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The Effect of Homogeneity Psycho Cognition Strategies on Students' Understanding of Physics Concepts in Static Fluid Topics

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Abstract

Students' difficulties related to the concepts underlying the static fluid phenomenon are still lacking serious attention from physics education researchers. This study aims to increase students' understanding of physical concepts in solving conceptual problems related to static fluid phenomena using the Homogeneity Psycho Cognition (HPC) strategy. The analysis was carried out based on student answers to brief description questions and the level of student confidence in the accuracy of the answers. The results of the study show that the HPC strategy can improve students' understanding of concepts. At the initial meeting the students did not understand well and even indicated they had misconceptions. However, after carrying out the learning process, the results of students' understanding of concepts at each meeting are increasing. The increase in students' understanding of physics concepts with the HPC strategy is higher than the increase in students with teacher-centered or conventional learning. Thus, HPC can be recommended to improve students' understanding of physics.

Keywords: Concept Understanding, HPC Strategy, Fluid Static

INTRODUCTION

Misunderstanding of concepts greatly disrupts students' physics learning outcomes (Nussbaum, Cordova & Rehmat, 2017). The results of previous research reported that conceptions about natural phenomena still tend to hinder students' acquisition of scientific concepts (Braasch, Goldman & WIley, 2013). Until now, reading texts in the form of books and teachers can produce cognitive conflicts that will interfere with students' conceptual changes (Danielson, Sinatra & Kendeou, 2016). Therefore, professional teachers who have strong conceptual skills will produce works and formulate good scientific concepts. It should be noted that the physics sciences differ from other scientific domains (e.g., biology and chemistry) because of the breadth and complexity of knowledge in terms of content and the interconnection of knowledge at many different levels. Previous research has revealed that students tend to have inadequate understanding and misconceptions about physics knowledge (Hung & Fung, 2017). Students tend to carry their misconceptions about physics from primary to secondary education as they continue to study physics in college. Therefore, teachers need to design learning that is oriented towards understanding students' concepts and teachers can understand how students learn physics (Shen, Li & Lee, 2018).

Indicators of success in the learning process include students' understanding of concepts. Students can be said to understand concepts if they can state concepts in their own language so that students can associate and solve problems based on their basic abilities through the concepts they have understood (Fatqurhohman, 2016). While the results of other studies prove that students who have a memorizing learning style have poor quality when compared to conceptually oriented learning. Based on the results of the interviews, it was shown that students who have a conceptually oriented learning style are more skilled at solving physics problems than that of students who have a memorizing learning style (Sung, Swarat & Lo, 2020).

There is an interesting phenomenon, education in Germany is more directed at students' understanding and conceptual changes (Pinarbaşi et al., 2006). They believe that if a student's understanding of physics is good, it will have a significant impact on the student's own creativity. Creativity plays an important role in learning because creativity can encourage new and unusual ideas, unique thinking results in problem solving (Siswanto, 2018). In addition, conceptual understanding and the ability to think creatively in problem solving are important for further study because these two aspects have a mutually reinforcing synergistic relationship (Wulandari, 2016). This is inversely proportional to students in Indonesia, where teachers focus on helping students achieve learning indicators based on the national curriculum when compared to strengthening student conceptualization in certain physics topics that are still considered difficult for students (Soeharto & Csapo, 2022). Culture can encourage knowledge skills and competencies through a continuous learning process (Lin et al., 2018). Culture also influences students' way of thinking and learning outcomes; therefore, teachers must understand and consider the culture of each individual student, the teacher must study the cultural and environmental history of individual students as well as patterns, perceptions, and ideologies related to education and learning (Lam et al., 2019).

Understanding physics concepts is important for physics teachers and therefore physics education issues related to science and learning must be mastered. Several components that must be considered are students' qualitative understanding, preconceptions, motivation, and teaching context (Koponen & Nousiainen, 2013). Some students regard learning physics as memorizing formulas and problem-solving algorithms, while others think that learning involves developing a deeper conceptual understanding (Sahin, 2010). Redish et al. (1998) at the University of Maryland used the term 'cognitive expectations' which means expectations about understanding the process of learning physics and the structure of learning physics. Several physics topics that are considered difficult by students are static fluids (Besson, 2004).

