DEVELOPING A PMRI-BASED LEARNING DESIGN FOR SOCIAL ARITHMETIC THROUGH ONLINE BUYING AND SELLING CONTEXTS

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ABSTRACT Social arithmetic is closely related to students' daily economic activities; however, many students experience difficulties in understanding its concepts due to the abstract presentation of learning materials. This study aimed to develop a Hypothetical Learning Trajectory (HLT) based on the Indonesian Realistic Mathematics Education (PMRI) approach by utilizing online buying and selling as a learning context. The study employed a design research methodology of the developmental research type within a qualitative framework. The research was conducted through three phases: preparing for the experiment, design experiment, and retrospective analysis. Participants were seventh-grade students at SMP Muhammadiyah Pagaralam during the 2024/2025 academic year. Data were collected through classroom observations, interviews, document analysis, and pre- and post-tests. The results indicate that the developed HLT effectively supports students in constructing a meaningful understanding of social arithmetic concepts, such as discounts, taxes, and final costs, through contextual and experiential learning activities. The PMRI-based learning design also encourages active student participation and supports the development of critical thinking skills. These findings suggest that the proposed learning trajectory can serve as a practical reference for designing context-based social arithmetic instruction.

Keywords: PMRI, hypothetical learning trajectory, social arithmetic, online buying and selling

ABSTRAK Aritmetika sosial merupakan materi matematika yang berkaitan erat dengan aktivitas ekonomi dalam kehidupan sehari-hari, namun masih banyak peserta didik yang mengalami kesulitan dalam memahami konsep-konsepnya karena pembelajaran yang bersifat abstrak. Penelitian ini bertujuan untuk mengembangkan Hypothetical Learning Trajectory (HLT) berbasis pendekatan Pendidikan Matematika Realistik Indonesia (PMRI) dengan memanfaatkan konteks jual beli daring. Penelitian ini menggunakan metode design research tipe developmental research dalam kerangka kualitatif. Proses penelitian dilaksanakan melalui tiga tahap, yaitu preparing for the experiment, design experiment, dan

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retrospective analysis. Subjek penelitian adalah peserta didik kelas VII SMP Muhammadiyah Pagaralam pada tahun ajaran 2024/2025. Teknik pengumpulan data meliputi observasi kelas, wawancara, analisis dokumen, serta tes awal dan tes akhir. Hasil penelitian menunjukkan bahwa HLT yang dikembangkan mampu membantu peserta didik membangun pemahaman konsep aritmetika sosial, seperti diskon, pajak, dan harga akhir, secara bertahap dan bermakna melalui aktivitas pembelajaran kontekstual. Selain itu, desain pembelajaran berbasis PMRI mendorong keaktifan peserta didik dan mendukung pengembangan kemampuan berpikir kritis. Oleh karena itu, lintasan pembelajaran yang dihasilkan dapat dijadikan sebagai rujukan dalam perancangan pembelajaran aritmetika sosial yang kontekstual.

Kata-kata kunci: PMRI, hypothetical learning trajectory, aritmetika sosial, jual beli daring

INTRODUCTION

Social arithmetic is a branch of mathematics that focuses on the application of mathematical concepts in social contexts, particularly in economic activities and everyday transactions. This topic encompasses essential concepts such as selling price, purchase price, profit, loss, discount, tax, gross, and net (Sa'adah et al., 2019). Due to its close connection to students' daily experiences, social arithmetic plays a strategic role in developing functional numeracy skills that are crucial for real-life problem solving (Andayani & Lathifah, 2019).

Despite its relevance, many students experience difficulties in understanding and solving contextual problems related to social arithmetic. Based on classroom observations and interviews with mathematics teachers at SMP Negeri 3 Blora, this topic is perceived as relatively challenging for students (Mitasari & Murtiyasa, 2023). Common difficulties include understanding percentage concepts, calculating taxes, and systematically organizing total price calculations. In many cases, students tend to rely on memorizing formulas without comprehending the underlying context, which limits their ability to solve word problems and develop critical thinking skills (L. Fitriani et al., 2023). These challenges are further exacerbated by teacher-centered instructional practices that provide limited opportunities for active student engagement (Hidayati, 2013).

