Received : 21 October 2021
Revised : 17 May 2022
Accepted : 31 May 2022
Online : 24 June 2022
Published: 30 June 2022

DOI: doi.org/10.21009/1.08104

Conceptions and Conceptual Changes of Junior High-School Students in the Topic of Temperature and Heat

Suharto Linuwih[a)], Danastri Shahnaz Putri[b)], Puji Asih[c)]

Physics Department, Universitas Negeri Semarang, Semarang, Indonesia

✉: [a)]suhartolinuwih@mail.unnes.ac.id, [b)]danastrisp@gmail.com, [c)]pujiasihpj@gmail.com

Abstract

The qualitative research was conducted in junior high school to know students' conceptions and conceptual changes on temperature and heat, specifically on specific heat topics. This study uses the purposive sampling technique. The research was started by collecting data and observing the students. The next step was a try-out test instrument conducted in a regular eighth-grade class. The try-out test was used as an instrument test to the superior dan the regular class of seventh-grade and the superior class of eighth-grade. The research instrument was a conceptual test in essay form and then conducted an interview. The samples were the students who had many possibilities in answering the research instrument. Based on the result of the study, the students' concepts can be divided into three types: scientific, alternative, and parallel. The conceptions of the excellent class of the seventh-grade, the regular class of seventh-grade, and the excellent class of eighth-grade are alternative concepts. The conceptual changes in the excellent eighth-grade class are decreasing students' understanding of heat and temperature.

Keywords: conceptions, conceptual changes, temperature, heat

INTRODUCTION

In essence, humans and nature coexist. Various matters concerning nature and the symptoms that can be seen or felt can only be discussed in physics. The complexity of which is owned by physics makes it one of the sciences that have essential roles in the development of technology nowadays.

One way to learn physics is to put it into the school curriculum, including at the junior high school level. Physics has excellent potential to serve as a trigger for developing a wide range of high-level thinking skills. One of these skills can be seen in the mastery of a concept and problem-solving abilities related to that concept. Students' thinking skills can be taught by a teacher at school (Juliato et al. 2011). Students' ability to solve the problem of the extent to which they built their understanding of a concept (Simangungsong 2012). According to Julianto et al. (2013), the problem-solving process that six-grade from primary school own to eleventh-grade in high school is hypothetic problem-solving, which means a problem-solving process based on hypotheses without testing

During a learning process in the classroom, students properly do not start with an empty head and are ready to be filled with knowledge. Students have to understand construction and build their imaginative visualization to explain natural phenomena or events in the environment. These phenomena have been studied by Hidayatullah et al. (2020). An overview of the concept of an ambiguous form of alternative conceptions, or preconception or intuitive conception in the mind of the student, is a reflection on the construction of understanding and visualizing imaginatively conceived students to represent ideas or the ideas of the phenomenon or what he learned different conception of scientists (Laliyo 2011). According to Pujayanto (2012), the initial concept of the students about the

phenomena they encounter is where is right and where is wrong. Understanding students not following the concept recognized by the experts is called misconceptions.

Physics misconceptions can happen to anyone at any level of education, both in primary school students, high school (A'yun et al. 2018), college students (Linuwih 2012), and even teachers or lecturers (Mosik & Maulana 2010). Previous research reports that it has successfully identified heat and temperature misconceptions using a four-tier diagnostic test-assisted website (Septiyani & Nanto 2021). Another study also attempted this misconception problem through remediation using e-learning (Halim et al. 2020). A'yun et al. (2018) reveal students hold many misconceptions about atomic structures. Based on research conducted by Setyadi (2012), high school students' misconceptions about the temperature and the heat were considered relatively high, although this matter they've got at the level of junior high school.

Students learn through several processes, including the process of conceptual change. There are several processes in the conceptual change process, including identifying and recognizing, evaluating conceptions and beliefs, then deciding whether it is necessary to rebuild (Replenishing) or not conception and the belief by the new one (Suratno 2008). Another factor that affects the process of conceptual change is contextual factors. The student may receive and understand the scientific concepts in a particular context but may continue to use the initial conceptions (are misconceptions) in other contexts. The meaning of a context here is in terms of the application of the concept, and the concept is the same but different case examples. Therefore, the characteristics of the concept of change are contextual and unstable. Changes in long-term and stable concepts can only be achieved if students identify the relevant things and the scientific concept's general nature contextually.

