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Enhancing Civic Mathematics Knowledge of Students Through PMRI Approach

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Abstract

Critical mathematical thinking is inevitable in becoming a concerned citizen and an active part of modern society. Such knowledge would improve understanding of the learning mathematics process and suggest better teaching methods, which is especially crucial for teaching civic knowledge. This research develops mathematics learning tools and investigates the effectiveness of implementing the Indonesian Realistic Mathematics Learning (PMRI) approach based on civic mathematics in grade VII of Senior High School in the odd semester of 2024/2025. The learning tools in this study allow students to see issues in social contexts and relate them to mathematics. This study involved one participant teacher and 25 student participants. Action research and mixed methods were used in this research. This approach has allowed teachers and students to increase their activities in learning mathematics and improving students' mathematics achievement. Before implementing the approach, students completed only nine students or 36%; in the first cycle, the student's achievement increased to 16 students or 64%; in the second cycle, 23 students, or 88%, had met the completeness. Also, by designing materials that link mathematics education with citizenship education, based on an interdisciplinary basis, this research provides a new important example of the transfer of mathematical roles. In this study, mathematics education is allocated to its role in efforts to build a democratic society.

Keywords: Civic Mathematics, PMRI, Students' Achievement, Teaching Approach.

INTRODUCTION

The PMRI approach in Indonesia, rooted in the principles of Realistic Mathematics Education (RME), conceptualizes mathematics learning as an active process wherein students construct mathematical understanding through engagement with real-world problem solving

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(Gravemeijer, 1994; Putri et al., 2015). Contexts employed in PMRI are experientially meaningful, encompassing both everyday life situations and imaginative scenarios that resonate with students (Suwarto et al., 2023). This approach emphasizes problem-solving competencies by situating learning in realistic contexts and fostering environments where students utilize their mathematical intuition and prior knowledge (Lestari et al., 2023). Furthermore, mathematics education under this framework serves civic and social purposes, aiming to develop individuals who can think logically, act honestly, and participate responsibly in civic and economic life (Vogel & Chintala, 2024; Listiawati et al., 2023; Djam'an, 2014). Thus, mathematics has become a vehicle for empowering individuals as active citizens in an increasingly mathematized world (Adams, 1928), and a critical perspective on mathematics and citizenship is essential to promote students' engagement in societal issues (Ernest, 2002).

According to Gravemeijer (1994), the term *realistic* in RME derives from one of the four instructional approaches identified by Treffers (1987): mechanistic, structuralistic, empiristic, and realistic. RME incorporates two key processes—horizontal and vertical mathematization—that jointly support the development of long-term mathematical understanding (Freudenthal, 1973). These processes enable students to connect real-life experiences with abstract mathematical reasoning. The core objective is to identify meaningful problem situations that can be generalized and serve as a foundation for vertical mathematization (Ali, 2022; Van den Heuvel-Panhuizen & Drijvers, 2014; Van den Heuvel-Panhuizen et al., 2016). This study investigates the effectiveness of implementing the PMRI approach based on civic mathematics in teaching Grade VII secondary school students.

METHODOLOGY

Action research and mixed methods are methodologies. Action research is relevant to developing teaching methods and student learning by integrating civic mathematics with mathematics education.

Research Participants

This research occurred at SMP Tunas Harapan Malaka in the odd semester of 2024/2025. The class consisted of 25 students in grade VII. Prior to conducting the research, I approached the teacher participant to participate in the study. In the workshop session, the teacher was provided with an example of a student activity sheet. The two-day workshop was held in the school. This

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workshop served as a platform for the exchange and sharing of ideas and experiences related to this research.

Data Collection

This study collected data during each phase of the research cycle. Before this, learning tools such as lesson plans and student activity materials were developed. Qualitative data was gathered through field notes, observations, and interviews. The teaching and learning process in the classroom was observed, with detailed field notes taken throughout. Observations were also recorded using a video recorder after obtaining consent from all participants.

Additionally, a voice recorder was used during interviews with the teacher. After each lesson, an informal meeting was held with the teacher in their office. This meeting provided an opportunity for the teacher to receive feedback and reflect on the lesson that had just taken place.

