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The Learning Trajectory of Sphere Using *Megono Gunungan* Tradition Context

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Abstract

This study aims to develop a learning trajectory by utilizing the local wisdom of the *Megono Gunungan* tradition to help students grasp the sphere's notion. This research applied the approach of the Indonesian Realistic Mathematical Approach (PMRI). Ninth-grade students at SMP 38 Semarang, Central Java, Indonesia, were the subjects of this study. The methodology used is based on Graveimeijer and Cobb's three steps of design research: preliminary design, design experiment, and retrospective analysis. Numerous data collection methods were used, involving video, photography, the outcome of students' worksheets, and student interviews. The learning trajectory comprises four activities: identifying sphere components using the *Megono Gunungan* tradition interactive video context, discovering the sphere surfaces area using orange fruit, finding the sphere's volume through rice media, and solving problems of the sphere. This study's findings signify that the utilization of the Megono Gunungan tradition context could encourage learners to recognize the concept of the sphere through a sequence of designed activities.

Keywords: Design Research, *Megono Gunungan* Tradition, Sphere

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INTRODUCTION

Mathematics is crucial for developing a nation (Adolphus, 2011) and creates a significant impact on science and technology advancement (Yeh et al., 2019). Geometry is one of the core subjects in mathematics since it encourages students to attend in their social and daily lives and empowers them with various things that could use in other fields (Ozerem, 2012 and Darwish, 2014). Besides, geometry is crucial in secondary school mathematics syllabuses (Fabiyi, 2017). However, geometry is nevertheless a challenging material for students (Mashingaidze, 2012; Ozerem, 2012; Melo & Martins, 2015; Sunzuma et al., 2019), mainly the material of the curved surface of a sphere.

Based on the interview result with the teacher in one of the schools in Semarang, students still have difficulty with sphere materials since they do not recognize the fundamental concept of the sphere. In line with this, students frequently make procedural mistakes, manipulation errors in mathematical data, symbols misuse, and error to make conclusions (Nuraida, 2017; Anugrah & Pujiastuti, 2020). Despite all these significant aspects, rigorous findings showed the influencing factors for student notion of geometry: the lack of evidence from learners, the insufficient base concept in geometry material, impoverished reasoning ability in geometry, low mathematical communication, lack of visualization, the method of teaching, the absence of evidence from learning resources. Based on these problems, Markopoulos et al. (2015) and Sack (2013) state that the learning design and the teaching adjustment method are essential for the teacher to improve the learning process, especially in geometry.

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Furthermore, many teachers have not carried out learning design before teaching, so their learning targets have not been accomplished in the right manner (Tandiseru, 2015). Besides, it is significant to design learning in learning trajectory-based instruction by determining the proper approach and context and innovative learning instruments.

According to Sembiring (2010) and Bustang et al. (2013), the Indonesian Realistic Mathematical Approach (PMRI) is an appropriate approach for studying mathematics. PMRI is a teaching strategy that intends to assist learners in comprehending the ideas of mathematics from abstract to actual, connecting to daily life as a framework for learning and giving students with a description of the learning material in the context provided as a starting point (Nofriati et al., 2019; Zulkardi, 2002, 2020; Nuryahidah et al., 2020, 2021). Furthermore, the PMRI approach has also persisted in being used in the learning process to improve student interests, behaviors, and learning outcomes (Helsa & Hartono, 2011; Putri et al., 2012; Prahmana et al., 2012; Nursyahidah et al., 2013, 2014, 2018).

In this study, the authors selected the context of the *Megono Gunungan* tradition. In this tradition, there were fruits *gunungan* in the form of the hemisphere and several kinds of round fruits, representing the curved surface of the sphere that was never used as a context in previous mathematics learning. Moreover, the *Megono Gunungan* tradition's preference for context was also expected to allow students to explore central Javanese local wisdom and be more engaged by a substantive learning process.

The researchers were using the design research method to carry out this research analysis. It is divided into three stages: preliminary design, experimental research (including pilot experiment and teaching experiment), and retrospective analysis. To create a hypothetical learning trajectory, the researchers conduct a study based on the above-mentioned local tradition to facilitate learners to investigate the notion of surface area and volume of a sphere based on the *Megono Gunungan* tradition.

