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Angle Measurement Material Design Using Gymnastic Contexts for Pre-Service Elementary School Teacher

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ABSTRACT

This research aims to produce a learning trajectory and analyze the angle measurement material using the context of gymnastic movements. The method used in this study was a design research method with the type of validation studies with the PMRI (Pendidikan Matematika Realistik Indonesia) approach. The subjects in this study were pre-service elementary school teachers, totaling six people in the pilot experiment and 24 people in the teaching experiment. Data collection techniques using tests, observation, and documentation. Data were analyzed descriptively on test results, observations, and documentation obtained. The results of this study are in the form of material design, and the results of an analysis of angle measurements using the context of gymnastics in the angle measurement material about angle sizes, angle shapes, and types of angles form a learning trajectory. Gymnastic movements are viewed from the movements of the hands, feet, and limbs that form acute angles, right angles, half-full turns/straightened angles, one complete rotation angle, and reflex angles. The resulting angle varies from 20^0 to 3500.

Keywords: design, context, angle measurement, PMRI, pre-service primary school teacher

ABSTRAK

Tujuan penelitian ini adalah menghasilkan lintasan belajar dan menganalisis materi pengukuran sudut dengan menggunakan konteks gerakan senam. Metode yang digunakan dalam penelitian ini adalah metode design research tipe validation studies dengan pendekatan PMRI (Pendidikan Matematika Realistik Indonesia). Subjek dalam penelitian ini adalah calon guru sekolah dasar yang berjumlah 6 orang di pilot experiment dan 24 orang di teaching experiment. Teknik pengumpulan data menggunakan tes, observasi dan dokumentasi. Data dianalisis secara deskriptif terhadap hasil tes, observasi dan dokumentasi yang diperoleh. Hasil penelitian ini adalah berupa desain materi dan hasil analisis pengukuran sudut menggunakan konteks senam pada materi pengukuran sudut tentang besar sudut, bentuk sudut dan jenis sudut berbentuk lintasan belajar. Gerakan senam ditinjau dari gerakan tangan, kaki, anggota tubuh yang membentuk sudut lancip, siku-siku, setengah putaran penuh/sudut berpelurus, sudut 1 putaran penuh, dan sudut refleks. Besar sudut yang dihasil bervariasi 20^0-350^0.

Kata Kunci: desain, konteks, pengukuran sudut, PMRI, calon guru SD

INTRODUCTION

Education is essential in human life. Education is also the foundation of many other fields. Education can get maximum results if an educator can convey the material to the maximum. The delivery of this material is related to the method taken by an educator during the learning process. The learning process is an essential part of the overall education. Educators are the leading actor in creating interactions that describe a series of actions of educators and students based on reciprocal relationships in educational situations to achieve specific goals. The exchange of mutual relationships between educators and students is the main requirement for the teaching and learning process (Sari *et al*., 2018).

The learning process involves the teacher and students, especially in learning mathematics. Mathematics learning does not only consist of ready-to-do questions by students (Afriyanty & Izzati, 2019). Learners must be treated as active participants to develop opportunities to reinvent mathematics. At the elementary school level, learning mathematics has three scopes of material being studied, namely: 1) numbers; 2) geometry and measurements; 3) statistics (Kemdibud, 2018). One part that is also a problem for students is the scope of measurement material. The measurement material itself consists of measurements of length, area, volume, weight, angle, time, and speed.

One of the interesting materials to be used in research is angle measurement because the tendency to measure angles is not easy for pre-service elementary teacher education who will become educators in the future (Sari et al., 2015). Angle measurement is learned in fourth graders (Muhlis et al., 2022; Nada & Masniladevi, 2022; Supriatiningsih, 2018). Based on the results of direct questions and answers with students in the previous year, the student's difficulty was determining the angle type and measuring angles. Some students experience challenges in measuring angle material, namely difficulty determining the size of an angle and the kind of angle. In addition, students are used to studying angular material using something abstract in the form of lines that form angles (Sari, 2015; Van de Walle, 2008; Keiser, 2004; Lehrer, 2003). The types of angles are grouped into several types, namely as follows: 1) acute angles; 2) obtuse angles; 3) right angles; 4) zero degrees angles; 5) reflex angles; 6) one complete turn angle; 7) straight angle.