Data Analysis

The quantitative analysis utilized observation sheets to evaluate teacher and student activities during the PMRI implementation based on civic mathematics. The qualitative analysis followed the steps outlined by Creswell (1998), which include data preparation, thematic exploration, and coding, using grounded theory and NVivo 15. Audio and video data were transcribed promptly to ensure readiness for analysis.

RESULTS AND DISCUSSIONS

Quantitative Data

This research lasted for two cycles. Observations were made during the learning process of student activities in PMRI. Students' activity sheets and discourses are used to collect qualitative data. The following figure compares the data observations of teacher activity in the PMRI approach for each research cycle.

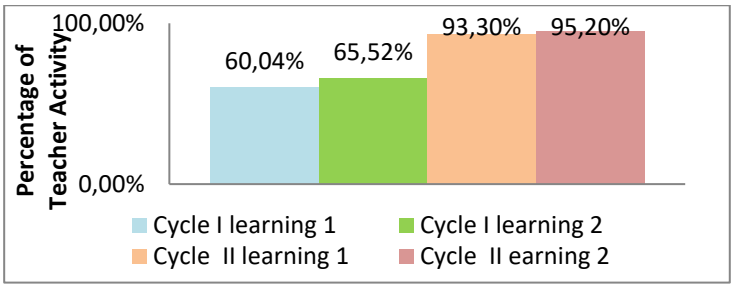


Figure 1 Observation Results on Teacher Activity in the PMRI Approach based on Citizenship

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Cycle I

In the first meeting of Cycle 1, the teacher introduced data collection by recording students' weights and eliciting their prior knowledge. The lesson progressed with demonstrations on organizing and analyzing data using tables and diagrams, followed by worksheet activities to reinforce these concepts. Students collaborated through board work and discussion to foster engagement and were assigned independent reviews for the subsequent session.

During the first meeting of the cycle, four core PMRI characteristics were evident: (1) *Using Context* was demonstrated through data collection grounded in real-life environmental settings; (2) *Using Models* appeared through instructional aids like worksheets to support conceptual understanding; (3) *Student Construction* emerged as students engaged with peer responses on the chalkboard, fostering collaborative learning; and (4) *Interconnected Learning* was observed as students reflected on shared experiences with researchers. These elements illustrated the PMRI approach's contextual, interactive, and reflective learning emphasis. In the second meeting, the teacher introduced diagram-related content through worksheets, first reviewing data collection to reinforce prerequisite knowledge. Students exhibited high engagement during the tasks.

In contrast to the first session, the second meeting demonstrated all five PMRI characteristics, notably interactivity, as students engaged in collaborative board work and peer responses. This interactive element was closely tied to interconnected learning, where students reflected on and built upon each other's insights. Through these activities, learners collectively constructed knowledge, exemplifying the effective integration of PMRI principles. The session highlighted how shared understanding and collaboration reinforce meaningful mathematics learning.

Cycle II

In the first meeting of the second cycle, students were introduced to data processing, beginning with foundational concepts before progressing to the primary material. Students worked in groups to foster collaboration; each receiving a booklet to guide discussions and develop presentations. High-performing students presented their group's findings, while peers responded and provided constructive feedback. The session concluded with two students summarizing key points, reinforcing the learning. All five PMRI characteristics were evident: (1) *Using Context* appeared through real-life problem scenarios; (2) *Using Models* involved the use of media tools to enhance conceptual understanding; (3) *Student Construction* was present during group discussions where students collaboratively built knowledge; (4) *Interactivity* emerged

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through active communication and peer feedback during presentations; and (5) *Interconnected Learning* was demonstrated in students' reflective discussions and joint reviews. These integrated characteristics resulted in a holistic and engaging mathematics learning experience.

