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Learning Design of Sphere using Realistic Mathematics Education Assisted by Interactive Video

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Abstract

Numerous studies, particularly in sphere material, have highlighted students' challenges in grasping the notion of geometry. Typically, the teacher only teaches the subject using the formula, omitting the notion altogether. Moreover, this study intends to create a hypothetical learning trajectory for the sphere material by incorporating the Syawalan tradition from Pekalongan into the learning process through the Indonesian Realistic Mathematics Education approach, or PMRI. The methodology employed is design research, divided into three stages: preliminary design, design experiment, and retrospective analysis. As a result, this study focuses exclusively on the outcomes of the design experiment process, namely the pilot experiment. Video recordings, photographs, observations, deep interviews, documentation, field memos, and student activity sheets were all used to collect and analyze data to improve HLT. The outcome of this study is a hypothetical learning trajectory for sphere material in the context of the Syawalan tradition. The student learning sequence comprises four series, which include observing an interactive video of the syawalan tradition context to characterize sphere elements, utilizing orange fruit to find the sphere's surface area, discovering the sphere's volume through the cylinder and magic seeds, and resolving sphere-related contextual problems. Additionally, the activities devised in this study can potentially develop students' interest and conception of sphere material in the ninth grade.

Keywords: Design Research, Interactive Video, PMRI, Sphere, Syawalan Tradition

Abstrak

Banyak penelitian khususnya dalam materi bola, telah menyoroti tantangan siswa dalam memahami pengertian geometri. Biasanya, guru mengajar mata pelajaran menggunakan rumus saja, menghilangkan pengertian sama sekali. Selain itu, penelitian ini bermaksud untuk mendesain hipotesis lintasan pembelajaran untuk materi bola dengan menggunakan tradisi Syawalan dari Pekalongan ke dalam proses pembelajaran melalui pendekatan Pendidikan Matematika Realistik Indonesia, atau PMRI. Metodologi yang digunakan adalah design research, dibagi menjadi tiga tahap: desain awal, eksperimen desain, dan analisis retrospektif. Penelitian ini berfokus pada hasil dari proses design experiment, yaitu pada tahap pilot experiment. Rekaman video, foto, observasi, wawancara mendalam, dokumentasi, catatan lapangan, dan lembar kegiatan siswa semuanya digunakan untuk mengumpulkan dan menganalisis data guna meningkatkan HLT. Hasil penelitian ini berupa hipotesis lintasan pembelajaran materi bola dalam konteks tradisi Syawalan. Rangkaian pembelajaran siswa terdiri dari empat rangkaian, yaitu mengamati video interaktif konteks tradisi Syawalan untuk mengenal unsur-unsur bola, memanfaatkan buah jeruk untuk mencari luas permukaan bola, menemukan volume bola melalui silinder dan biji-bijian, dan menyelesaikan masalah kontekstual yang terkait dengan bola. Selain itu, kegiatan yang dirancang dalam penelitian ini berpotensi untuk mengembangkan minat dan pemahaman konsep siswa tentang materi bola di kelas sembilan

Kata kunci: Desain Riset, Video Interaktif, PMRI, Bola, Tradisi Syawalan

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INTRODUCTION

Geometry is one of the subjects that student's study throughout their education, from preschool to high school. This demonstrates the importance of geometry as a subject to master. In line with Yavuz

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et al. (2016), geometry becomes essential to study since it allows students to stimulate their ideas, engage in problem-solving, analyze, generalize, and contextualize their capability development. It also provides a natural environment for students to build their deduction abilities. However, geometry remains a tough subject for students (Sutiarso & Coesamin, 2018), particularly curved sides topics in sphere material for students in the ninth grade.

Students frequently lack the visualization and investigation ability to know geometrical ideas, problem-solving abilities, and geometrical thinking (Muzaini et al., 2023; Özerem, 2012). According to Juman et al., (2022), geometry misconceptions are the primary reason for students' difficulties in studying geometry. Besides that, Muzaini et al. (2023) claims that students are discouraged by their inadequate knowledge of geometry, which leads to low performance in the topic. For instance, an insufficient connection of three-dimensional geometry with surface and volume area measurement and reliance on formula memorizing over conceptual comprehension might influence students' difficulties (Barrantes & Blanco, 2006; Chiphambo & Mtsi, 2021). Developing appropriate learning activities to aid students' conceptual grasp of surface and volume area measurement is critical for mathematics class.

Hence, teachers play a significant role in ensuring effective geometry learning. Teachers should consider students' interests while planning and preparing geometry courses. (Mamiala et al., 2021) proposed that indigenous cultural contexts could be incorporated into geometry instruction to assist students in transitioning from concrete to abstract knowledge of geometry, as geometry and culture are inextricably linked. This is consistent with numerous studies (Bustang et al., 2013; Fahrurozi et al., 2018; Nursyahidah et al., 2020, 2021; Saputro et al., 2015) demonstrating that integrating local context into a geometry problem could entice and motivate students to commence learning.

