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Conceptual Understanding and Difficulties of High School Students in Urban and Rural Areas: Case of Archimedes' Principles

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Abstract. This study aims to determine the differences of students' conceptual understanding about Archimedes' principle in. This study conducted with descriptive quantitative method involving 60 students. The instrument consists of open ended questions (r = 0.664). The results of Mann U Whitney test shows that there is significant differences of students' conceptual understanding between urban and rural area. The mean rank indicates that students in the urban have a higher conceptual understanding in Archimedes principle . Further analytical qualitative shows that high school students from the different areas revealed a difficulty to distinguish hydrostatic pressure and Archimedes' concepts. Based on these findings, it is hoped that public policies will be more equitable in paying attention to the conditions of students in urban and rural areas.

INTRODUCTION

One the aims of learning physics is how the students improve their understanding on basic conceptual physics and how the students apply these concepts in problems solving process [1][2]. These basic concepts includes the Archimedes' principle which is close to students' daily lives. Students' ability to understand these principles may greatly support the understanding of other principles in fluid mechanics. However, there are many misconceptions problems and difficulties in understanding of Archimedes' principle.

Misconception is part of the difficulty and one of the students' failure indicators to understanding the concept. There are some inequalities between real concepts and concepts understood by students. Archimedes' Principle topic misconceptions have been indentified by previous studies [3][4]. There are three misconceptions on the Archimedes topic was identified [5]. Firstly, students assume that buoyant force is influenced by the area of the container and the volume of fluid around the object. Secondly, students assume that buoyant force of objects immersed entirely in fluid is influenced by the depth of the object. Thirdly, student assume that buoyant force depends on the forces acting on the object.Some students assume the sinking object does not have a buoyant force, and the magnitude of the buoyancy force is equal to the volume of the liquid [6]. Students' misconceptions and difficulties can avoid the achievement of students' learning aim in understanding Archimedes principles.

Education underwent reforms with the development of the times. There are continuous improvements to achieving educational aims including in physics learning. The education provides benefits to all circles and to all aspects of life. Along with the continuous reform and improvement of education, in several studies was stated that there was an educational disparity between schools in urban and rural area [7]. Disparity is the difference between one object and another object in a particular field. Most of these differences are caused by social status, ethnic/racial differences, and geographical location of an area (eg between urban and rural). Educational disparity is caused by the absence of balance and justice in meeting public resources and facilities [7].

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Research about the disparity of urban and rural education in learning physics still rarely found in Indonesia. Most studies only focus on alternative learning solutions. Some overseas studies have revealed that the disparities that occur between urban and rural school education affect student learning, this will certainly affect students' ability to understand concepts [7][8][9][10]. Based on observations in urban and rural schools, researchers found that practicum tools in urban are more complete than those rural. So the learning process of Archimedes' principle in the urban and rural area is different. Archimedes learning in the urban uses laboratory facilities, whereas in rural it is not yet used. It is assumed that there is a difference in conceptual understanding between students in the urban and rural area. Therefore, this study aims to explore the conceptual understanding and difficulties of high school students in urban and rural area on the Archimedes' principle topic.

METHOD

This study employs descriptive quantitative approach. The subject of this study was students in two high schools, in the urban (N = 30) and rural area (N = 30). The high school is located in the urban is about 10.6 km from the central urban, while the high schools located rural area is about 32.3 km from the central urban. The majority of the students's parents in urban are working in private employees while students's parents in rural area work as farmers and construction workers. The High schools in urban earlier use the 2013 curriculum compared to high schools rural area.

This research instrument uses 9 open ended multiple choice questions. In open ended multiple choice questions students are required to provide reasons related to the answers their choose. The instrument consists of open ended questions (r = 0.664). The process of assessing open ended multiple choice questions is done by giving score 1 on the correct and 0 on the wrong answer. The reasons of the students' answers are used to describe the level difficulty of students in the Archimedes principle topic. The test results show non parametric data, therefore to compare the conceptual understanding of student using Mann Whitney U test [11]. Based on the Mann U Whitney test output, a mean rank value will be obtained to determine wich group who has a higher conceptual understanding. [11].