Addressing these issues requires an instructional approach that is contextual, interactive, and closely related to students' real-life experiences. One approach that has been widely recognized for this purpose is Indonesian Realistic Mathematics Education (PMRI), which is adapted from the Realistic Mathematics Education (RME) framework developed by Hans Freudenthal (Freudenthal, 1991; Gravemeijer, 1994; Lismareni et al., 2015). PMRI conceptualizes mathematics as a human activity and emphasizes that learning should begin with meaningful contexts familiar to students. Through guided reinvention and direct engagement with real-world problems, students are encouraged to actively construct their mathematical understanding (Kamsurya, 2019).

In addition, the PMRI approach is highly consistent with the principles of the Merdeka Curriculum, which promotes contextual and flexible learning while encouraging active student participation. Within this curriculum framework, teachers are given greater autonomy to design learning modules that are grounded in students' lived experiences (Ade Aransyah, 2023), including the implementation of PMRI as an effective instructional strategy. The Merdeka Curriculum also aims to create a more enjoyable and less pressured learning environment, thereby better preparing students to face future academic and real-world challenges (Kurniasari, 2020).

Empirical studies have consistently demonstrated the effectiveness of PMRI in teaching social arithmetic. Selviyani et al. (2024) reported that PMRI-based instructional materials help students grasp abstract concepts through contextual learning experiences. Similarly, Oktaviandy et al. (2023) and Octavia et al. (2024) found that incorporating games such as Monopoly within PMRI-based lessons enhances student motivation and thinking skills. Mangelep et al. (2024) further noted that integrating PMRI with sociodrama methods results in more engaging and meaningful learning experiences.

Support for PMRI also emerges from international research on RME. Yuanita et al. (2018) concluded that the RME approach effectively enhances students' problem-solving abilities through meaningful mathematical representations. Dewantara et al. (2020) demonstrated that PMRI contributes to the development of mathematical literacy by integrating digital and contextual scenarios into instruction. Furthermore, Inharjanto and Lisnani (2019) showed that PMRI grounded in local cultural contexts supports deeper conceptual understanding, while Rangkuti et al. (2023) and Saleh and Trisanti (2024) confirmed that RME positively influences students' conceptual understanding and mathematical creativity. Retta (2016) also emphasized that the mathematization process in PMRI facilitates students' understanding by guiding them from concrete situations toward abstract mathematical concepts.

In the context of contemporary education, online shopping activities through platforms such as Shopee, Tokopedia, and TikTok Shop have become an integral part of students' everyday experiences (Irma & Nada, 2024). This context strongly aligns with PMRI principles, which emphasize authentic student experiences as the starting point for learning. Therefore, integrating the context of online buying and selling into social arithmetic instruction through the PMRI approach is expected to enhance students' understanding in a more concrete, applicable, and relevant manner. Accordingly, this study aims to design a social arithmetic learning trajectory based on the PMRI approach within the context of online commerce. This contextual focus not only reflects real-world practices but also promotes active student engagement in constructing meaningful mathematical understanding.

METHODS

This study employed a design research methodology, specifically developmental research, within a qualitative research framework. The study aimed to develop a Hypothetical Learning Trajectory (HLT) for teaching social arithmetic by applying the Indonesian Realistic Mathematics Education (PMRI) approach in the context of online buying and selling activities. Design research was selected because it allows for the systematic development, testing, and refinement of instructional designs grounded in both theoretical perspectives and classroom practice.

The research process was conducted through three interconnected phases. The first phase, preparing for the experiment, focused on constructing an initial HLT based on an extensive review of relevant literature and preliminary classroom observations to identify students' learning needs and potential learning obstacles. The second phase, the design experiment, consisted of two stages: a pilot experiment and a teaching experiment. The pilot experiment was conducted to examine the feasibility and clarity of the designed learning activities, while the teaching experiment aimed to implement, test, and refine the HLT in an authentic classroom setting. The third phase, retrospective analysis, involved a systematic evaluation of the learning design by analyzing data collected during the teaching experiment to assess the coherence between the designed HLT and students' actual learning processes.