The use of context in mathematics education allows the mathematical concept to be relevant. Context may transform complex mathematical notions into simply comprehensible concepts (Fajriyah & Putri, 2018). Additionally, using context in learning mathematics will assist students in creating evident concepts among contexts and mathematical concepts, which is beneficial for their mathematical thinking growth (Susanta et al., 2022; Widjaja, 2013).

In Addition, Indonesian Realistic Mathematics Education (PMRI in Bahasa) is a learning approach that involves local context in mathematics instruction (Putri & Zulkardi, 2018; Deda & Maifa, 2021). As a result, PMRI can be used as an appropriate approach to learning geometry, particularly sphere material. Moreover, PMRI may lead to fascinating, contextual knowledge if employed in mathematics classes by increasing students' capacity to resolve issues applicable to their everyday lives (Nursyahidah & Albab, 2021; Risdiyanti & Prahmana, 2020; Ardani et al., 2023). Furthermore, due to modernization impact, local wisdom might rectify a student's diminished cultural significance and personality (Nuraida & Putri, 2020; Uge et al., 2019). Furthermore, the PMRI approach possesses five characteristics, which include contextual problems, using models and symbols, student involvement, interaction, and interrelationships, that may assist teachers in developing valuable learning processes (Meryansumayeka et al., 2022; Putri & Zulkardi, 2018).

A syawalan tradition is an annual event held by the community in Pekalongan Regency, which is in Linggosari tourism object, in the month of Shawwal as an event to stay associated among residents, as well to express gratefulness in the form of gunungan (farming productions) from each sub-district that is distributed to the community at the ending of the event (Ghofur & Ismanto, 2022; Pradhipta et al., 2021). Additionally, the context for the Megono Gunungan tradition is chosen to allow students to explore Central Javanese cultural wisdom and become more engaged in a meaningful learning experience. In this research, the authors chose the context of the Syawalan tradition as a starting point for learning the surface and volume area of the sphere since, in this tradition, there are fruits mountain that resemble hemispheres and various types of round fruits representing the sphere shape and never used as a context in mathematics learning before.

This context is then packaged in the form of an interactive video. In the video, a voice explains the Syawalan tradition and presents several questions asking for answers to stimulate students' prior knowledge through the context used in learning. Using multimedia assistance in interactive videos can help the learning process. According to Sühendan et al. (2022), students can construct and understand their knowledge through the interactive videos provided. This is by Mahadewi et al. (2020), who state that interactive media in the form of videos helps students with various abilities understand the material well. Observing the context of the Syawalan tradition of the Pekalongan community, which is packaged in video form, can help students visualize the object being observed as a starting point in learning sphere material.

The authors conducted this research analysis utilizing the design research method. This method entails the following phases: preliminary design, design experiment (pilot and teaching experiments), and retrospective analysis. Nonetheless, this study focused exclusively on the pilot phase of the design experiment. Research discussing mathematics learning using PMRI on the topic of a sphere has been carried out using various contexts, such as: sunflower seeds (Widiawati et al., 2019) and watermelon (Juwita et al., 2015). However, there are still few who explore the context of the Syawalan tradition in learning mathematics on the topic of a sphere. Apart from that, this research also uses interactive videos as a starting point in learning mathematics on the topic of a sphere. Therefore, the present study aimed to develop a hypothetical learning trajectory of sphere material for ninth-grade students using the Syawalan tradition.

METHODS

This study uses design research developed by Gravemeijer & Cobb (2006) as the research method. The design research method was adopted since it is a structured and adaptable strategy for enhancing the quality of instructional learning through engagement among researchers and educators to create a learning design. Developing a learning design is divided into three phases: preliminary design, design experiment, and retrospective analysis.

The early phase is the preliminary design. This step involved conducting a literature review on sphere material in the ninth grade, considering the 2013 curriculum, Indonesian realistic mathematics education, and the contexts for learning sphere material, specifically the Syawalan tradition in Pekalongan. The findings from the literature review from several journal articles and proceedings are utilized to formulate alleged starting strategies for learning or to develop learning trajectories for students. In addition, a hypothetical learning trajectory (HLT) will be developed based on the literature and tailored to the actual learning during the teaching experiment.

The teaching experiment is the second stage, consisting of a pilot experiment and a teaching experiment. Meanwhile, this study is limited to the result of the pilot experiment stage as a first step to try out the designed HLT in class. The pilot experiment was designed to evaluate the HLT on small groups of students to acquire data to alter and revise the initial HLT in the subsequent teaching experiment stage. So, after this pilot experiment stage, a better HLT can be obtained as a result of revisions from the implementation of the pilot experiment, which can then be used in the teaching experiment stage. Six ninth-grade students from one of Semarang's Junior High Schools participated in the pilot experiment, consisting of two students, each with low, moderate, and high abilities. The six students were selected based on recommendations from the class teacher, who already knew the characteristics of the students in the class being taught.

The last stage is a retrospective analysis. The data obtained during the design experiment are assessed by comparing conjecture and HLT with the finding of the implementation of the learning trajectory in the design experiment (Gravemeijer & Cobb, 2006). The study's outcomes will provide a trajectory description of the sphere material using the context of the Syawalan tradition.