RESEARCH METHOD

This research used Graveimeijer and Cobb's (2006) design research to develop a learning trajectory in the sphere's learning curved surface area by utilizing the context of Megono Gunungan. The subjects were 30 students of the ninth grade of SMP Negeri 38 Semarang. This research was carried out during the second semester of the academic year 2019/2020.

Design research is intended to establish a local instructional for teachers based on current (thoroughly researched) and empirical theories through collaboration between authors and teachers to enhance this study's significance in schooling policy and practice (Bakker, 2004; Gravemeijer & Eerde, 2009). A hypothetical learning trajectory was created in this study, which included several learning activities for students. This study's instructional design comprised three steps including preliminary design, design of the experiment, and retrospective analysis (Gravenmeijer & Cobb, 2006; Prahmana, 2017; Putri & Zulkardi, 2018).

Preliminary design is the first step. This phase's principal aim is to develop a series of learning activities and design instruments to assess the learning process. Furthermore, the authors define learning objectives or goals and the starting point for learning. The activities conducted in this phase analyze the curriculum's sphere's literature, designing the HLT with the Megono Gunungan tradition framework as the framework for the learning process. Creating an interactive video used as a learning media, developing student activity worksheets, and deliberating with educators and professional experts in this field.

The trajectory of learning planned at the preliminary design phase will be conducted in the learning process in the design experiment stage. This stage aims to discover and analyze students' strategies and ideas. This phase comprised two cycles, specifically pilot experiment and teaching experiment. The first cycle is a pilot experiment designed to assess and refine the planned learning trajectory. Moreover, the teaching experiment is the second cycle to conduct a learning path assessed and reviewed in the pilot experiment.

The last step is the retrospective analysis. The last step is the retrospective analysis. This stage involves reviewing the data acquired during the design experiment. The study's findings are used to create activities and formulate a study plan for the following learning. The aim is to establish a local instrument theory. Data collection techniques are used to solve research objectives by observing, interviewing, and documenting.

RESULTS AND DISCUSSION

The research carried out helps students to grasp the notion of sphere material by series of designed activities, notably: identifying sphere components using the *Megono Gunungan* interactive video context, discovering the sphere surfaces area using orange fruit, finding the sphere's volume through rice media, and solving problems of the sphere. The results can be defined and discussed in four activities.

Activity 1: Identifying sphere components using interactive video of the *Megono Gunungan* tradition context

The teacher gives the material that students have learned before beginning Activity 1. The teacher reviews material utilizing the query and response method, and the students were actively engaged in the discussion of previous material. The students also observed the video using the *Megono Gunungan* context with real enthusiasm, as the video was shown in interactive media. Figure 1 is an illustration of the students watching the *Megono Gunungan* video.

Figure 1. Students observing interactive video of *Megono Gunungan* tradition

Furthermore, teachers could also observe the *Megono Gunungan* tradition interactive video to engage students to rediscover sphere ideas by noticing the shape of fruits *gunungan* that formed a hemisphere. Utilizing the context given, students ought to have discovered and sketched the illustration of fruits gunungan in the form of sphere elements. The teacher asked students to discuss the student worksheet in a group about numerous problems. After the discussion completes, the teacher requested a group to display the classroom solutions' outcome to help all students comprehend their ideas. If they are not right, the teacher strengthens the answers of students. As an outcome of this phase, the students were excited about observing Megono Gunungan's interactive video including some questions to students related to the material. Then they could quickly sketch illustration fruits gunungan, a form of the hemisphere, and discovered its element through their activity sheets.

Activity 2: Discovering the surface area of sphere utilizing orange fruit

In this activity, each group was given one orange fruit and string. Furthermore, the students were asked to calculate the orange's circumference, utilize the string, and determine the radius. The students make several circles with the radius obtained in the previous phase on the cardboard that has been provided. Besides, the students peel the oranges that have been prepared and make them peel into small pieces. Then, the students stick the orange peel pieces on the circles that have been made until the parts of the peeled orange were over. Students can discover if the sphere's surface area is four times the circle area from this activity.

Students need precision, ingenuity, and critical thinking in this stage because they have to evaluate and determine the sphere's surface area by utilizing orange fruit. The outcome is students can make precisely if one peel of an orange fruit (as a sphere) is equal to four times the area of circles. Besides, students could accurately calculate and infer if the sphere surface area is four times the circle area. Figure 2 depicts the students' activities during this phase.