This can be seen in several sub-topics of static fluids, namely hydrostatic pressure. High school students in Mexico still have difficulty understanding hydrostatic pressure when given liquid in a container (Loverude, Heron & Kautz, 2010). Students in Thailand who have studied fluid mechanics from elementary school to the university level, it is found that there are still many students who experience misconceptions (Wuttiprom, 2018). The misconceptions explained are about the concept of weight and its implications. For example, to answer the question: if a tea bag is dipped into a teacup, does the other hand holding the teacup feel the change in weight or not? Students answered incorrectly as much as 63.3% with only 41.8% believing that the weight would stay the same. Students believe that when an object is submerged in water a fluid force acts on it. Newton's third law states that for every action there is an equal and opposite reaction. The downward force on the object on the water is equal to the upward force the force of the water on the object; the resultant force on objects is zero (Moreira, Almeida, & Carvalho, 2013). Another example is that students are asked to predict the value on the scale, once the ruler is dipped in a beaker filled with water and placed on the scale. Most students said that the weight read on the scale would not change, they confirmed that the ruler did not touch the scale directly. The demonstration shows that as the ruler is dipped deeper into the water, the value read on the scale increases. However, most students are still unable to explain why this is so. Some claim that the scale feels a greater force when the ruler is submerged because the fluid pressure at the bottom of the beaker is higher and exerts a greater downward force on the bottom of the beaker (Mohazzabi & James, 2012).

Scholars have investigated many different aspects of how culture shapes teacher and student learning experiences. However, how culture influences learning practices in schools varies greatly according to teachers' knowledge, awareness of the problem, and their beliefs about how culture affects student learning (Alghamdi & Malikan, 2020). Studies show that local culture plays an important role in the construction of an ethnic identity (Lidskog, 2017). Culture is closely related to local wisdom as a truth that has become a tradition or hereditary heritage in an area. Local wisdom is understood as a human effort to use their cognition to act and behave towards an object or event under certain circumstances. Local wisdom is a creative solution or answer to geopolitical, historical, local, and situational situations (Sandoval-Rivera, 2020). Therefore, the government can develop a curriculum through a learning process based on local wisdom to increase awareness of students as the next generation of the importance of local wisdom for people's lives. Local wisdom-based learning (PBKL) in essence must originate from people's lives. Learning will contribute to increasing knowledge and understanding of the local wisdom of the local community so that students as the next generation can use it as a guide in behaving and doing activities in everyday life.

PBKL is starting to be seen as an innovative learning with great potential, which explores community activities in an area that is sustainable and original. Through the application of PBKL, students' knowledge and understanding can be increased (Hairida, 2017; Uge, Neolaka & Yasin, 2019), as well as learning outcomes (Ramdiah, Abidinsyah, Royani, Husamah, & Fauzi, 2020). PBKL is also reported to be able to empower students' critical thinking (Asimeng-Boahene, 2009; Santiprasitkul, Sithivong, & Polnueangma, 2013) while also empowering conceptual understanding (Berardi, 2021) and student creativity (Lee, 2015). In line with these findings, students' problem-solving abilities can also be improved (McLaughlin et al., 2018). It is not surprising that PBKL is considered a suitable learning approach in the 21st century (Klieger, 2016).

PBKL is closely related to ethnophysics, where knowledge is owned by a cultural community. PBKL reflects the ethnophysics of a particular cultural community. Ethnophysics learning in schools can integrate modern science and traditional science so that students' learning processes can run effectively (Bandyopadhyay, 2001). This is because students are invited to understand their environment scientifically. So, this learning is didactic phenomenology which means that students learn concepts, principles, and science material that depart from various contextual phenomena that are often encountered in their surroundings (Graffigna, Vegni, Barello, Olson, & Bosio, 2011). This will make the negative stigma towards science lessons which are considered as difficult, boring, and frightening lessons turn into positive stigmas, namely the lessons are fun, useful, and exist in the student's environment (Fasasi, 2017). Indonesia is a unitary state with diverse cultures. Therefore, Indonesia will not experience lack of references in teaching ethnophysics. This diversity will provide students with a lot of knowledge. In addition, learning ethnophysics will make students more familiar with the local culture and wisdom of their nation so that it will create a sense of love and pride for their nation. This sense of love and pride is important for students to maintain the existence of the nation, maintain national identity, and preserve the nation's culture. Thus, students can later become cultured individuals and become agents who can transfer culture to the next generation.