The participants in this study were seventh-grade students at SMP Muhammadiyah Pagaralam during the 2024/2025 academic year. Data were collected through classroom observations, semi-structured interviews, document analysis, and pre- and post-tests. Data analysis was carried out using descriptive and retrospective analysis, with findings continuously aligned with the developed HLT. To ensure the trustworthiness of the results, data triangulation was applied across multiple data sources, enabling the validation, reliability, and traceability of the learning outcomes generated through the design research process.

FINDING AND DISCUSSION

Preparing For The Experiment

This study produced a design of a Hypothetical Learning Trajectory (HLT) for the topic of social arithmetic, developed based on the principles of the Indonesian Realistic Mathematics Education (PMRI) approach, and presented in the form of an iceberg diagram as shown in the figure 1.

The developed iceberg design is further elaborated based on the learning activities, the objectives of each activity, detailed descriptions, and the hypothesized student thinking and learning processes. At this stage, the researcher also prepares instructional tools such as lesson plans (RPP), student worksheets (LKPD), and test items aligned with the HLT design. This design is then considered appropriate for implementation and classroom trial.

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In this process, a learning trial was conducted in two stages, namely the pilot experiment and the teaching experiment. Both stages followed a similar learning sequence. The purpose of the pilot experiment was to evaluate and refine the learning design that had been developed, so that it could be revised and used optimally during the teaching experiment.

Figure 1. iceberg of total amount concept in online buying and selling

After the initial trial stage (pilot experiment) was conducted, the researcher carried out a revision process. This revision was developed based on data collected through direct observation, video recordings, interviews with students and the model teacher, Mrs. Septiana Putri Indah, S.Pd., as well as analysis of the activity sheets

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completed by the students. Through this process, improvements were made to the initial Hypothetical Learning Trajectory (HLT), resulting in the second version of the HLT. The revised HLT will be used in the next stage, namely the teaching experiment. The details of the changes made to the initial HLT are presented in Table 1 below.

Table 1. Revisions from HLT to ALT

Learning Phase	Observation Result	Reflection of Findings
Activity 1 (Context Exploration)	Students identified terms and components of online buying and selling transactions. Active discussions occurred.	The online shopping context is relevant to students' experiences.
Activity 2 (Online Transaction Simulation and Understanding Calculations)	Students simulated purchases, manually calculated discounts and taxes, and compared them with the app results.	Students began to understand the calculation sequence and develop thinking strategies.
Activity 3 (Problem Solving)	Students systematically calculated the final price. Some were able to explain their reasoning.	Improvement observed in mathematical thinking and strategy development.

The revised Student Activity Sheet (LAS).

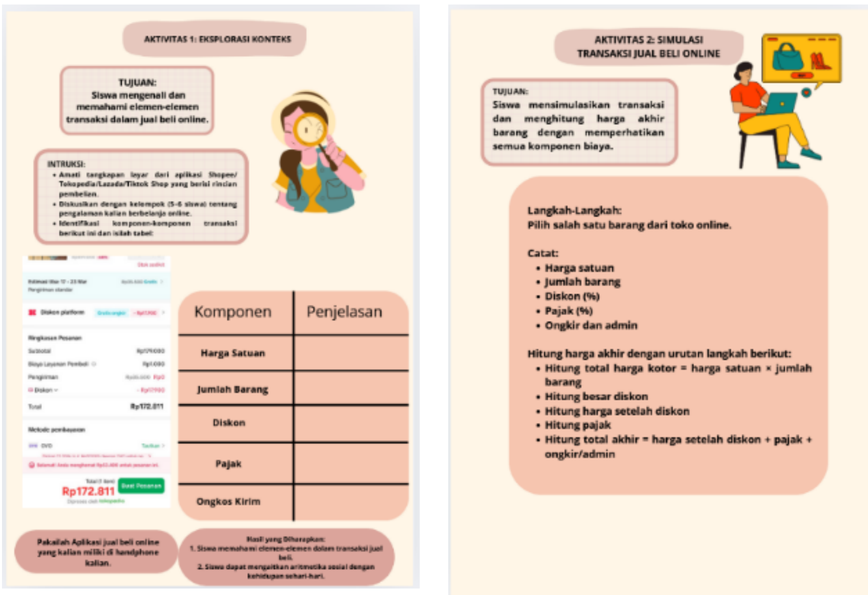

Figure 2. The Revised Student Activity Sheet

After the revision was completed and approved by the model teacher, the process proceeded to the next stage, teaching experimnet

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Activity 1: Exloring The Context Of online Transactions

In the initial activity, students were introduced to the components of online buying and selling transactions, such as unit price, discount, tax, and shipping cost. The activity began with a discussion of students' experiences using e-commerce platforms like Shopee and Tokopedia. Observation results indicated that students were able to identify key elements of transactions accurately and showed enthusiasm while participating in the simulation activities.