This study's data collection methods include video recordings, photographs, observations, documentation, field memos, and students' activity sheets collected and examined to develop HLT in the following cycle. The collected data was analyzed and described qualitatively.

RESULTS AND DISCUSSION

The findings of this study established a hypothetical learning trajectory (HLT) description for sphere material learning in the context of the Syawalan tradition. The learning series is divided into four activities: observing interactive videos of Syawalan tradition context to analyze sphere elements, utilizing orange fruit to find the sphere's surface area, discovering the sphere's volume through the cylinder and magic seeds, and resolving contextual problems related to sphere material. The series of activities in HLT can be seen in Figure 1.

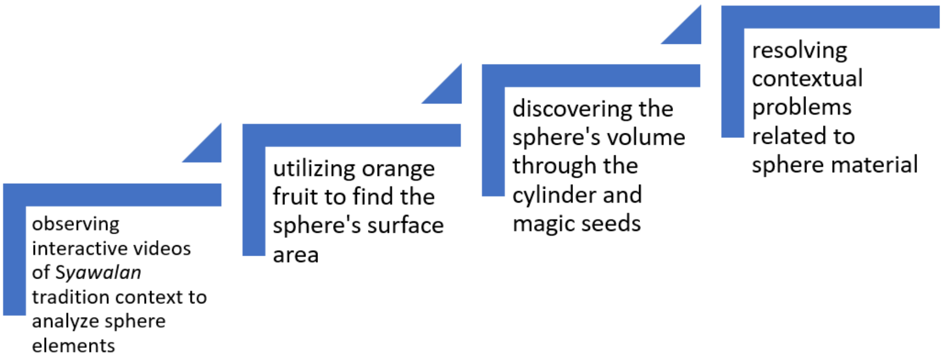


Figure 1. Hypothetical Learning Trajectory in Learning the Sphere

Students might comprehend the idea of the surface and volume area of the sphere by employing the Syawalan tradition context. It can be seen from the activity sequence results and the positive feedback from students (See Figure 1).

Concerning this study, the feedback indicates that students feel more at ease with the sphere material after being taught the context and activities series designed. The study's findings revealed that the learning design of sphere material based on the Syawalan tradition is significant as a starting point and can help enhance student motivation during classroom activities. The researchers explain the study's findings in detail in the following sections.

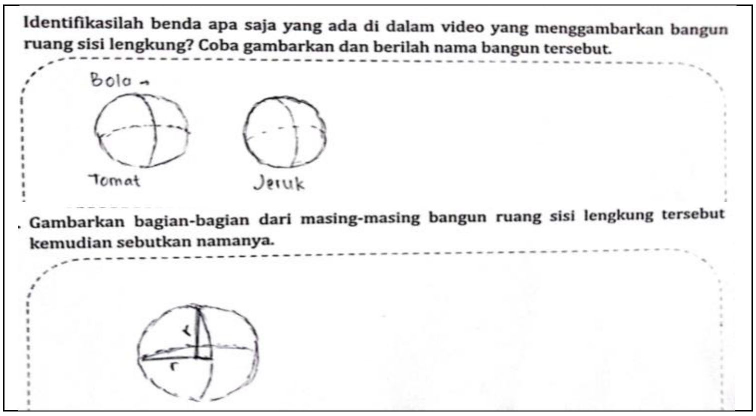
Activity 1: Observing Interactive Video of Syawalan Tradition Context to Analyze Sphere Elements

In Activity 1, the learning process commences with the teacher providing apperception content, cone, and cylinder material, using a question-and-answer technique to ensure that students have no doubts concerning the previous topic. Students observe an interactive video about the Syawalan tradition to discover the sphere shape found in the tradition as seen in Figure 2.

Figure 2. Observing Interactive Video of Syawalan Tradition

Students are pleased to watch the interactive video regarding Syawalan tradition, as evidenced by the following activity in Figure 2. The video can be accessed through this link https://drive.google.com/file/d/1U8vgoJvIEXfK_agol1aD1lhuoUIhoRq9/view?usp=sharing.

After that, the teacher assigned students into three groups according to their skills: groups with low, medium, and high abilities to locate the elements of the sphere. Those student groups were classified based on recommendations from the class teacher, who already knew the characteristics of the students in the class being taught, and from the result of the pretest. Using the context provided, students could have identified and drawn fruit mountain in the shape of sphere components. Afterward, one of the groups was asked to deliver their findings to the class. Students' conception of the sphere component began to take shape due to the solutions offered. Students might determine the components of a sphere and describe each element. The results of students' group discussions are depicted in Figure 3.



Translated to English:

Identify what objects in the video describe the curved 3D shape.

Draw and give the name of that 3D shape.