The presence of ethnophysics is of course inseparable from trial and error or trials as one of the scientific methods used by ancient people and has produced new knowledge but is unable to explore the scientific potential contained due to limited knowledge. Ethnophysics helps to correct assumptions that people accept from local indigenous knowledge that can be verified (Kirshbaum, Olson, Pongthavornkamol, & Graffigna, 2013).

Learning in the small islands of Maluku requires strategies that are relevant to the ethnophysics approach. The Homogeneity Psycho Cognition (HPC) learning strategy helps equalize learning opportunities for all students, because it reaches students on small islands. The HPC strategy can be driven by a variety of virtual learning platforms, mobile devices, and other software (Dabbagh & Kitsantas, 2012), thus encouraging students to interact, collaborate, and provide feedback (Bere & Rambe, 2016). HPC can be very helpful for students with low academic ability. HPC is recommended in learning based on the following points. 1) Students who are weak, not smart or slow, must follow the way of thinking of smarter students that more of their nods are only done as a sign of agreement on opinions not opinions; 2) Smart students often ignore input from weak students because their thinking skills are considered slow; 3) Not all students are happy or wholeheartedly taught or instructed by their peers (students' attitudes are generally nosy, ridicule each other, insult the poor, weak and slow); 4) Many students need to work quietly so that working together in groups will greatly interfere with their creative thinking; 5) Students who have had traumatic consequences from bad or unpleasant learning experiences from teachers (who are rude, impatient, angry or punitive) prefer to work alone without teacher supervision; 6) In a short time assignment, weak students become hasty in completing their work, learning outcomes become incomplete, incomplete or wrong. Based on the facts and conditions, the existence of this cooperative method involving diversity, togetherness and support from classmates is a positive thing that can help achieve mastery learning (Fenalamir et al., 2021).

Until now, information regarding the HPC strategy with an ethnophysics approach in teaching physics, including in relation to students' understanding of concepts, is still limited. The average student's conceptual exploration is more oriented towards general learning in class and does not even glance at ethnophysics or the cultures of society. For example, Fasasi's research (2017) focuses more on teaching ethnoscience which is related to the educational status of parents on students' attitudes towards science. Then Bandyopadhyay (2001) explores the wisdom and cognition of society towards ethnoscience in India. With this research, this study aims to analyze the effect of the HPC strategy on students' understanding of physics concepts with ethnophysics that encourage students' conceptual with HPC strategies on the topic of static fluids.

METHOD

A quantitative approach is used in this research. The experimental method was chosen as quasi-experimental research with nonequivalent control group design. This design was carried out to investigate the effect of the HPC strategy on students' ethnophysics according to Table 1.

Table 1. Nonequivalent Control Group Design

Group	Pretest	Intervention	Posttest
Experiment	A_1	B_1	A_2
Control	A_3	B_2	A_4

with

- B_1 : The experiment group used the HPC strategy with Ethnophysics
- B_2 : Groups with methods used in schools (Conventional)
- A_1 : Measurement of the initial ability of the experimental group
- A_2 : Measurement of the final ability of the experimental group
- A_3 : Measurement of the initial ability of the control group
- A_4 : Measuring the final ability of the control group

The population in this study were all semester 1 and 3 students of educational study programs for the 2022/2023 academic year. The sample in this study were 1st semester students totaling 26 students as the experimental group and the control class for 3rd semester students totaling 26 students as the control group. The sampling technique was carried out by using random sampling technique. The average sample referred to in this study is included in the medium level category based on the results of the initial survey.

The research instrument used was in the form of a pretest and posttest which were used to determine students' conceptual understanding of the topic of static fluid (Table 2). The pretest was carried out in the class before being given treatment. The posttest was carried out in the class after being given treatment. It has reached valid and reliable indicators. The conceptual understanding test instrument refers to the rubric developed by (Furtak, Hardy, Beinbrech, Shavelson, & Shemwell, 2010).

Table 2. The rubric of the level of student understanding of the concept based on the accuracy of the answers and the level of confidence

Answer accuracy	Level of understanding based on confidence score			
	3	2	1	0
True-False	Conceptual is based on evidence and conceptual is logical and coherent based on inductive-deductive rules	Conceptual based on data	There is no logical conceptual	Not Conceptual

Before carrying out research data collection, a test was carried out on the instrument questions to 100 people. The validation and rehabilitation values are 0.8. Testing the research instrument for understanding the concept of fluid on undergraduate students who have studied basic physics at several 5 public and private universities in Maluku. Students who were given try-out tests were in semesters 5 and 7. After that the researchers held a draw for sampling, from the samples obtained two sample classes were taken which would be used as the experimental group and the control group. The selected sample was the 1st semester students as the experimental group who received the HPC strategy treatment and the 3rd semester students as the control group who received the conventional learning model treatment.