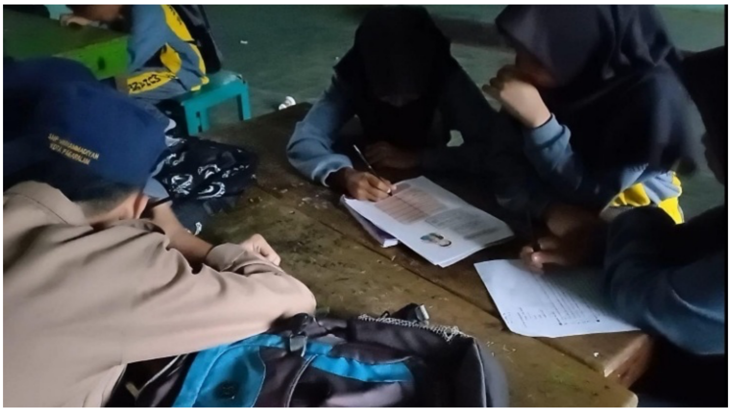
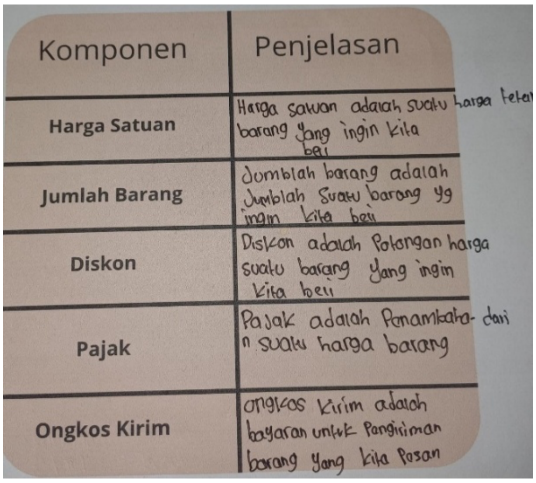


Figure 3. Students Working on Activity 1 during the Teaching Experiment

Students discussing key components of online buying and selling transactions, including item price, discount, tax, shipping cost, and any additional charges. This discussion served as an initial step in contextualizing mathematical concepts within students' everyday digital experiences.



Komponen	Penjelasan
Harga Satuan	Harga satuan adalah suatu harga teta barang yang ingin kita beli
Jumlah Barang	Jumlah barang adalah Jumlah suatu barang yg ingin kita beli
Diskon	Diskon adalah Potongan harga suatu barang yang ingin kita beli
Pajak	Pajak adalah Penambahan dari suatu harga barang
Ongkos Kirim	ongkos kirim adalah bayaran untuk Pengiriman barang yang kita Pesan

Figure 4. Example of a Student's Answer in the Table Format on the First Activity Sheet during the Teaching Experiment

Students demonstrated quicker understanding of key terms and were able to provide concrete examples. The use of visual media, such as screenshots, proved effective in enhancing student engagement and participation in discussions. Several students even began to independently inquire about the function of discounts and how taxes are calculated, indicating an increase in curiosity and intrinsic motivation.

Teacher	:	Children, who has ever shopped online?
Student	:	I have, Miss! I often buy clothes on Shopee.
Student	:	Me too, I usually buy stationery or phone credit on Tokopedia.
Teacher	:	Wow, that's great! Now, when you shop online, besides the price of the item, what else do you usually pay attention to?
Student	:	There's a discount, Miss. Sometimes we also get free shipping vouchers.
Student	:	Yes, and sometimes there are extra charges like tax or administrative fees.

Findings: Students began to realize that the total payment is influenced by multiple components. They also actively engaged in discussions to understand the terms discount and tax, which frequently appear in online shopping contexts.

