# CHAPTER III
# RESEARCH METHOD

This chapter presents the method used in this study. The detailed description of how this research was conducted, the research design, the participants, data collection processes, and data analysis including the problem identification and needs analysis, design development and implementation, evaluation, and research procedures were elaborated in this section. Since this research involved the human sources, the ethical issues also were described in this chapter.

## 3.1 Research Design

This research aims to contribute to the field of education for Teacher Professional Development, specifically to get optimal results for primary school teachers in implementing Realistic Mathematics Education (RME). To answer the research question of "What are the characteristics of effective in-service Professional Development program in promoting students' mathematical reasoning within the realistic context?" including the sub-research questions, design research is chosen to achieve this research goal. Design research in education is a type of research developed in the United States and The Netherlands aiming to design of new educational materials such as computer tools, learning activities, or a professional development program (Bakker, 2018).

In the instructional design of each activity provided a detailed outline of mathematical goals. Local instruction theory, as defined by Gravemeijer and Cobb (H. Julie et al., 2013) provides a description of the learning path framework for a specific topic. It consists of a series of instructional activities and support for the learning activities. Using the local instruction theory, a teacher could implement the instructional activities for a lesson by selecting appropriate materials and developing a conjectured learning process for students. This approach incorporates both temporary instructional activities and a conjectured learning process that anticipates how students' thinking and understanding may develop as they participate using the instructional activities in the classroom. Akker et al., (2013) stated that design research has a characteristic of a cyclic process of (re) designing

and examining instructional activities and other relevant facets of the design. The accumulative cyclic process of design research is depicted in figure 3.1.

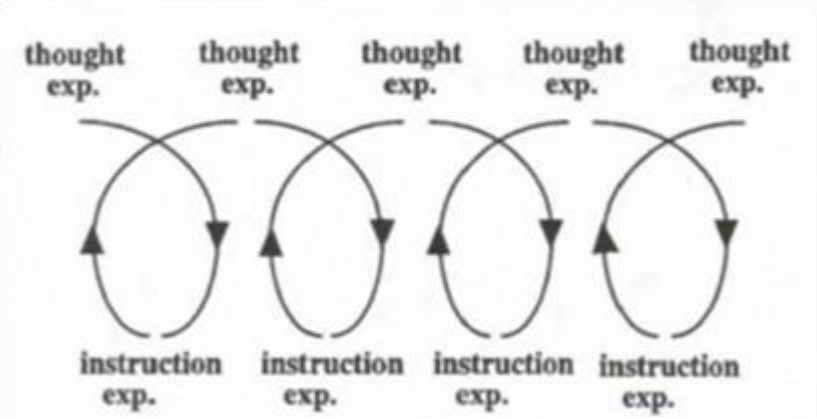



Figure 3.1 Design research, accumulative cyclic process

### 3.2 Participants

This study was conducted in two countries, Indonesia and The Netherlands. There were 3 Dutch RME Experts, 5 Dutch primary school teachers, 3 Indonesian RME Experts, 13 Indonesian primary school teachers, and 320 Indonesian primary school students in grade four from 5 schools in Banten and West Java involved in this study. The reason of choosing the participants in both countries is to get deeper knowledge on how RME is implemented in both countries, since it was found and developed in the Netherlands from 1970, and it has been adapted in Indonesia starting from 2000 to the present. The selected participants were those who were willing to be involved in this research. For Dutch RME Experts, the researcher chose them based on the recommendation from the supervisor in which they are known as a researcher, lecturer, and practitioner who focus in developing and teaching mathematics using RME approach. The Dutch primary school teachers were selected based on the recommendation from the Dutch RME Experts who became the participants.

For Indonesian RME/ PMRI Experts, the researcher chose them based on their willingness to be involved in this research. When there was an event about PMRI focus group discussion, the researcher used this opportunity to interview some PMRI experts. From 13 PMRI area coordinators who attended the meeting,

the researcher was succesfull interviewing 3 PMRI experts about PMRI training conducted in Indonesia.

