knowledge involved in the commercialization of chontaduro and its importance in the community of La Capilla, Santander de Quilichao, highlighting arithmetic operations (see **Figure 16** and **Figure 17**).

Figure 16. Ethnomathematical connection to count and explain numerical relationships within the chontaduro trade (Source: Field study)

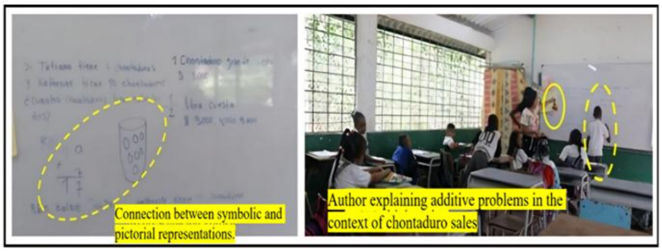


Figure 17. Pictorial graphics of additive problems (Source: Field study)

Development activity: This session is organized into two activities, each containing tasks classified according to the structures of change, combination, comparison, and equalization. The first activity was developed in which the researchers presented the additive problems (proposed in **Table 8**) to the students, who solved them using paper and pencil.

The second activity was conducted with the students in activity 2, which deals with multiplication problems. At times, they were questioned about the solution process implemented in order to gain more in-depth knowledge. Given space limitations, student P5 and student P8 were selected for the analysis of the first activity. They completely solved the sequence, and their responses were similar. This allows us to observe the problem-solving behaviors they engage in, considering the additive AWP solved based on their semantic structure and syntactic components.

The analysis of the change problems (C1, C2, C3, C4, C5, and C6) with unknowns in the final, initial and change quantities carried out by P5 and P8 are shown schematically in **Figure 18**.

To solve the first problem, P8 used the semantic structure of C1 increased with the unknown in the final amount (67 + 12 = 79) where 12 is the change or amount that modifies 67. In the second problem, P8 used a semantic structure of C2 subtraction with unknown in the final amount (457 - 64 = 393) where 64 is the amount that modifies 457. In this sense, a mathematical connection was identified in P8's procedure to answer the second question How many chontaduros did Yeimy have left at the end? where he used the semantic structure of change (C2) operand (393 - 24 = 369). Student P8 understands the place of the unknown in the

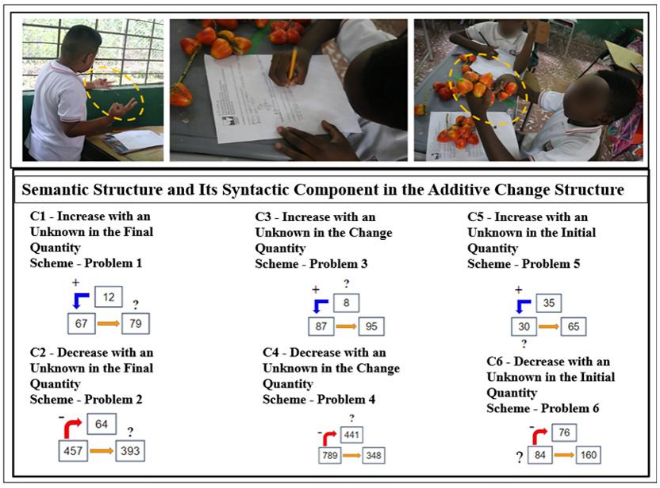


Figure 18. Resolution of change structure problems (Source: Field study)

statement, which allows him to operate directly because they are problems that can be solved by a direct resolution method (Rodríguez-Nieto et al., 2019). It was identified that nine students solved the change problems adequately and only one student had errors or did not make procedural connections because he did not solve the problems with C1 and C2 structures. It is worth noting that the intra-mathematical connections (procedural and different representations) are taken from the ETC because the students have used them in solving the problems (Rodríguez-Nieto et al., 2025a).

In solving the third problem, student P8 used the semantic structure of C3 increased with the unknown in the amount of change (87 + ? = 95) this structure depends on a modification (95 - 87 = 8) where 87 is the change or amount that modifies 95, giving as an answer P8 that "in total they have given him 8 chontaduros" it is evident that P8 recognized in the statement the unknown part which allowed him to operate correctly. Next, P8 to solve the fourth problem using the semantic structure of C4 decreased with the unknown in the amount of change (789 - ? = 348) and P8 carried out the following strategy (789 - 348 = 441) where 348 is the amount that modifies 789, in this way P8 gives as an answer "in total he gave him 441 chontaduros", in this semantic structure C4.