Prior to the treatment, an equivalence test was carried out between the classes used, then a pretest was carried out both in the experimental class and the control class, the purpose of giving the pretest was to find out the initial abilities of each class. The learning process is carried out in several meetings. After the treatment, a posttest was given to each class with the aim of giving a posttest to find out differences in cognitive learning outcomes between students in the experimental group and the control group.

The data obtained were analyzed based on data analysis techniques which included descriptive analysis, assumption or prerequisite tests, and hypothesis testing. After being tested for normality and homogeneity, then the average difference for the achievement of the two classes was carried out. The analysis used was Anacova test analysis with a significant level of 0.05 in SPSS 16 software.

RESULTS AND DISCUSSION

The average results of students' understanding of physics concepts using the HPC strategy in the experimental and control classes for several sub-topics on static fluids can be seen in Figure 1. In the sub-topics 1) Explain the concept of density, 2) Explain the concept of pressure and hydrostatic pressure, 3) Explain the law Pascal, 4) Explaining Archimedes' law, 5) Explaining the state of floating, floating, and sinking objects.

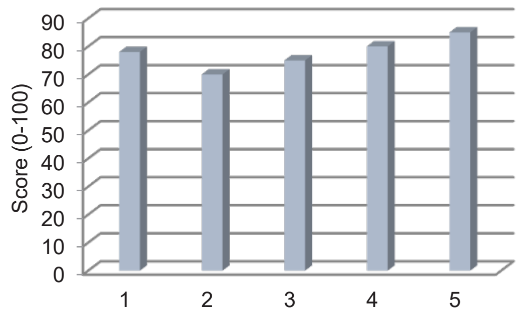

Figure 1. The average result of understanding the concept of the sub-topic in static fluid

The results of Figure 1 show that data on students' conceptual understanding has increased on each topic, from topics 1 to 5. Understanding of physics concepts is measured in each meeting on the topic of static fluids. On sub-topic 2 students experienced a decrease. It can be revealed that the characteristics of the material also affect students' understanding of physics concepts. Field findings indicate that students have difficulty understanding hydrostatic pressure applied in everyday cases.

Understanding the concept has an important role in the learning process and is the basis for achieving learning outcomes. To embed a concept in learning, a teacher needs to teach it in a real context by relating it to the surrounding environment. This will be able to develop students' critical thinking skills and improve their conceptual understanding of the topics being taught. Teachers experience difficulties in teaching new concepts that are mostly unfamiliar to students (Kerby et al., 2016). Another obstacle is in linking these concepts into new or more complex concepts. Teachers are often overwhelmed to guide students to build conceptual knowledge in a structured learning activity. Students are rarely trained to connect knowledge in building a concept (Pouta, Lehtinen, & Palonen, 2021). In addition, the HPC strategy also influences students' understanding of physics concepts, which can be seen in Table 3.

Table 3. Anacova test the effect of the HPC strategy on students' understanding of physics concepts

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2063.616[a]	2	1031.808	7.614	.000
Intercept	3738.273	1	3738.273	27.585	.000
Pretest	1016.206	1	1016.206	7.499	.008
Learning Strategy	1475.095	1	1475.095	10.885	.002
Error	7318.103	54	135.520		
Total	75002.000	57			
Corrected Total	9381.719	56			

The results of the pretest normality test for the experimental group obtained a sig. (2-tailed) > α (0.091 > 0.05), which means that the pretest data distribution for the experimental group is normally distributed. The posttest normality test results for the experimental group stated the sig. (2-tailed) > α (0.200 > 0.05), which means that the posttest data distribution for the experimental group is normally distributed. The results of the pretest normality test for the control group stated the sig. (2-tailed) > α (0.034 > 0.05), which means that the pretest data distribution for the control group was normally distributed. The posttest normality test results for the experimental group stated the sig. (2-tailed) > α (0.136 > 0.05), which means that the posttest data distribution for the control group is normally distributed. The results of the data homogeneity test obtained sig. (2-tailed) for the pretest of experimental group students and control group students of 0.934 > 0.05, the pretest data is homogeneous, and the posttest data is sig. (2-tailed) 0.936 > 0.05 means that the posttest data is homogeneous.