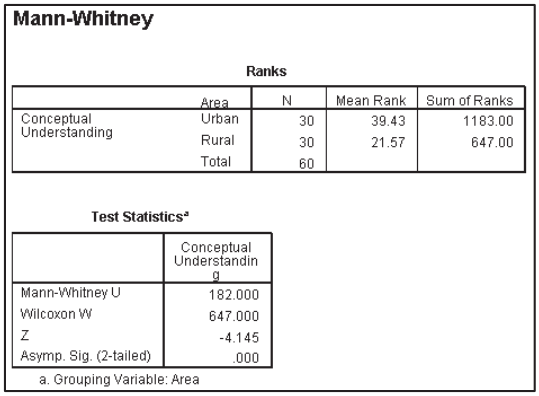
RESULT AND DISCUSSION

The results of analysis students conceptual understanding in the urban and rural area on Archimedes' principle topic are explained in TABLE 1 - 3. Descriptive statistics that comparing the conceptual understanding of urban and rural high school students can be seen in TABLE 1.

TABLE 1. Descriptive Statistics Differences in Conceptual Understanding in Urban and Rural High School (Maximum Value 100)

Statistics	Urban High School	Rural High School
Median	44,44	33,33
Modus	44,44	33,33
Minimum	33,33	22,22
Maximum	66,66	66,66

Based on TABLE 1 it is known that the median value of the conceptual understanding student in urban high school is 44.44 with modus value is 44.44 too. Beside that, median value of conceptual understanding students in rural is 33.33 with the modus value also 33.33. The median and modus score show the students conceptual understanding differences in urban school and rural area. This is supported by the results of the Mann U Whitney test that show in the Fig. 1.



Mann-Whitney

Ranks

	Area	N	Mean Rank	Sum of Ranks
Conceptual Understanding	Urban	30	39.43	1183.00
	Rural	30	21.57	647.00
	Total	60		

Test Statistics[a]

	Conceptual Understanding
Mann-Whitney U	182.000
Wilcoxon W	647.000
Z	-4.145
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Area

FIGURE 1. The Results of the Mann U Whitney Test

Based on the test results shown in Fig. 1 it is known that the value of p (0.00) <α (0.05), meaning that there are significant differences conceptual understanding between students in urban and rural area. From Fig. 1 known the mean Rank of each group. In the urban group the mean rank is 39.43 higher than the rural group , which is 21.57. This indicates that students in the urban have a higher conceptual understanding in Archimedes principle. The data obtained are analyzed by each indicator so that data is obtained as TABLE 2.

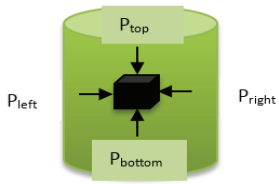
TABLE 2. Analysis of Students Conceptual Understanding and Indicator Every Questions

Indicator of Achievement	Number of Questions	Students Answer Correctly	
		Urban High School	Rural High School
Explain the Archimedes' force/lift force/buoyancy force as the resultant force by fluid pressure on the object.	1, 2, 3	28,89%	12,22%
Apply the principle that the magnitude of buoyant force is influenced by the volume of objects dipped in the fluid	4	93,33%	73,33 %
Explain the effect of fluid density on buoyancy	5, 6	60,00%	46,67%
Explain the effect of gravitational acceleration on buoyancy	7	33,33%	46,67%
Apply force analysis to several states of matter in the fluid	8, 9	48,33%	38,33%

From TABLE 2, it appears that urban and rural high school students are weak on the first indicator, namely explaining that Archimedes' force/ upward force / buoyancy force as the resultant force by fluid pressure on objects. The subsequent is a more detail discussion on several achievement indicators by displaying student responses to each item answer and then comparing it with the underlying theory or research. Based on TABLE 2, the first indicator of the concept of Archimedes' force towards the resultant force of pressure shown the lowest percentage of the correct answers. Analysis of student answers to the first indicator (item number 2) is shown in Fig. 2 (U = Urban high school and R = Rural high school).

1. A cube is arranged so that it is quietly floating on a fluid as shown in the figure. If the length of the cube's side is h, what is the resultant force on the cube produced by fluid pressure? (fluid density $=\rho_f$)

   A. $\rho_f\ g\ h^3$, towards the top → (U = 0%), (R = 10%)
   B. $\rho_f\ g\ h^3$, downward → (U = 0%), (R = 3,3%)
   C. $\rho_f\ g\ h^3$, to the side → (U = 0%), (R= 3,3%)
   D. $\rho_f\ g\ h^3$, in all directions → (U = 96,7%), (R = 20%)
   E. Zero → (U = 0%), (R= 60%)



   Reason: ...