The primary school teachers encompassed in this research were those who joined the workshop conducted by the researcher. From 23 participants involved in the workshop, 13 primary school teachers who declared that they were willing to continue to do the classroom practices which is a part of this TPD program. They were also the teachers who got permission from their headmaster. Following that, their students also involved in this research.

The problem identification and needs analysis for TPD program including expert review were conducted in The Netherlands from August to October 2022. After that, it was continued with the design development and implementation in Indonesia during 1 academic year 2022/2023.

### 3.3 Data Collection

During the classroom practices, there were an observation, video recorded, and document study. The analysis of teachers' noticing was achieved through the video transcript of teaching and learning process. Teacher's reflective ability was analysed through interview transcript among teachers and the researcher. Students' mathematical reasoning was depicted through video transcript of teaching and learning process and also from students' works. To get the visualization of those abilities, it was analysed using NVIVO software version 1.2 (426).

### 3.4 Data Analysis

The prototype consists of a task design that starts with a fraction problem. Considering the validity and reliability of the task design, it was piloted to several 4th-grade primary school students, aged 9-10, in Banten and West Java, Indonesia. The process of validity and reliability follows the assessment criteria related to the stages in design research proposed by Akker et al., (2013) that can be reffered in table 3.1.

Table 3.1
The Quality Criteria of The Stages in Design Research

| Phase | Criteria | Short description of activities |
|---|---|---|
| Preliminary research | Emphasis mainly on *content validity,* not much on *consistency* and *practicality* | Review of the literature and of (past and/or present) projects addressing questions similar to the ones in this study. This results in (guidelines for) a framework and first blueprint for the intervention. |
| Development or Prototyping phase | Initially: *consistency (construct validity)* and practicality.<br>Later on, mainly practicality and gradually attention for effectiveness. | Development of a sequence of prototypes that will be tried out and revised on the basis of formative evaluations. Early prototypes can be just paper-based for which the formative evaluation takes place via expert judgments resulting in expected practicality |
| Assessment phase | *practicality* and *effectiveness* | Evaluate whether target users can work with intervention (actual practicality) and are willing to apply it in their teaching (relevance & sustainability). Also whether the intervention is effective. |

Source: Educational Design Research book by Akker et al., (2013)

Furthermore, as exampled by Bakker (2018) the validity and reliability in this design research includes the triangulation process (observation results, students' works, and transcripts of video implementation in the classroom practices). Those encompass the internal validity consisting the quality of data and arguments, the ways of data collection, triangulation, and method of analysis. Besides, the external validity consisting generalisability, the use of the results and theory for other contexts, and ecological validity that is analysed in classroom practices. Furthermore, Freudenthal (1991) described that in reporting the design research, it involves actively engaging the iterative process deliberately. By documenting this experience with honesty, it becomes justified and can be effectively shared with others, allowing them to assimilate and get benefit from it as if it becomes their own experience.

In the preliminary research, the participants selected were the students who got permission from their parents to solve the problem designed by the researchers. The findings of this study revealed the struggles experienced by the students, which can be categorised as follow: struggles in referring to the whole, referring to the

complete partition, and challenges to understand the incomplete partition. The questions show that it was not a guarantee that students understand the basic concept of fraction, even though they have learned about it. According to these findings, it is recommended that when students study fractions, their comprehension of the concept of fraction should be adequate to address the challenges of part-whole relationship.

Following that, the task design was tried out on the six students, the researchers discussed with their teachers, and agreed to conduct further research on a larger group of participants (whole class) to develop the knowledge for educators in teaching fractions especially in promoting students' mathematical reasoning. Four primary school teachers from two schools involved in the pilot experiment.

