Primary school student teachers’ perception to *Pendidikan Matematika Realistik Indonesia* (PMRI) instruction

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Abstract. This article aimed to report the perceptions of the students of primary school education to PMRI. PMRI or Realistic Mathematics Education (RME) in Indonesian version is one of the promising mathematics learning innovations developed in Indonesia. The research method consisted of three steps, namely preliminary, teaching experiment, and retrospective Analysis. The participants were six students of the primary school teacher education. In the second phase, the participants took an PMRI lesson. Then, they filled in the perception questionnaire (open and closed). The results of the study showed that the participants agreed that learning by realistic mathematics education principles helped them understand the topic.

1. Introduction

PMRI (*Pendidikan Matematika Realistik Indonesia*) is one of the innovations in learning mathematics in Indonesia. It has been developed in Indonesia since 2001 [1]. RME is a Dutch-derived mathematical approach introduced by Freudenthal stating that mathematics is a human activity and math must be related to the real world [2]. According to Freudenthal, students should have the opportunity to reinvent mathematics, using well-chosen tasks, with the help of teachers. The learning process will occur if the knowledge learned by the students are meaningful to them [3].

Besides as a learning innovation, PMRI is also a reform movement of mathematics education. It is not only a method of learning mathematics, but also it encourages the transformation of social culture [4]. Sembiring [5] adds that PMRI is an approach oriented to the technical ability of mathematics education based on problem-solving. He points out that the reform of mathematics education is based on two pillars, namely: (1) the ability of teachers to create a problem-oriented classroom culture and invites students in interactive learning and (2) designing learning activities that can encourage re-invention of mathematics together with teachers' ability to help the rediscovery process. Thus, the PMRI requires a change in the attitude of teachers in teaching and treating students.

One of the challenges faced in the dissemination of PMRI in Indonesia is the education of teachers, especially the Primary School Teacher Education [5]. Sembiring [5] further stated that primary school teacher education is at the forefront of PMRI development. If candidates for primary school teacher education have been given teaching on PMRI during their study and then after the graduation, they are expected to become teachers, these primary school teacher education graduates are ready to teach using PMRI in their school. Also, learning PMRI in primary school teacher education can also be one way to overcome the problem of Indonesian mathematics education, which is still encountered by high school.
even college students who cannot solve the problem of how many basic concepts in mathematics. Fauzan [6] argues that it is because of something wrong in mathematics education in primary schools. The learning of the basic concepts is given as something that has been made, not through the process of rediscovering so that the concept becomes less meaningful for the students. One concept that is often not understood by students is about angular topics. Several studies have shown that students are often mistaken about the definition of angles, angular representation, angular size and right angles in different orientations [7-9].

Based on some of the above facts, the researcher then conducted PMRI lesson in primary school teacher education class and looked at how the participant reaction after the learning was given. The researchers provided materials of angular topics including right angles, acute angles and obtuse angles. Therefore, this study aimed to see how the perception of primary school teacher education students on PMRI after they were given a lesson on angular topics.

2. Pendidikan matematika realistik Indonesia (PMRI)

In PMRI, mathematics learning must be related to the real world and mathematics is a human activity [2]. Based on the mathematical view as a human activity, there are three principles in realistic mathematics learning by Gravemeijer [10], namely (1) Guided reinvention and progressive mathematizing (guided discovery and progressive mathematics); (2) Didactical phenomenology (didactic phenomena); (3) Self-developed models. According to these principles, mathematics learning should give students the opportunity to understand and process the rediscovery of mathematics itself. Mathematics is not given as a finished thing but through a mathematical activity called mathematization. The situation used in learning mathematics should start from the real situation prior to formal mathematics. Then, the principle of building an independent model as a bridge for students from the real to the abstract or from informal to formal mathematics. The first model is connected to the real world and then gradually solves the problem. The model emerges from the student's own activities and serves as a catalyst for the process toward formal mathematics. Sometimes the model can also be given to the students but in this case, the model helps move from the thinking process of students to more formal mathematics.