Activity 2: Transaction Simulation and Understanding the Calculation of Total Price

Students were asked to simulate a shopping activity using an e-commerce application and calculate the final total price using real data from the selected platform. The Student Activity Sheet (LAS) was revised to include more systematic steps, supported by a visual sequence of calculations, starting from Discount → Net Price → Tax → Final Cost.

Learning Activity: Each group was instructed to select one product from an e-commerce platform they frequently use. The chosen product had to contain complete information, including unit price, discount amount, shipping fee, and administrative cost. Students then recorded the transaction data, which included unit price, quantity purchased, percentage of discount and tax, as well as shipping and administrative fees.

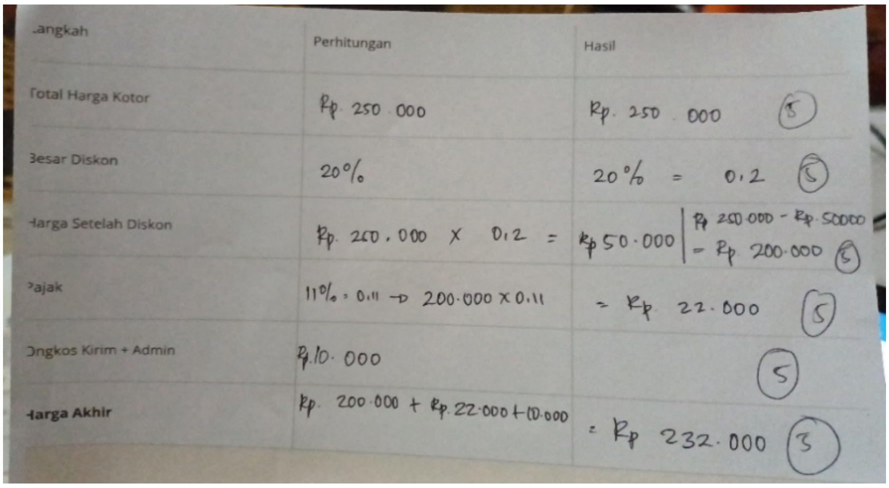
Figure 5. Students Conducting a Group Online Buying and Selling Simulation during the Teaching Experiment

Next, students calculated the final price by following the visual steps outlined in the Student Activity Sheet (LAS), which included:

1. Calculating the gross total price (unit price × quantity),

2. Determining the discount amount from the gross total price,
3. Subtracting the discount to obtain the price after discount,
4. Calculating the tax based on the price after discount, and
5. Summing the price after discount, tax, shipping cost, and administrative fee to arrive at the final price.

Throughout the activity, students engaged in group discussions and collaboration to understand the real-world and relevant application of social arithmetic concepts. Their calculations were recorded in the provided worksheets, which served as the basis for the next learning activity. The following is an example of a student's response based on the simulation.



angkah	Perhitungan	Hasil
Total Harga Kotor	Rp. 250.000	Rp. 250.000 (5)
esar Diskon	20%	20% = 0,2 (5)
arga Setelah Diskon	Rp. 250.000 x 0,2 =	Rp 50.000 | Rp 250.000 - Rp. 50.000 = Rp. 200.000 (5)
ajak	11% = 0,11 → 200.000 x 0,11	= Rp. 22.000 (5)
ngkos Kirim + Admin	Rp.10.000	(5)
arga Akhir	Rp. 200.000 + Rp. 22.000 + 10.000	= Rp 232.000 (3)

Figure 6. Example Of A Student's Answer In Activity 2 During The Teaching Experiment

Based on observations from the figure, students were able to determine the final price of an online buying and selling transaction through a simulation using real data.

Teacher	:	Now, each group please choose one product from your online shopping app. Make sure the product has complete information!
Student	:	Miss, we chose a watch priced at Rp250,000. There's a 20% discount, 11% tax, and Rp10,000 for shipping.
Teacher	:	Great. Now try to calculate manually what the final total price is. The order should be: Discount → Price after discount → Tax → Shipping and admin fees → Final price.
Student	:	The discount is Rp50,000, so the price after discount is Rp200,000. The tax is 11% of Rp200,000, which is Rp22,000. So the final total is Rp232,000.
Teacher	:	Good job, you followed the calculation steps correctly. Now check if the result matches what's shown in the app.
Student	:	It matches, Miss! The final amount is the same.