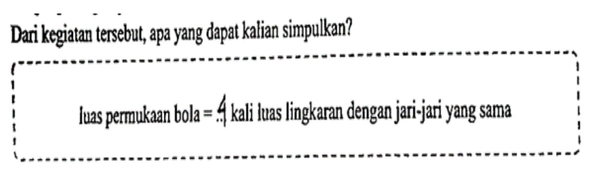
Figure 3. The results of students' answers in the first activity

Activity 2: Utilizing orange fruit and a circle to find the sphere's surface area

In activity 2, students experimented to determine the surface area of the sphere with an orange. The teacher distributes one orange, yarn, glue, and colored HVS paper to each group. Then, using yarn and mathematical calculations, the students were required to discover the diameter of the orange fruit. Figure 4 illustrates students conducting experiments throughout activity two.

Figure 4. Students Experiment to Locate the Surface Area of a Sphere

Figure 4 depicts students' experiment to locate the surface area of a sphere. Students were instructed to draw multiple circles on the HVS paper using the diameters obtained in the preceding activity. Students then cut the orange peel that had been prepared and made it into small pieces. Additionally, students glue orange peel pieces into a circle that has been created and repeated until all the orange peel pieces are up. After doing an experiment to locate the orange peel into some circles that have the same diameter as the orange, students might conclude from this activity that the surface area of a sphere is equal to four times the surface area of a circle with the same radius.



Translated to English:

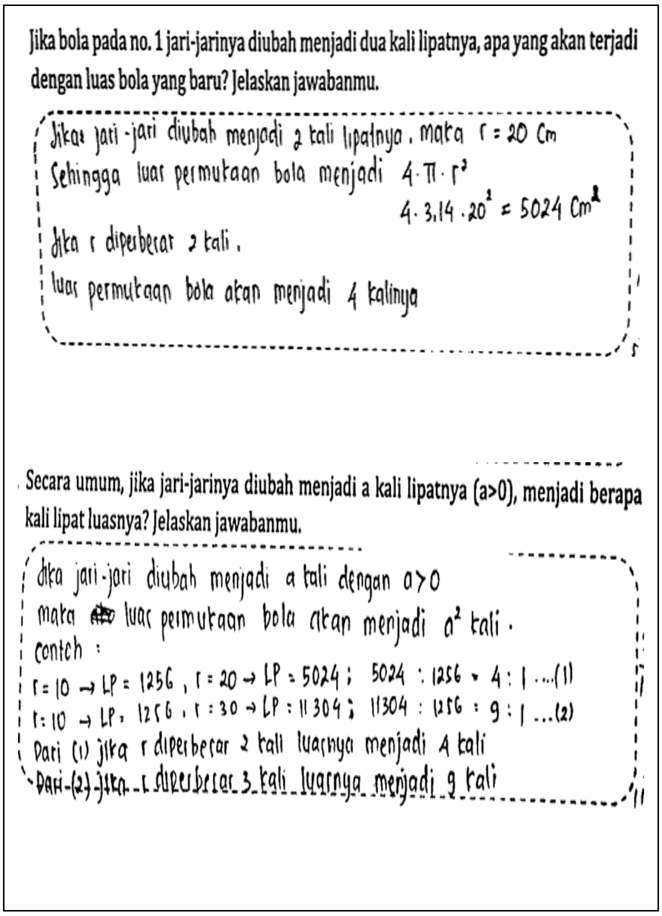
Question
From these activities, what can you conclude?

Solution
The surface area of sphere = 4 times the area of a circle with the same radius

Figure 5. The Results of Students' Answers in the Second Activity

Students were able to answer the student's worksheet in finding the formula of the surface area of a circle through an experiment of peeling an orange as seen in Figure 5. Students found that all parts of the orange peel cut into small pieces could cover 4 circular surfaces. So, they concluded that the surface area of a sphere is four times the area of a circle with the same radius.

Students then can solve a problem related to the surface area of a sphere and try to find the relationship between the surface area and the length of the radius. The students were given a problem: if there is a change in the size of the radius, then what happens with the surface area of the sphere? The sample of students' responses in solving this problem can be seen in Figure 6.



Translated to English:

Question
If the radius of the sphere in problem 1 is doubled, what will happen to the surface area of the new sphere? Explain your answer.

Solution
If the radius is doubled, then r = 20 cm
So, the surface area of the sphere becomes $4\pi r^2 = 4.3{,}14.20^2 = 5024\ cm^2$
If r is doubled, the surface area of the sphere will be 4 times.

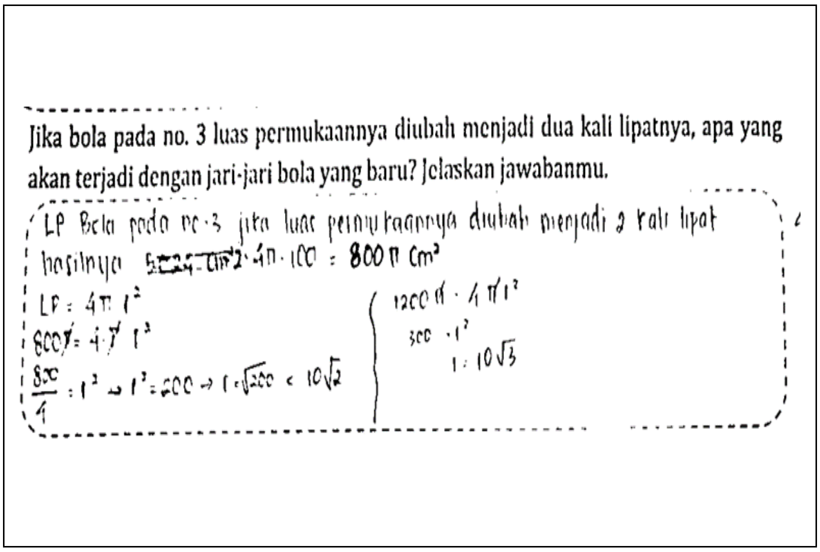
Translated to English:

Question
In general, if the radius is changed to a times (a>0), how many times is the surface area? Explain your answer.