The researchers needed an approach to solving the problem of learning about angle measurement, and the approach is Pendidikan Matematika Realistik Indonesia (PMRI) approach in learning angle measurement (Mariyana et al., 2018). The PMRI approach makes learning mathematics that is abstract real. PMRI emphasizes the meaningfulness of mathematical concepts (Wijaya, 2015). This approach is based on the philosophy of "mathematics is a human activity" from Hans Freudenthal which explains that students are not passive recipients. Still, students need to be allowed to reinvent mathematical concepts through activities they experience (Zulkardi, 2002).

PMRI chose three principles (Gravemeijer (1994), namely: 1) guided reinvention/progressive mathematizing; 2) educational phenomena (didactical phenomenology); 3) Developing their models (self-developed models). Besides that, there are five characteristics of PMRI (Wijaya, 2015): 1) using contextual problems/phenomenological exploration or the use of context; 2) using models or bridges as vertical instruments/using models and symbols for progressive mathematization; 3) Using student contributions/using student's contribution and production; 4) Interactivity/interactivity; 5) Integrated with other learning topics/intertwinement

PMRI is also a learning approach that begins by using real contextual situations and problems for students. In solving the given contextual issues, educators guide students until the rediscovery of mathematical concepts and formulas (Maimuna et al., 2018; Mumu, 2018). The PMRI approach makes learning mathematics more real (real). This aligns with Freudenthal's statement that mathematics is a human activity. Based on this opinion, mathematics must be connected with something real, around students, and relevant. The term "Reality" in this context does not mean that students constantly encounter these situations in everyday life but that these situations are based on real experiences for students (Wijaya, 2015). Therefore, educators must prepare a mathematics lesson exploring students' knowledge. One of them through the use of contexts that are suitable for students' cognitive abilities in mathematics.

The use of context is one of the characteristics of learning mathematics with PMRI (Irfan et al., 2019). Context is very well applied in learning mathematics and plays an important role. This is because students not only learn about mathematical material, but students will know in-depth about the context. In addition, using context in learning mathematics can help students implement mathematics in solving everyday context problems that surround students. The context in learning mathematics can make mathematical concepts more meaningful for students because context can present abstract mathematical concepts in the form of representations that are easy for students to understand (Wijaya, 2015). Questions using context will make it easier for students to situation mathematics into context so that it will help students use literacy skills in answering questions and can challenge students' mathematical thinking patterns.

Several other researchers have carried out research using the context and PMRI approach, namely: 1) Context of Weight Measurement Based on the PMRI Approach (Maimuna et al., 2018); 2. Statistical Learning Design Using Mal Context in Class V (Surya, 2016); 3) Learning Design of Data Concentration Size Using Game Rating Context (Kusumaningsih et al., 2019). However, no researcher has used the gymnastic context in designing angle measurement materials. The context of gymnastics is a context that is carried out in everyday life, which is closely related to angle measurement material and is beneficial to our health. That is why the researcher chose to use the context of floor gymnastic movements so that students could understand angle measurements using only formulas. Using the context of gymnastic movements is an example of a real problem situation experienced by students, and students learn to find. The choice of a context for gymnastic movements is based on the fact that gymnastic movements are around students. This research aims to produce a learning trajectory and analyze the angle measurement material using the context of gymnastic movements.

METHOD

The research method used was the design research method with validation studies that focus on proving the theory (van Eerde, 2013; Akker et al., 2006; Bakker, 2004). Design research requires a thorough observation of how these variables affect the environment considering that there are many variables within the scope of the statement that the researcher cannot control. With these characteristics, this type of research will produce a lot of data, so it takes quite a long time to analyze and draw conclusions. The most critical components of design research are HLT and LIT (Prahmana, 2017; Gravemeijer & Cobb, 2006).

The method designed in this study is design research which designs angle measurement materials using the PMRI approach through the context of gymnastics for pre-service elementary school teachers. The design research method used is a validation study that aims to prove learning theories (Akker et al., 2006).

1. Preparing for the experiment

Researchers prepared various literature reviews on angle measurement material studied at the tertiary level for the pre-service teacher. Researchers arrange material and questions related to the material to be delivered. Next, the researcher designed a learning trajectory (Hypothetical Learning Trajectory). The designed HLT is dynamic, so a cyclic process can change and develop during the teaching experiment (Fuadiah, 2017; Ramadhanti, 2015). HLT makes related results about angles and gymnastics contexts.