After the pilot experiment was conducted, there were several findings and materials that have to be revised. The researchers agreed to extend the model become 3 types of models. The three models are: the complete partition of martabak, the missing part of martabak, and both martabak including the price. The questions that were asked to the teachers can be seen in picture 3.2 and these became the research instruments that were applied in TPD program and implemented in the classroom practices.

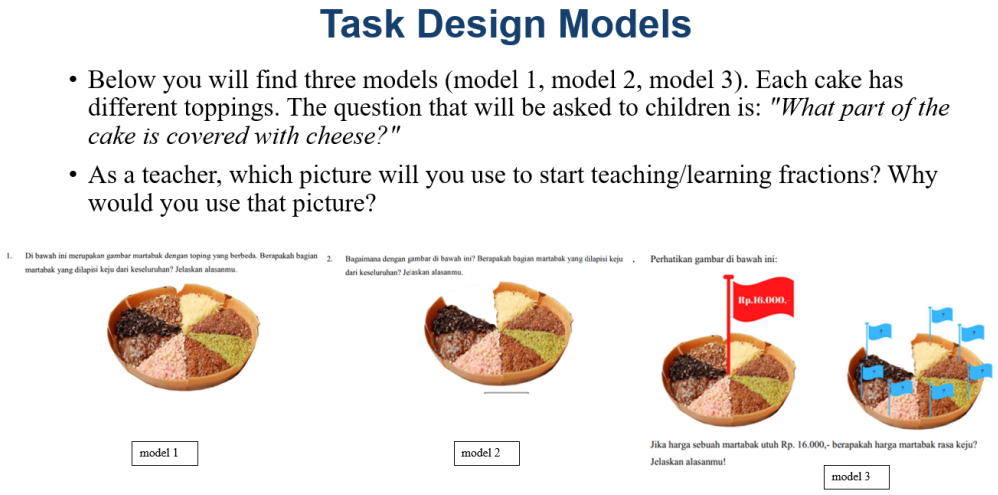



Figure 3.2 The Questions for Teachers in Professional Development Design

In the in-service training the teachers were given the topics of Realistic in Mathematics Education contexts and several examples in it. There were 26 4th-

grade teachers from 11 primary schools involved in the in-service trainings. However, there were only 9 teachers from 3 schools who would continue to the next stages and declared they were willing to conduct the series activities in their classroom.

The researchers and the target research made an agreement about the time spend to conduct the research. After applying the task design in each classroom, the series of Focus Group Discussion with all teachers in each school were conducted. The researcher facilitated the teachers to make their own reflection toward their teaching and learning processes; what did they see in their class when the students learned and solved the task design? How they reflect themselves and in what way they will improve their teaching?

The things that were discussed in this section are the stages of design research. The following figures are the flowchart of professional development design:

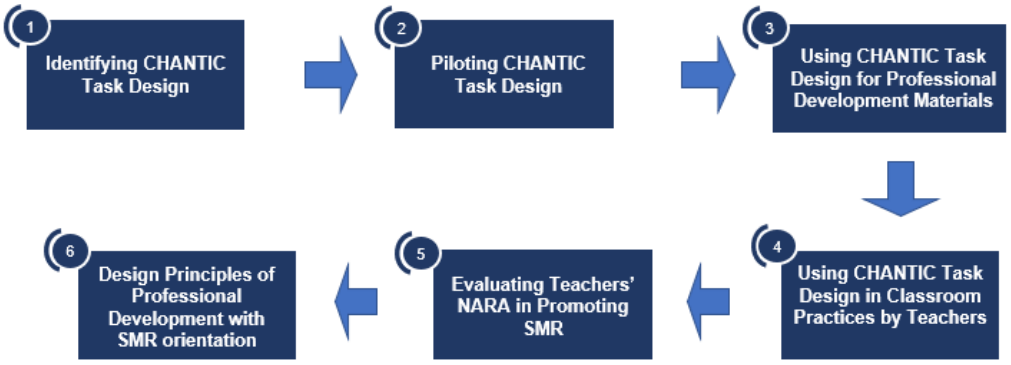



Figure 3.3 Research Flowchart

Adapting from a cumulative cyclic process in design research proposed by Akker et al., (2013), in this research the phases of this study were elaborated as follows:

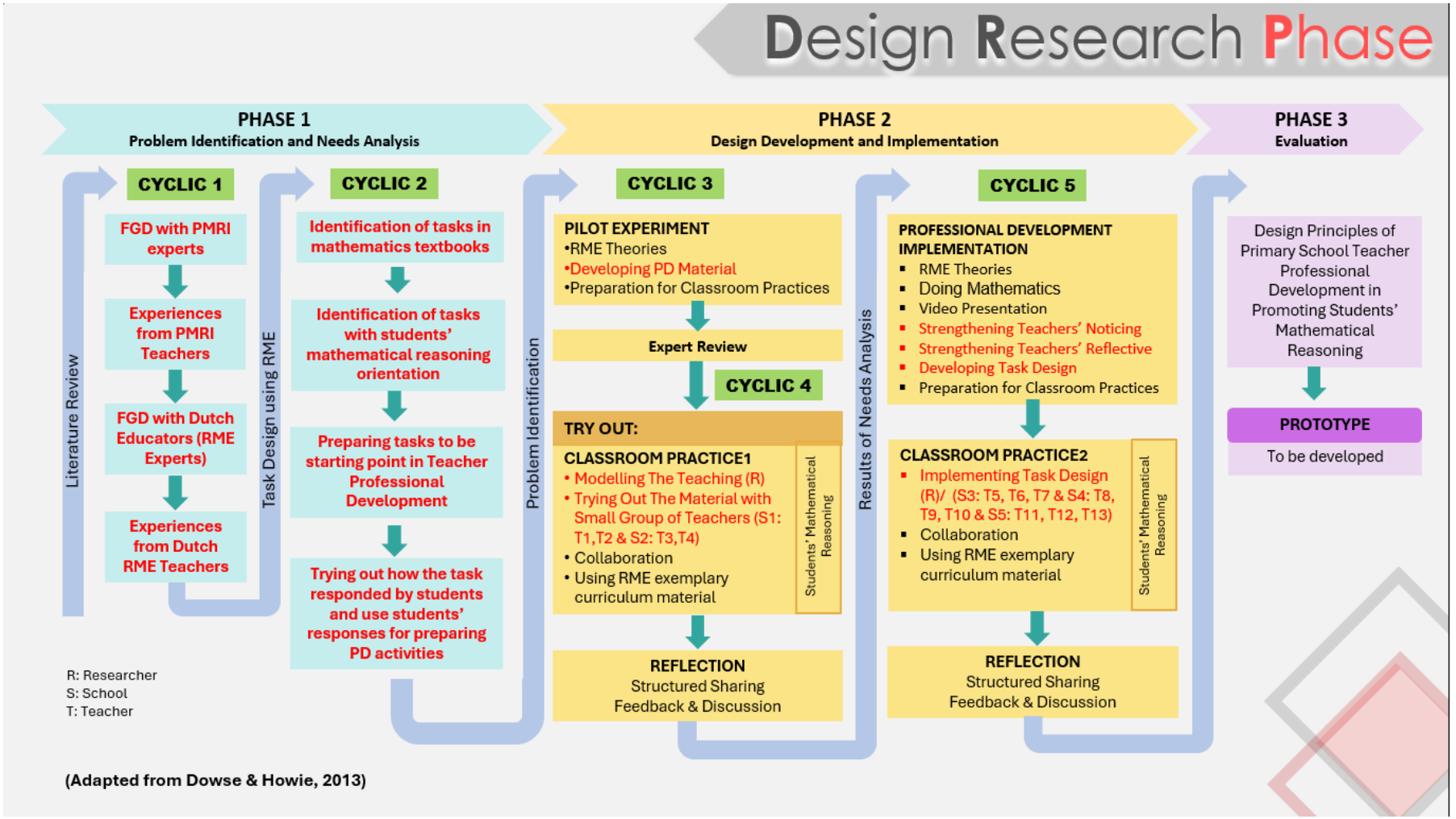



Figure 3.4 The Phases of Design Research for Teacher Professional Development in Primary School