Solution
If the radius is changed to a times that of $a > 0$, then the surface area of the sphere will be a^2 times.
Example:
r = 10, surface area = 1256, r = 20, surface area = 5024, 5024:1256 = 4 … (1)
r = 10, surface area = 1256, r = 30, surface area = 11304, 11304:1256 = 9 … (2)
from (1), if r is extended 2 times, the area becomes 4 times
from (2), if r is extended 3 times, the area becomes 9 times

Figure 6. Students' Responses in Solving Problems Related to the Surface Area of the Sphere

Figure 6 depicts the student's solution to the problems related to the surface area of the sphere. They can find the surface area of the sphere if the radius is given. Then can find the surface area if r is doubled, that is surface area of the sphere will be 4 times. Moreover, they also can find the surface area of the sphere if the given radius is a times with $a > 0$, so the surface area of a sphere will be a^2 times and they can give some examples of it. After solving problems related to changing the length of the radius of the sphere, the student solved problems for other cases that are changing in the surface area of the sphere. The student's responses can be seen in Figure 7.



Translated to English:

Question

What will happen to the new ball's radius if the sphere in problem number 3 is doubled? Explain your answer.

Solution

The surface area of the sphere in problem number 3 if it is changed to 2 times, the result is $2.4\pi.100 = 800\pi \text{ cm}^2$

$\text{Surface area} = 4\pi r^2$

$800\pi = 4\pi r^2$

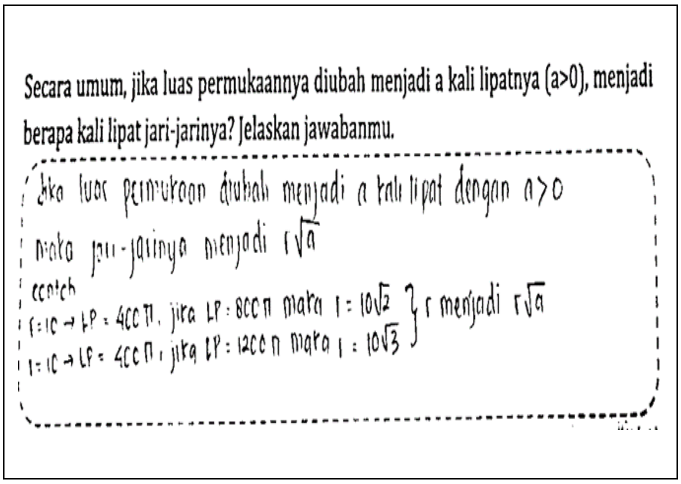
$\frac{800}{4} = r^2 \rightarrow r^2 = 200 \rightarrow r = \sqrt{200} = 10\sqrt{2}$

$1200\pi = 4\pi r^2$

$300 = r^2 \rightarrow r = 10\sqrt{3}$

Figure 7. Students' Responses in Solving Problems Related to the Surface Area of the Sphere

Figure 7 depicts students can solve problems related to a surface area if the surface area of the sphere is changing into doubled, the radius will be $10\sqrt{2}$. After this activity, the students were able to make a generalization from this case, that if the surface area is changed to a times, then the length of the radius will be $r\sqrt{a}$. The sample of student's responses can be seen in Figure 8.



Translated to English:

Question

In general, if the surface area is changed to a times (a>0), how many times is the radius? Explain your answer.

Solution

If the surface area is doubled with a>0, then the radius becomes $r\sqrt{a}$.

Example:

$r = 10, \text{surface area} = 400\pi, \text{if surface area} = 800\pi,$

$r = 10\sqrt{2}$

$r = 10, \text{surface area} = 400\pi, \text{if surface area} = 1200\pi,$

$r = 10\sqrt{3}$

So, we get r becomes $r\sqrt{a}$.

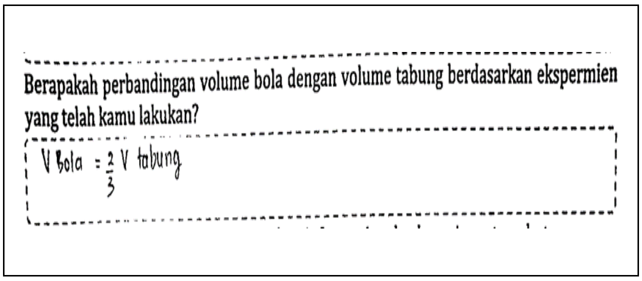
Figure 8. Students' Responses in Generalizing from a Given Problem Related to the Surface Area of the Sphere

Activity 3: Discovering the Sphere's Volume through the Cylinder and Seeds

In activity 3, students experimented to determine a sphere's volume using two tubes and seeds. The teacher gave plastic balls and two open tubes with a radius equal to the radius of the plastic ball, while the height was the same as the diameter of the plastic ball. Then, the students were asked to punch holes in the plastic ball using a cutter and fill the plastic ball with magic seeds until it was full. After the ball is filled with magic seeds, students are instructed to pour the seeds into an open tube and repeat until both tubes are filled. The students' experiment was documented in Figure 9.