To solve the fifth problem, P8 used the semantic structure of change C5 increase with the unknown in the initial amount (? + 35 = 65) and operated considering the procedural connections to know the unknown value: 65 - 35 = 30 where 35 is the amount that modifies 65 to know the unknown of the problem. That is, P8 identified the change that had to be made by giving as an answer "in total at the beginning I had 30 chontaduros". In this way, it is recognized that student P8 establishes connections between the additive structures of change by activating procedural connections. To solve the sixth problem, P5 used the semantic structure of C6 of decrease with the unknown in the initial amount (? - 76 = 160), student P5 made the following procedural connection (160 - 76 = 84)

Figure 19. Example of some students using mathematical strategies (Source: Field study)

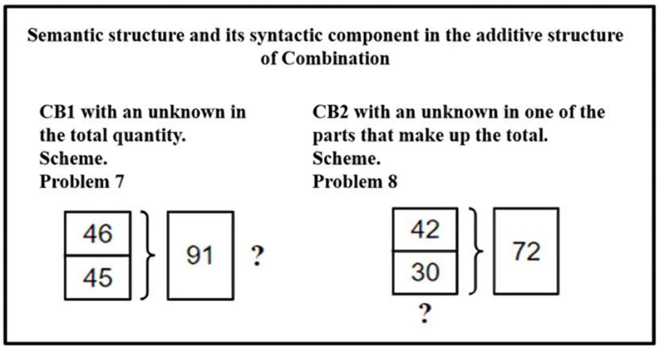


Figure 20. Schemes of the semantic structure and syntactic structure of combination (Source: Field study)

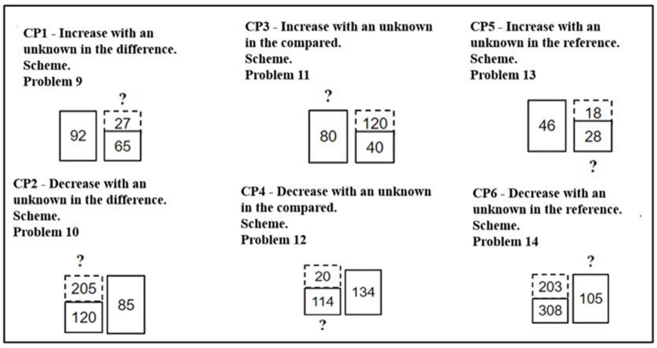


Figure 21. Schemes of the semantic structure and syntactic component in the resolution of comparison problems (Source: Field study)

where 76 is the change that modifies 160, the execution process allows him to identify the unknown amount and in turn find that amount that he had at the beginning.

In the case of the combination problems (seventh and eighth), student P8 used the operation 46 + 45 = 91 to solve the problem with the semantic structure of CB1 with an unknown quantity as whole. P8 solved the problem with the semantic structure of CB2 with an unknown quantity in a part that makes up the whole using the operation 72 - 42 = 30 where 42 is the quantity that was missing to complete 72 (see **Figure 19**).

Next, the semantic structures used by the students when solving the combination problems (**Figure 20**) manipulating the chontaduros are schematized.

In solving the ninth problem, P5 used the semantic structure of comparison CP1 increase with the unknown in the difference (92 - 65 = 27), meaning that his solution is consistent and is carried out directly, establishing a procedural connection and different representations. To solve the tenth problem, P5 used the semantic structure of CP2 decrease with the unknown in the difference (120 + 85 = 205); these quantities only require a comparison between the data (see **Figure 21**). To solve problem eleven, P5 activated the semantic structure of CP3: increase with the unknown in the comparison (80 + 40 = 120), which identifies that it includes the verbal statement and accounts for the syntactic component. In solving problem twelve of semantic structure CP4: decrease with the unknown in the comparison (134 - 20 = 114). In this sense, it is evident that the students used procedural mathematical connections and different representations associated with the part-whole scheme (**Figure 21**).

