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# DESIGN RESEARCH IN PMRI: USING MATH TRADITIONAL DANCE IN LEARNING SYMMETRY FOR GRADE FOUR OF PRIMARY SCHOOL

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**Abstract**

The new innovation of education is an important point of Pendidikan Matematika Realistik Indonesia (PMRI), Indonesian version of Realistic Mathematics Education (RME). Using the theory of RME we conducted design research with the aims to build upon students' reasoning and reach the mathematical goals of symmetry. This research aims to produce a learning process and to understand the concept of symmetry. Design research was chosen to get the goal of this research. Three steps of design research were followed namely preliminary design, teaching experiment and retrospective analysis. This research was conducted with 22 students in MIN 2 Palembang. The result of this research is students' understanding of the symmetry concept using math traditional dance.

**Keywords**: PMRI, RME, design research, math dance, symmetry

## Introduction

Creating an atmosphere of learning mathematics in the classroom to be fully inspirative, creative, and innovative for the learners is one of the duties and responsibilities of teachers. One of the innovative learnings that utilizes local-cultural context is combining culture (arts) and mathematics. "*Culture and Arts can help practitioners train and develop a further understanding of Dance Mathematics principals*," (Kokona: 2009, p.3). At first glance, it might seem that mathematics, realm of rationality, and dance that is in the form of art of physical and emotional expression has little in common.

There are a lot of significant mathematical ideas that can be found in dance such as symmetry, time and space, combinatorics, rotation, number, geometry, patterns, and also for learning in higher education, such as Graph. This opinion is supported by McCutchen (2006, p.315): "*Math is a good partner for dance because of the geometric shapes in space, patterns, symmetry and asymmetry, and counting of phrases. However, geometric shapes are mathematical constructs that can be difficult to translate into artful movement. Oftentimes they are too stiff and contrived. Geometrics can be more useful the concepts are more organic and less contrived.*" Learning mathematics using dance is known as Math Dance. It is interesting because using dance means students do learning activities by moving their limbs. It is parallel with Fruedhethal (1991, p.16-17) who emphasized the idea of mathematics that must be connected to reality through problems. The term "reality" in this context does not mean that the problem that always encounter in daily life. The term "reality" means that the problem will occur based on students' real experience.

Math Dance is an exploration that will be liked by students because it is combined by the rhythm in language, math in art, and a good source to examine the ideas of the dance movements. This idea is supported by Mulyardi (http://www.p4mriunp.wordpress.com) that: "*Semua permainan, tarian, alat musik, randai, pitatah dan petitih Minangkabau bisa dijadikan sumber dan inovasi dalam belajar matematika, contohnya Tari Indang. Melalui pemanfaatan budaya bangsa berarti kita tetap menjaga kelestarian budaya sehingga pembelajaran matematika lebih bermakna dan menyenangkan bagi siswa.* "

Although Indang dance originated from West Sumatra, but the dance is very famous and its movements are not difficult, then this dance is usually danced by students in South Sumatra. Hilda, she is an art teacher in MIN 2 Palembang telling us that: "Learners are taught with arts and

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culture through dance, painting, folk music. Through cultural arts classes' nation is expected to remain sustainably."

To combine math concepts with dance which was followed by students to get some experiences, a physical sensation that always makes an abstract concept in mathematics must be the activity that was more meaningful for students. According to the opinion of Schaffer: *Mathematical problem-solving is incorporated when creating new dances, which can even inspire new mathematics. Concepts can be taught in the ballroom and applied in the classroom, bring together movement, rhythm, geometry, and more.* Math Dance in classroom will be more delightful because the students feel more fun. Wistrom (2009, p.2) said: "*Try using math and science teaching methods. Teaching strategies that are both unexpected and fun are, after all, often the most memorable.*" In Math Dance, students are expected to have creative thinking in order to train the process of critical thinking and logical learners.

## Literature Review

This chapter provides the theorical framework that is addressed to construct grounded of this research. Literature about symmetry was studied to identify the basic concepts that are required to do a correct result to count fold symmetry. Futhermore, this literature was useful in designing instructional activities in which each of the basic concepts of symmetry are taught in the proper level of young children and also how mirror be connected to daily life reasoning.

In this research, Indonesian traditional dances were exploited as experience-based activities and contextual situation to build upon students' reasoning and reach the mathematical goals of symmetry.