Based on the three principles of realistic mathematical approach, there are five characteristics according to Gravemeijer [10] as follows:
1. Use of contextual problems (contextual problems as an application and a starting point of the intended mathematics).
2. Use of models or bridging by vertical instruments (the focus is on building models, schemes, and symbols rather than giving rules or formal maths).
3. Use of students’ contribution (a major contribution to learning is coming from self-constructing students, who deliver students from informal to formal math).
4. Interactivity (explicit negotiation, intervention, discussion, cooperation and evaluation among students and teachers) is an important element in the learning process where an informal strategy is used as a lifter to achieve formal mathematics.
5. An intertwining of learning strands (a holistic approach causes the learning strands to be inseparable, even the linkages of the learning sequences are used in solving problems).

The PMRI study is designed and based on the six principles of learning RME by Van den Heuvel-Panhuizen [11] as follows:
1. Activity principle
   This principle is an interpretation of mathematics as a human activity [12]. Students participate actively in the learning process. Students are faced with a problem situation so that students are able to develop a way of finding mathematical concepts based on the information provided [11].
2. Reality Principle
   These principles include two things. First, the importance to reach the learning objectives of mathematics, including the student's ability to apply mathematics in the problem of "real-life", and
second, mathematics learning must start from the problem situation which means giving students the opportunity to build the concept during problem-solving [13].

3. Level principle
   Students must pass a wide variety of levels of understanding, ranging from an informal context to how concepts and strategies are related [13]. In other words, students begin learning with the informal level situation related to the issue of context. then, using a mathematical model concretely representing the mathematical object. This level is called a level model of depicting a concrete model close to the situation described in the problem [14]. Next level is the level of transition, known as a model for, which focuses on the completion of the procedures used to solve a new problem situation. The latter level is a purely formal.

4. Intertwinement principle
   This principle means that the mathematics content domain does not stand alone but is integrated with other contents [13]. For example, the content is not only related to the angle but also associated with other contents in mathematics.

5. Interactivity principle
   Learning mathematics is not only an activity of its own but also a social activity [13]. Learning provides students the opportunity to share their strategies and discoveries with others.

6. Guidance principle
   This principle refers to the principle of guided reinvention proposed by Freudenthal. Students are given guided opportunities until rediscovering mathematical concepts by balancing between the power of instruction and freedom of learning [12].

3. Method
   This study using design research method consisted of three stages: preliminary analysis, teaching experiment, and retrospective analysis [15, 16]. This article only discussed the related perceptions of the students after being given the lesson. To obtain students' perceptions, a perception questionnaire (closed and open) was distributed to the participants who had been given PMRI on the topic of angles (right angle, acute angle and obtuse angle). The study involved six students of primary school teacher education (a small group) as part of the pilot experiment in the teaching experiment phase.

   The questionnaire used a likert scale excluding the hesitant options. It asked the participants to explain each choice answer statement. The questionnaire was based on the six indicators of the principle of learning RME (reality principle, activity principle, level principle, interactivity principle, intertwinement principle, and guidance principle). Each indicator consisted of one positive statement and one negative statement.

4. Result and discussion
   Table 1 shows the results of the perception questionnaire as indicated by the six principles of PMRI learning. Overall, the average participant agreed (score more than 3) that the learning occurred with the PMRI principles. Although there were three indicators (reality principle, principle level, interaction principle), there was a participant who disagreed (score 2), but after being confirmed by asking for an explanation of the intent of the statement, the participant agreed.

   Table 1. Participant perception’s about learning

   | Indicator              | N | Score | Mean | Max | Min |
   |------------------------|---|-------|------|-----|-----|
   | Reality principle      | 6 | 20    | 3.33 | 4   | 2   |
   | Activity principle     | 6 | 22    | 3.67 | 4   | 3   |
   | Level principle        | 6 | 18    | 3    | 4   | 2   |
   | Intertwinement principle| 6 | 20    | 3.33 | 4   | 3   |
   | Interaction principle  | 6 | 19    | 3.17 | 4   | 2   |
   | Guidance principle     | 6 | 20    | 3.33 | 4   | 3   |
Table 2 is the result of the perception of each statement indicating that most participants agree that learning taking place in the context of daily life (score 2.8). The context helped in understanding the topic (score 3.8). The average participant also agreed that the learning made them perform mathematical activities (score 3.8), participate actively in learning (score 3.5), and the provided problems help the participants understand the topic gradually (score 3.3). As for the statement that the problem was easy and did not make the participant think hard, there were 3 participants disagreeing (score 2.7). Furthermore, most participants strongly agreed that learning provide an opportunity for them to share resolution strategies with others (score 3.5), active participation (score 3.2), problems given in relation to other topics (score 3.3), learning did not only discuss angular topics, but also others (score 3), activity sheet guided participants to understand the topic (score 3.3), the teachers only functioned as facilitators (score 3.3).