METHODS

This qualitative research is carried out on junior high school students of SMP 1 Pati. Sampling using purposive sampling technique classes, namely sampling data sources with particular consideration (Sugiyono 2012). Students who become the research sample are of classes VII A, VII E, and VIII B.

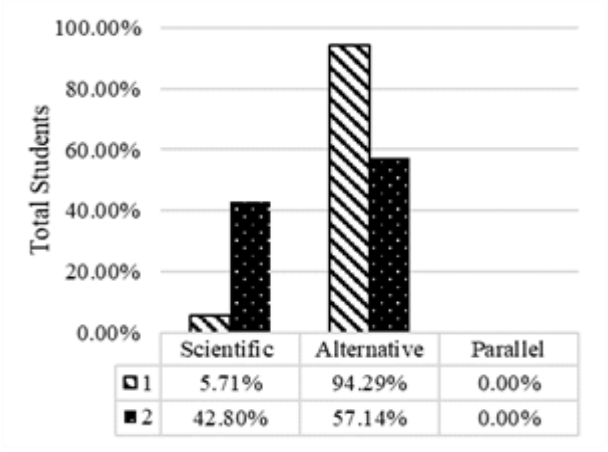
TABLE 1. Classes of research samples

No	Classes	Category
1	VII A	Excellent
2	VII E	Regular
3	VIII B	Excellent

Class VII A is considered to have a better level of understanding of the concepts of temperature and heat than class VII E since class VII A is an excellent class while class VII E is a regular class. Class VIII B is also an excellent class, but its students experience a degraded state of understanding because of the time. However, both VII A and VII E are in peak condition for getting new material.

RESULTS AND DISCUSSION

After the written test, the results were obtained for the students' three types of conceptions. The conception is scientific, alternative, and parallel conceptions. The parallel conceptions are a blend of scientific and alternative conceptions and a blend of two alternative conceptions. Scientific conceptions are derived from correct answers, while alternative conceptions and parallel are obtained from the wrong answers. This article only discusses the analysis of students' conceptions about the specific heat contained in the matter of number 1 and number 2. Conception students of excellent class VII can be seen in FIGURE 1, regular class VII resented in FIGURE 2, and class VIII featured in FIGURE 3.



(a) (b)

FIGURE 1. Descriptions of Conceptions of Class VII students in Excellent Class

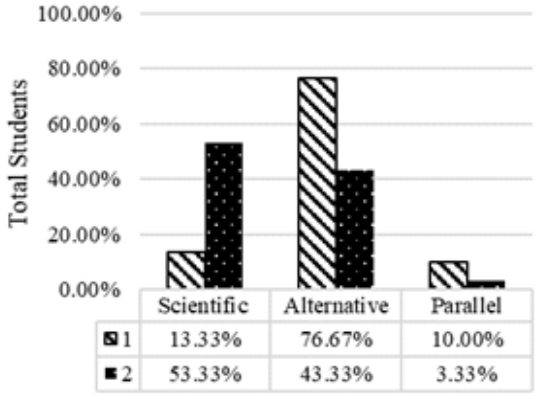


FIGURE 2. Descriptions of Conceptions of Class VII students in Regular Class

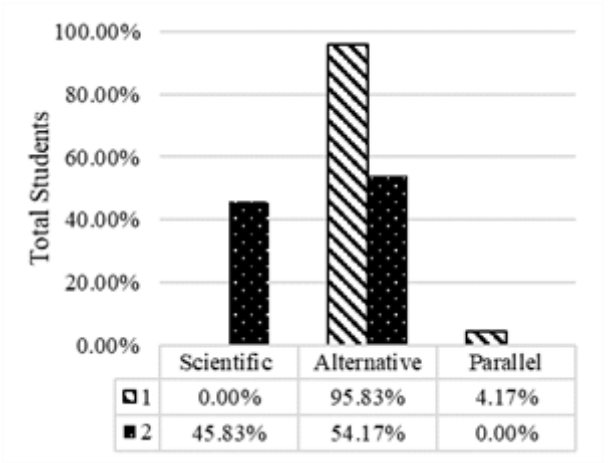


FIGURE 3. Descriptions of conceptions of Excellent VIII Class students

Problem number 1 aims to raise students' conceptions about the specific heat of a substance. In the seventh grade, 13.33% answered correctly, regular VII grade students answered correctly, 5.71%, and class VIII featured none of the students who answered correctly.