### *Symmetry*

Symmetry is a fundamental part of geometry, nature, and shapes. It creates patterns that help us organize our world conceptually. We see it every day but often don't realize it. *The implementation of symmetry not only we found in geometry but also in architecture, design of graphics, arts, music, dance, etc* (Adams, 2005, p.18). If a spatial operation can be applied to a shape that leaves the shape unchanged, then the object has symmetry. There are three fundamental symmetries: translational symmetry, rotational symmetry, and reflection symmetry.

Symmetri is also a part of geometry's lesson in the school that is learned when students study in kindergarten, like fold of origami's paper. This topic is found in fourth and fifth graders in primary school. In primary school, this topic just introduces folding symmetry and rotated symmetry. In the fourth grade, students only learn folding symmetry. Students from each early grade got some experiences of symmetry because it is an aspect of our bodies and nature. Owen (2003) said that: "*Student may move away from the initial symmetry but still all the shapes and balance their art works.*" In everyday, we found the symmetry concepts likes butterfly, plane, building, etc.

### *Indang Dance*

Indonesia rate consists of several customs and traditions. Its diverse culture can be found in Indonesia. Indang's dance reflects Islam arrival in West Sumatra. It is also called "tarian badindin," from the lyrics "dindin ba dindin" the song accompanying this dance. The lyrics also tell about the Allah the Almighty, everything is done aimed to rend God Blessy.

Current Indang art nowadays has changed and movement along with the development of cultural-social of the society from time to time. Art is a product of society culture which is never escape from society; with several cultural activities including: creating, giving opportunity to glide, maintaining, spreading, and developing again. Those of things are satisfied by Indang art video which is applied, some motions of Indang dance have been modernised without losing important aspects.

The art of Indang has three dimension of art which are literatures, music, and dance. *The formal of presentation are three groups to make triangle in rows position* (Ediwar, 1999, p.18).

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The formal presentation of Indang's dance is compensation. The text consists of art of Indang from distich and line up. So, to mach it with math, we can see the move of dance.

In history, the art of Indang's dance consist of the growth and development of Moslem religion in West Sumatra. The first, its show uses the medium to teach the Islam from Ulama and religion's teacher in mosque, so that, the opinion of society about Indang dance is art of mosque.

Indang is one of several art forms with an Islamic flavour to be found in West Sumatra. This torically speaking, its presence is a realization of the Islamic education system of the prayer house or *surau,* in stride with the Islamic missionary activities and process of Islamization taking place in this area. It subsequently developed into a folk art from which was performed in a place known as laga-laga.

During the last few years, Indang has developed into an art form which is market oriented. Its players have begun to package its form of performance, text and music in accordance with the current taste of the masses. In addition, nowadays Indang is also starting to be used as a tourist commodity, particulary in the West Sumatra areas.

*Math Dance*

Combining math and dance concepts allows people to experience a physical sensation of abstract concepts of math. Mathematical problem solving is incorporated when creating new dances, which can inspire new mathematics. The concepts of math dance can be taught in the ballroom and applied in the classroom, brought together such as movement, rhythim, geometry and more.

Wistrom (2009, p.2) said that: "*Try using these math and science teaching methods. Strategies such as these will help your students learn science and math. Teaching strategies that are both unexpected and fun are, after all, often the most memorable.*" It sometimes so happens that a physics teacher is expected to work with no material resource. This is a situation in which simple and decent body movements can some to the teachers rescue as science and math teaching strategies. We usually associate such activities by teaching language and social studies only. "*Math is a good parther for dance because of the geometric shape in space, patterns, symmetry and asymmetry, and counting of phrases,* (McCuthchen, 2006, p.315)." However, geometric shapes are mathematical construction that can be difficult to translate into artful movement.

All dances can be sources of learning using the Math Dance, but the dance should be adjusted with mathematical concepts to be developed. In class, learning Math Dance is creating a full atmosphere of inspiration, creativity, and enthusiasm for students, because it uses a context that has been experienced by learners.

***Realistics Mathematics Education in Indonesia (PMRI)***

A decade of PMRI in Indonesia tells a story mathematics reform project in Indonesia. PMRI is adopted from RME, this method from Dutch. Over the last ten years, the PMRI teams, with the support of a group of Ducth mathematics educators, created a new image of mathematics education in primary or middle school. The PMRI movement is on the brink of scaling up to a condesiderably larger number of schools. There is an urgentneed to putin place some tools that will communicate the basic ideas of PMRI development and pilots, vast body knowledge has been acquired on PMRI education in Indonesia. This body of knowledge has been discussed on many occasions. According to Fruedenthal by Ariyadi, mathematics should be connected to reality through problem situations. The terrm "reality" means that the problem situation must be experientially real for students.