   Doesn't answer→ (U = 3,3%), (R = 3,3%)

FIGURE 2. Analysis of the first indicator (item 2)

In question number 1, there were no urban high school students who answered correctly and only 3 high school students located in rural area answered correctly. The reason for students' answers shown that most students cannot distinguish between the concept of hydrostatic pressure and the concept of Archimedes' principle. This shown that there are still many students who are fooled by the choice of answers given. Most students choose the D answer because students consider the formula $\rho_f\ g\ h$ as F_A. In addition, most students did not understand that the direction of the Archimedes force is upward. The student thought that the Archimedes' direction is same as the direction of the hydrostatic pressure, which is in all directions. The models of reasons for student answers can be seen in fig. 3 as follows.

1.	**A** B C D E	Known : cube's side = h $\rho = \rho_f$ Asked : Force Resultan Answer : $F_A = \rho_f \cdot g \cdot h^3$ (to the top)	Student have understood the concept well
2.	A B C **D** E	$F_A = \rho_f \cdot g \cdot h$, fluids formula → $\rho \cdot g \cdot h$ When objects in water, objects get water pressure from various directions	Student can't differentiate the concept of hydrostatic pressure and archimedes force

FIGURE 3. Models of reasons for students answers in question No.2

The following is a discussion about urban and rural high school students' conceptual understanding of Archimedes' concept on the fourth indicator about the gravitational acceleration effect on buoyancy. Analysis of students' answers on the fourth indicator (item no. 7) is shown in Fig. 4 (K = Urban high school and LK = Rural high school).

7. When on the earth, a beam is floating in the water. What is the buoyant force acting on the beam if the experiment is brought to a planet where the gravitational acceleration is 1/2 the Earth's gravitational acceleration? (the beam is still floating)

A. Becomes ½ time → (U = 33,3%), (R = 46,7%)

B. Being 2 times → (U = 53,3%), (R = 26,7%)

C. Becomes ¼ time→ (U = 3,3%), (R = 10%)

D. Stay the same→ (U = 0%), (R = 10%)

E. All choices of answers are wrong, the truth is ... → (U = 0%), (R = 0%)

Reason: ...

Doesn't answer→ (U = 10%), (R = 6,67%)

FIGURE 4. Analysis of the fourth indicator (item 7)

In question number 7, 10 urban high school students and 14 high school students'in rural area answered correctly. The reason for students' answers indicated that most of the students cannot use mathematical equations to find the concept of the influence of gravitational acceleration on Archimedes topic. Most students understood that the acceleration of gravity is inversely proportional to the Archimedes' force without showing its mathematical equations. The models for student answers can be seen in Fig. 5 as follows.

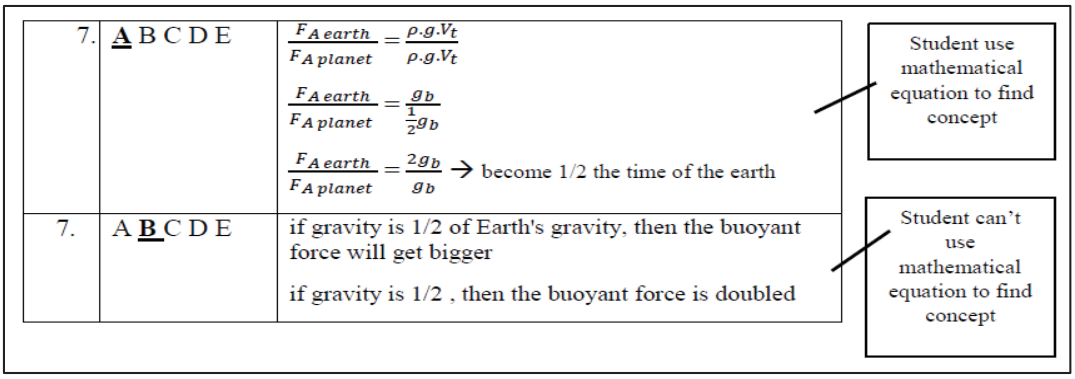


FIGURE 5. Models of reasons for students answers on question No.7

Through the reason column, it can be seen that many students have an incorrect conceptual understanding. Although multiple choice answers are appropriate, sometimes students give reasons that are not related even with the wrong reasons. Based on the results of the analysis, it was concluded that the students' incorrect conceptual understanding was due to some difficulties experienced by students. Some difficulties of students can be seen TABLE 3.