The results of the analysis of the Anacova test on the pretets obtained sig. (2-tailed) > α i.e. 0.013 > 0.05 then H0 is accepted and Ha is rejected, ie there is no difference in students' cognitive learning outcomes between the experimental group and the control group in the initial measurement (pretest), while the posttest results of the experimental group and the control group are obtained sig. (2-tailed) < α ie 0.000 < 0.05 then H0 is rejected and Ha is accepted, ie there is a difference in students' cognitive learning outcomes between the experimental group and the control group in the final measurement (posttest). More complete test results can be seen in Table 2.

In the learning model, the F count is 10,885 with a significance of 0,000 far below the sig value <0.05, then H0 is rejected while Hα is accepted. It is concluded that there are differences in student learning outcomes between those participating in learning using the macromedia flash-assisted inquiry model and the conventional model. The average corrected score for learning outcomes is shown in Table 4.

Table 4. The average value is corrected as a result of understanding the concept

Learning Strategy	Pretest	Posttest	Difference	Average Corrected	Notation
HPC	58.12	78.91	20.79	71.78	a
Conventional	56.42	75.52	19.10	59.42	b

The corrected average score for understanding the concept of the experimental group (HPC Strategy) was 71.78 while the average corrected score for the Control class (conventional model) was 59.42. Based on the research results obtained, the HPC strategy can affect students' cognitive learning outcomes. It can be proven in hypothesis testing with Anacova analysis showing that the significant level value is 0.000 (p = <0.05). This is because HPC empowers students' abilities to search and investigate critically, systematically, and analytically so that they formulate their findings well (Zorn & Seelmeyer, 2017).

HPC refers to group learning that the HPC learning strategy is a learning strategy that prioritizes collaboration between students in groups to achieve learning goals, but grouping is done with the target of homogeneity or similarity in students' cognitive abilities. The purpose of forming a cognitive homogeneous group is to provide opportunities for students to be actively involved in thought processes and expressions in learning activities without feeling burdened by the characteristics of other students who are smarter or more aggressive. This also makes them pay less attention to the treatment, characteristics, and characteristics of the teacher's temperament, as well as the monotonous approach. In this case, most learning activities, such as studying material and discussing how to solve problems, are student-centered. Students are divided into several small groups and directed to study predetermined subject matter. The HPC learning strategy was formed by prioritizing collaboration in groups and cooperative learning (Fenanlampir, Leasa, & Batlolona, 2021).

Generally, students fail in two processes. The first process is in defining the problem. This is related to the nature of the content that students have never known before, such as physical and chemical properties. This content is prerequisite knowledge to be able to understand the concept of physical change, the concept of chemical change and the separation of mixtures (Melhuish, 2019). Another process that becomes a problem for students is bridging the prerequisite knowledge obtained by students with learning problems. The teacher's constraints and the student's failure caused students' conceptual understanding to be low. Understanding the concept has various definitions, depending on the respective field of study. Understanding concepts in the context of natural science based on the opinions of experts is the ability of students to understand the relationship between concepts so that they can be applied to solve problems (Holme, Luxford, Brandriet, 2015). An understanding of less established concepts can be characterized by not understanding the meaning of knowledge content, definitions, and reasons for interrelated parts of knowledge.

The trigger factor for low conceptual understanding is that students are not given enough practice to solve learning problems in the past (Jo & Hong, 2020). Students become unaccustomed to connecting past knowledge and newly acquired knowledge. Students also have difficulty sorting out the knowledge needed in learning problem-solving operations. As a result, students have difficulty understanding the concepts being taught.

Science phenomena can be related to everyday life, which greatly contributes to student learning (Lutsenko, 2018). Therefore, encouraging the improvement of higher order thinking skills and problem solving (Kantar, 2014). With physics problem-based learning, students can be empowered to analyze, make quick answers, analyze data, and conclude certain answers based on the data obtained (Wijnia, Loyens, Gog, Derous, & Schmidt, 2014). This means that problem-based learning can encourage students to think scientifically (Adulyasas & Abdul Rahman, 2014). In addition, it helps students find new information, trains collective work skills, and makes students innovators. Conceptual change theory begins in childhood, and humans tend to draw connections between various elements of knowledge. Someone who acquires new knowledge from both formal and informal environments will select this information, and if the information can be scientifically measured, he will revise his previous knowledge (Eshach, Lin & Tsai, 2018).

