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Learning numeracy using new Pempek mathematics

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Abstract

This study addresses the challenges faced by students in comprehending and articulating the concepts of cost, selling price, and profit, despite their ability to perform related calculations. Contributing factors include a limited learning context and a didactic approach that often prioritizes rote memorization of formulas, thereby hindering a deeper understanding of these concepts. The objective of this research is to design a learning trajectory utilizing the context of New Pempek Mathematics, an innovative adaptation of the traditional Pempek dish, represented in geometric forms such as cones, trapezoidal prisms, cuboids, and cubes, to facilitate students' understanding of cost price, selling price, and profit. The study employs a design research methodology, consisting of three stages: preliminary design, experimental design, and retrospective analysis. The study involved 31 junior high school students from Belitang, Indonesia. Data collection was conducted using a variety of instruments, including student worksheets, video recordings of lessons, interviews with students, and photographs of their presentation work. The proposed learning trajectory, centered around the New Pempek Mathematics production project, emphasizes activities such as identifying cost prices, estimating selling prices, and calculating profit. The findings indicate that integrating mathematics with local cultural contexts, such as New Pempek Mathematics, enhances student engagement and makes the learning experience more relevant, thus improving students' understanding of these fundamental economic concepts.

Keywords: Cost Price, New Pempek Mathematics, Profit, Realistic Context, Selling Price

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The concepts of cost price, selling price, and profit are fundamental components of economic mathematics (Proust & Middeke-Conlin, 2014), which are integral to financial literacy and entrepreneurship education (Sawatzki & Sullivan, 2018). In the context of Indonesia, these concepts are commonly referred to as social arithmetic, particularly related to transactions in buying and selling (Fauzan et al., 2018). There is a widespread consensus across various nations regarding the critical importance of financial education for adults, adolescents, and school-age children (Sagita et al., 2022). The integration of financial education and entrepreneurship within mathematics curricula is crucial in equipping students with the necessary skills to address the complexities of the labor market and effectively manage increasingly sophisticated financial challenges (Pinto & Blue, 2016). Furthermore, such an approach fosters the development of both mathematical and entrepreneurial competencies, which are vital for students' future success (Palmér & Johansson, 2018). It is imperative to prepare young individuals to not only seek employment but also to become entrepreneurs capable of creating job opportunities, thereby contributing to economic growth (Foundation for Young, 2016). Consequently, the incorporation of financial mathematics with entrepreneurship education is essential for preparing students to navigate the economic landscape and workplace challenges. Equipped with these skills, students will be better prepared to address financial issues and possess entrepreneurial capabilities that may enable them to create employment opportunities for themselves and others in the future.

The findings of Sawatzki and Goos (2018) indicate that students continue to experience difficulties when solving problems related to prices. While some students are able to determine the selling price required for making a profit and calculate the profit from sales, they still struggle to explain the definitions of cost price, selling price, and profit. Additionally, students face another challenge due to the limited contextualization of price-related learning, which hinders more effective understanding. The didactic system in use tends to focus on the rote memorization of formulas, resulting in a lack of deep comprehension of the underlying concepts (Kurniasi et al., 2022). This situation underscores the need for innovative teaching methods to enhance conceptual understanding and enable students to explain the meanings of cost price, selling price, and profit with greater depth. A promising approach to address this issue involves utilizing learning methods that are more closely aligned with students' real-life contexts. One such approach is Pendidikan Matematika Realistik Indonesia (PMRI), which aims to make the learning process more relevant and meaningful.

PMRI is the Indonesian adaptation of the Realistic Mathematics Education (RME) approach (Heuvel-Panhuizen & Drijvers, 2020; Prahmana et al., 2020). This approach emphasizes problem-solving rather than rote memorization of formulas, guiding students to discover and construct mathematical knowledge through contextual learning experiences (Zulkardi et al., 2020). PMRI facilitates the transition of students' thinking from real-world situations or concrete experiences that are familiar to them, towards more abstract mathematical concepts (Zulkardi & Putri, 2019). Through this process, students are encouraged to independently identify mathematical concepts and apply them to solve problems (Bakker, 2018; Wijaya et al., 2021). Furthermore, the use of real-world contexts enhances students' engagement and focus during the learning process (Zulkardi & Putri, 2020), which in turn promotes greater student participation (Madrazo & Dio, 2020). These findings indicate that PMRI is an effective approach for fostering problem-solving skills and conceptual understanding through relevant contexts, while also boosting students' interest, concentration, and active participation in learning mathematics.

Contextual learning can draw upon cultural elements that are closely related to students' lives (Putri et al., 2022; Risdiyanti & Prahmana, 2021). Cultural aspects play a crucial role in lesson design (d'Entremont, 2015), and local cultural elements can serve as valuable contexts for integrating mathematics into the classroom (Rosa et al., 2017). Traditional foods are one such cultural element that can be used effectively in this regard (Kuhnlein & Receveur, 1996). Pempek, a traditional dish from South Sumatra, is an important aspect of the region's cultural identity, history, and lifestyle (Guerrero et al., 2009; Wargadalem et al., 2023). Several studies have explored the use of Pempek as a context for mathematics instruction. For instance, the context of Pempek Lenjer has been used to help students understand the concept of fractions (Meryansumayeka et al., 2019), and Pempek has been employed in the development of PISA-based questions (Lestari & Putri, 2020). Additionally, Pempek has been utilized in developing algebraic problems to assess students' problem-solving skills (Putri et al., 2022). Although these studies have yielded positive results, the application of Pempek as a context in mathematics learning has not been fully explored. The use of Pempek in these studies has been limited to topics such as geometric shapes, the preparation and packaging of Pempek, and sales data related to Pempek.

This study explores the use of Pempek, a traditional local food, as a context for learning concepts related to cost price, selling price, and profit. The mathematical form of Pempek refers to the various shapes of Palembang Pempek, such as tube, ball, circle, and others (Malalina et al., 2022). Additionally, "New Pempek Mathematics" refers to an innovative version of Pempek, designed with geometric shapes including cone-shaped Pempek, trapezoidal prism Pempek, cube-shaped Pempek, and cuboid-shaped Pempek. The novelty of this research lies in the fact that students engage in project-based activities to create New Pempek Mathematics, under the guidance of their teacher. These activities involve students preparing the ingredients, making the dough, shaping it into the geometric forms of New Pempek Mathematics, cooking, and presenting the final product with appropriate packaging. The objective of these activities is to enable students to calculate production costs, estimate cost prices, determine sales prices, and assess profits. These activities highlight the relationship between mathematical concepts and the context of New Pempek Mathematics, aligning with the findings of Fauzan et al. (2018), which emphasize that contextualized learning—rooted in real-life experiences—can help students connect mathematical concepts to practical situations, such as buying and selling.

The primary objective of this research is to design a learning trajectory utilizing the context of New Pempek Mathematics to teach the concepts of cost price, selling price, and profit. This study will investigate the effective implementation of PMRI to enhance students' understanding of these mathematical concepts. By selecting contexts that are relevant to students' lives, the learning experience becomes more meaningful, thereby improving students' problem-solving abilities (Sawatzki & Goos, 2018). This approach also facilitates students' re-engagement with mathematical concepts (Fauzan et al., 2018).