2. The design experiments

The design experiments consist of two cycles. Namely, the first cycle is the pilot experiment, and the second is the teaching experiment. In the pilot stage, six students with heterogeneous abilities (high ability, moderate ability, low ability). Next, the researcher revised the HLT for further use in the teaching experiment stage, which used the whole class, where this cycle is a cyclic process.

3. Retrospective analysis.

As a continuation of the teaching experiment, the final stage is analyzed. The analysis results are used to produce LIT on angle measurement material in the context of gymnastic movements as well as being the answer to the research problem formulation.

The subjects in this study were pre-service elementary school teachers at the university who took part in High-Class Mathematics Learning lectures consisting of six students as pilot experiments and as many as twenty-four students as teaching experiments in the odd semester of the 2020/2021 academic year. To support this research, two methods are used in collecting research data: 1) a test to determine students' abilities in using the context of gymnastic movements in angle measurement material; 2) documentation to collect responses and evidence related to the implementation of design research. Data obtained from the data collection process in the form of tests and documentation were analyzed further, primarily related to the results of the analysis of HLT, LIT, designed questions, and student answers

RESULT AND DISCUSSION

Result

The results of this study are described in 3 stages, namely as follows (van Eerde, 2013; Akker et al., 2006; Bakker, 2004):

1. The Preparing for the Experiment

At this stage, the researcher reviewed the Semester Learning Plan) in the PGSD Study Program to determine the material to be studied, namely Angle Measurement material which was studied in the 5th meeting out of 16 sessions, including UTS (Mid Semester Examination) and UAS (Secondary Examination). End of Semester). The material discussed on measuring angles is the size of the angle and the types of angles. Furthermore, the researcher prepared materials and questions about angle measurements that would be explained and worked on by students. The researcher gave open-ended questions where students created various gymnastic movements, determined the angles of the gymnastic movements by measuring pictures of the gymnastic exercises, and determined the type of angles of the gymnastic movements. After selecting the material, the researcher designed a series of Hypothetical Learning Trajectory (HLT) on angle measurement material using gymnastic contexts. These are essential points for joint analysis to be used in angle measurements using gymnastic contexts, as shown in Figure 1.

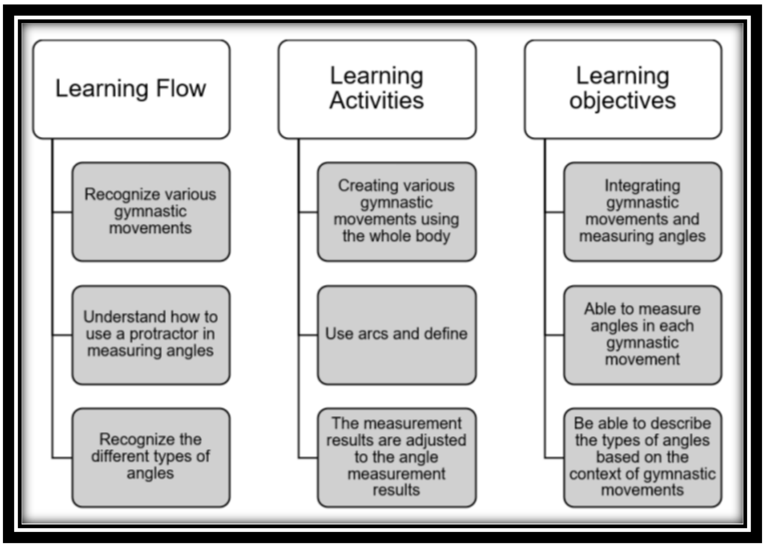


Figure 1. HLT Angle Measurement Using the Context of Gymnastic Movements

Figure 1describesd HLT angle measurement using the context of gymnastics movements consisting of the learning flow, learning activities, and learning objective for pre-service elementary school teacher

2. The Design Experiment

At this stage,e the design experiment is divided into two phases, namely pilot experimnts and teaching experiment

a. The pilot experiments

At this stage, the researcher used six students with the criteria of 2 people with low ability (initials R1 and R2), two people with moderate knowledge (initial S1 and S2), and two people with high power (initials T1 and T2). These six students created various forms of gymnastic movements, then took pictures and described their answers on double polio/ A4 paper. The results of student answers with the initials R1 are shown in Figure 2.

