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The Analysis of Primary Students' Learning Obstacles on Plane Figures' Perimeter and Area using Onto-Semiotic Approach

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Abstract

Primary school students frequently encounter plane figures' perimeter and area. Using an onto-semiotic approach, this study examine students' learning challenges when learning the plane figures' perimeter and area. As part of the didactic design research, this study used an interpretive paradigm. The study included 25 fourth-grade students in one of elementary school in Sidoarjo, Indonesia. Data was gathered through tests, interviews, and documentation, as well as descriptive analysis techniques. The results showed that students face three types of learning obstacles, i.e. ontogenic, epistemological, and didactic. Students have difficulty describing plane figures, understanding mathematical situations in problems, and using mathematical procedures to solve problems using the onto-semiotic approach. This study examines students' reactions to learning about the plane figures' perimeter and area. Furthermore, the findings of this study serve as a starting point for educators, practitioners, and researchers in developing new didactic designs. So that grade four primary students can overcome the obstacles discovered.

Keywords: *learning obstacles, plane figures, onto-semiotic approach.*

Abstrak

Siswa sekolah dasar sering menjumpai keliling dan luas bangun datar. Dengan menggunakan pendekatan onto-semiotik, penelitian ini mengkaji hambatan belajar siswa dalam mempelajari keliling dan luas bangun datar. Sebagai bagian dari penelitian desain didaktik, penelitian ini menggunakan paradigma interpretif. Penelitian ini melibatkan 25 siswa kelas empat di salah satu sekolah dasar di Sidoarjo, Indonesia. Pengumpulan data dilakukan melalui tes, wawancara, dan dokumentasi, serta teknik analisis deskriptif. Hasil penelitian menunjukkan bahwa siswa menghadapi tiga jenis hambatan belajar, yaitu ontogenik, epistemologis, dan didaktik. Siswa mengalami kesulitan mendeskripsikan bangun datar, memahami situasi matematis dalam masalah, dan menggunakan prosedur matematis untuk

menyelesaikan masalah dengan menggunakan pendekatan onto-semiotik. Penelitian ini menguji reaksi siswa terhadap pembelajaran tentang keliling dan luas bangun datar. Selanjutnya, temuan penelitian ini menjadi titik awal bagi pendidik, praktisi, dan peneliti dalam mengembangkan desain didaktik baru. Sehingga siswa kelas empat sekolah dasar dapat mengatasi hambatan yang ditemukan.

Kata kunci: *hambatan belajar, bangun datar, pendekatan onto-semiotik.*

INTRODUCTION

Mathematics in primary school is essential to support the potential of mathematics performance at the next level (Deruaz et al., 2020). Mathematics has a structured and organized nature (Purnomo, Salsabila, Nafisa, Rahmawati, & Mawaddah, 2021). In this case, content knowledge and student prerequisites are essential to note (Glogger-Frey, Deutscher, & Renkl, 2018). However, primary school students' content knowledge and mathematical prerequisites are often problematic (Achmetli, Schukajlow, & Rakoczy, 2019). So, primary school students have difficulty in solving problems (Kusumadewi & Retnawati, 2020).

Primary school students often have difficulty learning and solving perimeter and area problems (Nur'aeni, Pranata, Hodidjah, Apriani, & Suryati, 2019; Hwang, Hoang, & Tu, 2020). It has an effect on primary school students' low learning outcomes in-plane figures' perimeter and area (Espejo, Woods, Schools, Deters, & View, 2011; Hanifaturrochmah, Sary, & Azizah, 2021). Research results by Fauzi and Arisetyawan (2020) found that the percentage of learning outcomes from 26 students who answered the perimeter of plane figures correctly was 4 students (15.3%) and 22 students (84,7%) answered incorrectly. Meanwhile, only 1 student (3.8%) answered the area of plane figures correctly and 25 students (96.2%) answered incorrectly. Students often have difficulty to solve perimeter and area problems using concepts, principles, and verbal problems (Abadi & Amir, 2022; Fauzi & Arisetyawan, 2020). Other difficulties experienced are spatial relationship disorders, visual perception abnormalities, and difficulties using symbols, language, and reading (Simbolon, Sofiyan, & Ramadhani, 2019). These difficulties can affect students' success in learning the following material, namely building space (Fauzi & Arisetyawan, 2020). These difficulties cause students to experience obstacles in processing and constructing knowledge (Jatisunda, 2019).

Obstacles are seen as bits of information gleaned from didactic situations that lead to the formation of incorrect concepts (Brousseau, 2002). Students face three types of challenges when it comes to completing the plane figures' perimeter and area: ontogenic, epistemological, and didactic (Hermawan, Nur, Abdul, Lidinillah, & Apriani, 2021; Suryati & L, 2020). Epistemology is an obstacle that comes from the limitations of students in understanding knowledge of certain concepts. It relates to restrictions when first

understanding the concept. Ontogenic is an obstacle that comes from the constraints of students during the development process. So, it is related to cognitive maturity and mental readiness. Didactic is an obstacle to the teachers' teaching (Fauzi & Suryadi, 2020; Rachma & Rosjanuardi, 2021).