The PMRI approach emphasizes student-centered learning, where students are actively involved in the learning process and encouraged to apply their own strategies (Zulkardi & Putri, 2019). In this context, students collaborate actively in completing the project of making New Pempek Mathematics, fostering a dynamic, interactive learning environment. In this setting, students engage in various tasks such as measuring, weighing, and molding the New Pempek Mathematics dough. Through the PMRI approach, students not only strengthen their mathematical understanding but also develop their problem-solving skills through the practical application of their knowledge in real-world scenarios (Zulkardi & Putri, 2019). For instance, students can calculate the production costs of making New Pempek Mathematics by determining the price of the ingredients and the quantities needed, ultimately adding the costs to compute the total production cost.

Furthermore, teachers play a critical role in designing and facilitating the learning process, ensuring that it is both engaging and relevant to students' lives in the PMRI approach (Zulkardi & Putri, 2019). By incorporating real-world contexts, such as New Pempek Mathematics, which reflect local culture, teachers can help students recognize the applicability of mathematics in their everyday experiences. This approach not only preserves local cultural heritage but also enhances the learning process by making it more meaningful, enjoyable, and capable of maintaining students' interest. In the PMRI framework, students are not merely taught to memorize formulas but are encouraged to develop a deeper conceptual understanding of mathematical calculations (Fauzan et al., 2018). For instance, students are empowered to estimate the cost price after calculating production costs and to determine the selling price based on the cost price, with the ultimate goal of helping them understand the concepts of profit, cost price, and selling price through the project of creating New Pempek Mathematics.

In conclusion, this study seeks to answer the question: "How can a learning trajectory incorporating the PMRI approach be designed to teach the concepts of cost price, selling price, and profit, using the context of New Pempek Mathematics?" This research aims to provide valuable insights into the application of the PMRI approach for teaching financial concepts, particularly related to buying and selling, focusing on cost price, selling price, and profit. It is anticipated that this approach will not only enhance students' understanding of these concepts but also preserve local cultural knowledge through the context of New Pempek Mathematics. The findings of this study are expected to offer recommendations for improving the teaching of buying and selling concepts, thereby optimizing the learning outcomes for junior high school students.

METHODS

This study employs a validation research design to develop a learning trajectory for the teaching of buying and selling concepts, including cost price, sales price, and profit, through the framework of PMRI. The primary objective is to design a learning trajectory that enhances the quality of mathematics education by fostering collaboration between researchers and classroom teachers. Additionally, this research serves as a validation of the proposed learning trajectory, focusing on its design and application to the teaching of buying and selling concepts. The specific aim is to develop a Hypothetical Learning Trajectory (HLT) that incorporates the context of New Pempek Mathematics, facilitating students' understanding of these concepts. The study was conducted at SMP N 2 Belitang, a secondary school in South Sumatra, Indonesia, and followed a three-phase methodology: preliminary design, design experiment, and retrospective analysis (Gravemeijer & Cobb, 2013).

Preliminary Design

The research commenced with a comprehensive literature review on the topic of buying and selling, mathematical modeling within the PMRI approach, and an analysis of the curriculum to predict possible student thought processes. Furthermore, an examination of the Pempek recipe and its various forms was conducted to inform the development of the learning trajectory. Based on this review, the researcher designed a learning trajectory in the form of an HLT, comprising three distinct activities aimed at deepening students' understanding of buying and selling concepts (cost price, sales price, and profit) through the use of New Pempek Mathematics. These activities involved the introduction of geometric shapes such as the Pempek cube, Pempek cuboid, Pempek prism trapezium, and Pempek cone. In addition, student worksheets were created, teaching modules developed, and teacher instructions were designed and tested from the perspective of experienced educators.

Design Experiment

The design experiment phase consists of two distinct stages: the pilot experiment and the teaching experiment. During the pilot experiment, the HLT and the New Pempek Mathematics recipe were initially tested on a group of thirty students who worked collaboratively in small groups. The objective at this stage was to assess the clarity, comprehensibility, and usability of the student worksheets, the instructions for creating New Pempek Mathematics, and the overall effectiveness of the materials in facilitating students' understanding of buying and selling concepts. Based on the findings from the pilot experiment, revisions were made to the HLT and accompanying instructions, which were then implemented in the subsequent teaching experiment. Throughout the learning process, data were collected using various methods, including video recordings of classroom interactions, student responses on worksheets, and student interviews. Group discussions and student presentations were also recorded to gather insights into student learning. Observations were conducted to assess the fidelity of HLT implementation, and interviews were employed to examine the alignment between Actual Learning and the proposed HLT. In addition, field notes were taken to support the findings from the interviews.

Retrospective Analysis

The retrospective analysis phase involved comparing the HLT with the Actual Learning that occurred during the teaching experiment. This phase aimed to identify the problem-solving strategies employed by students, investigate potential alternative solutions, and design mathematical models to represent processes such as converting kilograms to grams, estimating costs, and calculating sales prices. These models were developed to assist students in understanding the concepts of buying and selling. The analysis of learning videos and student interviews provided valuable insights into students' prior knowledge of arithmetic operations, including addition, multiplication, division, and decimal numbers. The findings from this phase played a critical role in explaining how the New Pempek Mathematics context facilitated students' conceptual understanding of buying and selling. This research demonstrates how the integration of New Pempek Mathematics effectively supports students in discovering key principles related to the buying and selling concepts.

RESULTS AND DISCUSSION

This study introduces a novel approach to teaching mathematics through the "New Pempek Mathematics" project, which also provides a learning trajectory focused on concepts related to buying and selling materials. In this lesson, students are encouraged to determine production costs by engaging with the New Pempek Mathematics project. The study design incorporates the five core principles of PMRI (Pendidikan Matematika Realistik Indonesia), beginning with the use of context that is relevant to students' daily lives (Stacey et al., 2015). This context enables active student participation and fosters motivation in learning (Siligar et al., 2018).