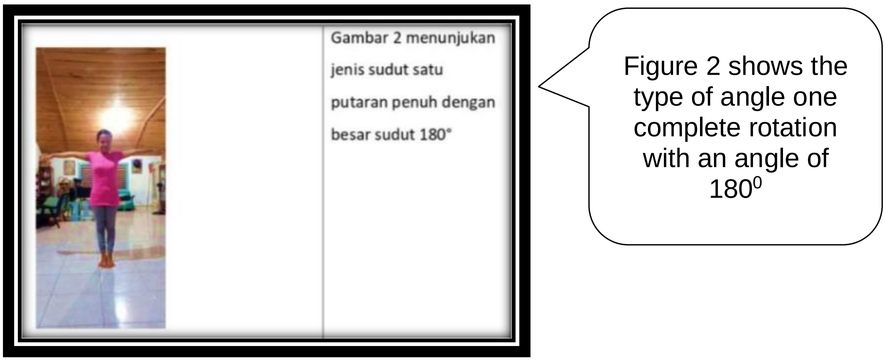


Figure 2. Results of R1's Answers

Figure 2 explains that R1 can describe the size of the angle and the type of angle, but R1 does not give any indication of the curve that is measured anywhere and does not form the legs of the angle, the head of the angle and other parts of the angle so that students cannot find how to determine the size of the angle and the type of angle. Furthermore, the results of R2's answers are shown in Figure 3.

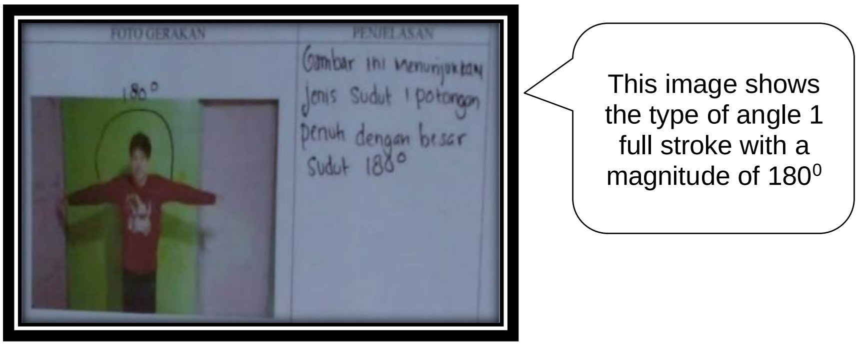


Figure 3. Results of R2's Answers

Figure 3 explains that R2 can describe the angle size and the results of measuring the angle from the gymnastic movement shown by the student with the initials R2. Still, there is an error in describing the angle type in R2's answer, namely the kind of angle "1 full cut" should be the answer "1 full rotation". R2 only describes one angle in the exercise movement performed. Also, Figure 3 does not show the line class, which shows the size of the angle 1800. The answers of students with the initials S1 are described in Figure 4.

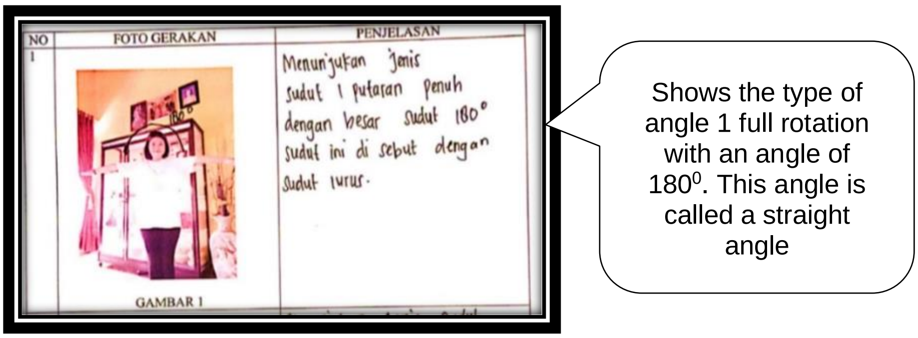


Figure 4. Results of S1 Answers

Figure 4 describes the results of the student's answers with the initials S1, which correctly explains the angle size and the angle type. However, the photo results do not depict the angle head and corner legs. In addition, S1 is only able to describe 1 type of angle in 1 gymnastic movement. Apart from S1, the results of S2's answers are illustrated in Figure 5.