### 3.4.1 Problem Identification and Needs Analysis

The initial phase of this research involves describing the research goals, combined with anticipatory thought experiments in which a suitable model or pattern is developed according to the desired outcome. This preliminary step produces a conjectured local instruction theory consisting of three components: (a) learning objectives for primary school teachers, (b) planned learning activities and tools used, and (c) measurable learning processes (a conjectured learning process). Within this context the researcher anticipates the development of primary school teachers' comprehension towards the principles of RME when the activities are implemented in a classroom (adapted from Gravemeijer, 2004).

In this phase, a sequence of activities contains the conjectured primary school teachers' ability to perform mathematical teaching problem, teachers' comprehension of Realistic Mathematics Education (RME) principles, and teachers' creativity in crafting, observing, and reflecting on their mathematical lesson. The lesson material is developed based on the literature and adjusted to the in-service training that the teachers follow.

### 3.4.2 Design Development and Implementation

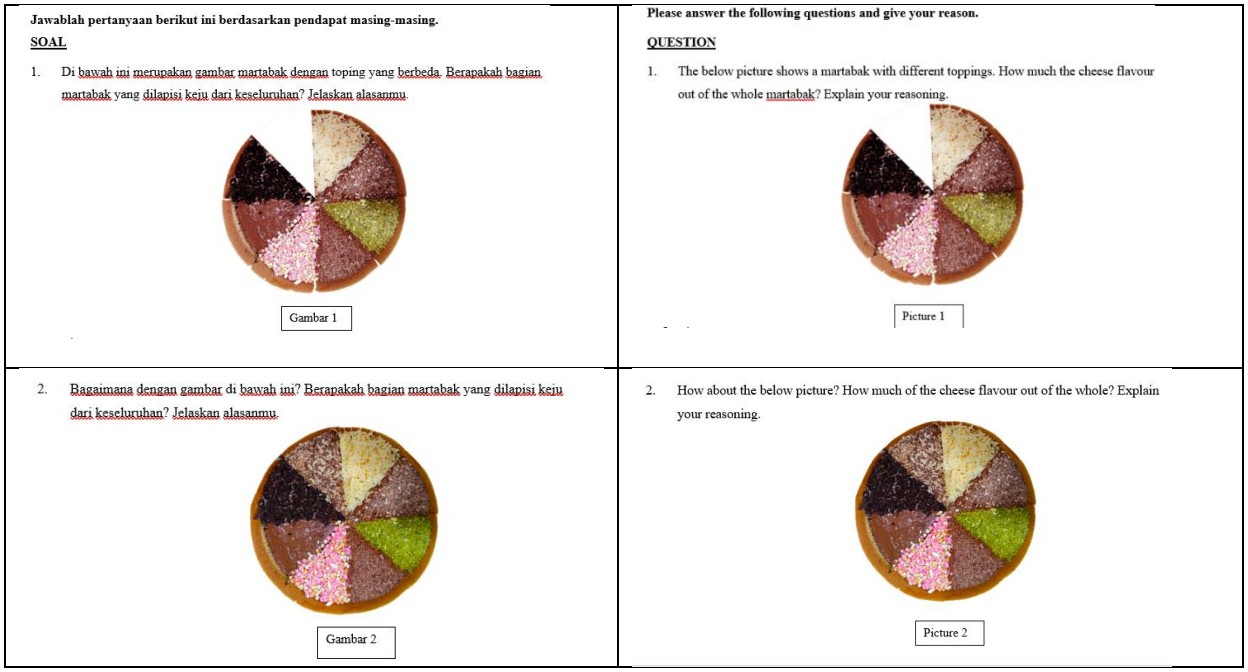
The purpose of the pilot experiment is to discuss and examine the basic principles that describe how design is explained and refined in conducting learning experiments. It also includes pre-assessment, which assesses pre-knowledge of Primary School Teachers in mathematical teaching, especially for fractions. Trials and interviews are conducted to adjust the Improved Design. There were 4 teachers from 2 primary schools in Banten and West Java involved in the pilot experiment.