TABLE 3. Student Errors in Answering Questions

Indicator of Achievement	Error (s)	
	Urban High School	**Rural High School**
Explain that the Archimedes' force / lift force / buoyancy force is same as the resultant of force by fluid pressure on the object.	● Students cannot distinguish between the concept of hydrostatic pressure and the concept of Archimedes' ● Students cannot determine the direction of the Archimedes' force	
Apply the principle that the magnitude of buoyant force is influenced by the volume of objects dipped in the fluid	Does not understand the relationship between the volume of objects immersed in buoyancy.	The volume (V) of a dipped object is the result of a reduction between the weight of objects in the air (w_A) and the weight of objects in the water (w_w) ($V = w_A - w_w$)
Explain the effect of fluid density on buoyancy	Determine the amount of buoyancy based on the position of the object on the fluid.	Determine the amount of buoyancy force based on the position of the object on the fluid and the density of the object.
Explain the effect of gravitational acceleration on buoyancy	Gravity is inversely proportional to buoyancy	
Apply force analysis to several states of matter in the fluid	Cannot connect the volume of fluid transferred to the weight of the dipped object	● Does not understand the relation of the shape of the ship to the principle of Archimedes' ● Cannot connect the volume of fluid transferred to the weight of the dipped object.

There is difference between conceptual understanding of urban and rural students. The results indicate that urban students have better conceptual understanding than students in rural area. This statement in accordance with the previous analysis of PISA data concluded that in several countries, there were differences in the level of conceptual understanding between students in urban and rural areas with urban students having better understanding [10]. Although the results indicate that the average understanding of the concept of urban students is higher, based on TABLE 4 was found that students in each school experience almost the same misconceptions.

Previous research found several misconceptions on the Archimedes' principle topic, including the sinking object not having a buoyant force, and the magnitude of the buoyant force equal to the volume of liquid [6]. In this study most of the urban and rural high school students could not distinguish between the concept of hydrostatic pressure and the concept of Archimedes' force, the students understood that the direction of the Archimedes' force was same as the direction of the hydrostatic pressure. It means that students have a difficulty in identifying the force by the fluid that pushes objects and recognizing the factors influencing it [4]. The misconception of high school students in the urban and rural area may be caused by most of them cannot use mathematical equations to find the concept of the influence of gravitational acceleration on Archimedes' [12].

The ability of students to analyze events in everyday life based on physics is an important thing to analyze [13]. Urban High School students have more control over the application of Archimedes' in everyday life. Students in urban

area more often use laboratories for learning than students in rural area, this is one of the factors conceptual understanding of students in the urban area is higher. Studying physics is not enough just with books as a reference to get a theory but also needs to be supported by equipment for demonstrations, experiments, or practices [13]. Students in urban area prefer laboratories for science learning because these activities help students remember and make learning more concrete, laboratories make students think about phenomena and make learning more active and alive so as to make concepts more reliable and understandable [14][15][16]. Rural high school students who lack the supporting facilities and infrastructure in schools show a disparity between education in urban and rural schools. This affects student learning and understanding of students' concepts of subject matter [7-9].

The gap in education between urban areas and outside urban areas is absolute, narrowing the difference in education between urban areas and outside urban areas does not mean eliminating differences in education between the two [7]. One of the alternative solution to improve students' conceptual understanding of Archimedes' principle is implementing remidial instruction using technology for the effective way, for example using intelligent tutoring (iTutor)[17]. Furthermore, the findings of student difficulties are able to help teachers in designing better learning. There is a weakness in this study that the number of samples is limited therefore the findings just represented on this study area only. It is important to investigate student's achivement differences with use more samples.

CONCLUSION

There is a significant difference between physics conceptual understanding of urban and rural high school students, which is indicated by the results of nonparametric inferential statistical tests ($p < 0.05$). Conceptual understanding of urban high school students was higher than rural high school student. The analysis shows that high school students from the urban and rural area have difficulty in distinguishing between the concepts of hydrostatic pressure and the concept of Archimedes'. Urban High School students better understand the application of Archimedes law in everyday life. Furthermore, the findings of student difficulties are able to help teachers in designing better learning.

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