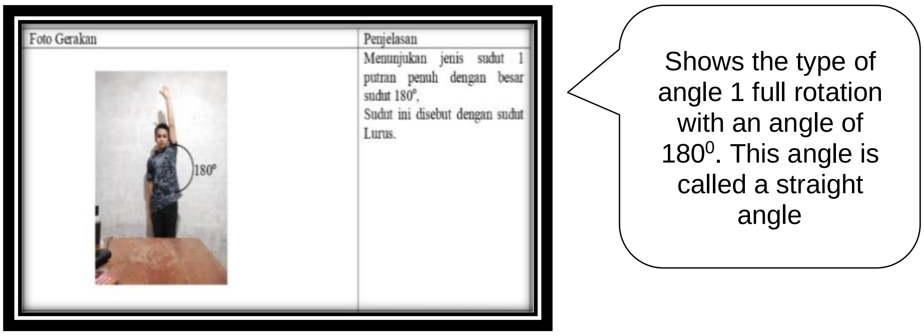


Figure 5. Results of S2 Answers

Figure 5 describes that S2 can correctly determine the size of the angle and the type of angle, namely 180^{0,} and the kind of angle, namely the angle of 1 complete rotation. However, S2 could not depict the head and foot angles correctly. The results of students' answers with the initials T1 are described as shown in Figure 6.

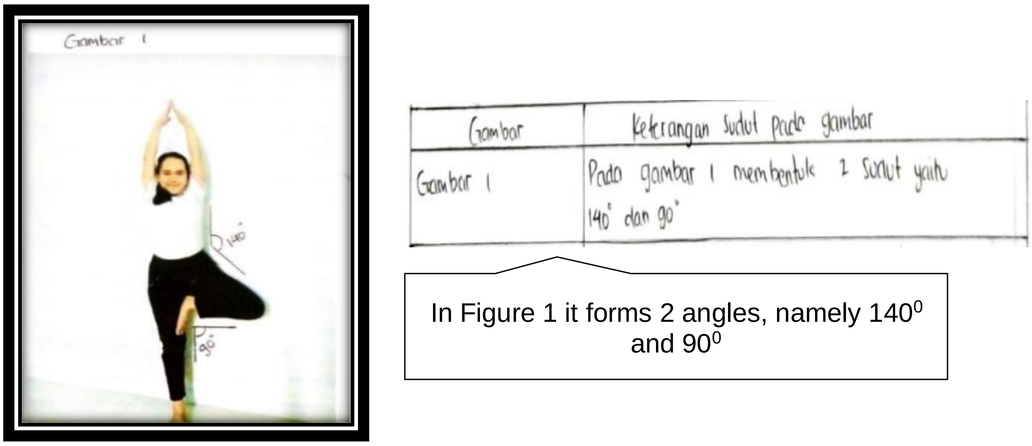


Figure 6. Results of Answers to T1

Figure 6 explains that T1 can describe the total angle size starting from the corner leg and the angle head in 1 exercise movement; several angles are formed, namely, with a magnitude of 90^0 and 140^0. T1 and describes the results of measuring angles from gymnastic movements carried out by T1. But T1 does not represent the type of angle formed on the answer sheet. Besides T1, T2 also answers Figure 7.

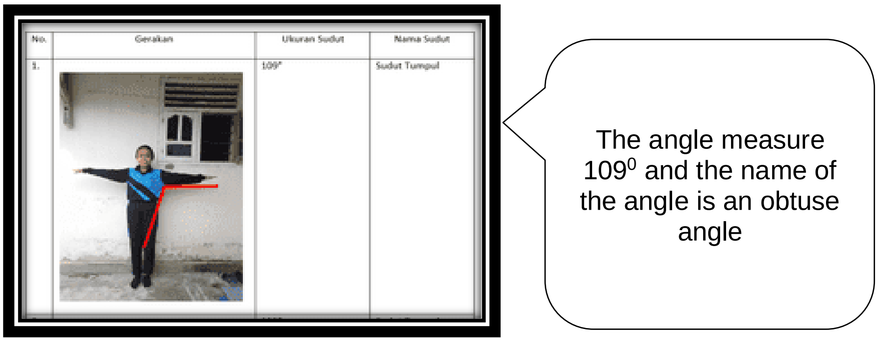


Figure 7. Results of T2 Answers

Figure 7 explains that T2 can describe the total size of the angle, starting from the foot of the angle and the head of the angle. T2 can only describe 1 type of angle formed from the exercise movement, namely 109^0, categorized as an obtuse angle. The results of student work are described in Table 1.