Figure 2. Students activity in discovering the surface area of the sphere

Activity 3: Finding the volume of the sphere through rice media

In the third activity, the teacher gives rice media, a plastic ball, two-cylinder without a top whose radius is the same as the plastic ball's radius, while the height is the same as the plastic ball's diameter. The students were then asked to make a hole in the plastic ball using a cutter and fill up the plastic ball that was already hollow with magic rice until it was full. Furthermore, students pour the rice into open cylinders. Students were asked to repeat these steps until both cylinders were filled. The students will also determine the number of times the student filled two-cylinder to the brim with the rice using the plastic ball.

Based on these activities, students will get if the volume of the cylinder's volume to the sphere's volume is 2: 3. Moreover, the volume of the sphere could be identified by students. This stage's activity is necessary to encourage the idea of the sphere's volume from formal to informal steps to be grasped.

Figure 3. Students activity in finding the volume of a sphere

Activity 4: Solving problems of the sphere

Throughout this learning process, learners were required to resolve the spheres word problem. With the idea gained in the previous lessons, students were able to fix the issues. Additionally, Figure 4 illustrates the students' outcomes from this activity.

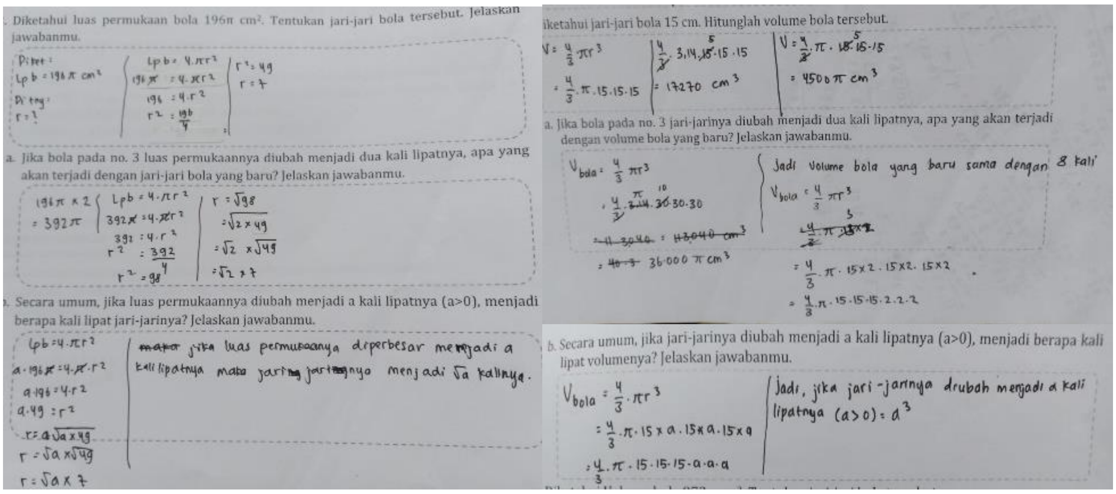

Figure 4. Students' answers from a given problem

As illustrated in Figure 4, learners are already familiar with the sphere's issues, indicating that they have mastered the sphere's idea adequately to resolve the problem. The findings are compatible with the objectives of a hypothetical learning trajectory. In addition, the iceberg of those series activities from informal to formal level can be seen in Figure 5.