Figure 9. Students Experiment to Locate the Volume Area of a Sphere

Students were required to calculate the ratio of the volume of the ball to the tube volume based on the experiments that had been done (See Figure 9). Students could discover that the volume of the sphere is equal to two-thirds of the volume of the cylinder through this activity. A sample of students' responses can be seen in Figure 10.



Berapakah perbandingan volume bola dengan volume tabung berdasarkan ekspermien yang telah kamu lakukan?

V bola = $\frac{2}{3}$ V tabung

Translated to English:

Question

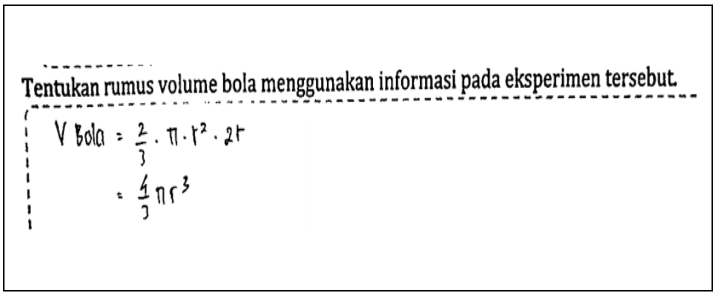
What is the ratio of the volume of the sphere to the volume of the cylinder based on the experiments you have done?

Solution

Volume of the sphere = $\frac{2}{3}$ volume of cylinder

Figure 10. The Results of Students' Answers in the Third Activity

Students were able to find that three times of volume of the sphere is two times the volume of the cylinder as seen in Figure 10. The students can write the volume of the sphere = $\frac{2}{3}$ volume of a cylinder. From this experiment, the students can find the formula of the sphere volume. The sample students' responses can be seen in Figure 11.



Tentukan rumus volume bola menggunakan informasi pada eksperimen tersebut.

V bola = $\frac{2}{3} \cdot \pi \cdot r^2 \cdot 2r$

$= \frac{4}{3} \pi r^3$

Translated to English:

Question

Determine the volume formula of the sphere using the information in the experiment.

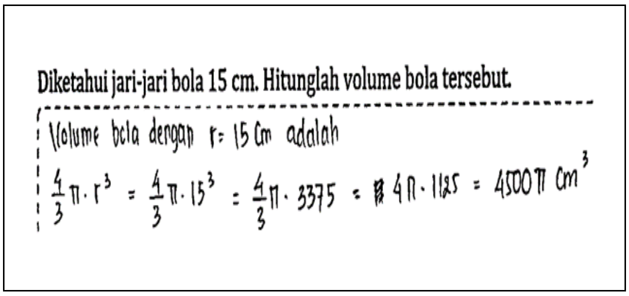
Solution

Volume of the sphere = $\frac{2}{3} \times \pi \times r^2 \times 2r$

Volume of the sphere = $\frac{4}{3}\ \pi\ r^3$

Figure 11. Students' Responses in Finding the Volume of the Sphere

Figure 11 depicts the students finding the formula of the sphere volume, that is $V = \frac{4}{3}\pi r^3$. After finding the formula of the sphere, the students can solve problems related to the volume of the sphere. The sample students' responses can be seen in Figure 12.


Diketahui jari-jari bola 15 cm. Hitunglah volume bola tersebut.

Volume bola dengan r = 15 cm adalah

$\frac{4}{3}\pi \cdot r^3 = \frac{4}{3}\pi \cdot 15^3 = \frac{4}{3}\pi \cdot 3375 = 4\pi \cdot 1125 = 4500\pi\ cm^3$

Translated to English:

Question

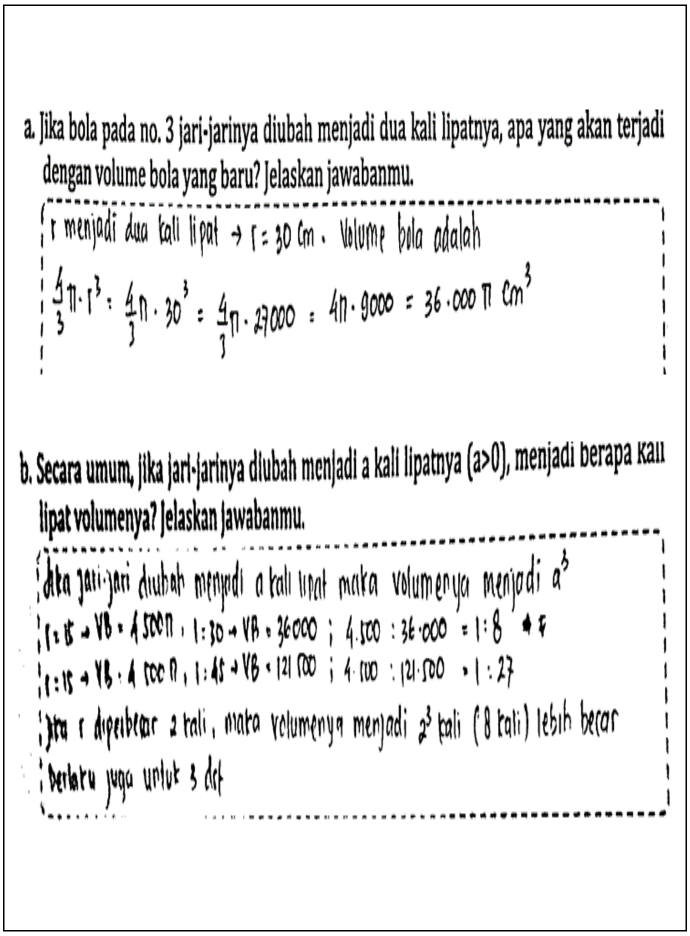
Given the radius of the ball is 15 cm. Calculate the volume of the ball.

Solution

Volume of the sphere = $\frac{4}{3}\pi r^3 = \frac{4}{3}\pi 15^3 = \frac{4}{3}\pi . 3375 = 4\pi . 1125 = 4500\pi\ cm^3$

Figure 12. Students' Responses in Solving the Problem Related to the Volume of the Sphere

Based on Figure 12, students were able to solve the sphere volume problem given that is if given radius is 15 cm, they could find the volume of the sphere is 4500 πcm^3. Then, the students solved problems related to the volume of the sphere in the case changing of the radius length (See Figure 13).


a. Jika bola pada no. 3 jari-jarinya diubah menjadi dua kali lipatnya, apa yang akan terjadi dengan volume bola yang baru? Jelaskan jawabanmu.

r menjadi dua kali lipat → r = 30 cm. Volume bola adalah

$\frac{4}{3}\pi \cdot r^3 = \frac{4}{3}\pi \cdot 30^3 = \frac{4}{3}\pi \cdot 27000 = 4\pi \cdot 9000 = 36.000\pi\ cm^3$

b. Secara umum, jika jari-jarinya diubah menjadi a kali lipatnya (a>0), menjadi berapa kali lipat volumenya? Jelaskan jawabanmu.

Jika jari-jari diubah menjadi a kali lipat maka volumenya menjadi a^3

r = 15 → VB = 4.500π, r = 30 → VB = 36.000 ; 4.500 : 36.000 = 1 : 8

r = 15 → VB = 4.500π, r = 45 → VB = 121.500 ; 4.500 : 121.500 = 1 : 27

Jika r diperbesar 2 kali, maka volumenya menjadi 2^3 kali (8 kali) lebih besar

berlaku juga untuk 3 dst

Translated to English:

Question

a. If the radius of the sphere in question no. 3 is doubled, what will happen to the new volume of the ball? Explain your answer.

Solution

r becomes doubled, r = 30 cm

volume of the sphere is $\frac{4}{3}\pi r^3 = \frac{4}{3}\pi 30^3 = \frac{4}{3}\pi . 27000 = 4\pi . 9000 = 36000\pi\ cm^3$

Question

b. In general, if the radius is changed to a times (a>0), how many times will the volume be? Explain your answer

Solution.

If the radius is changed to a times, the volume becomes a^3

$r = 15 \rightarrow V = 4.500\pi, r = 30 \rightarrow V = 36.000, 4.500 : 36.000 = 1 : 8$

$r = 15 \rightarrow V = 4.500\pi, r = 45 \rightarrow V = 121.500, 4.500 : 121.500 = 1 : 27$

If r is doubled, the volume becomes 2^3 times (8 times) larger.

Figure 13. Students' Responses in Generalizing from a Given Problem Related to the Volume of the Sphere

Figure 13 depicts the student's solution to the given problem. The students can find the ball volume if the radius is changed from 15 cm to doubled (30 cm) that is the ball volume will be 36000π

cm^3. In addition, students also generalized from the case by changing the radius length with the a. That is if the radius is changed to a times ($a > 0$) then the volume of the ball will be a^3. They know it from the volume formula of the sphere that is $V = \frac{4}{3}\pi r^3$. They also can give an explanation by giving some examples in changing radius cases, for example if the radius is changed into 2 times, then the volume will be 8 times larger or 2^3, if the radius is changed into 3 times, then the volume will be 27 times or 3^3 larger, and so on.

Activity 4: Solving sphere-related contextual problems

In activity 4, students were requested to resolve contextual issues involving the sphere's surface and volume area. Students have been able to solve the problem using the concept acquired in earlier lessons. Additionally, Figure 14 depicts the results of the student's responses.

