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Difficulty and Mastery of Physics Concepts for Middle School Students in Density Material

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Abstract: *The purpose of this research is exploring the student's density conception as early as possible so that when heading to essential topics that involve density in physics (like statics and dynamics fluid), students can easily understand these essential topics. In general, students' concept understanding of density is already relatively high with 63,5%. There are differences between the conceptual understanding of male and female students, which the conceptual understanding of density in female students was better than male students. The notable difference between them is the understanding of the concepts relating mass, volume, and density. Some students also shown that they had not been able to understand the basic conception of the density and properties of matter. For further research, it is better to provide a short interview session and give students the opportunity to describe mental models of the properties of substances that students have understood.*

Keywords: *Conceptual understanding, density, mass, volume*

Kesulitan dan Penguasaan Konsep Fisika Siswa SMP pada Materi Massa Jenis

Abstrak: Tujuan dari penelitian ini adalah untuk mengeksplorasi konsepsi massa jenis siswa sedini mungkin sehingga ketika memasuki topik-topik penting yang melibatkan massa jenis dalam fisika (seperti fluida statis dan dinamis), siswa dapat dengan mudah memahami topik-topik penting tersebut. Secara umum, pemahaman konsep siswa tentang massa jenis sudah relatif tinggi yaitu 63,5%. Terdapat perbedaan antara pemahaman konsep antara siswa laki-laki dan perempuan, dimana pemahaman konsep massa jenis pada siswa perempuan lebih baik daripada siswa laki-laki. Perbedaan yang mencolok di antara keduanya adalah pemahaman konsep yang berhubungan dengan massa, volume, dan massa jenis. Beberapa siswa juga menunjukkan bahwa mereka belum dapat memahami konsepsi dasar massa jenis dan sifat-sifat materi. Untuk penelitian selanjutnya, ada baiknya memberikan sesi wawancara singkat dan memberikan kesempatan kepada siswa untuk menggambarkan model mental dari sifat-sifat zat yang telah dipahami siswa.

Kata kunci: Massa, massa jenis, penguasaan konsep, volume

PENDAHULUAN

The Density concept is the basic and the first thing we must learn on natural science, especially in fluid. In Indonesia, density has been learned in Middle School. In middle school, density is introduced in the sub-topic of quantities and units, where density is one of the derived quantities. Conceptual understanding in density is one of the most important aspects for student achievement competence in natural science course. Students with good performance in conceptual understanding are indicated by how they explain the concept clearly and correctly with their own word (Ida Kholida & Sunarti,

2021). The research conducted by Yudhittiara, Hindarto, & Mosik (2017) in Kudus shows that there are some students still wrong on density understanding. They have the conception that density is equal to pressure. This is shown in the student's answers on mass per unit volume is the definition of pressure. In addition, the research conducted by Nakġboğlu (2016) shows that university chemistry student who have had the problem about concept of mass which is a pre-requisite concept for density. From the two studies, Density material must be emphasized since the first topic in learning physics, such as topic of quantity and unit. However, there is still limited research that has explored student's conceptual understanding especially in density and comparison based on gender.

The wrong concept of density will certainly result in misconceptions on other essential physics topics. As in research conducted by Rosdiana, Sutopo, & Kusairi (2019), there are students who are unable to figure out the value of the object's density because they do not use appropriate physics concepts so that students experience difficulties with static fluid material. The teacher needs to explore students' conceptual understanding of density so that they can see students understanding or explaining a concept with sentences or their own thoughts (Sulastri, Hikmawati, & Gunada, 2018). Therefore, it is necessary to explore the student's conceptual understanding of density as early as possible so that when heading to essential topics that involve density (such as static fluids), students can easily understand these essential topics. It is also strengthened by Nakġboğlu (2016) that before teaching density, students' prerequisite knowledge of concepts such as mass and volume are also checked and corrected. Therefore, the research we conducted to find students' difficulties in the concept of density can help teachers to find the proper density learning.

METHOD

This research used descriptive analysis in student's conceptual understanding of density. The research was conducted at boarding school, Malang Regency with 81 middle school students in seventh grade in two classes. There are ten questions for the exploration student's concept understanding of density that adapted from density survey (DS). From each concept in the density survey, it's categorized into four main concepts, such as 1) the relationship between volume and density, 2) determining density, 3) comparing density, and 4) the relationship between mass and density. According to the results of data collection from both classes, general descriptive data were obtained such as reliability, difficulty, item discrimination index, and biserial correlation as on Table 1.