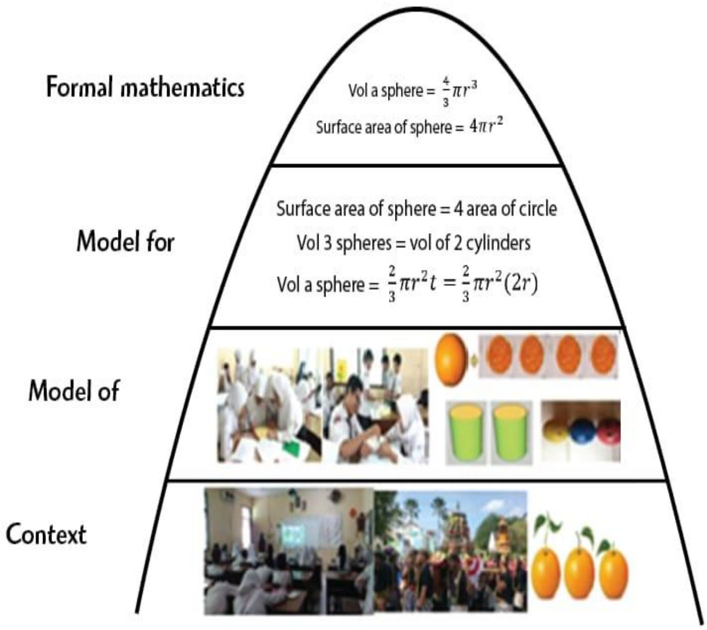

Figure 5. An iceberg of surface area and volume of a sphere

From the above discussion, it can be inferred that the design learning of PMRI utilizing the Megono Gunungan tradition context integrated with an interactive video could encourage students to discover the idea of surface area and volume of sphere quickly. Learners can freely find the idea since they can find and acquaint themselves with their notion of sphere material. In the learning phase, students were also more engaged throughout discussing and collaborating in an attempt to resolve the challenges among the group. Moreover, in-class discussion, students often can convey their views more effortlessly. It is also premised on PMRI's characteristics, which is to suggest, interactivity, meaning that the learning process is indeed a process of individual learning as well as being a process of social learning (Zulkardi et al, 2002; Prahmana et al, 2012; Nursyahidah et al., 2013, 2014, 2018, 2020).

CONCLUSION

The learning trajectory developed in this research consists of four activities: identifying sphere components using the *Megono Gunungan* tradition context in interactive video, discovering the sphere surfaces area using orange fruit, finding the sphere's volume through rice, and solving problems of the sphere. The study's findings show that by utilizing the Megono Gunungan tradition context, students could be encouraged to comprehend the notion of the sphere's surface area and volume through a series of designed activities represented in figures one to five.

REFERENCES

Adolphus, T. (2011). Problems of Teaching and Learning Geometry in Secondary Schools in Rivers State, Nigeria. *Int. J. Emerg. Sci., 1(2)*, 143-152.

Anugrah, A. & Pujiastuti, H. (2020). Analisis Kesalahan Siswa dalam Menyelesaikan Soal HOTS Bangun Ruang Sisi Lengkung. *Jurnal Pendidikan Matematika*, *11(2)*, 213-225.

Arbowo, B. W., Lestari, A. A. P., Aisyah, F., & Nursyahidah, F. (2018). Developing Student's Activity with Wisanggeni Puppet Context to Enhance Students' Understanding of Addition and Subtraction Thousands Number. MISEIC. *MISEIC. (Surabaya: UNESA)*.

Aysen, O. (2012). Misconceptions in geometry and suggested solutions for seventh-grade students. *International Journal of New Trends in Arts, Sports and Science Education*, *1(4)*, 1-13.

Bakker, A. (2004). *Design Research in Statistic Education on Symbolizing and Computer tools*. Amersfoort: Wilco Press.

Bustang, Zulkardi, Darmowijoyo, dolk, M. & Van Eerde, D. (2013). Developing a Local Instruction Theory for learning the Concept of Angle through Visual Field Activities and Spatial Representation. *International Education Studies*. *6(8).*

Darwish, A. H. (2014). The Abstract Thinking Levels of the Science Education Students in Gaza Universities. *Asia-Pacific Forum on Science Learning and Teaching*, *15(2)*, 1-24.

Fabiyi, T. R. (2017). Geometry Concepts in Mathematics Perceived Difficult To Learn By Senior Secondary School Students in Ekiti State, Nigeria. *IOSR Journal of Research & Method In Education (IOSRJRME)*, *7(1)*, 83-90.

Fahrurozi, A., Maesaroh, S., Suwanto, I., & Nursyahidah, F. (2018). Developing Learning Trajectory Based Instruction of the Congruence for Ninth Grade Using Central Java Historical Building. *Jramathedu (Journal of Research and Advances In Mathematics Education)*, *3*(2), 78-85.

Gravemeijer, K. & Cobb, P. (2006). Design research from a Learning Design Perspective. In (Eds) van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N., *Educational design research* (h. 17-51). New York: Routledge.

Gravemeijer, K. & Eerde, V. S. (2009). Design Research as a Means for Building a Knowledge Base for Teaching in Mathematics Education. *The Elementary School Journal*, *109(5)*.

Helsa, Y. & Hartono, Y. (2011). Designing Reflection and Symmetry Learning by Using Math Traditional Dance in Primary School. *Journal on Mathematics Education*, *2(1)*, 79-94.