To solve problem thirteen, student P8 used the semantic structure CP5 increase with the unknown in the referent (46 + 18 = 64) where 18 is the change or amount that modifies 64, which is the difference in the referent. In this sense, only one student gave the correct answer and nine did not adequately respond to the additive AWP, which is why these problems present greater complexity when solving. Furthermore, it coincides with previous literature, which states that comparison problems are the most complex to solve. In solving problem fourteen, student P5 used the semantic structure CP6 decrease with the unknown in the referent, executing the mathematical connection procedure (308 - 203 = 105) where 203 is the change or amount that modifies 308, which is the difference found in the referent. It is worth mentioning that four of the students answered correctly and six did not give an account of the answer because they incorrectly used the operation that implicitly involves a procedural connection (**Figure 21**).

In the analysis of the equalization problems (EQ1, EQ2, EQ3, EQ4, EQ5, and EQ6) with unknown in the equalization, the compared and the referent, the following results were evident: to solve problem fifteen,

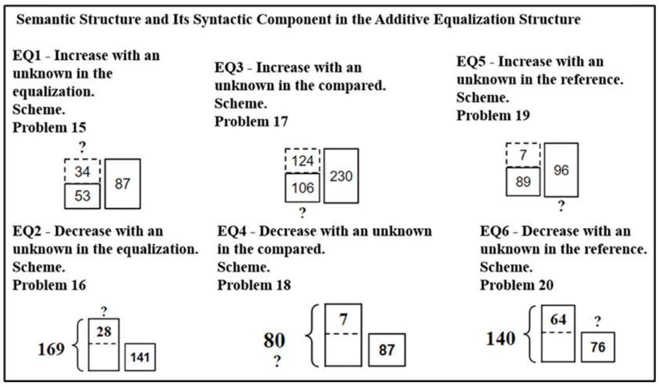


Figure 22. Schemes of the semantic structure and syntactic component of equalization (Source: Field study)

student P5 used the semantic structure EQ1 increase with unknown in the equalization and activated the procedure connection (53 + 34 = 87) where 34 is the change or quantity that modifies 87, which is the difference found when equalization the quantities. It is important to mention that four of the students answered correctly and six did not give an account of the indicated answer, so there is no evidence of a relationship between what the statement requires and the form of solution that said students presented.

Regarding the resolution of problem sixteen, student P8 used the semantic structure EQ2 decrease with unknown in the equalization, activating the procedural connection (169 - 141 = 28), where 141 is the change or quantity that modifies 169, which is the difference found when equalization the quantities. It was recognized that seven students did not respond correctly and only three students did so consistently, where greater complexity is evident in understanding the statement (Orrantia et al., 2005), and the mathematical connection of different representations is not activated; that is, the failure to establish a mathematical connection explains the reasons why the student does not solve the problem adequately (Rodríguez-Nieto et al., 2022).

In solving problem seventeen, student P8 used the semantic structure EQ3 increase with unknown in the comparison, establishing procedural connections and different representations (124 + 106 = 230), where 106 is the change or amount that modifies 230, which refers to the difference found when comparing these quantities. It is confirmed that seven students did not answer correctly, and only three students did so due to the misuse of basic operations. To solve problem eighteen, student P5 used the semantic structure of EQ4 decrease with unknown in the comparison (87 - 7 = 80), where 7 is the change or amount that modifies 87, which is the difference found when comparing the quantities. It is worth mentioning that three students answered correctly and seven did not obtain the appropriate answer due to making errors in the procedure (Figure 22).

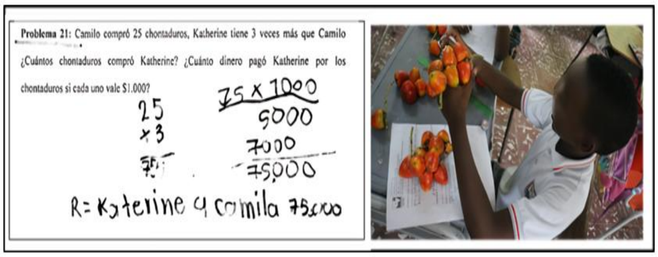


Figure 23. Example of students performing activity 2 (Source: Field study)

To solve problem nineteen, student P8 used the IG5 semantic structure of increase with an unknown in the referent (89 + 7 = 96). This type of problem requires a physical action for one quantity to become equal to another (Cañadas & Castro, 2011). Thus, a relationship is established between change and comparison problems, in which an action occurs when comparing two quantities. For his part, P5 solved problem twenty using the IG6 semantic structure of decrease with an unknown in the referent (140 - 64 = 76), where 64 represents the change or modified amount of 140, which is equivalent to the difference obtained when comparing both quantities. It is worth noting that five of the students answered the problem incorrectly with the IG6 structure, demonstrating that they require a necessary mathematical procedural connection to solve the problem properly (Figure 22).