Table 1. Descriptive Data of Reliability, Difficulties Level, Item Discrimination Index, and Point-Biserial Correlation

KR-20 = -0,22				
Concept	**Item**	**Difficulty**	**Item Discrimination Index**	**Point-Biserial Correlation**
The relationship between volume and density	1	0,95	0,10	0,237
	8	0,51	0,23	0,338
Determining density	10	0,91	0,10	0,277
Comparing density	2	0,65	0,37	0,373
	4	0,51	0,23	0,3
	5	0,53	0,13	0,163
	6	0,54	0,0	0,133
	9	0,75	0,21	0,284
The relationship between mass and density	3	0,60	0,38	0,409
	7	0,63	0,37	0,411

Because of boarding school has a system where male and female student's classes are separated. Male and female students do their activity in different building so that there is no interaction between male and female students. Because their answers were not normal distribution, we analyzed using the Mann Whitney test (Aslam & Sattam Aldosari, 2020) to look at the different between male and female concept acquisition. Then, we use Fisher Exact Test (Bind & Rubin, 2020) to find the different in every item between male and female.

RESULT AND DISCUSSION

As mentioned earlier, male and female students have separate classes, so there is no interaction between the two classes. Table 2 describes the results of the general descriptive analysis of the two classes.

Table 2. Descriptive Analysis Data in Two Classes

Description	Male Class	Female Class
Total	39	42
Mean	5,9	7,2
Sd	1,2	1,1
Min	3	5
Max	8	9
Range Score	0-10	0-10

From table 2, we can see that the average score of female students is higher than male students. Table 3 shows in more detail how the percentage of understanding of male students and female students in each concept and item of density.

Table 3. The Results of the Percentage of Concept Mastery of Each Item and Each Concept from Each Gender

Concept	Item	Percentage of Each Item (M+F)	Percentage of Each Concept (M+F)	Percentage of Each Item (M)	Percentage of Each Concept (M)	Percentage of Each Item (F)	Percentage of Each Concept (F)
The relationship between volume and density	1	95,06%	72,84%	94,87%	66,67%	95,24%	78,57%
	8	50,62%		38,46%		61,90%	
Determining density	10	91,36%	91,36%	89,74%	89,74%	92,86%	92,86%
Comparing density	2	65,43%	59,75%	58,97%	54,36%	71,43%	64,76%
	4	50,62%		43,59%		57,14%	
	5	53,09%		46,15%		59,53%	
	6	54,32%		48,72%		59,52%	
	9	75,31%		74,36%		76,19%	
The relationship between mass and density	3	60,49%	61,73%	46,15%	50%	73,81%	72,62%
	7	62,96%		53,85%		71,43%	

From table 3, we can see that the percentage in understanding of each concept and item of female students is always higher than that of male students. To prove the difference between the two classes, we used mann-whitney statistical data analysis which is presented in Table 4.

Table 4. Mann Whitney Tested Student's Concept Understanding of Density

Concept	Gender	N	Mean	P
All	Male	39	29.73	.000
	Female	42	51.46	
The relationship between volume and density	Male	39	1.33	.033
	Female	42	1.57	
Determining density	Male	39	0.90	.706
	Female	42	0.93	
Comparing density	Male	39	2.72	.009
	Female	42	3.24	
The relationship between mass and density	Male	39	1.00	.004
	Female	42	1.45	

Based on Table 4, there are differences on student's concept understanding of density between male and female. In terms of overall concept density, the T-test results show that there is a difference between the male and female classes. Then, we explore each concept as we have explained in the percentage of concept mastery. The first concept is the relationship between volume and density, the results of the Mann-Whitney t-test show that there is a difference between the male and female classes. The second concept is determining density, the results of the difference test using the fisher exact test, because there is only one item, show that there is no difference between the two classes. The third concept is comparing density, the results of the Mann-Whitney test show that there is a difference between the two classes. The fourth concept is the relationship between mass and density, the results of the difference test which also uses Mann-Whitney show that there is a difference between male and female classes. Other research, such as the research of Fitriani, Asy'ari, Zubaidah, & Mahanal (2019) also shows that it is natural for any differences in abilities between women and men and shows that women's abilities are better than men. Three of four concept, there were a difference between male and female classes. To further investigate, fisher exact test was used to see the difference between male and female classes in each question.

Table 5 shows some of the questions that have notable differences in average. We found that there were two items in numbers 3 and 8 that showed that there was a difference between the male and female classes, while the other items showed no difference between the two classes.