Mashingaidze, S. (2012). The Teaching of Geometric (Isometric) Transformations at Secondary School Level: What Approach to Use and Why? *Asian Social Science, 8(15).*

Markopoulos, C., Chaseling, M., Petta, K., Lake, W. & Boyd, W. (2015) Pre-Service Teachers' 3D Visualization Strategies. *Creative Education*, *6(10)*, 1053-1059.

Melo, H. S. & Martins, M. C. (2015). Behaviors and Attitudes in the Teaching and Learning of Geometry. *European Scientific Journal August*, 98-104.

Nofriati, N. F., Hartono, Y., & Somakim. Learning Direct and Inverse Proportion Using Musi Tour. *International Journal on Emerging Mathematics Education*, 3(2).

Nuraida, I. (2017). Analisis Kesalahan Penyelesaian Soal Bangun Ruang Sisi Lengkung Siswa Kelas IX SMP Negeri 5 Kota Tasikmalaya. *Jurnal Teori dan Riset Matematika (TEOREMA)*, *1(2)*, 25-30.

Nursyahidah, F., Ilma, R., & Somakim, S. (2013). Supporting First Grade Student's Understanding of Addition up to 20 Using Traditional Game. *Journal on Mathematics Education*, *4(2)*, 212-223.

Nursyahidah, F., Ilma, R., & Somakim. (2014). Instructional Design of Subtraction Using PMRI Approach Based on Traditional Game. *SEA-DR, Palembang.*

Nursyahidah, F., Saputro, B. A., & Rubowo, M. R. (2018). A Secondary Student's Problem

Solving Ability in Learning Based on Realistic Mathematics with Ethnomathematics. *JRAMathEdu*, *3(1)*, 13–24.

Nursyahidah, F., Saputro, B. A., & Albab, I. (2020). Learning reflection through the context of Central Java historical building. *Journal of Physics: Conference Series, 1567.*

Ozerem, A. (2012). Misconceptions in Geometry and Suggested Solutions for Seventh Grade Students. *Journal of New Trends in Arts, Sports and Science Education*, *1(4)*, 23-25.

Prahmana, R. C. I. (2017). *Design Research (Theory and its implementation: An Introduction)*. Jakarta: Rajawali Pers.

Prahmana, R., Zulkardi, Z., & Hartono, Y. (2012). Learning Multiplication Using Indonesian Traditional game in Third Grade. *Journal on Mathematics Education*, *3(2)*, 115-132.

Puri, R. I. I. (2012). Developing learning trajectory using traditional games in supporting students learning greatest common divisor in Indonesian primary school. *Proceeding 12th ICME COEX Soul Korea, 2012*, *1*, 7721.

Putri, R. I. I, & Zulkardi. (2018). Noticing Students Thinking and Quality of Interactivity during Mathematics Learning. *Proceedings of First Indonesian Communication Forum of Teacher Training and Education Faculty Leaders International Conference on Education 2017 (ICE 2017), Paris.*

Sack, J. J. (2013). Development of a Top-View Numeric Coding Teaching-Learning Trajectory within an Elementary Grades 3-D Visualization Design Research Project. *The Journal of Mathematical Behavior, 32,* 183-196.

Sembiring, Robert K. (2010). Pendidikan Matematika Realistik Indonesia (PMRI) : Perkembangan dan Tantangannya. *Journal on Mathematics Education*, *1(1)*, 11-16

Sunzuma, G. & Maharaj A. (2019). In-service Teachers' Geometry Content Knowledge: Implications for how Geometry is Taught in Teacher Training Institutions. *International Electronic Journal of Mathematics Education*, *14(3)*, 633-646.

Tandiseru, S. R. (2015). The Effectiveness of Local Culture-Based Mathematical Heuristic-KR Learning towards Enhancing Student's Creative Thinking Skill. *Journal of Education and Practice*, *6*(12), 74-81.

Yeh, C. Y., Cheng, H. N., Chen, Z. H., Liao, C. C., & Chan, T. W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning*, *14*(1), 1-19.

Zulkardi, Z. (2002). *Developing a learning environment on realistic mathematics education for Indonesian student teachers* (Doctoral dissertation, University of Twente, Enschede).

Zulkardi, Z., Putri, R. I. I., & Wijaya, A. (2020). Two decades of realistic mathematics education in Indonesia. In *International reflections on the Netherlands didactics of mathematics* (pp. 325-340). Springer, Cham.