In general, in the additive structure it was identified that problems continue to arise in solving certain additive verbal problems, for example: difficulties in change problems (subtraction), difficulty in combination problems (unknown in one part) and they present greater difficulty in comparison and equalization problems (increase-decrease).

On the other hand, to solve problems with multiplicative structures (MF, repeated addition, and ratio) that involve quantities to increase, reduce, find quantifiers and identify larger quantities in objects or money, the following results were recognized. This type of problems, from the literature, are reported to have a greater degree of complexity than additive problems.

However, when solving these problems, students had prior stimulation associated with addition and subtraction. In this context, to solve problem twenty-one on MF, student P5 used the MF structure with direct multiplication in the amplification of a magnitude (25 * 3 = 75), where 3 is the MF of 25. Of course, a mathematical connection was identified in P5's procedure to answer the second question, "How much money did Katherine pay if each chontaduro is $1,000?", where she used the MF structure operand (1,000 * 75 = 75,000). From the above, it is considered that student P5 establishes a procedural mathematical connection linked to a multiplicative structure (Figure 23).

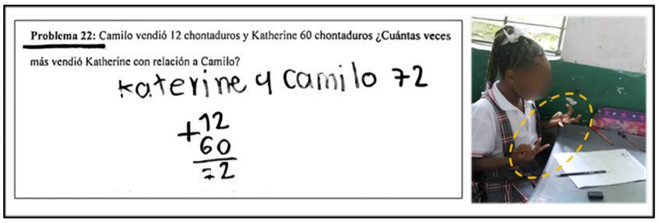


Figure 24. Solving multiplication problem on quantifiers (Source: Field study)

Figure 25. Example of the student carrying out the sequence (Source: Field study)

To solve problem twenty-two, which refers to finding quantifiers, student P5 performed an addition operation to find the unknown variable in the statement. This indicates that no procedural mathematical connection associated with the multiplicative structure of quantifiers was identified. In other words, the student did not correctly solve the problem, and there is evidence of difficulty in understanding the statement (see **Figure 24**).

To solve problem twenty-three on reduction of magnitude, student P8 used the semantic structure of MF with inverse multiplication to find the reduction of magnitude (24 * 6 = 144) where 6 is the inverse MF between 24. From the above, it is considered that the student establishes connections between the multiplicative structures and intends to determine mathematical concepts through basic operations which strengthen the learning of said problems related to multiplication (**Figure 25**).

In solving the twenty-four multiplication problem as repeated addition, student P8 used the repeated addition operation to determine it as a multiplication, that is, he makes a relationship between the quantities of each bag. In this case, it is expressed mathematically as 7 + 7 + 7 = 21 this expression is equal to 3 x 7 = 21 which indicates a multiplicative operation. In this problem it is evident that there is confusion when locating the values, that is, despite the commutative property being fulfilled, the student indicates that the number 3 is repeated 7 times (see **Figure 26**).

To solve problem twenty-five, student P8 used the multiplicative structure of ratio or proportion (R) to find the total (12 * 7 = 84) where 7 is the inverse MF between 12. In this sense, a mathematical connection was identified in the procedure of P24. Therefore, it is considered that students establish procedural connections between the multiplicative structures and

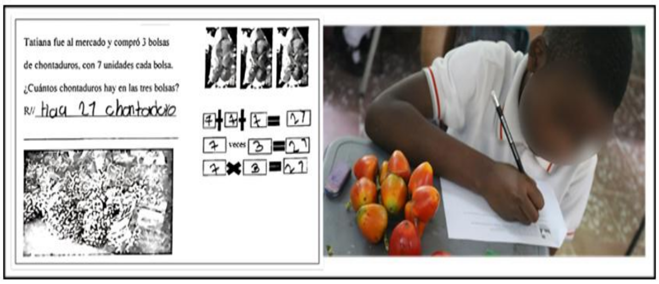


Figure 26. Example of the student solving activity 5, repeated addition (Source: Field study)