The results of learning in Italy explained that before students were faced with physics cases, the teacher brought students' previous thoughts to explain the history of physics related to the topic to be studied. The goal is to reconstruct students' understanding to bring prior knowledge into deeper material (Leone, 2014).

Some examples of ethnophysics concepts and principles contained within Maluku local wisdom which are still endemic and can be used as student learning resources and used by teachers in ethnoscience learning in class which can be shown in Table 5.

Table 5. The concepts and principles of physics contained in the Maluku local wisdom

Ethophysics of Maluku	Concepts and Principles of Science	Desa atau Daerah Asal
Bakar Batu	Heat Transfer	Porto, Central Maluku, and Tanimbar Islands District (KKT)
Kain Tenun	Viscosity	Tanimbar Islands Regency (KKT)
Pembuatan Enbal	Newton's Laws and Heat Transfer	Tual City and Southeast Maluku Regency
Ukulele	Sounds, vibrations, and waves	Amahusu Village, Soya Village- Ambon City
Making of Sempe	Heat Transfer	Ou, Central Maluku Regency
Meti Kei	Environment	Southeast Maluku Regency
Timba Laor	Newton's laws	The coasts of Ambon Island, Kei, Lease, and Seram Island
Morea	Animal Ecology	Waai and Morela, Central Maluku District
Kus-Kus	Mammals	SBB, Ambon City and Central Maluku Regency
Pukul Sapu	Concept of Impulse and Momentum	Mamala and Morela, Central Maluku District
Totobuang	Sounds, vibrations, and waves	Amahusu, Soya, Kusu-kusu, Refinery, Naku, Hukurila – Ambon City
Katerji Dance	Rotational Motion	Ambon Islands

Table 5 only contains a small number of local wisdoms that can be studied as a source of learning in ethnoscience learning for students in Maluku and even in Indonesia. Of course, there is still a lot of local wisdom that can be studied scientifically. All this local wisdom is a cultural heritage from the past that is still being preserved because it is our valuable source of knowledge. Therefore, ethnophysics learning should be implemented in schools so that the next generation of the nation can become intelligent people, love the motherland, and be proud of their culture. If the region and the millennial generation can develop creativity with this abundant natural potential, it will become a strong foundation for sportourism. This is of course based on a good concept. Therefore, students must be equipped with good concepts and creativity from an early age so that they can develop regional potentials in the future to support the creative economy and regional progress in terms of education, social, culture and even tourism.

Ethnophysics in Maluku which is becoming crucial currently is the management of coastal and marine areas on small islands which receive less attention from the government and are almost threatened with extinction due to community activities that are not concerned with ecosystem sustainability. In general, small islands have the potential to experience habitat destruction, changes in natural ecosystem processes and pollution. The management of small islands is increasingly complex as conflicts of interest occur internally within the community and at the government level. The availability of resources in the small island areas is an indicator or basis for the carrying capacity of the area to support all activities that will be allocated. This is in accordance with the carrying capacity of coastal areas which is an area management approach that pays attention to the comparison of aspects of the availability and capability of resources to the number of populations and activities above them.

Conceptual benefits are an alternative way of learning that is appropriate for students. Conceptual understanding can help students gain knowledge, seek, and find concepts to be studied to develop thinking skills (Hogenboom et al., 2021). Physics problem-based learning is a technique currently offered to stimulate thinking skills and encourage students to learn actively. The main goal of the teacher in learning is that students can think openly and logically to find alternative solutions to problems to foster a scientific attitude (Mantri, 2014).

CONCLUSION

Based on the description of the findings, it can be concluded that the HPC strategy influences students' understanding of physics concepts. Between the two learning strategies, the HPC strategy has more influence on cognitive learning outcomes than the conventional model. Therefore, the HPC strategy can be recommended as a learning strategy that has the potential to increase students' understanding of concepts. HPC can also be recommended as a learning strategy in the 21st Century with relevant innovative learning used in learning to improve students' physics competence. The suggestion for the future is that learning using the HPC can be used as an alternative in learning physics in tertiary institutions, especially physics classes in a more extended learning time, for example half or one semester. In addition, HPC can be mastered by teachers and objectives can be explored in student learning activities in class in improving student academic achievement.

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