In the teaching experiment, instructional learning activities are tested, revised, and designed within the designated timeframe outlined in the research timeline (Gravemeijer, 2004). The learning experiment aims to collect data that will address the research questions. The research was carried out in multiple stages. Before conducting the learning experiment, the researchers and other experts discuss a series of activities to prepare the designed activities that would be implemented within the instructional network. After each activity, the researchers make reflections to improve the designed activities and providing feedback to correct weaknesses or challenges in the teaching and learning process.

The instructional activities investigated students' mathematical reasoning in performing CHANTIC task design. In this study, the mathematical tasks that were used to promote students' learning, and conjectures about the students' mathematical reasoning process were researched. According to Gravemeijer (2004), a teacher should consider students' responses to each stage of the learning trajectories toward the learning goals when designing an instructional activity. It consists of learning goals for students, planned instructional activities, and a conjectured learning process. The goals for developing the tasks are:

1) To make connections between phenomenological exploration and mathematical idea (fractional problem);
2) To explore students' mathematical reasoning;
3) To get an insight about the context of challenging realistic (CHANTIC) task design and its role in promoting students' mathematical reasoning;
4) To be able to perform task design using their own reasoning.

The series of task design developed as follows:



**Jawablah pertanyaan berikut ini berdasarkan pendapat masing-masing.**

**SOAL**

1. Di bawah ini merupakan gambar martabak dengan toping yang berbeda. Berapakah bagian martabak yang dilapisi keju dari keseluruhan? Jelaskan alasanmu.

Gambar 1

2. Bagaimana dengan gambar di bawah ini? Berapakah bagian martabak yang dilapisi keju dari keseluruhan? Jelaskan alasanmu.

Gambar 2

**Please answer the following questions and give your reason.**

**QUESTION**

1. The below picture shows a martabak with different toppings. How much the cheese flavour out of the whole martabak? Explain your reasoning.