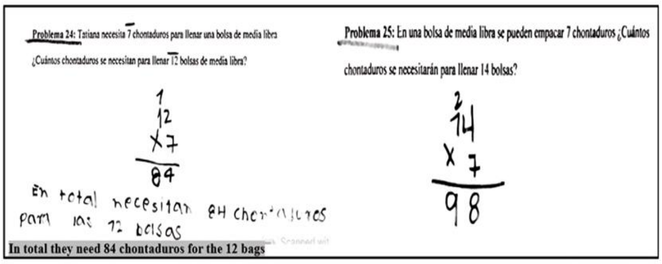


Figure 27. Student responses P5 and P8 (Source: Field study)

determine which are those mathematical concepts that help strengthen learning from the use of basic operations, the above alludes to problems related to multiplication or the MF. Problem twenty-six was solved by student P5, who used the multiplicative structure of ratio or proportion (R) to find the total (14 * 7 = 98) where 7 is the inverse MF between 14. It is considered that the student establishes procedural connections between the multiplicative structures and determines which are the mathematical concepts that help to strengthen learning from the use of basic operations, the above alludes to problems related to multiplication or the MF, see **Figure 27**.

Regarding the resolution of problem twenty-seven, student P8 used the multiplicative structure of single-digit ratio or proportion (R) (77 * 5 = 385) where 5 is the inverse MF between 77, then to answer the second question How many chontaduros are needed to pack 5 bags? P8 performed a division (385/11 = 35) where 11 is the factor that divides 385. In this sense, two procedural connections were identified. Therefore, it is considered that the student establishes mathematical connections between the multiplicative structures and determines which of these concepts contain problems related to multiplication or the MF. For his part, P5 to solve problem twenty-eight used the multiplicative structure of single-digit ratio or proportion (R) (7 * 7 = 49) where 7 is the inverse MF between 49 activating the procedural mathematical connection (**Figure 28**).

Closing activity: Teacher-researchers implemented a participatory activity where students reflected on solving additive and multiplicative problems and their relevance to chontaduro marketing. Students stated that this teaching approach improved their understanding of

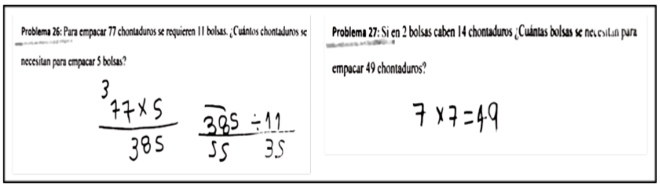


Figure 28. Example of P5 answers on multiplicative problems (Source: Field study)

market vendors' activities and motivated them to explore other topics. Teachers explained that chontaduro could also serve to address problems in economics, administration, business, and other fields. An activity simulating chontaduro marketing was conducted, with one student as vendor and others as buyers, fostering mental arithmetic, basic operations, and related skills, while linking mathematics to real-life economic contexts.

DISCUSSION

The didactic-ethnomathematical sequence implemented in third grade allowed for the analysis of the resolution of additive and multiplicative AWP from a semantic and syntactic perspective. The results revealed the students' difficulties and successes in solving these problems. It was identified that difficulties persist in solving certain additive word problems, especially in problems involving subtraction, combinations with an unknown in one of the parts, as well as in comparison and equalization problems (increase-decrease), which presented a greater degree of complexity for the students (Nesher, 1999; Rodríguez-Nieto et al., 2019; Socas & Bueno, 1997).

Regarding the multiplicative structure (MF, repeated addition, and ratio), it was observed that some students limited their solution strategy to a single form, interpreting multiplication exclusively as repeated addition. This restricted approach indicates a reliance on addition and difficulties in transitioning from graphical to arithmetic representations. Although these problems may seem simple, each one implies a particular level of difficulty, so it is essential that students understand the problem before proceeding to solve it (Castro et al., 1995). Overall, the didactic-ethnomathematical sequence contributed significantly to the resolution of verbally stated additive and multiplicative problems. The application of specific strategies significantly strengthened mathematics learning, since the problems were contextualized in the students' reality, facilitating their understanding and resolution (Pinzón-Pérez & González-Palacio, 2022).