Obstacles studied on the plane figures' perimeter and the area must be thoroughly examined. This study can help teachers to create appropriate didactic designs for their students. The onto-semiotic approach can assist in concentrating on what needs to be examined (Rachma & Rosjanuardi, 2021). An onto-semiotic approach considers the nature or meaning of mathematical objects and includes three aspects of mathematics: problem-solving, symbolic language, and organized logical and conceptual systems (Godino, Batanero, & Roa, 2005). The mathematical objects in this study include: (1) language (terms, notations, expressions, graphics); (2) mathematical problem situations; (3) the definition or description of a mathematical idea; (4) proposition, property, or attribute; (5) procedures (operations, algorithms, or mathematical problem-solving strategies); and (6) justifying and explaining mathematical propositions and procedures, arguments are used (Amin, Juniati, & Sulaiman, 2018; Godino, Burgos, & Gea, 2021)

The onto-semiotic approach has been used to analyze the obstacles to learning mathematics based on previous research: (1) analyze students' understanding of algebra using the onto-semiotic approach, which focuses on language components, descriptions, procedures, propositions, and arguments (Amin et al., 2018); (2) examine learning obstacles related to sequences and series, with a focus on situation components, descriptions, and procedures (Rachma & Rosjanuardi, 2021); (3) examine students' difficulties with the Pythagorean theorem, focusing on language elements, situations, descriptions, procedures, propositions, and arguments (Rudi, Suryadi, & Rosjanuardi, 2020); (4) analyze the understanding of integration focusing on language components, problems, concepts, procedures, propositions, and arguments (Borji & Font, 2019).

Thus, based on the facts of the research findings, the students' primary challenge in calculating the plane figures' perimeter and the area is the application of principles, concepts, and verbal communication. Meanwhile, the onto-semiotic approach has the characteristics of analyzing the obstacles that occur in mathematical objects that use and understand concepts and principles verbally. Furthermore, the study of learning obstacles employs an onto-semiotic approach that focuses on language, situations, and procedures, which are only available to high school students (Burgos & Godino, 2020; Godino, Font, Wilhelmi, & Lurduy, 2010). This study will analyze learning obstacles using an onto-semiotic approach to

primary school students. It needs to be done to ensure that primary school students' mathematical knowledge does not experience mathematical obstacles, so that students have good mathematical performance in the next material and at the next level (Fitriani, Mulyasari, Mufliva, & Harsa, 2019; Kenedi, Helsa, Ariani, Zainil, & Hendri, 2019). As a result, this research aims to examine the challenges that primary school students face when solving the problem of plane figures' perimeter and area using the onto-semiotic approach.

METHODS

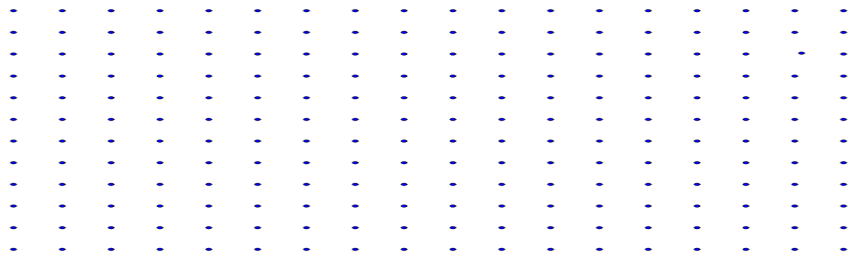
The stages of research in didactic design (DDR) consist of (1) situational analysis in didactic, which is an analysis to predict conditions that will occur to those that may occur in learning; (2) metapedadidactic analysis is an analysis during the process of implementing activities that present the relationship between three aspects, namely educators, students, and teaching materials, and (3) the results of the hypothetical didactic situation analysis are linked to the results of the metapedadidactic analysis in a retrospective analysis (Suryadi, 2011). As part of DDR, this research employs an interpretive paradigm. The interpretive paradigm is concerned with how individual and group perspectives influence the meaning of knowledge (Creswell, 2018). It refers to the outcomes of the didactic situation in this case. The interpretive paradigm is used to identify obstacles that students face when learning about the plane figures' perimeter and area. As a result, this research is the first stage of DDR. As a result, this research can be continued to develop a new didactic design based on the discovered learning obstacles.

The students in this study were fourth-graders from one of primary school in Sidoarjo, East Java, the total of 25 primary four-graders. Tasks, interviews, and documentation were used to collect the data. Students are given tasks to determine the different types of obstacles that can be found in the plane figures' perimeter and area. Three students who indicated they were having difficulty learning were chosen to be interviewed based on their responses to the task. Semi-structured interviews were conducted to learn more about the challenges that students faced. The documentation in this study was used to analyze the fourth-grade textbooks used during the teaching and learning process.

This research instrument is a modified the representation task with one item related to the perimeter and area of a plane figure (Clarke & Roche, 2018), presented in Figure 1.

Make two plane figures that have the same area relationship, but have different perimeters. Then state the relationship between the area and perimeter of the two figures mathematically.