Table 2. Participant perceptions for each item

| Indicator | P1 | P2 | P3 | P4 | P5 | P6 |
|-----------|----|----|----|----|----|----|
| Statement | Score total | 17 | 22 | 23 | 21 | 20 | 16 | 21 | 19 | 20 | 18 | 20 | 20 |
|           | Mean | 2.8 | 3.7 | 3.8 | 3.5 | 3.3 | 3.2 | 3.5 | 3.2 | 3.3 | 3 | 3 | 3.3 |
|           | Max | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 4 | 4 |
|           | Min | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

In a perceptual questionnaire, in addition to a closed statement, the questionnaire asked the participants to clarify the choice of selected answers.

First, on the reality principle indicator, there were two statements: (1) Learning about angular topics using real context in everyday life; (2) The context used does not help me in understanding the topic being taught. Some participants provided explanations regarding the choice of answers as follows:
Participant 1: I agree because I think using the real context makes me better understand the learning of the angle rather than I use an unreal context, which only confuses me.
Participant 4: Because using the real context, frankly speaking it makes me more passionate about completing the task and looking for answers and also adding to the general knowledge. Context helps me more easily in understanding the topics that are on the subject being taught.
Participant 6: Disagree because the images in the real-life context are sometimes less symmetry and less similar to the original form of the building so as to make it confusing and to examine what type requires accuracy and conspiracy in calculating the number of angles as in the image roster that makes me confused where the acute angle and right angle because the picture is too complicated to see.

Then, the second principle consisted of two statements as follows: (1) Ongoing learning does not give me the opportunity to do math activities; (2) I actively participate in learning. Most participants agreed with the statements by providing the following explanation:
Participant 2: Even in the learning that goes on I always do math activities like counting angle count, drawing corner etc. I actively participated in the group and conveyed the results of the discussion.
Participant 3: The learning I do has a mathematical element in which I can go directly into the world of mathematics and further understand the lesson. Given a problem-solving context, I co-administered and responded and provided ideas, ideas or more on the topic being discussed.
Furthermore, the statements for the principle level indicator were as follows: (1) The provided problem helps me understand the topic gradually; (2) The given problem is easy and does not make me think hard. Concerning the second statement, there was a participant agreeing that the given problem was easy because they just forgot the material and thought a little hard because they had to recall.

Participant 1: Problems in learning angles are arranged gradually and make me better understand the material than my previous learning lessons. Observing the roster image for the angle made me think harder and more thoroughly, as well as on conblock images and the Pentagon building. I did not think there was a picture of a pentagon building, and that made me think hard.

Participant 5: The given problems helped me a lot in understanding the gradual topic of learning from the things I thought that had no relevance to the mathematics and certain topics, now that I have understood it. I do not agree if it was an easy problem and did not make me think hard. Although it looked trivial, it turned out to be the problem that could not be done carelessly and it made me think hard.

Participant 3: Agreed if the given problem was easy and did not make me think hard because of the topic I learned before, but maybe I forgot a little, and as result I rather thought hard and tried to recall.

On the interactivity principle, two statements were given as follows: (1) Learning gives me the opportunity to share the strategies I use in solving problems for others; (2) I solve problems in individual learning. Participant agreed with these two statements by giving the following explanation.

Participant 4: By sharing the strategy, it made us open with friends and express our opinions. If friends had different opinions, we could search together, so we knew the true midpoint/answer. I worked with friends, sharing information we knew.