Problem number 1. Is the amount of calories needed to increase the temperature of 1 kg of water by 1^{o}C the same as the number of calories needed to increase the temperature of 1 kg of cooking oil by 1^{o}C? Why?

Students who answered correctly stated that the heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil have different specific heat. Students who answer incorrectly give different answers to question number 1. There were talks about the density, the density of a substance, and so on. The pattern of responses to question number 1 can be seen in TABLE 1 for the Excellent Class VII, TABLE 2 for the Regular VII Class, and TABLE 3 for the VIII Class.

TABLE 1. Patterns of the Answers of the Student of Excellent Class VII to Problem No. 1

Percentage	Students' Answer	Category
13.33%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil have different specific heats.	Right
10%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because of different boiling points. Besides, the water and oil substances are also different.	False
3.33%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because the specific heat of water is less than oil.	False
3.33%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because it is more difficult to evaporate water.	
6,67%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because the distance between the water particles more tenuous than in oil	False
43.33%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because frying oil heat faster. Students did not provide further explanation about why.	False
3.33%	The heat is required to raise the temperature of 1 kg of water more than the temperature of 1 kg of cooking oil.	False
3.33%	The heat is required to raise the temperature of 1 kg of water more because of the mass of water than oil.	False
6,67%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil have different boiling points.	False
3.33%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil have a mass of different types.	False
3.33%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil are different substances.	False

TABLE 2. Patterns of the Answers of the Students of Regular Class VII to Problem No. 1

Percentage	Students' Answer	Category
5,71%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil have different specific heat.	Right
14.29%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is the same as water and oil has a density equal.	False
22.86%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because frying oil heat faster. Students did not provide further explanation about why.	False
2,86%	The heat was required to raise the temperature of 1 kg of water more because the mass of water was more than oil.	False
2,86%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different. Students did not mention the reason.	False
8.57%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because hot water is faster than cooking oil.	False
8.57%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil have a mass of different types.	False
2.86%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil have different volumes	False

Percentage	Students' Answer	Category
8.57%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is the same as water, and cooking oil has the same mass.	False
2.86%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because of the mass of the two substances together.	False
5.71%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because of water expansion coefficient is greater than oil	False
2.86%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because of the influence of radiation.	False
2.86%	The heat required to raise the temperature of 1 kg of water and 1 kg of the same cooking oil because heat equal to the heat released is received.	False
2.86%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because the amount of cooking oil is too much.	False
2.86%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because if oil is mixed with water, the heated water will disappear, and cooking oil will be in the frying pan.	False
2.86%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil could be different for the fish fry.	False

TABLE 3. Patterns of the Answers of the Students of VIII Class to Problem No. 1

Percentage	Students' Answer	Category
33.33%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because the water and oil have different constituent molecules	False
12.50%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because frying oil heat faster.	False
4.17%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because the distance between the water particles is more tenuous than in oil.	False
4.17%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil differs because of different boiling points.	False
4.17%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because cooking oil is denser than water—the more heat the surface of solids (oil), the faster the heat propagation. While the surface of the liquid (water), the propagation of heat is longer.	False
33.33%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because water and cooking oil have a mass of different types.	False
4.17%	The heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because the water and oil have different pressure.	False
4.17%	The heat required to raise the temperature of 1 kg of water is less than 1 kg of cooking oil. Students did not mention the reason.	False

Most of the students gave wrong answers because there are answers that the heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil is different because of some quantities. They are the density of the two different substances, liquids of different densities, boiling points of both substances, and the mass of the two different substances. Various conceptions of the students could arise because **of knowledge as separate fragments** and **conceptual appreciation**. Excerpts of the interview between the researcher and the respondents were as follows: P is the researcher, and R is the respondent.

Q: ... whether the heat required to raise the temperature of 1 kg of water and 1 kg of cooking oil the same?

R: different ..

Q: Why such a difference?

R: because its density is different.

P: Then if its density is different what happens?
R: boiling point to be different.
P: high boiling point which is different then?
R: big oil., Less water than oil.
Q: Why bigger oil?
R: because the molecules making up more oil than water.