Answer :



Identify the relationship between the area and perimeter of the two shapes that you make mathematically

Figure 1. Perimeter and Area Problems

Students' answers from the task results were analyzed using descriptive analysis techniques that refer to a language, situation, and procedure focused onto-semiotic approach. According to Amin et al (2018) and Font, Godino, & Amore (2015) based on mathematical objects in the onto-semiotic approach, indicators are made in Table 1 to analyze students' obstacles.

Table 1. Indicators of Learning Obstacles in the Plane Figures' Perimeter and Area Problem Solved Using an Onto-Semiotic Approach

Obstacles / Onto-semiotic	**Indicator**	
	Obstacle Through Onto-semiotic Approach	**Obstacle Through Onto-semiotic Approach in the Perimeter and Area**
	Epistemology	
Language	Pictures, symbols, or mathematical terms used by students are associated with the development of their knowledge	Describing two different plane figures but not having the same area relationship and different perimeters
Situation	Dealing with mathematical situations is associated with the development of their knowledge	Understanding the area and perimeter of plane figures but not relating it to the relationship between the same area and different perimeters
Procedure	Solving mathematical problems chosen by students is associated with the development of their knowledge	Performing calculations according to the formula for the area and perimeter of plane figures. But not related to the concepts in the problem
	Ontogenic	
Language	Pictures, symbols, or mathematical terms used by students are associated with students' readiness for the concepts being studied	Drawing two plane figures of the same type
Situation	Dealing with mathematical situations is associated with students' readiness for the concepts being studied	Understanding plane figures but do not understand the concept of area and perimeter of plane figures
Procedure	Problem-solving that students choose is associated with students' readiness for the concepts being studied	Performing calculations that are not by the formula for the area and perimeter of plane figures
	Didactic	
Language	Pictures, symbols, or mathematical terms used by students are related to the teachers' teaching method	Describing plane figures that tend to be common
Situation	Dealing with mathematical situations is related to the teachers' teaching method	Understanding plane figures are only limited to what is taught
Procedure	Problem-solving chosen by students is related to the teachers' teaching method	Performing calculations that do not fully comply with the formula for the area and perimeter of plane figures

RESULTS AND DISCUSSION

Based on task responses, interview results, and teaching materials documentation. Ontogenic, epistemological, and didactic challenges are all faced by students. These roadblocks are examined through an onto-semiotic lens that focuses on language, situations, and procedures.

Epistemological Obstacle

Epistemological obstacles are related to students' limitations in using their knowledge in specific contexts. Once students already know the formulas for finding plane figures' perimeter and area, epistemological obstacles in solving plane figures' perimeter and area can be identified. Students, however, are unable to apply them in specific situations. A total of ten students (40%) faced an epistemological challenge, as did student A in Figure 2.

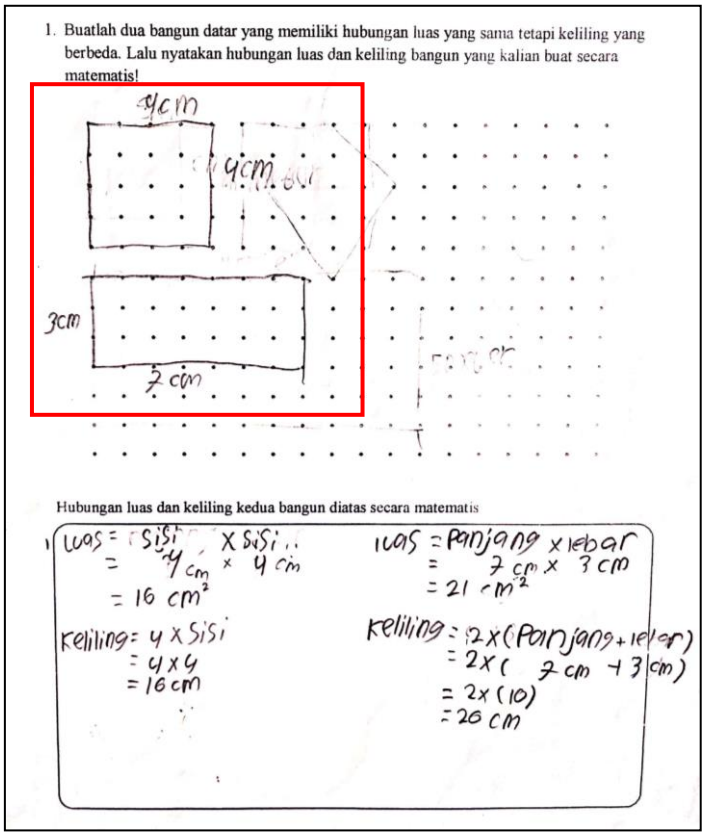


Figure 2. Student Response A

Figure 2 shows student A drawing a 4 cm x 4 cm square and a 7 cm x 3 cm rectangle. Student A believes the two plane figures share the same area relationship but have different perimeters. However, mathematically judging from the proof of the answer does not show this relationship. Based on the interviews, students did not understand the existing problems; they had to describe two plane figures with the same area but different perimeters, so from Figure 2, we get plane figures with an area of 16 cm^2 and 21 cm^2. It demonstrates that primary school

students struggle with geometry problems (Hock, Tarmizi, Aida, & Ayub, 2015; Hwang et al., 2019; Nurkaeti, 2018; Sholihah & Afriansyah, 2018).