Forward, on the intertwinement principle, the first statement was a positive statement, while the second one was a negative statement as follows: (1) Problems related to other topics in learning; (2) Learning only about angle topics. All participants agreed that the learning not only provided with the topic of right angles, acute angles, and obtuse angles, but also linked them to topics of other geometries.

Participant 2: Problems were given regarding flat and angular issues, as well as other knowledge such as starfish, rooster and conblock on the floor.

Participant 6: Problems assigned to / related to other topics, namely the image problem in the form of a flat wake of pentagon and hexagon and look for large angles on each wake flat.

Then, on guidance principle, two statements were given concerning guiding principle as follows: (1) The activity sheet provided does not lead me to understand the topic being studied; (2) The teacher functions as a facilitator when the learning process takes place. The explanations given by participant are as follows:

Participant 4: Precisely with the activity sheet guiding step by step made me understand the topic being studied. The teacher helped us in many ways not only with the material but also helped me think to be more careful in working on a problem and she could bring us into the given context.

Participant 5: The activity sheet I received helped me understand the given topic even though I understood it gradually. The teacher functioned as a facilitator because she facilitated and guided me so that I had a better understanding and could understand the given topic.

The results showed that the participants felt that the learning occurred according to the PMRI principles. Learning took place under the principle of reality because the problems were given in
relation to the daily life. The given contexts were related to rooster, starfish, conblock and pentagon building. Figure 1 is rooster image that given on the first activity sheet. The Participants felt that the given contexts allowed them to understand the topics. Based on these results, Bustang et al [17], Putri and Zulkardi [18] have also stated that the context can make learning meaningful.

![Figure 1](image1.png)

**Figure 1.** Roster, the context given on the first activity sheet

Following with the principle of activity, the participants were asked to perform mathematical activities such as counting the number of right angles, acute angles and obtuse angles contained in the given roster images. By doing these mathematical activities, they felt actively involved in the learning process. One of the interesting things was when they were asked to create a different form of roster containing right angles, acute angles and obtuse angles. Two participant groups drew the following shape (Figure 2).

![Figure 2](image2.png)

**Figure 2.** Students’ answers

Then the learning began with the participant predicting the sizes of acute angle and obtuse angle. However, to be able to predict the size of an angle, the participant had to have an understanding of the number of inner angles contained in the polygon. This suggests that the change from one level to another in learning requires the scaffolding of others and the sequence of learning activities that are structured for new knowledge to be gained on the basis of prior knowledge [19]. This is in line with the preliminary level in PMRI learning. The learning also used the interactivity principle because
participants were actively involved in small group learning, completed the activity sheet, and had the opportunity to share the strategies they used to solve the problems. Similarly, in the intertwinenment principle, the topics given in the learning were related not only to angles but also to polygon topics or facets. This enabled the participants to remember recalling the related topics to solve the given problem. The learning was conducted with the guidance principle, because the participants felt that the teacher was indeed a facilitator directing and guiding them to recall the related topics such as the definition of angles, right angles, acute and obtuse angles. She also helped them when they found difficult to solve the problems by providing guidance clues that could make them find the solutions by themselves. This is the importance of the guiding principles of learning that teachers can predict and anticipate the student's understanding and new skills [14, 15, 18]

The results of this study are similar to those conducted by Zulkardi [2]. He found out the positive results on the given RME course. They were satisfied with the lectures given because there are are different topics from different contexts. The RME course participants provided by him also gained a better understanding of RME's principle. Several researches also showed that RME materials had a positive influence on student and student teachers in Indonesia [20-24]. So as Ndlovu [19], which states that teachers after being given RME lessons provide positive outputs and will adopt RME learning activities in their own classrooms.

5. Conclusion

The quantitative results show the results of the students’ perceptions of the given PMRI learning, and the qualitative results show the explanation of the answers given by the participant. On the average, most participants agreed that the given learning was in following with the PMRI principles. They felt it was new in their learning because they rarely began the learning by using the context. They did not just listen; they got more active in math activities in the classroom. It was easy for them to understand the topic and they felt there was something new in the learning process even though the topic had been taught previously. This indicates that PMRI learning in primary school teacher education can provide benefits for prospective primary school teachers, judging from their positive reactions and perceptions on the learning that has been given.