This research answered the question: How to implement a teaching sequence based on emerging ethnomathematical connections from the commercialization of chontaduro and its links with curricular materials to promote the resolution of additive and multiplicative problems in primary school children? Based on the exploration of the daily practice of chontaduro marketing, a didactic-ethnomathematical sequence was designed to impact the mathematics classroom. In third grade, additive and multiplicative problems are suggested by the MNE (2006) and the BLR, which highlights the relevance of this study to the teaching of school mathematics (Livaque, 2018; Pacheco, 2019).

The results of this study emphasize the value of ethnomathematical approaches in strengthening early learners' problem-solving skills by connecting mathematics with their cultural context. International literature (Orrantia et al., 2005; Rodríguez-Nieto et al., 2019, 2023b; Rojas & Sotelo, 2022) reports recurrent difficulties, such as unfamiliarity with additive and multiplicative structures, incorrect operation selection, and reading and comprehension challenges, which generate conceptual and procedural errors. In this study, students showed progress from statement comprehension to solution, suggesting that problem contextualization enhanced learning (Orrantia et al., 2005; Ufer et al., 2024). Theoretical and methodological foundations drew on Díaz-Barriga (2013) and Mansilla et al. (2023) to outline a new research path with ethnomathematical tasks. The findings are expected to benefit students, teachers, and communities in Colombia, as chontaduro is a regional cultural and gastronomic symbol. Arithmetic operations, essential in daily life, should be taught beyond the classroom so students recognize their applicability in varied social contexts. This research contributes to learning additive and multiplicative problems, fostering comprehensive reasoning and supporting a deeper understanding of arithmetic in higher grades and everyday situations (Rum & Juandi, 2022).

CONCLUSION

This research showed that implementing a didactic-ethnomathematical sequence in teaching AWP in third grade enhances understanding and resolution. Difficulties were found with additive structures change, combination, comparison, equalization and with interpreting multiplication only as repeated addition. Contextualized strategies proved effective, as familiarity with everyday situations supports learning. Ethnomathematics fosters critical thinking and reasoning applied to daily life, especially through connections with artifacts and manipulative materials (Rodríguez-Nieto & Alsina, 2022). A limitation is its focus on a specific group, hindering generalization. Future research should address other levels and regions and assess the role of digital tools in teaching arithmetic problems, considering variables like teaching experience and socioeconomic background.

It is recommended to strengthen the implementation of ethnomathematical-didactic sequences in early grades, systematically integrating local practices such as chontaduro commercialization with national mathematics standards. Future studies should expand the number of participating students and examine whether improvements in problem-solving skills persist over time and across different educational levels. It is also advisable to incorporate digital tools that support the understanding of additive and multiplicative structures, allowing comparisons between contextual, manipulative, and technology-enhanced strategies. Additionally, teacher training should include deeper preparation on how to use ethnomathematical connections as pedagogical resources to improve students' semantic and syntactic comprehension of word problems. Finally, exploring other sociocultural contexts within the region is suggested to diversify scenarios and enrich contextualized arithmetic teaching, fostering meaningful learning and stronger links between students' cultural practices and school mathematics.

Author contributions: CAR-N, KTL-P, & YKP-B: conceptualization, methodology, investigation, formal analysis, visualization, and writing–original draft; **AG-M & ACI:** conceptualization, supervision, and writing–review & editing; **BMC-R & SS:** supervision and writing–review & editing. All authors agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Ethical statement: The authors stated that the study was endorsed by the principal of the public educational institution in Capilla de Santander de Quilichao, where the students were enrolled, but no document with an ethical approval code was issued. Furthermore, it was important to note that one of the authors of this article was a teacher at the institution and taught by the students; therefore, written informed consent was not required. The authors further stated that they also indicated that the article reflects an academic collaboration at the Universidad del Valle, Colombia, aimed at improving the teaching and learning of mathematics, with the permission of all participating universities (Universidad de la Costa, Institución Universitaria de Barranquilla, Universidad San Sebastián, and Universitas Terbuka).

AI statement: The authors stated that no generative AI or AI-based tools were used in any part of the study, including data analysis, writing, or editing.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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