Findings: Most students began to understand how to calculate percentage-based discounts, although some still made mistakes in the order of operations. However, through group discussions and teacher feedback, students' understanding gradually improved.

Activity 3: Students Solve Contextual Problems

Students were given problems that integrated various components of social arithmetic. Based on their responses, it was evident that they were beginning to structure their solution steps in a systematic and organized manner.

Learning Activity: In this activity, students were challenged to solve complex word problems that reflected real-life situations in online buying and selling transactions. The aim of this activity was to assess students' ability to comprehensively apply social arithmetic concepts, supported by mathematical reasoning and structured problem-solving steps.

Students began by reading a contextual problem that included various transaction components such as unit price, quantity, discount, tax, shipping cost, and administrative fees. From the problem, students identified key data needed for the calculation process. They were then asked to formulate their solution steps based on the sequence previously learned, namely:

1. Calculating the total gross price (unit price × quantity)
2. Determining the discount amount (discount percentage × total gross price)
3. Calculating the price after discount (total gross price – discount)
4. Calculating the tax (tax percentage × price after discount)
5. Adding the shipping cost and administrative fee based on the data provided
6. Calculating the final price (price after discount + tax + shipping cost + admin fee)

During the activity, students worked in groups to ensure each calculation was accurate. They also compared the strategies used in solving the problems. The final results were recorded in a table provided in the Student Activity Sheet (LAS), arranged in a logical and sequential manner for clarity.

The following are the activities and students' responses:

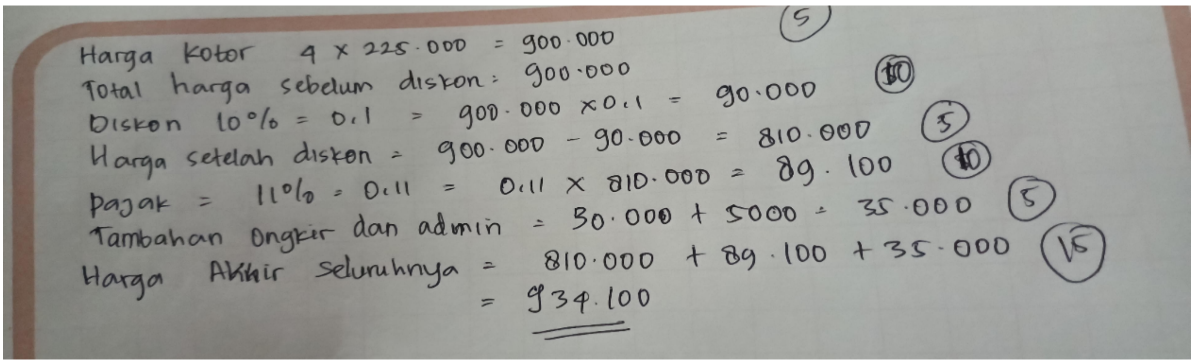


Figure 7. Example of A Student's Answer In Activity 3

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Based on the figure, students were able to solve complex word problems related to calculating the total cost in online buying and selling transactions using well-organized steps and logical reasoning.

Teacher	:	Now let's try a more complex problem. Look at the question in the LAS: "A customer buys 4 headsets at Rp225,000 each. The store gives a 10% discount, charges 11% tax, shipping costs Rp30,000, and an admin fee of Rp5,000.
Student	:	First, let's calculate the gross price: 4 × 225,000 = Rp900,000.
Student	:	The discount is 10%, so 0.1 × Rp900,000 = Rp90,000. The price after the discount is Rp810,000.
Student	:	The tax is 11% of Rp810,000, which is Rp89,100. So the total is: Rp810,000 + Rp89,100 + Rp30,000 + Rp5,000 = Rp934,100.
Teacher	:	Excellent! You've managed to organize the calculation logically and systematically. That's exactly what we aim for in context-based learning like this.