Table 1. Description of the Results of Student Answers in the Pilot Experiment Stage

No	Category	Angle Analysis Capabilities		
		Angle creations	Angle measurement results	Angle type
1	R1	-	√	√
2	R2	-	√	√
3	S1	-	√	√
4	S2	-	√	√
5	T1	√	√	√
6	T2	-	√	√

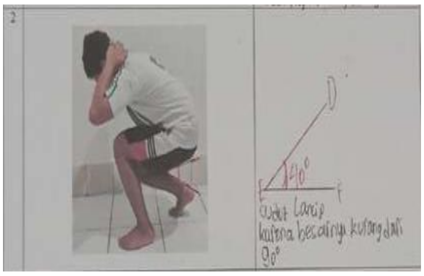
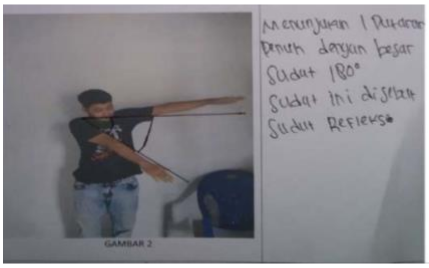
Table 1 describes that high-ability students give different answers compared to other students because, in 1 gymnastic movement, they can tell several angles in each part of the gymnastic movement, both hands, feet, body

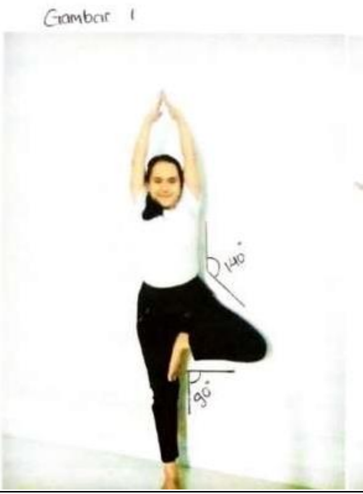
b. The teaching experiments

At this stage, researchers used students not part of the pilot experiment. At this stage, there are several differences in student answers to the questions about measuring angles in the context of gymnastics in terms of the ability to create various gymnastic movements, the ability to determine the tips formed, the ability to measure angles, and the ability to describe the types of curves shown in Table 2.

In Table 2, various variations of student answers are described at the teaching experiment stage, where most students have not been able to be creative in describing several angles and types of hooks in 1 gymnastic movement created by students. In addition, students still focus on simple angles, namely right angles, and develop more angles using hand movements instead of combining one body part with another.

Table 2. Differences in Student Answers

No	Student Answers	Analysis Results
1	 It showed a straight line in 180^0	1. Ability to create various gymnastic movements: students can make multiple gymnastic movements using their limbs. 2. Ability to determine the angle formed: students can only choose one angle in each movement. 3. Ability to measure angles: students can measure angles even though there are no angle legs and angle heads in each movement. 4. Ability to describe types of angles: students have not been able to tell the kinds of angles precisely.
2	 Indicates the type of right angle with a measure of 90^0	1. Ability to create various gymnastic movements: students can make multiple gymnastic movements using their limbs. 2. Ability to determine the angle formed: students can only choose one angle in each movement. 3. Ability to measure angles: students can measure angles and determine the angle of legs and heads. 4. Ability to describe the types of angles: students represent the types of tips correctly.
3	 An acute angle because the magnitude is less than 90^0	1. Ability to create various gymnastic movements: students can make multiple gymnastic movements using their limbs. 2. Ability to determine the angle formed: students can only choose one angle in each movement. 3. Ability to measure angles: students can measure angles and determine the tips of legs and heads. 4. Ability to describe types of angles: students can define types of angles precisely.
4	 Shows one full rotation with an angle of 180^0. This angle is called the reflex angle	1. Ability to create various gymnastic movements: students can make multiple gymnastic movements using their limbs 2. Ability to determine the angle formed: students can only choose one angle in each movement. 3. Ability to measure angles: students have not been able to measure angles but can determine the angle legs and angle heads. 4. Ability to describe types of angles: students have not been able to tell the kinds of angles precisely.