References

[1] Putri R I I, Dolk M and Zulkardi 2015 Professional development of PMRI teacher for introducing social norms Journal on Mathematics Education 1 11
[2] Zulkardi Z 2002 Developing a learning environment on realistic mathematics education for Indonesian Students Teacher Dissertation University of Twente
[3] Gravemeijer K 2010 Realistic mathematics education theory as a guideline for problem- centered, inter-active mathematics education. In R K Sembiring, K Hoogland and M Dolk (Eds) A decade of PMRI in Indonesia (Utrecht: APS International)
[4] Sembiring R K, Hadi S, and Dolk M 2008 Reforming mathematics learning in Indonesia classrooms through RME ZDM Mathematics education 40 927
[5] Sembiring R K 2010 Pendidikan Matematika Realistik Indonesia (PMRI): Perkembangan dan tantangannya IndoMS-JME 1 11
[6] Fauzan A 2002 Applying Realistic Mathematics Education (RME) in teaching geometry in Indonesian primary schools Dissertation (Enschede : University of Twente)
[7] Mitchelmore M and White P 1998 Development of angle concepts: a framework for research Mathematical Education Research Journal 10 4
[8] Clements D Hand Burns B A 2000 Students' development of strategies for turn and angle measure Edu. Stud.in Math 4 31
[9] Keiser J M 2004 Struggles with developing the concept of angle: comparing sixth-grade students’ discourse to the history of the angle concept Mathematics Thinking and Learning 6 285
[10] Gravemeijer K 1994 Educational development and developmental research in mathematics education Research in mathematics education 25 443
[11] Van den Heuvel-Panhuizen M 2000 Mathematics education in Netherland: a guided tour
Freudenthal institute cd-rom for ICME9 (Utrecht : Utrecht University)
[12] Freudenthal 1991 Revisiting mathematics education China lectures (Dordrecht: Kluwer
Academic Publishers)
[13] Van den Heuvel-Panhuizen M and Drijvers P 2014 Realistic Mathematics Education
Encyclopedia of mathematics education Dordrecht, Heidelberg, New York, (London:
Springer)
[14] Van den Heuvel-Panhuizen M 2003 The didactical use of models in realistic mathematics
education: an example from longitudinal trajectory on percentage Educational studies in
mathematics 54
[15] Prahmana R C I and Kusumah Y S 2016 The hypothetical learning trajectory on research in
mathematics education using research-based learning Pedagogika 123 42-54
[16] Prahmana R C I, Kusumah Y S and Darhim 2017 Didactic trajectory of research in mathematics
education using research-based learning J. Phys.: Conf. Ser. 893 012001
[17] Bustang, Zulkardi, Darmawijoyo, Dolk M and Van Erde D 2013 Developing a local instruction
theory for learning the concept of angle through visual field activities and spatial
representations International Education Studies 6 58
[18] Putri R I I and Zulkardi 2017 Fraction in shot-put: a learning trajectory Proc. AIP Conf. 4th
(Yogyakarta: Universitas Negeri Yogyakarta)
[19] Ndlovu M 2014 The Effectiveness of a teacher professional learning programme : the perceptions
and performance of mathematics teachers Phytagoras 35 1
[20] Sundayana R, Herman T, Dahlan J A and Prahmana R C I 2017 Using ASSURE learning design
to develop students’ mathematical communication ability World Transactions on Engineering
and Technology Education 15 245
[21] Hadi S 2002 Effective teacher professional development for the implementation of realistic
mathematics education in indonesia Dissertation (Enschede: University of Twente)
[22] Armanto D 2002 Teaching multiplication and division realistically in Indonesian primary school:
a prototype of local instruction theory Dissertation (Enschede: University of Twente)
[23] Tanujaya B, Prahmana R C I and Mumu J 2017 Mathematics instruction, problems, challenges,
and opportunities: A case study in Manokwari regency, Indonesia World Transactions on
Engineering and Technology Education 15 287
[24] Wahyu K, Amin S M, and Lukito A 2017 Motivation cards to support students’ understanding on
fraction divisions International Journal on Emerging Mathematics Education 1 99