The initial learning trajectory was revised following the pilot experiment. The revisions included the addition of visual elements in the Student Activity Sheet (LAS), more detailed calculation steps, and problem contexts that were more closely aligned with students' real-life experiences. These improvements proved to enhance the effectiveness of learning during the teaching experiment.

The learning trajectory developed in this study aims to gradually build students' understanding of social arithmetic concepts through the PMRI (Indonesian Realistic Mathematics Education) approach using the context of online shopping. Each activity in the trajectory is designed to support the process of mathematization from concrete situations to formal understanding.

In the first activity, students were introduced to real-life contexts involving online transactions on platforms such as Shopee and Tokopedia. This activity is positioned at the situational level in the iceberg model, where students draw upon personal experiences to understand transaction elements such as price, discount, and tax. Student responses showed high engagement and increased learning enthusiasm, indicating that authentic contexts are effective in enhancing learning motivation.

The second activity involved calculating discounts and taxes as an initial form of mathematization. Some students encountered difficulties with percentages; however, through teacher guidance and group discussions, they were able to revise their problem-solving strategies. This activity reflects the process of guided reinvention, where students reconstruct mathematical concepts based on their own experiences.

The third activity required the integration of all price components to determine the total cost. Students began to demonstrate an understanding of systematic calculation structures and were able to explain the solution procedures logically. This reflects a cognitive shift from model of to model for, in line with the PMRI principle that emphasizes the development of understanding from concrete to formal.

Overall, the resulting learning trajectory has proven to:

1. Increase students' active participation in the learning process;
2. Support the construction of understanding of discount, tax, and final price concepts;
3. Promote mathematical communication through discussion and reflection;
4. Connect real-life experiences with symbolic mathematical representations.

These findings align with the study by Selviyani et al. (2024), which demonstrated that PMRI-based teaching materials are effective in building understanding through contexts close to students' lives. This study also reinforces the findings of Oktaviandy et al. (2023) and Mangelep et al. (2024), showing that authentic contexts and realistic approaches can significantly improve mathematics learning outcomes. Yuanita et al. (2018) concluded that the Realistic Mathematics Education (RME) approach is effective in enhancing students' problem-solving skills by utilizing meaningful mathematical representations. Similarly, Dewantara et al. (2020) highlighted that PMRI can improve students' mathematical literacy through the integration of digital tools and real-life contexts into learning. Inharjanto and Lisnani (2019) emphasized that implementing PMRI with culturally relevant contexts enables students to develop a more profound understanding of mathematical concepts. Supporting this, Rangkuti et al. (2023) and Saleh & Trisanti (2024) found that applying the RME approach positively influences students' conceptual grasp and fosters their mathematical creativity. Additionally, Retta (2016) pointed out that the mathematization process in PMRI supports students in developing their understanding by progressing from concrete experiences to more abstract thinking.

CONCLUSIONS AND RECOMMENDATIONS

This study aimed to develop a Hypothetical Learning Trajectory (HLT) based on the Indonesian Realistic Mathematics Education (PMRI) approach by utilizing online shopping as a learning context to enhance students' understanding of social arithmetic concepts. The findings of the design research process indicate that the developed learning trajectory was effective in linking mathematical concepts to students' everyday experiences. The sequence of activities within the HLT—ranging from contextual exploration and transaction simulation to contextual problem solving—successfully supported students in constructing a gradual, meaningful, and contextual understanding of key social arithmetic concepts, including discounts, taxes, and final costs.

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Furthermore, students' active engagement during group discussions, the use of authentic media such as screenshots from online shopping applications, and the implementation of structured calculation procedures demonstrate that the PMRI-based learning design fostered active participation and supported the development of students' critical thinking skills. These findings suggest that the learning trajectory developed in this study can serve as a practical reference for designing social arithmetic instruction that is contextually relevant and pedagogically meaningful.

Based on these results, it is recommended that the PMRI-based learning design be implemented and examined in diverse educational settings and across different grade levels to assess the consistency and sustainability of its effectiveness. Future studies may also extend the application of this approach to other mathematical topics by incorporating contextual learning environments closely aligned with students' digital experiences and daily activities. In addition, sustained collaboration between teachers and researchers is strongly encouraged to support the development and evaluation of innovative, context-based instructional designs that are both theoretically grounded and practically applicable.

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