Picture 1

2. How about the below picture? How much of the cheese flavour out of the whole? Explain your reasoning.

Picture 2

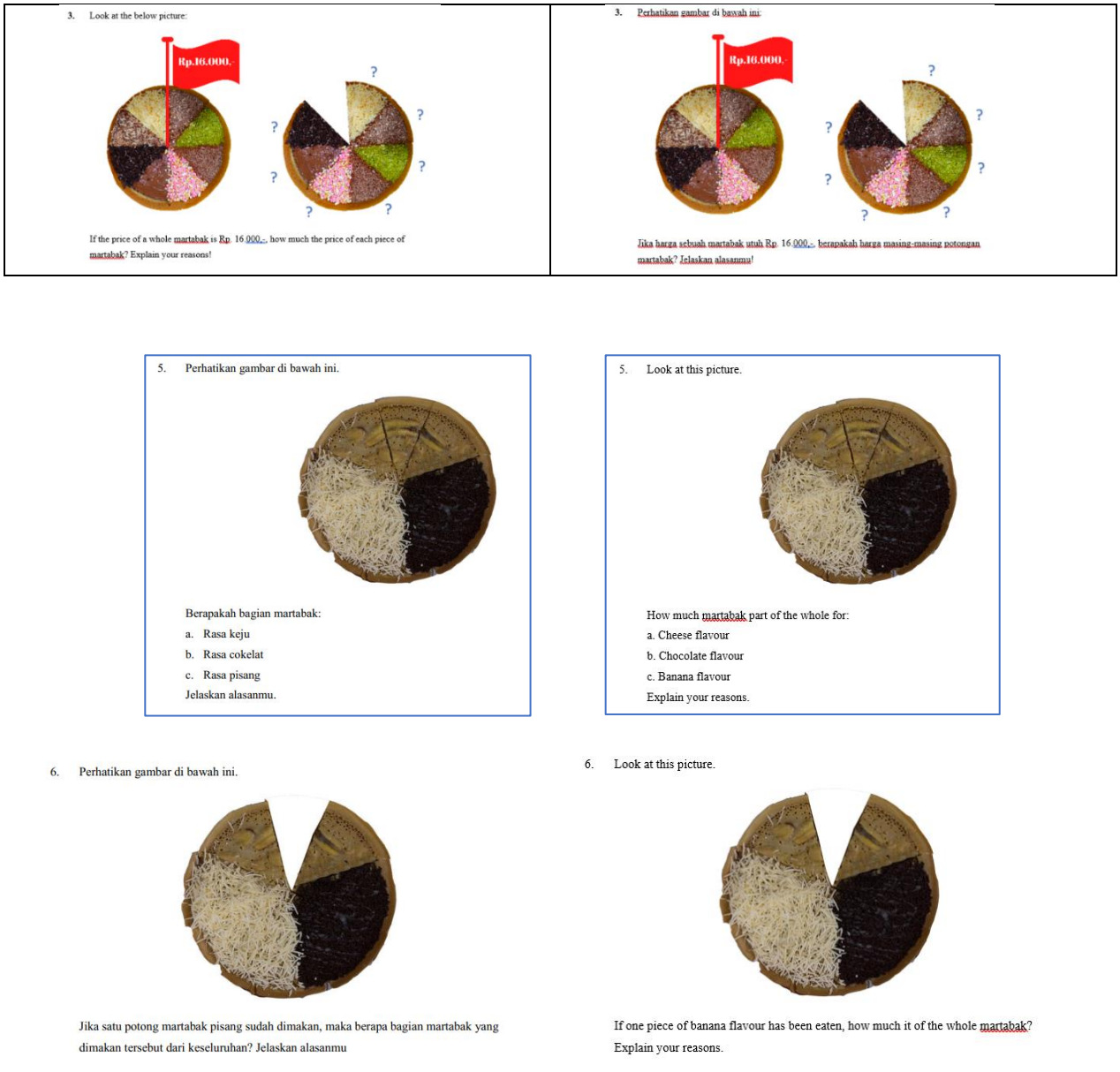



Figure 3.5 Series of task design developed

The diference among model 1, 2, and 3 is in the starting point, whereas model 1 starts from the full martabak context, model 2 starts from missing martabak context, and model 3 starts from the martabak with the price.

### 3.4.3 Evaluation

In this phase, all data obtained during the teaching experiment were analysed. Various data of the learning activities including group discussions were collected and recorded on video. Important fragments were selected and analysed.

Written data including Primary School Teachers' work in each activity, observation sheets, assessment results including final assessments and some notes were collected and analysed to see how the series of activities work for them. Data interviews were also included to determine the feedback from Primary School Teachers' in implementing the mathematical context using RME.

During the classroom practices, there were an observation, video recorded, and document study. The analysis of teachers' noticing was achieved through the video transcript of teaching and learning process. Teacher's reflective ability was analysed through interview transcript among teachers and the researcher. Students' mathematical reasoning was depicted through video transcript of teaching and learning process and also from students' works. To get the visualization of those abilities, it was analysed using qualitative descriptive with the aids of NVIVO software version 1.2 (426).