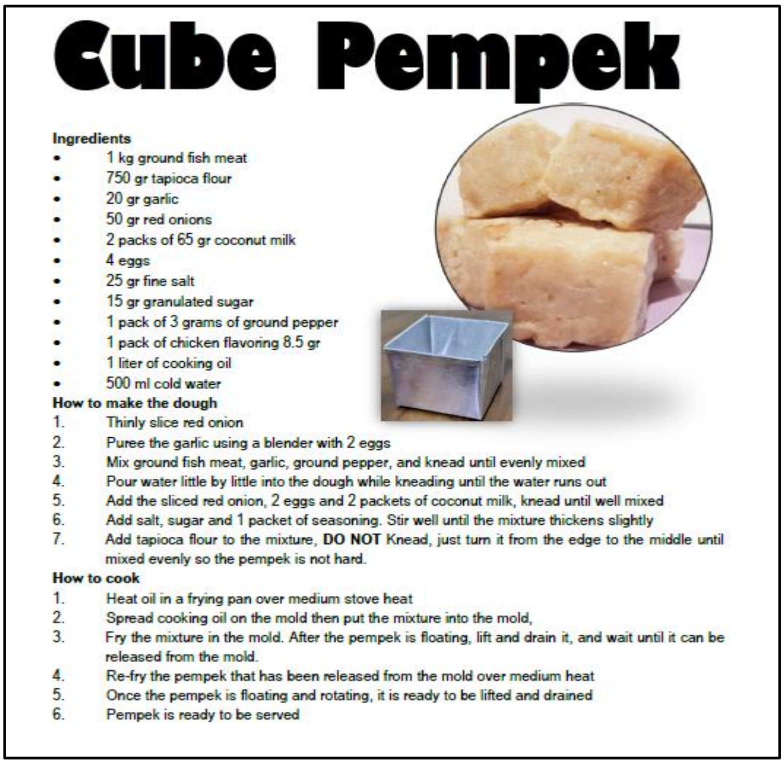


Figure 1. Recipe for cube Pempek

Pempek, a traditional dish made from a mixture of fish and tapioca flour, is an integral part of local culture and heritage. Its production techniques and distinct shapes contribute to the creation of a product that embodies local wisdom and culinary tradition (Wargadalem et al., 2023). The concept of "Mathematics Pempek" refers to a Palembang-style Pempek designed to resemble architectural structures such as tubes and spheres (Malalina et al., 2022). The "New Pempek Mathematics" expands on this by introducing Pempek shapes that resemble conical and trapezoidal prisms, cubes, and cuboids.

In this study, Pempek shaped like cones and trapezoidal prisms are boiled, while Pempek shaped as cubes and cuboids are fried. The Pempek cones and trapezoidal prisms are made using ground snakehead fish, whereas the Pempek cubes and cuboids incorporate a mixture of snakehead fish and ground mackerel skin. The recipes for the New Pempek Mathematics are illustrated in Figures 1 to 4.

Figure 1 presents the recipe for cube Pempek, a variation made from a mixture of fish meat, tapioca flour, coconut milk, pepper, sliced red onions, and other ingredients. This type of Pempek is named "cube" due to its preparation using a cube-shaped mold. The cooking method involves frying the Pempek immediately after molding, resulting in a crispy outer surface and a soft interior, complemented by the aromatic flavors of onions and pepper. It is traditionally served with Palembang’s signature *cuko* sauce.

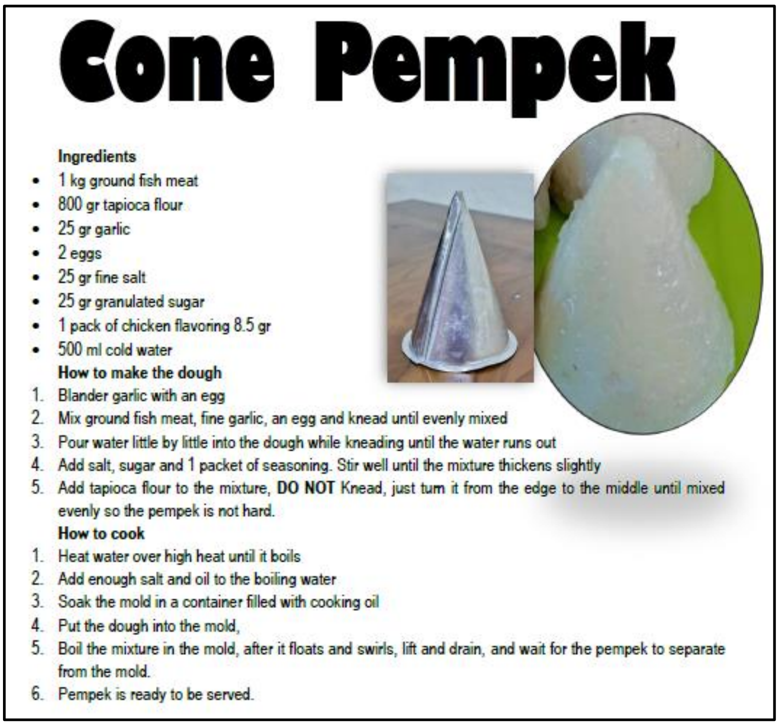


Figure 2. Recipe for cone Pempek

Figure 2 illustrates the recipe for cone Pempek, a variety made from a blend of fish meat, tapioca flour, eggs, and other ingredients. The term "cone" derives from the use of a cone-shaped mold during preparation. After molding, the Pempek is boiled, giving it a chewy texture and a rich, savory fish flavor. There are two common serving options: it can be served immediately after boiling, or it can be fried post-boiling for added crispness, depending on personal preference. Both versions are accompanied by Palembang's characteristic *cuko* sauce.

Trapezoidal Prism Pempek

Ingredients

- 1 kg ground fish meat
- 800 gr tapioca flour
- 25 gr garlic
- 2 eggs 25 gr fine salt
- 25 gr granulated sugar
- 1 pack of chicken flavoring 8.5 gr
- 500 ml cold water

How to make the dough

1. Blander garlic with an egg
2. Mix ground fish meat, fine garlic, an egg and knead until evenly mixed
3. Pour water little by little into the dough while kneading until the water runs out
4. Add salt, sugar and 1 packet of seasoning. Stir well until the mixture thickens slightly
5. Add tapioca flour to the mixture, **DO NOT** Knead, just turn it from the edge to the middle until mixed evenly so the pempek is not hard.

How to cook

1. Heat water over high heat until it boils
2. Add enough salt and oil to the boiling water
3. Soak the mold in a container filled with cooking oil
4. Put the dough into the mold and, boil the mixture in the mold, after it floats and swirls, lift and drain, and wait for the pempek to separate from the mold.
5. Pempek is ready to be served.

Figure 3. Recipe for trapezoidal prism Pempek

Figure 3 depicts the recipe for trapezoidal prism Pempek, a new variant of mathematical Pempek. This version is created using a trapezoidal prism-shaped mold, with ingredients similar to those of cone Pempek, including fish meat, tapioca flour, eggs, and other ingredients. The Pempek is boiled immediately after molding, resulting in a chewy texture and distinct fish flavor. Like the cone Pempek, it can be served either immediately after boiling or fried post-boiling, according to personal taste. It is also served with Palembang's traditional *cuko* sauce.

Cuboid Pempek

Ingredients

- ½ kg ground fish meat
- ½ kg ground fish skin
- 500 gr tapioca flour
- 20 gr garlic
- 50 gr red onions
- 2 packs of 65 gr coconut milk
- 4 eggs
- 20 gr fine salt
- 15 gr granulated sugar
- 1 pack of 3 grams of ground pepper
- 1 pack of chicken flavoring 8.5 gr
- 1 liter of cooking oil
- 350 ml cold water

How to make the dough

1. Thinly slice red onion
2. Blend the garlic with two eggs
3. Mix ground fish meat, fine garlic, ground pepper, and knead until evenly mixed
4. Pour water little by little into the dough while kneading until the water runs out
5. Add the sliced shallots, 2 eggs, and 2 packets of coconut milk, knead until well mixed
6. Add salt, sugar and 1 packet of seasoning. Stir well until the mixture thickens slightly
7. Add tapioca flour to the mixture, **DO NOT** Knead, just turn it from the edge to the middle until mixed evenly so the pempek is not hard.