Bu Ani merupakan salah satu pemilik toko oleh-oleh dan beliau berencana untuk menambah satu jenis makanan di toko oleh-olehnya yaitu kue onde-onde. Kue onde-onde yang akan dijual di toko Bu Ani ini menggunakan kemasan berbentuk balok dan setiap kemasan berisi 10 onde-onde seperti gambar di bawah ini.  Kue onde-onde tersebut berbentuk bola sempurna. Jika ukuran kemasan onde-onde tersebut adalah 17,5 *cm* × 7*cm* × 3,5 *cm*, berapakah volume satu onde-onde tersebut? Volume Balok : p x l x t = 17,5 x 7 x 3,5 = 328,75 Karena Dalam kemasan berisi 10 onde-onde maka volume 1 onde-onde adalah $\frac{328,75}{10}$ = 32,875 cm³	**Translated to English:** **Question** Mrs. Ani is one of the souvenir shop owners and she plans to add one type of food to her souvenir shop, namely onde-onde cake. The onde-onde cakes sold at Mrs. Ani's shop use block-shaped packaging; each package contains 10 onde-onde as seen in figure below. The onde-onde cake is shaped like a perfect ball. If the size of the onde-onde is 17.5 cm x 7 cm x 3.5 cm, what is the volume of one onde-onde? **Solution** Volume of cuboid = length x width x height = 17,5 x 7 x 3,5 = 328,75 Because the package contains 10 onde-onde, the volume of 1 onde-onde is $\frac{328,75}{10} = 32,875$ cm^3

Figure 14. Students' Responses in Solving the Contextual Problem of Sphere Volume

Based on Figure 14, students indeed comprehend the sphere material problem, indicating that they have understood the concept of sphere material to address the problem given appropriately. The findings were to the study's objectives. Of the six subjects, one can solve the given problem. Students with high ability categories can solve problems with shorter calculation procedures, students with medium and low ability categories can solve problems with longer calculation procedures, and through class discussion, the six subjects can understand concepts and solve problems given during the learning process.

The developed activities can aid students' knowledge of the curved side of the sphere. Students' comprehension can be improved from the informal to the formal level. Besides, a sequence of activities has been accomplished using the PMRI approach, demonstrating the PMRI characteristics (Nuraida & Putri, 2020; Putri & Zulkardi, 2018).

The first characteristic is the use of contexts for phenomenologist exploration. The Syawalan tradition in Pekalongan is the context employed as a starting point for students to connect mathematics to everyday life. This is aligned with other earlier research that concluded that incorporating everyday life contexts into mathematics instruction would make the subject more engaging and might help students increase their mathematical ability, for example mathematical concept understanding (Aisyah et al., 2021; Fahrurozi et al., 2018), problem-solving (Nursyahidah et al., 2020, 2021), Risdiyanti & Prahmana, 2020), knowledge and social attitude (Uge et al., 2019).

The second characteristic is the use of models for mathematical concept construction (Nursyahidah & Albab, 2021). Using orange fruit and circle models with the same diameter facilitates students in determining the sphere's surface area. Also, the volume of a sphere was determined using cylinders and balls of equal height and diameter, as well as three different types of seeds.

The third characteristic is the use of students' creations and contributions (Meryansumayeka et al., 2022). This aspect is exemplified by the student-centered learning strategy used in this research, which allows students to discover a sphere's surface area and volume through simple experiments that enable their own inventiveness.

The fourth characteristic is students' activity and interactivity in the learning process (Putri & Zulkardi, 2018). Interaction involving students and teachers is an integral part of the learning process. Students in the pilot experiment are ecstatic about the material and context used in the learning process, enabling effective learning and goal attainment.

The last characteristic is the intertwine of mathematics concepts, aspects, and units (connectivity) (Putri & Zulkardi, 2018). Sphere learning can only be designed with additional materials such as cylinders, cones, and circles that serve as apperception material. Students investigate previously studied content to facilitate a more meaningful learning process.

Students can enhance their notion of sphere material with the interactive video of the Syawalan tradition context, which they already know. Students can visualize the material by observing the context of the Syawalan tradition, which is packaged in video form as the starting point in this learning. This is supported by the previous research that interactive video can help students learn more enthusiastically and help them visualize the learning context joyfully (Sühendan et al., 2022; Mahadewi et al., 2020; Sari & Nursyahidah, 2022).

CONCLUSION

Learning the sphere concept utilizing the Syawalan tradition context in Pekalongan, assisted by interactive video, can support the understanding of students as a significant initial stage. The result of the hypothetical learning trajectory in this research consists of four activities, including observing an interactive video of the Syawalan tradition context to analyze the sphere element, utilizing orange fruit and a circle to find the sphere's surface area, discovering sphere's volume through the cylinder and seeds, and resolving sphere-related contextual problems. The designed activities in this study could escalate students' enthusiasm and comprehension of ninth-grade sphere material. Moreover, interactive video use has a significant role in encouraging students' understanding. In addition, the hypothetical learning trajectory of the sphere material resulting in this study can be implemented in the teaching experiment stage involving all students in the class to improve the quality of the learning process and help students understand through meaningful learning.

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