### 3.4.4 Research Procedures

This research was conducted starting from 2021 to 2023 contained 3 phases: Problem Identification and Needs Analysis, Development and Implementation, and Reflection as follows:

Table 3.2
Research Procedures

| No | Phase | Cyclic | Activities | Output |
|---|---|---|---|---|
| 1 | Phase 1: Problem Identification and Needs Analysis | Cyclic 1 | Literature Review | Problem identification of students' mathematical reasoning |
| 2 | | | Observation to the Target Schools for Pilot Experiment | Problem identification of students' difficulties in matematical reasoning |
| 3 | | | Collecting Data Information about Research Targets | Information about research targets |
| 4 | | | Focus Group Discussion with PMRI Experts and Teachers | Problem identification and needs analysis of TPD in Indonesia, especially in mathematics |
| 5 | | | Sharing Experiences with PMRI Teachers | Problem identification and needs analysis of TPD in Indonesia, especially in mathematics |
| 6 | | | Analysis Preliminary Study Result | Problem identification and needs analysis of TPD in |

| No | Phase | Cyclic | Activities | Output |
|---|---|---|---|---|
| | | | | Indonesia, especially in mathematics |
| 7 | | | FGD with Dutch Educators (RME Experts) in The Netherlands | Research framework and detail insight of developing TPD using RME approach |
| 8 | | | Sharing Experiences with Dutch RME Teachers and Classroom Observation in The Netherlands | Analysing the implementation of RME in The Netherlands by Dutch Educators |
| 9 | | Cyclic 2 | Identification of tasks in mathematics textbooks | Problem identification towards mathematical concepts |
| 10 | | | Identification of tasks with students' mathematical reasoning orientation | Problem identification toward students' mathematical reasoning |
| 11 | | | Preparing tasks to be starting point in professional development to develop students' mathematical reasoning | Detail insight toward PD materials |
| 12 | | | Trying out how the task responded by students and use students' responses for preparing PD activities | Analysis the task design developed |
| 13 | Phase 2: Design Development and Implementation | Cyclic 3 | PILOT EXPERIMENT<br>RME Theories<br>Developing PD Material<br>Preparation for Classroom Practices | Preliminary PD Design |
| 14 | | | Expert Review | Revised PD Design |
| 15 | | Cyclic 4 | TRY OUT:<br>CLASSROOM PRACTICE1<br>Modelling the Teaching (R)<br>Trying Out the Material with Small Group of Teachers (S1: T1, T2 & S2: T3, T4)<br>Collaboration<br>Using RME exemplary curriculum material | Developed PD Design |
| 16 | | | REFLECTION<br>Structured Sharing<br>Feedback & Discussion | Revised PD Design |
| 17 | | Cyclic 5 | PROFESSIONAL DEVELOPMENT IMPLEMENTATION<br>Doing Mathematics<br>RME Theories<br>Video Presentation<br>Strengthening Teachers' Noticing<br>Strengthening Teachers' Reflection<br>Developing Task Design<br>Preparation for Classroom Practices | Design Principles of PD |

| No | Phase | Cyclic | Activities | Output |
|---|---|---|---|---|
| 18 | | | CLASSROOM PRACTICE2<br>Implementing Task Design (R)/ (S3: T5, T6, T7 & S4: T8, T9, T10 & S5: T11, T12, T13)<br>Collaboration<br>Using RME exemplary curriculum material | Design Principles of PD |
| 19 | | | REFLECTION<br>Structured Sharing<br>Feedback & Discussion | Design Principles of PD |
| 20 | | | Publication | Publication |

### 3.5 Ethical Issues

In this design research, two layers of design were developed. First, the researcher developed the task design known as (CHANTIC) for teaching fractions. This task design was tried out to several students in selected schools. Since this activity aims to design and disseminate the learning material developed that focused on fractions, the researcher asked the teacher's permission to present the learning activities' documentation. For the problem of identification in two countries, the Netherlands and Indonesia, the researcher has asked permission to share documentation of the activities.

Second, in the teaching experiment in Classroom Condition II, which aimed to assess the teachers' ability to promote students' mathematical reasoning using the developed task design, the researcher decided not to share the pictures or documentation, and all the participants' names involved were replaced with pseudonyms. Detailed activities are provided in the Appendix.