How to cook

1. Heat oil in a frying pan over medium stove heat
2. Weigh the dough according to the desired size
3. Coat the weighed dough with tapioca flour (just coat it)
4. Coat the mold with tapioca flour until evenly coated.
5. Put the dough that has been weighed and coated with tapioca flour into the mold (print according to the shape of the mold)
6. Fry the molded dough until cooked through
7. Pempek is ready to be served

Figure 4. Recipe for cuboid Pempek

Figure 4 presents the recipe for cuboid Pempek, a variant of the New Pempek Mathematics series. This Pempek is made from a mixture of mackerel fish skin, fish meat, tapioca flour, garlic, shallots, eggs, pepper, and other ingredients. It is named "cuboid" due to its use of a cuboid-shaped mold during preparation. The Pempek is fried immediately after molding, resulting in a fragrant, crispy outer layer. The distinct aroma arises from the combination of mackerel fish skin and sliced red onions. It is traditionally served with Palembang's typical *cuko* sauce.

Before beginning the project, both researchers and students hold a briefing to determine the specific New Pempek Mathematics project to be undertaken. Students are given the autonomy to select the type of Pempek they wish to create, choose the location for the project, decide on the day and time for its execution, and prepare the necessary materials. The project is implemented at SMP N 2 Belitang.

The HLT of Mathematics Learning

A HLT is a conjecture or hypothesis that connects a situational problem to formal knowledge through learning activities (Akker et al., 2013). When designing learning activities, it is essential to understand students' existing knowledge and cognitive processes, which can engage their interest and foster active participation. This understanding allows for anticipation and consideration of student reactions during the learning process. Additionally, Bakker (2018) asserts that an HLT represents the relationship between instructional theory and an empirical teaching experiment.

Confrey et al. (2017) further elaborate that an HLT begins with students' initial understanding of the target concept, identifying key elements and potential obstacles that students may encounter as they progress toward a deeper understanding. Furthermore, the combination of teachers' knowledge of mathematics, their understanding of mathematical activities, and their familiarity with various representations constitutes the pedagogical content knowledge required to develop an effective HLT (Amador & Lamberg, 2013).

An HLT is, therefore, a thoughtful conjecture encompassing learning activities, learning objectives, student responses, and teacher reactions. The final HLT developed by the researcher consists of three distinct activities, which are outlined in Table 1.

Table 1. The HLT for learning cost price, selling price, and profit

No	Activity	Main Goals	Conjectures	
			Predictions of Students' Responses	**Teacher's Responses**
1	Students create a form of New Pempek Mathematics, calculate production costs, and understand cost prices.	1. Students can innovate new forms of Mathematics Pempek. 2. Students can identify production costs. 3. Students can understand cost prices.	1. Each group of students will be able to create a new form of Mathematics Pempek. 2. Students will understand all the costs involved in making the new form of Mathematics Pempek and be able to calculate the material quantities required along with their prices.	1. The teacher will provide verbal appreciation to students who succeed in creating the new form of Mathematics Pempek, calculating production costs, and determining the cost price. 2. The teacher will guide students who are struggling by encouraging collaboration with groups

			3. Students will understand that cost price includes the cost of necessities plus services and other operational expenses.	that have successfully completed the task. 3. If students struggle with cost calculations, the teacher will reinforce the concepts by reminding them of whole number operations.
2	Estimate the appropriate selling price for New Pempek Mathematics	Students understand that the selling price is the sum of cost price and profit.	1. Students will calculate the selling price by dividing the total cost price by the number of Pempek produced. 2. Students will recognize that the selling price is the sum of cost price and profit. 3. Students may be unable to estimate the selling price or comprehend its components.	1. The teacher will encourage students who are struggling to collaborate with peers who have successfully estimated the selling price. 2. If all students face difficulties, the teacher will guide them by emphasizing the concept that the goal of pricing is to achieve profit.
3	Solve buying and selling problems by understanding cost price and estimating selling prices to make a profit	Students can apply strategies to solve problems involving cost prices for a package containing 10 Pempek.	1. Students calculate the cost price for each type of Pempek. 2. Students calculate the mixed Pempek cost price and estimate profits of reducing the selling price with the cost price. 3. Students are unable to calculate the cost price of each type of Pempek, the cost price of one package of mixed Pempek containing 10 Pempek, and estimate profits.	1. The teacher will encourage students who are unable to collaborate to seek assistance from peers who can solve the problem. 2. If all students face challenges, the teacher will prompt them to recall previous lessons on production costs and price estimations to support their problem-solving process.

The researchers have demonstrated excellence in designing this learning activity, with the primary goal of enhancing students' understanding of buying and selling materials. The final HLT was refined based on feedback, suggestions, and guidance from supervisors who are experts in the PMRI approach and design research. Additionally, the HLT underwent validation with mathematics education teachers at SMP N 2 Belitang.

The HLT was subsequently piloted in two stages. Initially, a pilot was conducted with six students from class 7G, who were divided into two groups. Following this, a larger-scale pilot was conducted with 31 students from class 7F, divided into six groups. This approach facilitated collaborative learning among students, which contributed to the effectiveness of the HLT implementation at SMP N 2 Belitang. Figure 5 illustrates the iceberg model used in this study.