Usually, students get questions in the form of plane figures with a specific size to directly determine the perimeter and area. So that when they encounter questions that require drawing plane figures with particular provisions, students have difficulty. This inability is caused by the limited context when students first learn the concept of plane figures' perimeter and area. It means that the mathematics learning obtained by students is not indicated, so students' understanding of mathematical concepts is still weak (Morsanyi, van Bers, McCormack, & McGourty, 2018; Soviawati, 2011). Students should be taught to build their understanding independently through a series of activities that can support them in making their developed models and understanding the plane figures' perimeter and area (Tzoumpa, Karvounidis, & Douligeris, 2020; Winarti, Amin, Lukito, & Gallen, 2012). With this model, students can use it to solve problems in different contexts. According to the onto-semiotic approach, students with language difficulties have difficulty in describing two plane figures with the same area but different perimeters. Students also do not understand the mathematical situation and do not perform the correct procedure in solving problems.

Ontogenic Obstacle

The ontogenic obstacle is related to students' mental readiness for learning. When students do not fully understand the perimeter and area formulas, ontogenic obstacles in solving plane figures' perimeter and area can be identified. A total of 15 students (60%) experienced ontogenic obstacles, as did student B in Figure 3.

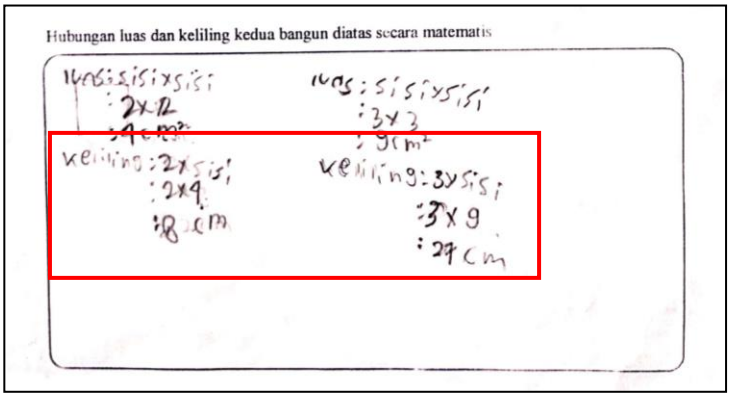


Figure 3. Student Response B

In Figure 3, it can be seen that student B wrote a different perimeter formula. In the first plane figures, student B writes the formula for the perimeter is 2 x sides, and then the perimeter formula for the second shape is 3 x sides. Based on the interview results, student B made a mistake by replacing the number four in the formula for the perimeter of the square with the side length of the square that the perimeter would be looking for. In essence, the

number four is absolute. It comes from the nature of a square having sides of equal length and opposite sides parallel so that the formula for the perimeter of a square can be written as K = 4 x sides (Suryaningtyas, 2019). Errors in writing formulas are often experienced by students (Leong, Cheng, Toh, Kaur, & Toh, 2019). In addition, students also have difficulty in determining mathematical formulas and concepts that are applied to a problem (Hwang et al., 2019; Nurkaeti, 2018). Another mistake of student B is when student B interprets the side in the formula for the perimeter of a square he wrote as the result of its area. This error can be motivated by the inability of students to remember a sufficient condition for an object which is expressed in terms that represent the concept of the perimeter of a square (Fauzi & Arisetyawan, 2020; Peng & Lin, 2019). Students have been unable to solve mathematical procedures correctly by using the onto-semiotic approach. They could not draw plane figures with the same relationship area and different perimeters as did student C in Figure 4.