In the second meeting of the second cycle, instruction focused on solving data processing problems involving pie charts and calculating central angles based on percentages. The teacher reviewed previous material before problem-solving to reinforce students' understanding and readiness. Worksheets were distributed, and students worked individually before one student presented their solution to the board, prompting peer feedback and discussion. All five PMRI characteristics were evident: (1) *Using Context* was demonstrated as students connected tasks to real-life situations; (2) *Using Models* appeared through the use of worksheets that supported conceptual development; (3) *Student Construction* emerged in students' independent problem-solving; (4) *Interactivity* was visible in classroom discussions and active competition during board work; and (5) *Interconnected Learning* occurred as students applied prior knowledge of percentages and geometry to deepen understanding across mathematical domains. This session exemplified a comprehensive application of the PMRI approach.

Many students stated that:

"I finally understood how to calculate percentages and angles for pie charts by connecting it to what we learned about multiplication and addition. It feels good to see how it all fits together. Using real-life examples like the export data made me realize how important math is in understanding what's happening in our country."

This meeting provided a dynamic and interactive learning environment, incorporating all PMRI characteristics. Relevantly, other research has shown that the PMRI approach significantly improves mathematical literacy, including achieving higher marks in classical completeness, increasing the proportion of students with strong mathematical literacy, and showing better overall outcomes than conventional learning methods (Wigati et al., 2020).

Figure 2 compares student activities applying the PMRI approach based on civic principles across Cycles I and II.

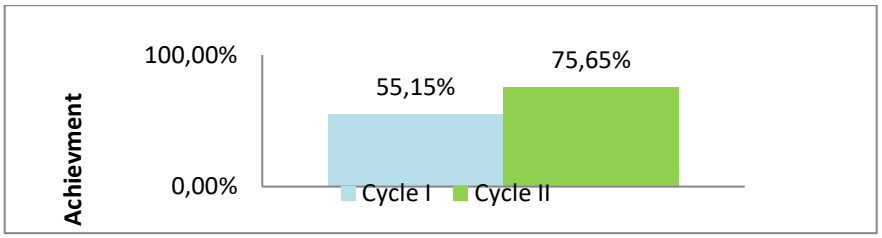


Figure 2. Observation Results of Student Activities

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Figure 2 illustrates that the activity level of secondary school students increased significantly, rising from 55.15% in the first research cycle to 75.65% in the second. This highlights a noticeable improvement in students' overall engagement and achievement across the research cycles.

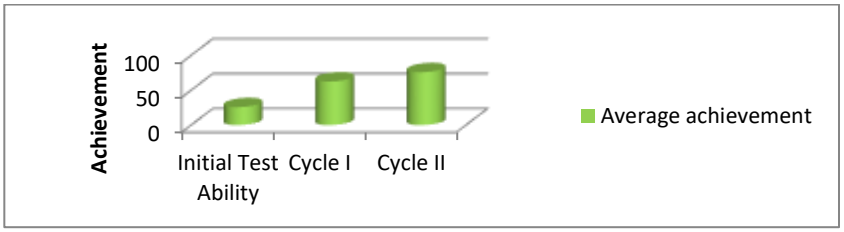


Figure 3. The Average Achievement of Students on Each Cycle

Figure 3 shows that the student's average achievement in the first research cycle was 62.5, with a completeness rate of 64%. In the second cycle, the average achievement increased to 75.8, with a higher completeness rate of 88%.

The results from the first meeting of the second learning cycle show that students were more actively engaged in the learning process. While they could apply mathematical facts, rules, and structures to find solutions, they still struggled to fully evaluate and justify the reasoning behind their mathematical solutions to real-world problems.

During the second meeting of the learning process in the second cycle, students demonstrated significant improvement in their mathematical literacy skills. They showed increased enthusiasm for solving real-life problems, particularly during group activities. Students were attentive, actively participated in group discussions, and confidently asked questions when they needed clarification. These behaviors significantly contributed to enhancing their mathematical literacy.

Students could formulate mathematical situations, interpret and use mathematical concepts, and evaluate the results effectively, showcasing their growing understanding and engagement in learning.