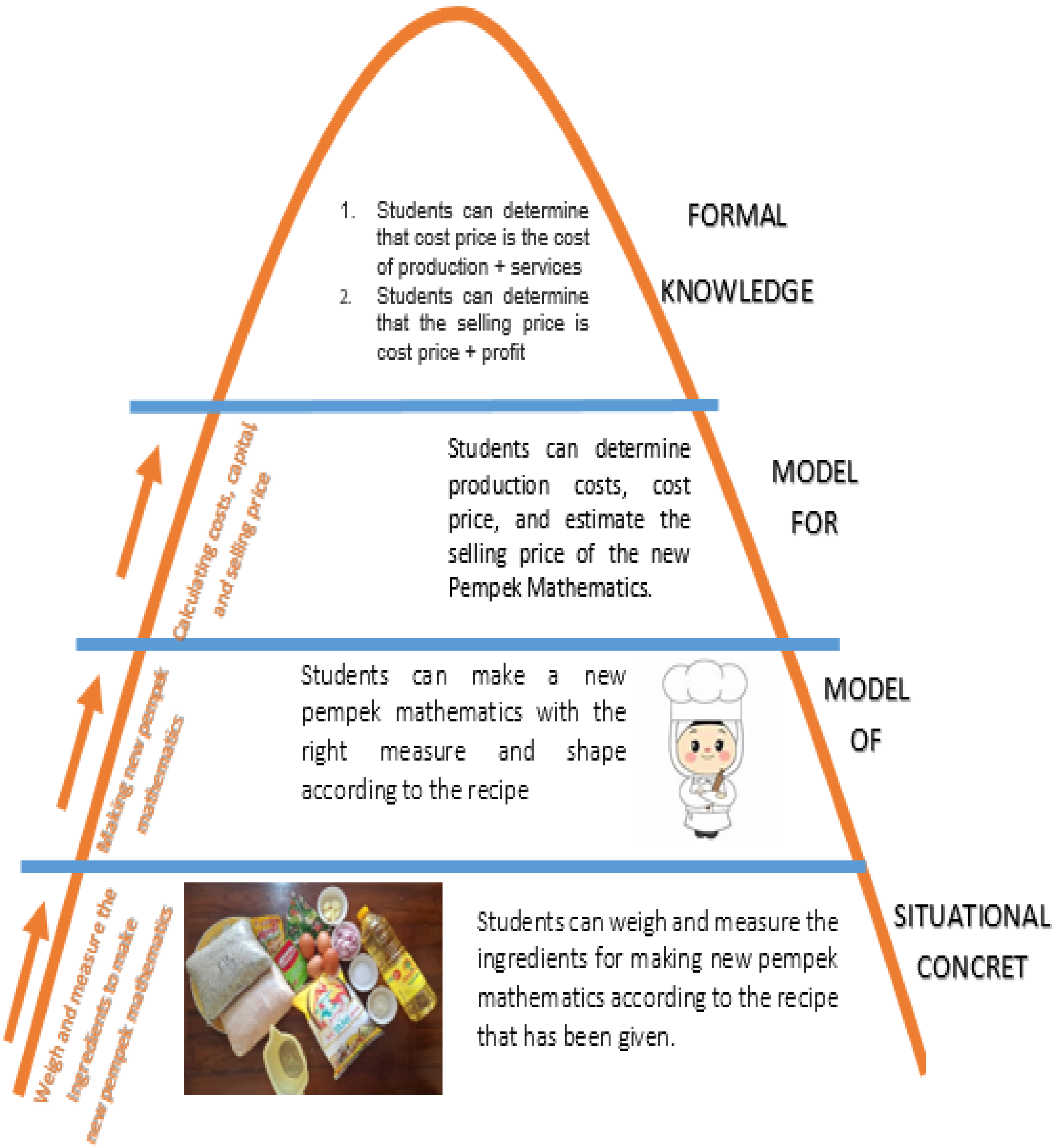


Figure 5. Iceberg of buying and selling concepts

As depicted in Figure 5, at the "situational concretization" stage, students work in groups to prepare the necessary materials for creating New Pempek Mathematics. During this phase, each group is responsible for weighing and measuring the ingredients, allowing students to align the recipe with the materials provided by the researcher.

In the "model of" stage, students follow the recipe and mold specifications to create their own New Mathematical Pempek. At this stage, student groups knead, cook, and package the newly created Pempek. The objective is for students to innovate and produce new shapes, such as cube Pempek, cuboid Pempek, trapezoidal prism Pempek, and cone Pempek, collectively referred to as New Mathematical Pempek.

Subsequently, in the "model for" stage, the student groups calculate the production costs, cost price, and estimate a suitable selling price for the New Mathematical Pempek they have produced. The goal is to enable students to identify production costs, determine cost prices, and estimate sales prices that would yield a profit. Finally, in the "formal knowledge" stage, students are able to conclude that the cost price is the sum of production costs, services, and other operational needs, while the selling price is the total of the cost price and profit.

Activity 1: New Pempek Mathematics Creation Project, Identification of Production Costs, and Cost Price

The learning process for Activity 1 begins with the researcher organizing all materials and tools required for the New Pempek Mathematics project. Subsequently, the researcher distributes the recipes for New Pempek Mathematics to each student group. Group 1 receives the recipe for cone Pempek, Group 2 receives the cuboid Pempek recipe, Group 3 receives the cube Pempek recipe, Group 4 receives the trapezoidal prism Pempek recipe, Group 5 receives the cone Pempek recipe, and Group 6 receives the trapezoidal prism Pempek recipe. The objective of Activity 1 is for students to innovate with new mathematical Pempek shapes, identify production costs, and understand the concept of cost price. The activities involved in the New Pempek Mathematics project are as follows:

1. Preparation of Materials for Making New Pempek Mathematics
   The student groups begin by reading the recipes provided by the researcher. They then collaboratively prepare the ingredients, including fish, tapioca flour, salt, sugar, garlic, etc., and measure the necessary quantities using appropriate tools, such as a measuring glass.
2. Making the New Pempek Mathematics Dough
   The students work together to prepare the dough for the New Pempek Mathematics, following the instructions outlined in the recipe. A key technique in preparing the dough is ensuring that once salt, sugar, and flavoring are added, the dough is no longer kneaded but simply flattened until it slightly thickens. When incorporating tapioca flour, the dough should be flipped back and forth from the edges to the center to ensure proper mixing. This process is crucial to avoid making the Pempek too hard.
3. Shaping and Cooking the New Pempek Mathematics
   After preparing the dough, students shape it using molds corresponding to the designated shapes. The dough is then cooked until ready and served with vinegar. The Pempek produced by the students is displayed in Figure 6.

Figure 6 illustrates one of the stages in the process where student groups prepare the New Pempek Mathematics. After the cooking process is completed, the Pempek is carefully served on a plate, ready to be enjoyed with vinegar. Following the presentation and serving of the Pempek, students are tasked with identifying the production costs and determining the overall cost for making the New Pempek Mathematics within their respective groups.

Figure 6. The process of making New Pempek Mathematics

Identification of Production Costs and Cost Price for the New Pempek Mathematics Manufacturing Project

The objective of this activity is to enable students to identify production costs and understand cost pricing for making New Pempek Mathematics. Students are given a worksheet and asked to fill out sections that begin with identifying the type of Pempek their group is producing. They are then asked to calculate the costs of the materials needed for their specific recipe and to conclude the overall cost price. Figure 7 illustrates the results of the student groups' answers during the activity of identifying production costs.