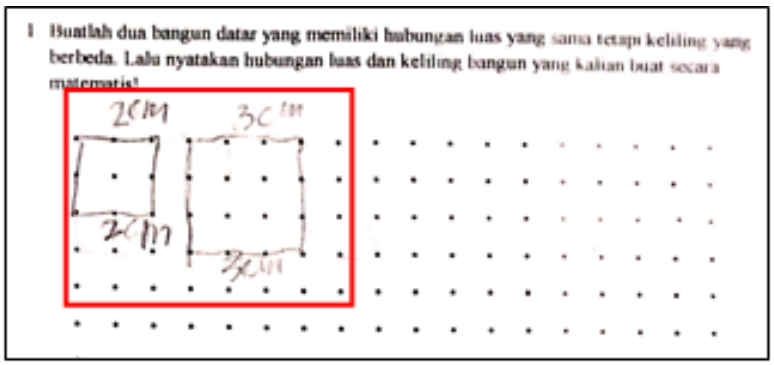


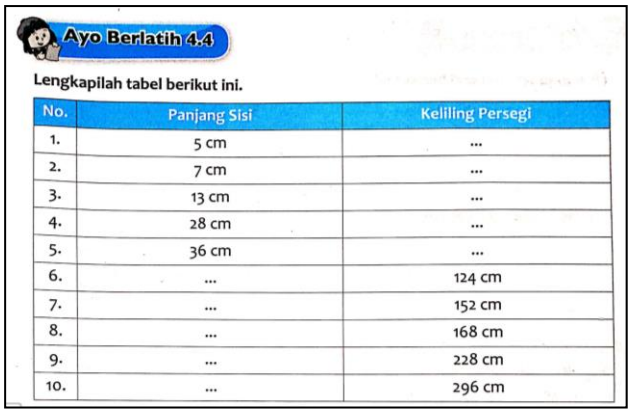
Figure 4. Student Response C

Based on the interview results, student C chose to draw a square because, according to him, the easy plane figure is a square. Suppose it is adjusted to the problem in the problem that asks students to draw two plane figures with the same relationship area but different perimeters. In that case, students will not find this relationship in the exact two plane figures because the area of a square is the number of unit squares covering the entire square area (Suryaningtyas, 2019). So, if two squares are of different sizes, different numbers of unit squares are needed to cover the whole square area exactly. Students struggle to describe two plane figures that have the same area but distinct perimeters using the onto-semiotic approach. Students also do not perform mathematical procedures correctly to solve problems.

Didactic Obstacle

The didactic obstacle can be caused by the teachers' teaching methods and strategies. In addition, the presentation of the material used by students is also a trigger for the emergence of didactic obstacles. By examining the errors made by students, didactic obstacles that appear to be related to the plane's perimeter and area can be identified. Most of the students made

two plane figures without paying attention to the relationship between the area and perimeter of the two plane figures. This is since students have never encountered the issue. Based on an examination of the textbooks utilized, it was found that the practice questions given were more symbolic. Students were directly presented formally and there were no activities, it is depicted in Figure 5.



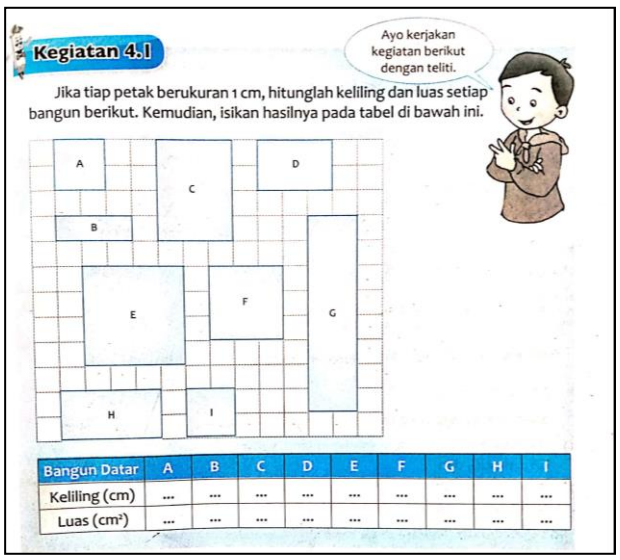
Ayo Berlatih 4.4

Lengkapilah tabel berikut ini.

No.	Panjang Sisi	Keliling Persegi
1.	5 cm	...
2.	7 cm	...
3.	13 cm	...
4.	28 cm	...
5.	36 cm	...
6.	...	124 cm
7.	...	152 cm
8.	...	168 cm
9.	...	228 cm
10.	...	296 cm

Figure 5. Forms of Questions in Textbooks

Another error is visible in the students' responses when they are asked to state the relationship between the perimeter and area of the two figures they draw. Most students continue to write the formula for the perimeter and area of a plane figure incorrectly. One of the students who made this error is Student B. Student B made a mistake in remembering the formula for the perimeter of a square. This error comes from the teachers' teaching method, which directly shows the perimeter and area formulas without involving student activities during the educational process. Based on the analysis of the textbooks used, it was found that in the textbooks, there were no activities that could build students' knowledge in understanding the plane figures' perimeter and area, which is depicted in Figure 6.



Kegiatan 4.1

Ayo kerjakan kegiatan berikut dengan teliti.

Jika tiap petak berukuran 1 cm, hitunglah keliling dan luas setiap bangun berikut. Kemudian, isikan hasilnya pada tabel di bawah ini.

Bangun Datar	A	B	C	D	E	F	G	H	I
Keliling (cm)	...	...	...	...	...	...	...	...	...
Luas (cm^2)	...	...	...	...	...	...	...	...	...

Figure 6. Student Activities in Textbooks

The activity of asking questions directly without the completion procedure does not form an active learning environment. Students become passive because they only imitate the examples provided (Fauzi & Suryadi, 2020). The teacher plays a critical role in establishing a didactic conducive environment to learning. As a result, when creating a didactic situation, a teacher needs to think about predicting student responses to didactic situations and their anticipation of creating a new didactic design. The suspense is related to the student-material relationship and the teacher-student relationship, as illustrated in Figure 7.