Qualitative Data

At the beginning of this study, the participating teachers encountered challenges in incorporating civic mathematics into their students' activities. However, they made significant efforts to implement the approach. For instance, during the first cycle, the teacher designed an

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activity sheet focused on *Indonesia's Top 5 Commodity Exports and their Destination Countries* to engage students and integrate civic mathematics into the lesson.

Activity 1

Graphs are powerful tools for representing data in a meaningful way, making the ability to read and interpret them an essential part of mathematical literacy (PISA, 2009). This task focuses on mathematical skills such as reading data from bar or pie charts and understanding fractions. To solve the problem, students must decode and interpret familiar, standardized representations of commonly encountered mathematical objects. The graphics below provide information on Indonesia's exports, presented in USD billions.

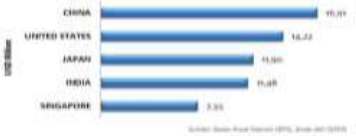


Figure 1. Distribution of non-oil and gas Exports from Indonesia based on Destination Countries in January-October 2017

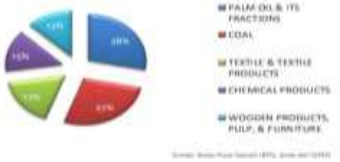


Figure 2. Indonesia's Top 5 Commodity Exports in January – October 2017

1. What was the total value (in USD Billion) of exports from Indonesia?
2. How much contribution was generated by the most exported commodity in (USD Billions) of Indonesia's total exports in 2017?

Figure 4. Activity 1 of the Students' Sheet

Throughout the study, students were given opportunities to develop formal mathematical knowledge by connecting it to civic issues. This approach enhanced their understanding of mathematics and enriched their learning experience by addressing social topics. The student revealed his interest in learning mathematics by saying:

"I liked how the pie chart activity used real data about exports from Indonesia. It helped me see how mathematics connects to our economy and what's happening around us. Working on percentages related to real-world problems made the topic more interesting and easier to understand because I could imagine how it applies to real situations."

Next, Dian also revealed his opinion that relates to interest:

"The worksheets helped a lot because the diagrams and problems were easy to follow and made me feel confident working through the steps."

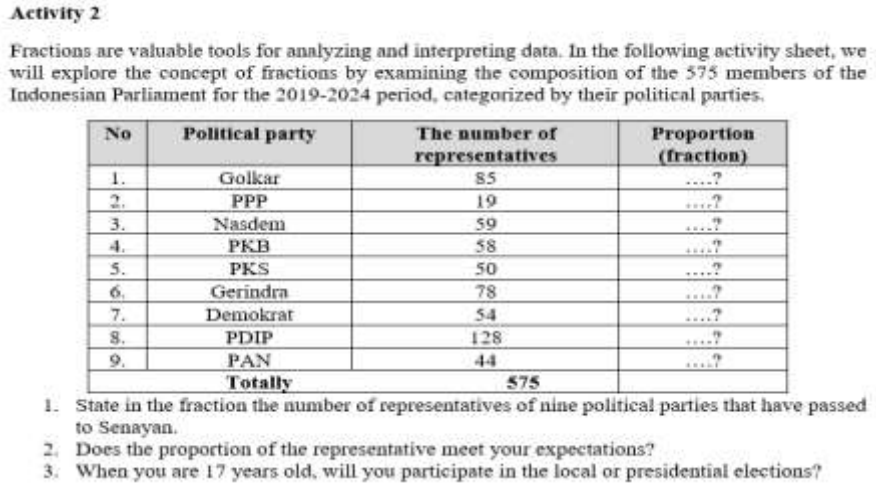
"Seeing the pie chart representation in the worksheet clarified how to connect fractions and percentages to real-life problems."

Related to this, Tenri stated that

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"It was fun solving problems on the board because I could explain my thinking, and my classmates gave me good ideas to improve it. When we worked on the worksheets, I felt I could use what I already knew to help my group finish the tasks."

To achieve this, the teacher designed activities that balanced mathematical concepts with civic themes. For instance, students were guided to engage in discussions and answer questions based on provided data, encouraging them to explore the intersection of mathematics and real-world social issues.