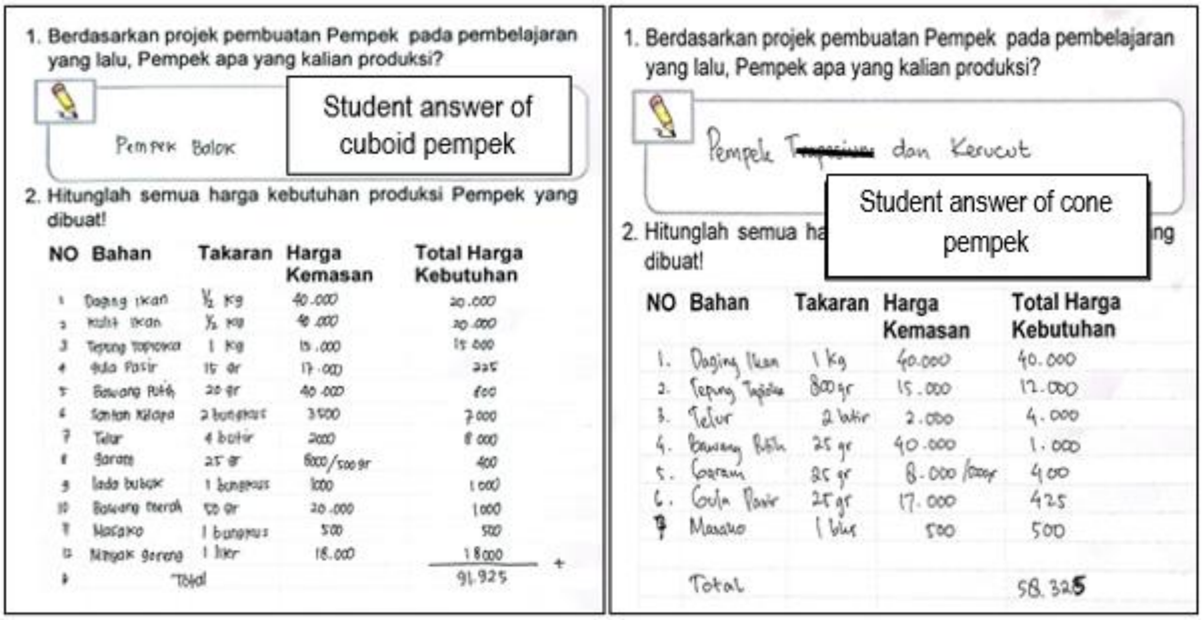


Figure 7. Production costs for New Pempek Mathematics

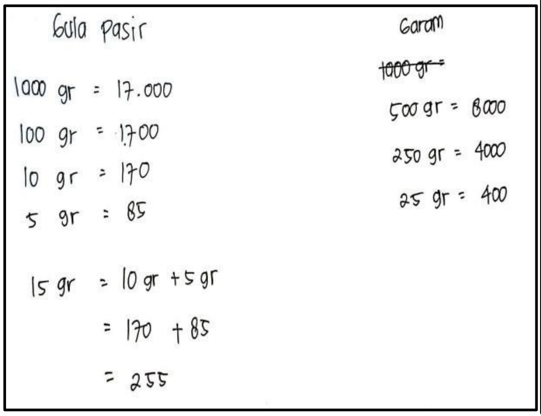
In Figure 7, the production cost results for each Pempek project are presented. Group 1, which produced cube Pempek, reported a production cost of IDR 91,925, while Group 2, which produced trapezoidal prism Pempek and cone Pempek, calculated a total production cost of IDR 58,325. Initially, students encountered challenges in calculating the cost of individual ingredients, such as determining the cost for 15 grams of granulated sugar required for making cube Pempek, given that the price for 1 kg of granulated sugar was IDR 17,000. However, with guidance from the researcher, the students developed strategies to solve the problem. Transcript 1 shows how the researcher guided the students.

Transcript 1

T : How much granulated sugar is used?
S4 : 15 grams
T : How much does one kilogram cost?
S3 : IDR 17,000.,
T : How many grams is a kilogram?
S4 : 1000 grams.
T : try to write on paper, if sugar is 1000 grams, how much is it?
S3 : IDR 17,000.,
T : If sugar is 100 grams, how much is it?
S4 : IDR 1700.,
T : Where did you get it from?
S4 : divided into 10 packs,
T : Okay, if 10 grams is how much money?
S3 : IDR 170.,
T : How many grams do you need?
S3 : 15 grams
T : So how much more is missing?
S4 : 5 grams more

T : how much money is for 5 grams?
S3 : IDR 85.,
T : Where did you get it from?
S3 : IDR 170 divided by 2
T : Good, so how much money does it cost for 15 grams of sugar to use?
S : IDR 255, which is obtained from 170 plus 85.
T : Good.

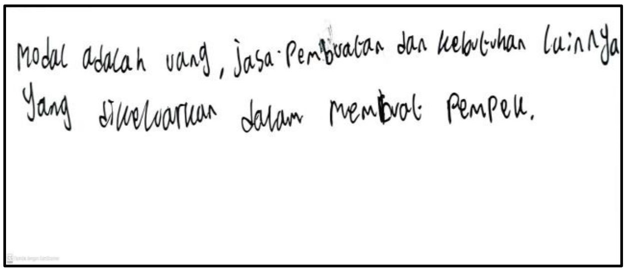
From Transcript 1, the researcher guided the students to divide the total price for 1000 grams of sugar into smaller portions (100 grams, then 10 grams, and finally 5 grams). This step-by-step guidance helped the students arrive at the correct cost of IDR 255 for 15 grams of sugar (IDR 170 + IDR 85). The students' answers can be seen in Figure 8.



Sugar
1000 gr = 17.000
100 gr = 1700
10 gr = 170
5 gr = 85
15 gr = 10 gr + 5 gr
= 170 + 85
= 225

Figure 8. Calculation of the price of granulated sugar needs

After the groups successfully identified the production costs for each Pempek project, students were asked to conclude what the concept of cost is. Figure 9 presents an example of the students' responses regarding the definition of cost price.



Translate:
Answer:
Cost price is money, manufacturing services, and other needs spent to make pempek

Figure 9. Students' answers about cost price

In Figure 9, an example of a student's response is provided, where the students concluded that cost includes the money spent on materials, manufacturing services, and other operational needs. To reach this conclusion, students were asked to re-estimate the production costs by considering the cost of manufacturing services and other necessary expenses.

Activity 2: Determination of Selling Price in the New Pempek Mathematics-Making Project

The objective of this activity is to enable students to estimate an appropriate selling price for the New Pempek Mathematics project that would yield a profit. The activity also aims to help students understand that the selling price is comprised of the cost price and the profit margin. The procedure begins with students being tasked to estimate the potential selling price of the Pempek produced in the project. Subsequently, students are instructed to calculate the total revenue generated from selling all the Pempek at the estimated price. They are then asked to determine the difference between the selling price and the cost price. Additionally, students are required to explain the concept of the surplus money generated, which is identified as profit, and to articulate the meaning of the selling price. Finally, students are expected to derive the formula for calculating the selling price, incorporating both the cost price and the profit margin. Figures 10 and 11 illustrate representative student responses to the activity.

1. Dengan memperhatikan modal dan ukuran Pempek, tentukan berapakah harga yang layak untuk menjual Pempek tersebut? (Harga per buah)

   Kami akan menjual Pempek dengan harga Rp2.500

2. Jika semua pempek laku terjual, berapakah total uang yang kalian perolah?

   2500 × 50 = 0 000 + 12 5 00 = 125.000 — Uang yang akan kami peroleh Rp125.000

3. Berdasarkan soal no 2, berapakah selisih uang yang kalian peroleh dari modal?

   125 000 − 91 925 = 33.075 — Selisih uang yang diperoleh dari harga modal adalah Rp 33.075

Translate:

1. By paying attention to the cost price and size of pempek, determine what is the oppropriate price to sell the pempek? (price per piece).
   Answer: we are selling pempek at IDR2.500
2. If all the pempek sells well, how much money do you get?
   Answer: the money we will eam is IDR125.000
3. Based on question number 2, what is the difference in money you get from cost price?
   Answer: the difference in money obtained from the cost price is IDR33.075

Figure 10. Responses to Activity 2 (Questions 1-3)

Figure 10 shows that the students set the selling price of each Pempek at IDR 2,500. The total revenue, calculated by multiplying the number of Pempek produced (50 pieces) by the unit price (IDR 2,500), amounts to IDR 125,000. Furthermore, the students determined that the difference between the revenue generated, and the cost price is IDR 33,075, representing the profit made from the transaction.