**1. Three Principles of PMRI:**

*a) Guided reinvention and didactical phenomenology*

The theory of mathematics in PMRI is a human activity, so guided reinvention can be described that teacher should give students a chance to understand and do mathematics process by them when mathematics was found. This principal can be inspired by using procedure informally. This effort will be reached if teaching and learning processes use real context in daily life which are related to mathematics concept. This research will use traditional's dance,

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in general, we can know that dancing is a habit for students who are starting from kindergarten. So this context is something that has been experienced by students.

b) *Progressive mathematization*
The situation that contained with phenomenon that can be used for material and application area in teaching and learning mathematics should be started from real situation before getting to the top (formal mathematics). Two kinds of mathematization should be used as references in teaching and learning mathematics from concrete to abstract (formal).

c) *Self-developed models*
The role of self-developed models is as a bridge for students from concrete to abstract or informal to formal. It means that students can make their own model to solve problem. The problem is started with the situation that closed to the students' daily life. From generalization and formalization, the model will be changed into *model-of*. Then, *model-of* will be shifted to *model-for* in the same problems. In this section, the students will be assisted by using nail planes, terraced sheets, handkerchiefs, and origami's paper.

For the next question of how to proceed from situational activities to formal mathematics, the tenets of Pendidikan Matematika Realistik Indonesia (PMRI) offer clues and design hueristics.

## 2. Five tenets of PMRI

The process of designing a sequence of instructional activities that starts with experience-based activities in this research was inspired by five tenets for realistic mathematics education defined by Treffers (1987) that are described in the following ways:

a). *Phenomenological exploration*
As the first instructional activity, a concrete context is used as the base of mathematical activity. The mathematical activity is not started from a formal level but from situation that is experientially real for students. Consequently, this research employed Indonesian traditional dances as the contextual situation.

b). *Using Model and symbols for progressive mathematization*
The second tenet of RME is bridging from a concrete level to a more formal level by using models and symbols. Students' informal knowledge as the result of experience-based activities needs to be developed into formal knowledge of symmetry. Consequently, the " making math dance" activity in this research was drawn on to bridge from symmetry activities in the games as the concrete level to using a ruler in symmetry as the formal level of symmetry.

c). *Using students' own construction*
The freedom for students to use their own strategies could direct to the emergence of various solutions that can be used to develop the next learning process. The students' strategies in each activitywere discussed in the following class discussion to support students' acquisition of the basic concepts of symmetry. The students – made symmetry instrument served as the bases of the emergence of dance as the preliminary of a normal moving.

d). *Interactivity*
The learning process of students is not merely an individual process, but it is also a social process. The learning process of students can be shortened when students commmunicate their works and throughts in the social interaction emerging in the classroom. Dancing forms a natural situation for social interaction such as students' agreement in deciding a strategy for the fairness of their dances

e). *Intertwinement*
Intertwinement suggests integrating various mathematics topics in one activity. The Indonesian traditional dances used in this research did not merely support learning for symmetry, moreover they also supported the development of students' symmetry.

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## Methodology

Design research methodology, comprising design, teaching experiment, and retrospective analysis phase (Cobb et al., 2001; Gravemeijer, 2004), was employed as a research method in this study. Gravemeijer & van Eerde (2009) illustrate the reflexive relation between thought experiment and instructional or teaching experiment in design research as can be seen in Figure1.

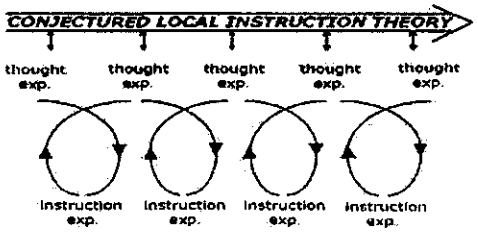


*Figure 1. Reflexive relation theory and experiments*

In this paper, we will go through the design research mini-cycles of meeting 2 briefly to justify our design in meeting 2, which contain the main discussion on the symmetry. During the preparation for the experiment, the researcher made the preliminary design, suchas studying literature and designing the hypothetical learning trajectory (HLT). In this phase, a sequence of intructional activities containing conjectures of students' thinking was developed. The conjectured hypothetical learning trajectory was dynamic and could be adjusted to students' actual learning during the teaching experiments. In teaching experiment phase wew conducted in two lessons in which the duration was 70 minutes for each lesson. Before doing a teaching experiment, teacher and researcher discussed the upcoming activity. Finally, the retrospective analysis phase, HLT was used in the retrospective analysis as guidelines and points of references in answering research questions.