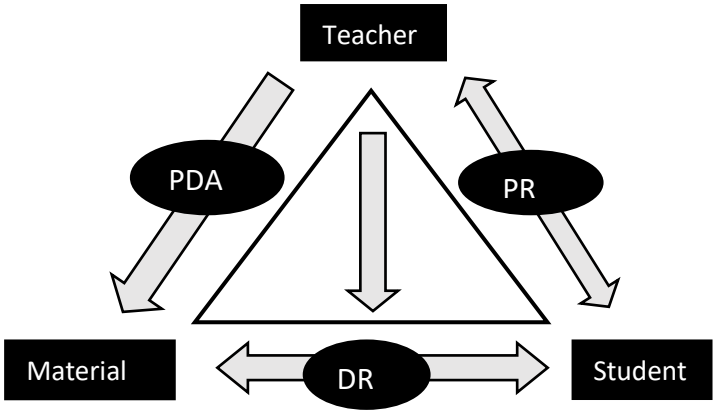


Figure 7. Modified Didactic Triangle (Suryadi, 2011)

Note:
PR : Pedagogical Relations
DR : Didactic Relationship
PDA : Pedagogical Didactic Anticipation

As illustrated in Figure 7, the teacher is critical in establishing a didactic situation within the didactic triangle for students to learn. A fundamental aspect of learning is the relationship between teachers and students, as well as students and the material. The teacher-student relationship in the didactic triangle is described as homework. Meanwhile, the student-material relationship is characterized by DR, and the teacher-material relationship is described as PDA. This anticipation helps the teacher in designing new didactic situations. So, in addition to being able to master the material, teachers also need to have other knowledge related to students (Bakar, 2018). In this case, the teacher must create a didactic relationship between students and the material to create an ideal didactic situation for students.

Active student involvement is essential in understanding the material being studied. This involvement can be physical or mental (Bergmark & Westman, 2018; Suryadi, 2011). The forms of activity include student activities in building their knowledge independently and the use of teaching aids around students. Students actively involved in learning enable students to gain learning achievement (Chen, Hwang, & Chang, 2019; Fung, Tan, & Chen,

2018). Thus students will get a meaningful learning experience. The knowledge gained is more embedded in students' memories (Stender, Schwichow, Zimmerman, & Härtig, 2018).

CONCLUSION

Based on the analysis of students' responses and interviews, it can be concluded that students face three distinct types of obstacles: epistemological, ontogenic, and didactic. Students encounter epistemological obstacles when they are unable to apply their knowledge in specific contexts, specifically when they are unable to describe two plane figures with the same area relationship but distinct perimeters. Additionally, students face ontogenic obstacles because they lack an understanding of the fundamental concepts of plane figures' perimeter and area. It results in students failing to comprehend the mathematical situation presented in the problem and in students failing to follow the proper procedure for solving the problem. Additionally, the teachers' learning process contributes to students encountering didactic obstacles.

REFERENCES

Abadi, M. A. S., & Amir, M. F. (2022). Analysis of the elementary school students difficulties of in solving perimeter and area problems. *Jurnal Ilmiah Pendidikan Matematika*, *10*(2), 396–408. https://doi.org/10.25273/jipm.v10i2.11053

Achmetli, K., Schukajlow, S., & Rakoczy, K. (2019). Multiple solutions for real-world problems, experience of competence and students' procedural and conceptual knowledge. *International Journal of Science and Mathematics Education*, *17*(8), 1605–1625. https://doi.org/10.1007/s10763-018-9936-5

Amin, M. E. I. A., Juniati, D., & Sulaiman, R. (2018). Onto semiotic approach to analyze students' understanding of algebra based on math ability. *AIP Conference Proceedings*. United States: American Institute of Physics. https://doi.org/10.1063/1.5054481

Bakar, R. (2018). The influence of professional teachers on Padang vocational school students' achievement. *Kasetsart Journal of Social Sciences*, *39*(1), 67–72. https://doi.org/10.1016/J.KJSS.2017.12.017

Bergmark, U., & Westman, S. (2018). Student participation within teacher education: emphasising democratic values, engagement and learning for a future profession. *Higher Education Research and Development*, *37*(7), 1–14. https://doi.org/10.1080/07294360.2018.1484708

Borji, V., & Font, V. (2019). Exploring students' understanding of integration by parts: A combined use of APOS and OSA. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(7), 1–13. https://doi.org/10.29333/EJMSTE/106166

Brousseau, G. (2002). *Theory of Didactical Situation in Mathematics*. USA: Kluwer Academic Publishers.

Burgos, M., & Godino, J. D. (2020). Prospective primary school teachers' competence for analysing the difficulties in solving proportionality problem. *Mathematics Education*

Research Journal 2020. https://doi.org/10.1007/S13394-020-00344-9

Chen, M. R. A., Hwang, G. J., & Chang, Y. Y. (2019). A reflective thinking-promoting approach to enhancing graduate students' flipped learning engagement, participation behaviors, reflective thinking and project learning outcomes. *British Journal of Educational Technology*, *50*(5), 2288–2307. https://doi.org/10.1111/BJET.12823

Clarke, D., & Roche, A. (2018). Using contextualized tasks to engage students in meaningful and worthwhile mathematics learning. *Journal of Mathematical Behavior*, *51*(November 2016), 95–108. https://doi.org/10.1016/j.jmathb.2017.11.006

Creswell, J. W. (2018). *Penelitian Kualitatif & Desain Riset : Memilih Diantara Lima Pendekatan* (Ketiga). Yogyakarta: Pustaka Pelajar.