Activity 2

Fractions are valuable tools for analyzing and interpreting data. In the following activity sheet, we will explore the concept of fractions by examining the composition of the 575 members of the Indonesian Parliament for the 2019-2024 period, categorized by their political parties.

No	Political party	The number of representatives	Proportion (fraction)
1.	Golkar	85	....?
2.	PPP	19	....?
3.	Nasdem	59	....?
4.	PKB	58	....?
5.	PKS	50	....?
6.	Gerindra	78	....?
7.	Demokrat	54	....?
8.	PDIP	128	....?
9.	PAN	44	....?
	Totally	**575**	

1. State in the fraction the number of representatives of nine political parties that have passed to Senayan.
2. Does the proportion of the representative meet your expectations?
3. When you are 17 years old, will you participate in the local or presidential elections?

Figure 5. Activity 2 of the Students' Sheet

This student worksheet is designed to teach mathematics while fostering critical awareness in young people. It helps them use mathematical skills to analyze real-world phenomena. The abundance of data in our daily lives provides countless opportunities for applying mathematics to everyday situations.

After students calculate the proportions of parliamentary representatives, a discussion is conducted. Through this, students are expected to recognize the unequal distribution of representatives among the nine political parties in the DPR RI, deepening their understanding of mathematics and civic issues. The students openly expressed these views with the statements:

"I liked how we could compete to solve the problem on board. It made the class more exciting, and I learned much from my classmates' feedback."

In another instance in focus group interviews, Chica revealed her interest by saying:

"Discussing the answers in groups helped me understand the steps better, especially when someone explained a different way to solve the problem."

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This study demonstrates the feasibility of developing learning materials, such as student activity sheets, that integrate citizenship into mathematics lessons using the PMRI approach. This study creates opportunities to enhance students' mathematical literacy by connecting mathematics education with civic themes.

The findings provide valuable insights into the learning process and suggest more effective methods for teaching mathematics. This is particularly important for incorporating civic knowledge into secondary school mathematics education, fostering a deeper understanding of both subjects.

In focus group interviews, students expressed their effort in learning like what Akbar said: *"This was the first time I really saw how math connects to real life and civic issues. It made me want to learn more about how numbers and data are used to solve problems in the world."*

In the focus group interviews, Yuyun stated:

"I never thought math could help me understand trade or politics. This activity made me think differently about why math is important."

Through this approach, students not only build their mathematical knowledge in meaningful, relatable contexts but also develop an awareness of societal issues, particularly in a democratic society. The PMRI approach positions students differently from traditional educational methods, encouraging them to be more self-reliant. Unlike conventional approaches, realistic mathematics, as inquiry-based mathematics, requires students to take on additional responsibilities, such as explaining and justifying their solutions, understanding the solutions of others, and seeking clarification or justification when needed. By fostering an inquiry-based learning environment where students actively discuss and defend their mathematical ideas, PMRI promotes deeper conceptual understanding and nurtures critical thinking skills. This approach empowers students to engage more meaningfully in mathematics, building confidence and independence in their learning process.

Furthermore, educators should also investigate ways to foster civic engagement through mathematics by integrating real-world civic issues into classroom learning. This approach connects mathematical skills to civic participation, enhancing students' understanding of mathematics while promoting their involvement as active citizens. Moreover, a thoughtfully structured course can significantly improve students' quantitative skills for active citizenship if instructors access adequate resources and support systems (Foley, 2025).

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CONCLUSION

The research findings revealed that applying the PMRI approach focusing on citizenship significantly benefited teachers and students during each research cycle. This approach was shown to play a key role in improving students' academic performance. By designing materials that integrate mathematics and citizenship education on an interdisciplinary basis, this study highlights a powerful example of how mathematics can be applied beyond its traditional scope. Here, mathematics education is positioned as a tool to support the development of a democratic society. Moreover, the emphasis on active learning and critical thinking equips students with the skills necessary for academic success and responsible citizenship. As schools aim to nurture well-rounded individuals prepared to contribute meaningfully to their communities, integrating civic knowledge through the PMRI approach offers a promising and effective solution.

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