No	Student Answers	Analysis Results
5	 Indicates the type of obtuse angle with an angle measure of 150^0	1. Ability to create various gymnastic movements: students can make multiple gymnastic movements using their limbs. 2. Ability to determine the angle formed: students can only determine 1 grade in each movement. 3. Ability to measure angles: students have not been able to measure angles but have not been able to determine the angle legs and angle heads. 4. Ability to describe types of angles: students have not been able to describe the angles precisely.
6		1. Ability to create various gymnastic movements: students can make multiple movements using their limbs. 2. Ability to determine the angles formed: students can only determine more than one angle in each movement. 3. Ability to measure angles: students have not been able to measure angles but have not been able to determine the angle legs and angle heads. 4. Ability to describe types of angles: students have not been able to precisely tell the types of angles.

3. The Retrospective Analysis

The learning trajectory is obtained at the retrospective analysis stage as Local Instructional Theory (LIT) described in Figure 8.

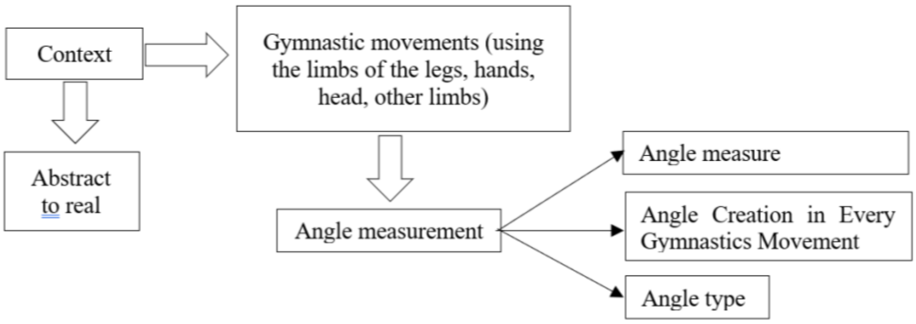


Figure 8. LIT Measurement of Angles in the Context of Gymnastic Movements

Figure 8 explains the results of the learning trajectory obtained during the lecture process in the High-Class Mathematics Learning subject in the Angle Measurement material using the context of gymnastic movements. Gymnastic movements use the limbs, legs, hands, head, and other body parts. Using the context of gymnastic exercises, the results of angular motions, the creation of angles in each gymnastic training, and the types of angles are obtained.

Angle measurement is a mathematical material in class IV SD (Kemdikbud, 2019). The use of context in learning mathematics is one of the characteristics of PMRI (Zulkardi, 2005) of 5 PMRI characteristics: 1) the use of context (using contextual problems); 2) the use of models (using various models); 3) student contributions (student contributions); 4) interactivity (interactivity); 5) intertwining (relatedness). Context is an essential point in leading the context of mathematics.

Context is something that is around humans that makes it easier for someone to be able to understand mathematics from an objective perspective. Context of gymnastics is a daily activity that is often carried out by humans for healthy (Sugihartono, 2019; Karim et al., 2023). Gymnastics improves physical fitness and contains mathematical content that can be learned and analyzed through every exercise movement. The gymnastic movements involve all body members starting from the head, legs, arms, shoulders, waist, legs, and a combination of other body parts.

Various angle sizes range from 20^0-$350^{0,}$ although the dominant angle is 20^0-180^0. The pre-service elementary teacher education measure Angle measurement using a protractorThis means that the context of the gymnastic movement only describes the types of acute angles, right angles, straightening angles, or ½ full rotation, obtuse angles. Meanwhile, the kind angle of one complete cycle is not precisely described in the student's answer. Based on the results of student answers, the problem that is obtained is that most students do not understand the difference between the angle of 1 complete rotation and the angle of ½ entire process, which results in the answer that should be the angle of ½ complete cycle being answered with an angle of 1 full rotation because students cannot distinguish the angle of ½ full rotation and one complete turn. Students assume that the angle is ½ full rotation. Students are familiar with acute, obtuse, right angles, straight angles, or ½ the entire process. This can be seen from the results of the varied student answers.

CONCLUSION

Based on the data obtained from the results and discussion, the researcher can conclude that the results of this study are described as follows: The design of this study has produced a learning trajectory in the form of Local Instructional Theory (LIT) material design for measuring angles using gymnastic contexts. The context of gymnastics is used to lead students' understanding of angle measurements starting from the size of the angle to the type of angle. Learning design results from the work of PGSD Study Program students through angular contexts. This research can be continued towards the development of students' worksheets. Other researchers can develop research on different materials and contexts

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