Deruaz, M., Dias, T., Gardes, M. L., Gregorio, F., Ouvrier-Buffet, C., Peteers, F., & Robotti, E. (2020). Exploring MLD in mathematics education: Ten years of research. *Journal of Mathematical Behavior*, *60*, 1–17. https://doi.org/10.1016/j.jmathb.2020.100807

Espejo, T., Woods, W., Schools, C., Deters, A., & View, V. (2011). Area or Perimeter : Using Representations for the Real World. *Ohio Journal of School Mathematics*, 11–16.

Fauzi, I., & Arisetyawan, A. (2020). Analisis kesulitan belajar siswa pada materi geometri di sekolah dasar. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *11*(1), 27–35. https://doi.org/10.15294/kreano.v11i1.20726

Fauzi, I., & Suryadi, D. (2020). The analysis of students' learning obstacles on the fraction addition material for five graders of elementary schools. *Al Ibtida: Jurnal Pendidikan Guru MI*, *7*(1), 33. https://doi.org/10.24235/al.ibtida.snj.v7i1.6020

Fitriani, A. D., Mulyasari, E., Mufliva, R., & Harsa, W. (2019). Implementation of mathematical knowledge for teaching (MKT) in the learning of mathematics in elementary school. *Proceedings of the 2nd International Conference on Educational Sciences*. Bandung, Indonesia: Atlantis Press. Retrieved from https://www.atlantis-press.com/proceedings/ices-18/125912380

Font, V., Godino, J. D., & Amore, B. D. (2015). Onto-Semiotic Representations in Mathematics Education. *FLM Publishing Association*, *27*(2), 2–7. Retrieved from http://www.jstor.org/stable/40248564

Fung, F., Tan, C. Y., & Chen, G. (2018). Student engagement and mathematics achievement: Unraveling main and interactive effects. *Psychology in the Schools*, *55*(7), 815–831. https://doi.org/10.1002/pits.22139

Glogger-Frey, I., Deutscher, M., & Renkl, A. (2018). Student teachers' prior knowledge as prerequisite to learn how to assess pupils' learning strategies. *Teaching and Teacher Education*, *30*, 1–15. https://doi.org/10.1016/j.tate.2018.01.012

Godino, J. D., Batanero, C., & Roa, R. (2005). An onto-semiotic analysis of combinatorial problems and the solving processes by university students. *Educational Studies in Mathematics*, *60*(1), 3–36. https://doi.org/10.1007/s10649-005-5893-3

Godino, J. D., Burgos, M., & Gea, M. M. (2021). Analysing theories of meaning in mathematics education from the onto-semiotic approach. *International Journal of Mathematical Education in Science and Technology*, 1–28. https://doi.org/10.1080/0020739X.2021.1896042

Godino, J. D., Font, V., Wilhelmi, M. R., & Lurduy, O. (2010). Why is the learning of elementary arithmetic concepts difficult? Semiotic tools for understanding the nature of mathematical objects. *Educational Studies in Mathematics*, *77*(2), 247–265.

https://doi.org/10.1007/S10649-010-9278-X

Hanifaturrochmah, Sary, R. M., & Azizah, M. (2021). Kesalahan Siswa Dalam Mengerjakan Soal Materi Bangun Datar Berdasarkan Teori Nolting Pada Siswa Kelas IV SD. *Elementary School*, *8*(2), 310–321. https://doi.org/10.31316/esjurnal.v8i2.1404

Hermawan, R. P., Nur, E., Abdul, D., Lidinillah, M., & Apriani, I. F. (2021). Desain didaktis keliling persegi berbasis permainan tradisional engklek di sekolah dasar. *Pedadidaktika: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar : Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, *8*(4), 1057–1065. Retrieved from https://ejournal.upi.edu/index.php/pedadidaktika/article/view/41903/17712

Hock, T. T., Tarmizi, R. A., Aida, A. S., & Ayub, A. F. (2015). Understanding the primary school students' van hiele levels of geometry thinking in learning shapes and spaces: A q-methodology. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(4), 793–802. https://doi.org/10.12973/EURASIA.2015.1439A

Hwang, W. Y., Hoang, A., & Tu, Y. H. (2019). Exploring authentic contexts with ubiquitous geometry to facilitate elementary school students' geometry learning. *Asia-Pacific Education Researcher*, *29*(3), 269–283. https://doi.org/10.1007/s40299-019-00476-y

Jatisunda, M. G. (2019). Kesulitan siswa dalam memahami konsep trigonometri dilihat dari learning obstacles. *Didactical Mathematics*, *2*(1), 9. https://doi.org/10.31949/dmj.v2i1.1664

Kenedi, A. K., Helsa, Y., Ariani, Y., Zainil, M., & Hendri, S. (2019). Mathematical connection of elementary school students to solve mathematical problems. *Journal on Mathematics Education*, *10*(1), 69–80. https://doi.org/10.22342/jme.10.1.5416.69-80

Kusumadewi, C. A., & Retnawati, H. (2020). Identification of elementary school students' difficulties in mathematical problem-solving. *Journal of Physics: Conference Series*, *1511*(1). https://doi.org/10.1088/1742-6596/1511/1/012031

Leong, Y. H., Cheng, L. P., Toh, W. Y. K., Kaur, B., & Toh, T. L. (2019). Teaching students to apply formula using instructional materials: a case of a Singapore teacher's practice. *Mathematics Education Research Journal*. https://doi.org/10.1007/S13394-019-00290-1