4. Apakah kalian mendapatkan uang lebih? Dan disebut apa uang lebih dari modal pada aktivitas penjualan?

   Iya, Keuntungan

5. Apa yang dimaksud dengan harga penjualan?

   Harga yang layak untuk menjual suatu produk agar memperoleh keuntungan

6. Bagaimana rumus memperoleh harga penjualan jika memperhatikan modal dan keuntungan?

   Keuntungan ditambah harga modal

Translate:

4. Do you get more money? And what is it called more money than cost price in sales activities?
   Answer: yes, profit
5. What is the selling price?
   Answer: the price that is feasible to sell a product in order to make profit
6. What is formula for obtaining the selling price if you pay attention to cost and profit?
   Answer: profit plus cost price.

Figure 11. Responses to Activity 2 (Questions 4-6)

In Figure 11, the students explain that the additional money earned above the cost price is identified as profit. Through this explanation, they demonstrate an understanding that the selling price must be sufficient to cover both the cost of production and the desired profit margin. The students concluded that the selling price is determined by adding the profit to the cost price.

Activity 3: Solving Buying and Selling Problems

In Activity 3, students are tasked with solving problems related to buying and selling, with the freedom to apply the strategies and concepts they acquired in previous activities.

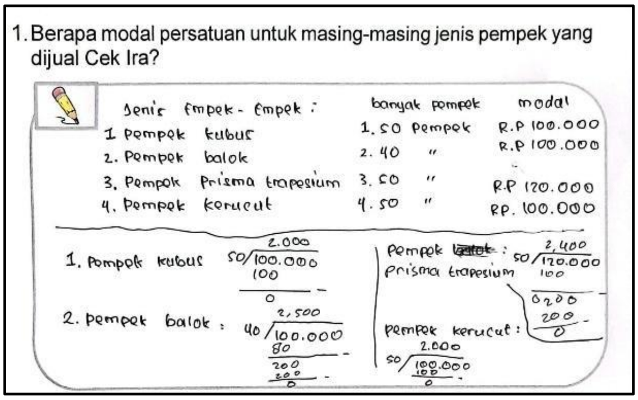
Problem Description:

Cek Ira is a Pempek trader who produces four types of Pempek: cubes, cuboids, cones, and trapezoidal prisms. The cost price for each type of Pempek is presented in the Table 2.

Table 2. The cost price for each type of Pempek

Types Pempek	Quantity	Cost Price
Cubes	50 Pempek	IDR100.000
Cuboids	40 Pempek	IDR100.000
Trapezoidal Prisms	50 Pempek	IDR120.000
Cones	50 Pempek	IDR100.000

Cek Ira packages the Pempek in vacuum-sealed packs. A vacuum-sealed Pempek is one that has been sealed airtight using a food vacuum device, ensuring long durability, which is especially useful for transportation over long distances. Each pack may contain a variety of Pempek types, which could include a single type or a combination of two, three, or all four types, depending on the buyer's preference. Figures 12 to 14 show examples of student responses to the problem posed.



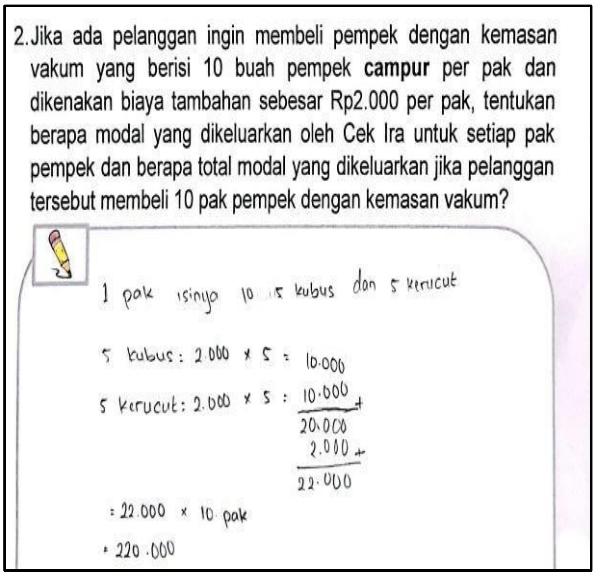
Translate:

1. How much is the cost price for one pempek in each type of pempek sold by Cek Ira?
   Answer:
   Cubes pempek IDR 2.000
   Cuboids pempek IDR 2.500
   Trapezoidal prisms IDR 2.400
   Cones pempek IDR 2.000

Figure 12. Responses to Activity 3 (Question 1)

Figure 12 illustrates how students calculate the cost price per unit for each type of Pempek. To obtain this value, students divide the total cost price of each Pempek type by the quantity produced. This method allows students to derive the individual cost of each Pempek type, which serves as the basis for subsequent calculations.

In Figure 13, an example of student group responses is presented. The students chose a mixed Pempek package containing 5 cube Pempek and 5 conical Pempek. The contents of the mixed Pempek package were determined through consensus among the group, taking into account the conditions described in the problem. The students concluded that the mixed Pempek package could only contain two types of Pempek. They then calculated the total cost for one package, which included the cost of 10 mixed Pempek (5 cubes and 5 cones) plus a vacuum sealing fee. The total cost for one mixed Pempek package was IDR 22,000, and the cost for 10 mixed Pempek packages amounted to IDR 220,000. Figure 13 illustrates the calculation process and the final cost breakdown.


2. Jika ada pelanggan ingin membeli pempek dengan kemasan vakum yang berisi 10 buah pempek **campur** per pak dan dikenakan biaya tambahan sebesar Rp2.000 per pak, tentukan berapa modal yang dikeluarkan oleh Cek Ira untuk setiap pak pempek dan berapa total modal yang dikeluarkan jika pelanggan tersebut membeli 10 pak pempek dengan kemasan vakum?

1 pak isinya 10 : 5 kubus dan 5 kerucut

5 kubus : 2.000 x 5 = 10.000

5 kerucut : 2.000 x 5 : 10.000 +

20.000

2.000 +

22.000

= 22.000 x 10 pak

= 220.000

Translate:

2. If there is a customer who wants to buy pempek with vacuum packaging containing 10 pieces of pempek mixed each pack and is charged an additional fee of IDR 2.000 for each pack, determine how much cost price is spent by Cek Ira for each pack of pempek and how much is the total cost price spent if the customer buys 10 pack of pempek with vacuum packaging?