Table 5. Fisher Exact Test

Number of Question	Gender	Mean	Right Answer	Wrong Answer	P
3	Male	.4615	18	21	0.13
	Female	.7381	31	11	
8	Male	.3846	15	24	0.46
	Female	.6190	26	16	

Item test number 3 is a question that measures students' concepts in the concept of analyzing the relationship between mass and density. Students are presented with objects that have three different sizes with the same type of material. This same material means that the density of the three objects is the same.

Table 6. The Question and Answer Number 3

A straight, uniform board is cut into three differently sized pieces. Each Piece has identical width and thickness.  	Which piece has the greatest mass? a. Piece A b. Piece B c. Piece C d. They are all the same

It was interesting to find that most male students answered incorrectly. 46% of male students answered D, which three objects had the same mass. The student's thinking about that is influenced by question 2, because the density is the same. But same density with different volumes, of course the masses are different too.

Table 7. The Question and Answer Number 7 and 8

When a ballon was taken outside on a very cold day it was observed to shrink. No air escaped from the ballon.	7. The mass of the air in the ballon after it had shrunk, was a. Greater than before it shrank b. Less than before it shrank c. The same as before it shrank d. It is impossible to tell from the information given
	8. The volume of the air in the ballon after it had shrunk, was e. Greater than before it shrank f. Less than before it shrank g. The same as before it shrank h. It is impossible to tell from the information given

Item 8 has the same phenomenon as item 7 but different questions. The question about the volume of air in the balloon when it is inflated. In number 7, 33% of male students answered that the mass of the balloon was larger than before shrinking. Students who answer this think that the closer together the gas particles are, the gas "compacts" and makes it heavier. Even though the gas in the balloon phenomenon when it shrinks is still in gaseous form there are no new particles added, so the mass is the same. There were oddities in the answers of male and female students. Most of the female students answered correctly, but most of the male students answered incorrectly. Most male students answered that the volume of air inside the block after shrinking was greater than before shrinking. This thought may have been influenced by question number 7 which answered incorrectly, and some others did not understand how events decreased. They thought that mass and volume have same ideas.

The overall mean obtained by the female class is higher than the male class. The t-test results showed a difference between males and females. This was also found by Jia, Yang, Qian, & Wu (2020) dan Dew, Perry, Ford, Bassichis, & Erukhimova (2021). But many previous studies have shown results that suggest there is no difference between male and female (Fawaiz, Handayanto, & Wahyudi, 2020; Whitcomb & Singh, 2020) with the condition that in one class there are males and females. This is different from the researcher's findings which require separate male and female classes. Therefore, the researcher gave a brief interview to one of the observer teachers from the school. The

teacher said that the female class got higher scores because the class conditions were more conducive and followed the teacher's directions well. In contrast, the male class tends to be less conducive and less disciplined, making it difficult for learning to take place. The learning process is indeed a complex thing (Kuo, Hull, Elby, & Gupta, 2020). There are many things that must be done to monitor students, one of which is to be given formative assessments so that appropriate interventions can be obtained as soon as possible.

Density material is closely related to fluid material. As a result of the pandemic, students' learning independence has decreased (Etika Rahmawati et al., 2021; Maghfirin, Kurniati, & Kusumawati, 2021; Sulistyowati & Amri, 2021) teachers should first provide formative assessments specifically on density material before fluid material in order to get maximum learning results (Azizah, Parno, & Supriana, 2020). In addition, providing formative assessment for density can also be a signpost for (Kusairi, 2013; Wiliam & Thompson, 2019) so that students realize that the basic skills they have are still not enough to learn fluid material. Providing formative assessments at each break in the material also helps students build their thinking skills and concept understanding (Ediyanto, 2015; Ilyas Ismail, 2012; Saptono, Rustaman, & Widodo, 2013; Sari, Mustikasari, & Pratiwi, 2019). But, for further research if you want to find mental or cognition clearly, we recommend to use mix method with exploration model.

CONCLUSION AND SUGGESTION

In general, student's conceptual understanding of density is already relatively high with 63,5%. With different gender groups and apart from each other, it proves that there are differences between the conceptual understanding of male and female students. It was also found that the concept understanding of density in female students was better than male students. There are several questions that students are less able to understand about the given phenomenon. Some students also shown that they had not been able to understand the basic conception of the density and properties of matter. For further research, it is better to provide a short interview session and give students the opportunity to describe mental models of the properties of substances that students have understood. Conception of density and properties of matter in junior high school students still requires further exploration of students' mental models.

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