Morsanyi, K., van Bers, B. M. C. W., McCormack, T., & McGourty, J. (2018). The prevalence of specific learning disorder in mathematics and comorbidity with other developmental disorders in primary school-age children. *British Journal of Psychology*, *109*(4), 917–940. https://doi.org/10.1111/BJOP.12322

Nur'aeni, L. E., Pranata, O. H., Hodidjah, H., Apriani, I. F., & Suryati, C. (2019). Didactic design of circumference and area of square based on Indonesia traditional game in elementary school. *Journal of Physics: Conference Series*, *1318*(1). https://doi.org/10.1088/1742-6596/1318/1/012020

Nurkaeti, N. (2018). Polya's strategy: An analysis of mathematical problem solving difficulty in 5Th grade elementary school. *EduHumaniora: Jurnal Pendidikan Dasar*, *10*(2), 140–147. https://doi.org/10.17509/eh.v10i2.10868

Peng, P., & Lin, X. (2019). The relation between mathematics vocabulary and mathematics performance among fourth graders. *Learning and Individual Differences*, *69*, 11–21. https://doi.org/10.1016/J.LINDIF.2018.11.006

Purnomo, Y. W., Salsabila, J. L., Nafisa, A., Rahmawati, R. D., & Mawaddah, F. (2021). Pembelajaran matematika secara daring membosankan bagi siswa sekolah dasar: Studi self-report siswa. *Aksioma: Jurnal Program Studi Pendidikan Matematika*, *10*(3),

1351–1359. https://doi.org/10.24127/ajpm.v10i3.3533

Rachma, A. A., & Rosjanuardi, R. (2021). Students' obstacles in learning sequence and series using onto-semiotic approach. *Jurnal Pendidikan Matematika*, *15*(2), 115–132. https://doi.org/10.22342/jpm.15.2.13519.115-132

Rudi, R., Suryadi, D., & Rosjanuardi, R. (2020). Identifying students' difficulties in understanding and applying pythagorean theorem with an onto-semiotic approach. *MaPan*, *8*(1), 1–18. https://doi.org/10.24252/mapan.2020v8n1a1

Sholihah, S. Z., & Afriansyah, E. A. (2018). Analisis kesulitan siswa dalam proses pemecahan masalah geometri berdasarkan tahapan berpikir van hiele. *Mosharafa: Jurnal Pendidikan Matematika*, *6*(2), 287–298. https://doi.org/10.31980/mosharafa.v6i2.317

Simbolon, H., Sofiyan, & Ramadhani, D. (2019). Analisis kesulitan belajar matematika materi bangun datar SD Negeri 7 Langsa. *Journal of Basic Education Studies*, *2*(1), 100–111. Retrieved from https://ejurnalunsam.id/index.php/jbes/article/view/1594

Soviawati, E. (2011). Pendekatan Matematika Realistik (PMR) untuk Meningkatkan Kemampuan Berfikir Siswa di Tingkat Sekolah Dasar. *Jurnal Edisi Khusus*, 79–85. Retrieved from http://jurnal.upi.edu/md/view/670/pendekatan-matematika-realistik-(pmr)-untuk-meningkatkan-kemampuan-berfikir-siswa-di-tingkat-sekolah-dasar.html

Stender, A., Schwichow, M., Zimmerman, C., & Härtig, H. (2018). Making inquiry-based science learning visible: the influence of CVS and cognitive skills on content knowledge learning in guided inquiry. *International Journal of Science Education*, *40*(15), 1–20. https://doi.org/10.1080/09500693.2018.1504346

Suryadi, D. (2011). Didactical design research (DDR) dalam pengembangan pembelajaran matematika. *Conference UPI-UiTM*. Bandung, Indonesia. Retrieved from http://a-research.upi.edu/operator/upload/pros_ui-uitm_2011_didi_didactical_design_research.pdf

Suryaningtyas, T. H. (2019). *Diagnosis kesulitan belajar materi keliling dan luas segiempat di kalangan siswa asrama kelas VII SMP Stela Duce 2 tahun pelajaran 2018/2019* (Universitas Sanata Dharma). Universitas Sanata Dharma. Retrieved from https://repository.usd.ac.id/36075/2/151414064_full.pdf

Suryati, A. Y., & L, E. N. (2020). Desain Didaktis Konsep Keliling Lingkaran Berbasis Model Pembelajaran SPADE. *Pedadidaktika: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, *7*(2), 66–76. Retrieved from https://ejournal.upi.edu/index.php/pedadidaktika/article/view/25795

Tzoumpa, D., Karvounidis, T., & Douligeris, C. (2020). Circle's ontology extended: circumference and surface area of a circle. *Advances in Intelligent Systems and Computing*, *916*, 120–132. https://doi.org/10.1007/978-3-030-11932-4_12

Winarti, D. W., Amin, S. M., Lukito, A., & Gallen, F. Van. (2012). Learning the concept of area and perimeter by exploring their relation. *Journal on Mathematics Education*, *3*(1), 41–54. https://doi.org/10.22342/jme.3.1.616.41-54