   Answer:

   One pack of 10; 5 cubes pempek and 5 cones pempek

   Cost price of one package pempek:

   2000 x 5 = 10.000

   2000 x 5 = 10.000

   = 2.000 vacuum charge

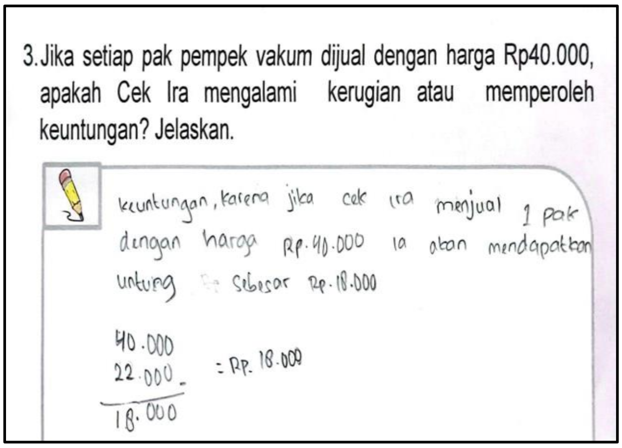
   Total IDR 22.000

   Cost price of ten package pempek

   22.000 x 10 = IDR 220.000

Figure 13. Responses to Activity 3 (Question 2)

Figure 14 shows that the student group successfully determined that Cek Ira made a profit. By subtracting the cost price from the selling price of one mixed Pempek package, the students calculated a profit of IDR 18,000 per package. This calculation confirms that the transaction resulted in a profitable outcome for Cek Ira.


3. Jika setiap pak pempek vakum dijual dengan harga Rp40.000, apakah Cek Ira mengalami kerugian atau memperoleh keuntungan? Jelaskan.

keuntungan, karena jika cek ira menjual 1 pak dengan harga Rp.40.000 ia akan mendapatkan untung sebesar Rp.18.000

40.000

22.000 -

18.000

= Rp. 18.000

Translate:

3. If the selling price of each pack of vakum pempek is IDR 40.000, does Cek Ira suffer a loss or profit? Explain.

   Answer:

   Profit : If Cek Ira sells a vacuum pempek package for IDR 40.000, then she will get a profit of IDR 18.000.

   40.000

   22.000 –

   18.000

Figure 14. Responses to Activity 3 (Question 3)

The New Pempek Mathematics initiative introduces innovative variations to traditional mathematical Pempek, including the Pempek cone, Pempek trapezoidal prism, Pempek cuboid, and

Pempek cube. This project-based learning activity, which encourages collaboration among students within their groups and provides guidance from the teacher, fosters active, creative, and enthusiastic participation. Such engagement is consistent with research suggesting that project-based learning supports student collaboration (Eickholt et al., 2019). The New Pempek Mathematics project offers a dynamic context for students to interactively explore key concepts such as cost price, selling price, and profit. Additionally, the project can be regarded as a cultural heritage initiative, utilizing Pempek—an iconic local dish—as its focal point. Pempek, a traditional food, is deeply embedded in the local culture and is an important example of inherited manufacturing techniques (Wargadalem et al., 2023), making it particularly relevant to students' real-life experiences (Lestari & Putri, 2020).

The integration of real-world contexts in teaching and assessment methodologies is vital, as it not only motivates students but also enhances the enjoyment of learning, encourages active participation in problem-solving, and builds student confidence (Stacey et al., 2015; Sawatzki & Goos, 2018). Through the New Pempek Mathematics project, students are actively involved in collaborative tasks such as preparing ingredients, measuring water requirements, and weighing materials like fish meat, tapioca flour, sugar, and salt. During this phase, students also acquire practical skills in ensuring proper dough preparation, which is crucial for producing Pempek with the desired texture. Subsequently, they engage in the cooking and packaging of the Pempek.

The project also emphasizes the application of basic mathematical calculations, enabling students to model and identify production costs, thereby understanding cost price as the sum of both production and service costs, as well as other related expenses. Gaining this understanding helps students estimate selling prices, leading to the recognition of profit as the difference between the selling price and cost price. As such, students learn that a sale is profitable when the selling price exceeds the cost price, with the selling price representing the accumulation of cost price plus profit (Sawatzki & Goos, 2018). Ultimately, the New Pempek Mathematics context serves as a valuable introductory experience to the concepts of buying and selling, aligning with the five key characteristics of the PMRI approach. By incorporating local cultural elements into mathematics education, this project provides students with meaningful and engaging learning experiences that combine hands-on product creation with academic exploration.

CONCLUSION

This research successfully develops a learning trajectory based on the context of New Pempek Mathematics through the PMRI approach, aimed at enhancing students' understanding of key mathematical concepts in the context of buying and selling, such as cost price, selling price, and profit. The trajectory comprises three interconnected activities that guide students through identifying production costs, estimating selling prices, and solving buying and selling problems. The first activity allows students to understand and identify the cost price of the new mathematical Pempek. In the second activity, students learn to estimate the selling price, understanding it as the accumulation of cost price and profit. The final activity enables students to apply their knowledge in solving real-world problems involving these concepts. This research demonstrates that the proposed learning trajectory, by focusing on collaborative learning and group discussions, promotes a deeper comprehension of the relationship between cost price, selling price, and profit, thus fostering students' ability to apply these concepts to solve contextual problems.

However, this study acknowledges several limitations that could impact the effectiveness and generalizability of the findings. One challenge is the complexity of the mathematical concepts involved, particularly for students who may not have prior exposure to economic and entrepreneurial principles. Introducing production costs and pricing models, as well as linking them to the new form of mathematical Pempek, may prove difficult for such students. Additionally, the availability of necessary materials and resources presents a logistical obstacle; creating geometric Pempek models requires specific tools and materials, which may not always be readily accessible, causing delays in the research process. Time management is also a critical limitation, as project-based learning of this nature demands more time compared to traditional teaching methods. The time required for students to construct the Pempek models and complete the associated calculations can disrupt the broader curriculum, making it challenging to balance practical learning with other academic goals.

In light of these limitations, future research should focus on overcoming the challenges related to material availability and time management. Researchers could explore a wider range of geometric forms for New Pempek Mathematics, thereby enhancing the generalization of findings and broadening the applicability of the approach. Expanding the scope to include other mathematical concepts and materials at different grade levels would also be beneficial in demonstrating the versatility of the learning trajectory. Moreover, future studies should aim to refine time management strategies, ensuring that learning goals can be achieved more effectively while minimizing disruptions to the broader curriculum. This would ensure that the benefits of project-based learning are maximized without compromising academic progress.

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Declarations

Author Contribution	:	RIIP: Conceptualization, Writing - Review, Editing, Methodology, Validation and Supervision. EPS: Writing - Review & Editing, Formal analysis, Methodology, Validation and Visualization. Z, H, LS, NS, YS: Writing – Review & Editing, Formal analysis, Validation and Supervision.
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Conflict of Interest	:	The authors declare no conflict of interest.
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