## Result and Discussion

Before the students get the concept of symmetry, students have learned and they have understood the concept of reflection, so that, the teacher continues the learning process by leading the students to process the axis line of reflection which is the axis of symmetry. From the results of the learning process, when students worked in a group, then teacher prepared the students to watch a video dancing symmetry. This is an art-infused lesson about symmetry that links dance and math. When dancers use symmetry, they think about a line of symmetry as a vertical line from top to down divided our bodies into right and left parts.

At the beginning, teacher gave apperception by discussing with students. Teacher asked about students' habit way in folding their clothes at home.

Teacher : "Why should you fold your clothes at home?"
Students : "So, they become neat."
Teacher : "How do you those neatly."
Intan : "Every corner of the clothes should coinside, Miss."
Teacher : "Good."

Following this, students worked together in small groups. As the students work in small groups to observe the video. In this activity, the students were given "badindin dance video" because they have already experienced by it. At MIN 2 Palembang, there has dance class as an extension of art subject, so because of that students do not need to dance directly, after that students were asked to work on students' worksheet.

In worksheets, the students have been facilitated with problems to determine the axis symmetry of the problem:

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Note the students' answers below:

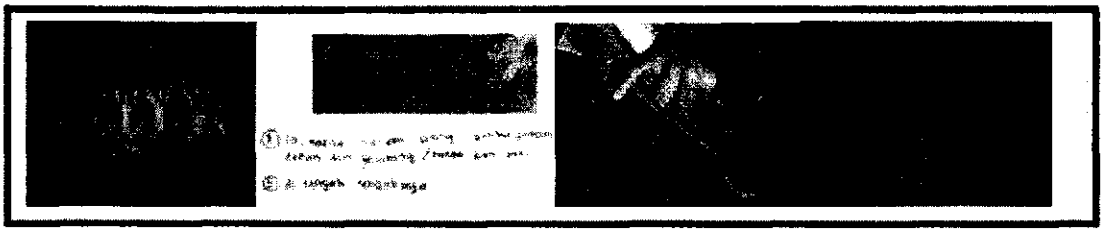

Figure 2: Video and strategies's students

There are three strategies, the student just estimation, folding the figure and the student try measure the figure. Then, the students just watched the video, and then they decided where the line axis of symmetry locates. After that, they were shown dancing butterfly, they were expected to solve the problems:

Figure 3. Video and Students

In second activity, students folded handkerchiefs that were distributed to each group. In this activity, we found that the students folded the handkerchiefs as following picture:

Figure 4: Results from Student

At the beginning, students folded the square handkerchiefts into four parts, after the teacher warned (how to fold the handkerchiefs into the former shape), and then the students understood and found 4 kinds of folding. In order to make students understood the symmetry concept; the teacher asked one of the groups to present their strategy in front of the class.

Then the third activity, the students folded the origami paper in various forms of flat shape that had been prepared. In this step, the students got their ideas in a long time, because some students still did not know the names of flat shape, the process in this step was so long, after doing their group, teacher guided students by observer of each group. There were some groups, who still had one way to fold it, then students were reminded again by teacher, how to fold the paper property. Some pictures in the process:

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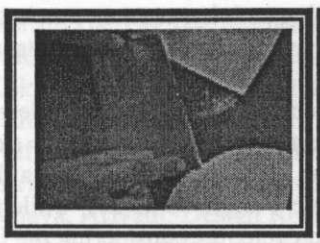

*Figure 5: Folding the square*

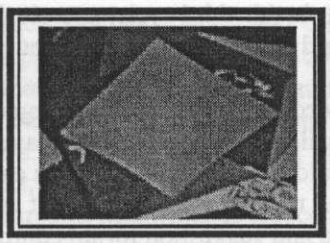

*Figure 6: Result of students*

*Figure 7: Strategies the students*

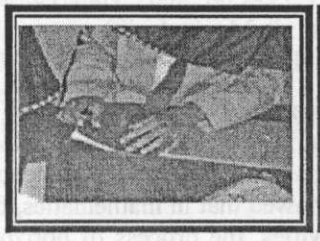

*Figure 8: Folding the flat shape*

*Figure 9. Students' explanations*

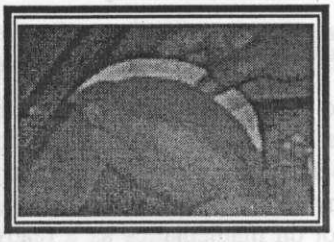

*Figure 10. Folding the circle*

In the paper folding activity, there were who made wrong answers, so the concepts of symmetry can be understood by students, teacher invited students to discuss in their group, and this discussion was guided by the teacher. Students wrote their answers on white board and then some groups were asked to be the next to present how many fold symmetry that each student obtained on flat shape, here we can see students were active, because it looked almost all students wanted to work, then the teacher wrote the correct answers from the students, students were not able to distinguish between rombus and parallelogram. To determine the number of fold symmetry, students didn't find the significant difficulty. However students difficulty found when they determined the number of fold symmetry on pentagram, have many students were wrong.

The smart discussion happened when teacher and students discussed about the number of fold symmetry on circle. Based on researcher's prediction, the responses of students would be varied greatly. These are following discussions between teacher and students:

Teacher : "Finally, we will discuss the number of fold symmetry of circle. So, please the Durian group, can you answer, how many fold symmetry of circle?"
Student : "Two, Miss ...."
Teacher : "Well, another do, do you have different answer?"
Student : "Twenty-nine, Miss ..."
Teacher : "Fine... What about your result the Buah Naga's group? "(while teacher wrote the answers of students on the whiteboard)
Student : "Four, Miss."
Teacher : "Okay ... What about your result Mangga's group??"
Student : "Two also, Miss."
Teacher : "Jambu Air's group."
Student : "Six, Miss..."
Teacher : "Waaach, there are so many different answers, let's try again!"
Student : "Fifteen, Miss ..."
Teacher : "Let's try again, it can be different again!"

Then came another student's answers, namely 35, 50, 100 and the last one of the students (Pasha) by saying the number of symmetry spontaneous of a circular object is "a lot Miss", then the teacher directly justified the student's answers while he asked another from other students, they answered "countless." At the end, the teacher explained that the number of fold symmetry of the flat shape of circle is "infinite" or rather the teacher said that "countless" in mathematics known as "infinite."

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Thus it ended all activities in this third cycle, as a closing activity, teacher concluded again the number of shape symmetry fold from several shapes that have been tried by students, and then he made it on the board.

On reflection activity according to the researcher argued that in the process of learning the material of fold symmetry was still good, however she gave the suggestions, before explaining about fold symmetry, teacher should explain so the students can calculate the angles of a flat shape at first, then folding the corner led to another corner so that every angle coincides, while from the other observer there were no critic and suggestion for this third cycle. By considering the HLT that has been made, in this cycle learning objectives have been achieved.

## Concluding Remarks

Used PMRI approach, teachers though students by linking learning with the reality of students experience and suitable with situational. Through traditional dances, students are expected to associate the concept of symmetry. In this design, the materials regulated that the students quided re-invention the concept of symmetry. This process learning showed that in mathematics, the focus is not on mathematics as a ready-made product but the activities, the process of horizontal and vertical matematisasi required the initiative and creative of students to make the active of students. Horizontal mathematizing in symmetry learning process is characterized by traditional dances and math dance, then the vertical matematizing studied by *model of* and *model for* such as folding a handkerchief, then the students folded the origami paper with the forms of flat shape and the last is equipped with formal matters.

The teacher and the teacher educators to facilitate students with worksheets, in our study, the students were found two strategies that students obtained in determining the axis of symmetry, there is a folded three directly, but there is also the first measure the distance between the dancers, then known at the material circle of students have many ways in determining the amount of folding of the plane symmetry of the circle, but eventually students are able to answer many of the later described by the teacher that is very much was known by the term "infinite."

Through these activities, students are trained in critical thinking and argumentative, it's very useful for students to develop their insight and knowledges. It is expected that through learning to use the math dance through traditional dances at the Indonesian context, to make students more interested and excited in learning math.

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