The knowledge factors as fragments separated as forming the students' conceptions which revealed that alternative conceptions derived from a collection of several fragmentary knowledge, gained from the experience of daily life relatively early, simple, and general (Linuwih 2011). It provides further abstracted basic knowledge and higher reasoning about physical processes. Relatively early experiences experienced by students are a flake of knowledge that does not require an explanation. Alternative conceptions because these factors look like the students' answers on the expansion of the liquid in which students express cause spilled water when heated because of the emergence of bubbles of water when boiling.

Conceptual appreciations are also factors that affect students' conceptions. An alternative conception occurs because students cannot develop a meaningful relationship with a new context introduced in physics learning activities (Linuwih 2011). In other words, they can not distinguish between the context in which they developed the initial concept and the context in which the concept of physics is defined. When faced with the problem of students relying on context-specific conceptions that are considered already to solve the problem practically, it is said to be an appreciation (appreciation) concept. Indication, as well as a parallel alternative conception in students because of the conceptual appreciation, can be done through interviews, and the student will be replied by directly applying the theory/formula that is already believed to be accurate. As an example of water heating and cooking oil phenomena, students answer when heat is needed to heat the two differ because of the differences in density, particle density, the composition of constituent particles, and the boiling point. Here we see that the students have many new concepts but do not follow the material in question. This means that students are experiencing fragmentation. Problem number 2 aims to raise students' conceptions about the mechanism of onshore wind. In the seventh grade, excellent answered correctly 53.33%, 42.86% of regular VII class students answered correctly, and excellent VIII class students 45.83% answered correctly.

Students who answered correctly stated that onshore wind goes from land to sea at night because at that time, the temperature on the ground is faster than the cold sea temperatures, and pressures in the oceans are lower than the pressure in the mainland. This resulted in cold air above the land to the ocean, warm air over the water moving up and the air becoming cooler while moving down. Students who answer incorrectly have different answers. Patterns of students' answers to question number 2 can be seen in TABLE 4 to the excellent VII class, and TABLE 5 for the regular VII class.

TABLE 4. Patterns of the Answers of the Students of Excellent Class VII to Problem No. 2

Percentage	Students' Answer	Category
53.33%	The onshore wind goes from land to sea at night because at that time, the temperature on the cold ground is faster than ocean temperatures and pressures in the oceans are lower than the pressure on the mainland. This resulted in cold air above the land to the ocean and warm air over the water moving up and while moving down, the air becomes cooler.	Right
13.33%	Onshore winds occur due to convection	False
3.33%	Onshore wind occurs because of the vines from the high to the low area.	False
3.33%	Onshore wind occurs because the wind blows from land to sea.	False
16.67%	Onshore wind occurs because the ocean is cooler than the mainland.	False
3.33%	Onshore winds occur due to temperature changes in the ocean.	False
3.33%	Onshore wind occurs because the wind is blowing in the direction of the mainland with a very strong wind.	False
3.33%	Unable to express opinions about the mechanism of onshore wind.	False

TABLE 5. Patterns of the Answers of the Students of Regular Class VII to Problem No. 2

Percentage	Students' Answer	Category
42.86%	The onshore wind goes from land to sea at night because at that time, the temperature on the cold ground is faster than ocean temperatures and pressures in the oceans are lower than the pressure on the mainland. This resulted in cold air above the land to the ocean and warm air over the water moving up and while moving down, the air becomes cooler.	Right
22.86%	Onshore wind going from land to sea.	False
2,86%	Onshore wind is the wind that spins to the mainland and then back again to the sea.	False
2.86%	Onshore wind occurs because of the oceans are faster than onshore wind.	False
2.86%	Onshore wind occurs because the land's wind mixes with sea water vapor.	False
2.86%	The onshore wind pushed the boat to sea	False
8.57%	Onshore wind occurs because, during the night, the wind is strong.	False
2,86%	Onshore winds occur due to radiation	False
5,71%	Onshore winds occur because the land is hotter than the ocean.	False
8.57%	Explaining the mechanism of onshore wind with pictures without any description	False

Onshore wind and sea breezes are things side by side. Some students have not been able to distinguish events of the onshore winds and sea breezes, so answered questions still distorted between the two. Based on the results of the written test, a group of students identified mechanisms of onshore wind with a picture like the one in the science textbook. The picture given by the students were not given any explanation. We conducted interviews, and students answered with the wrong answer.

Q: if you could explain the phenomenon of onshore wind?
R: ... (just smile)
P: you know .. in your answer sheet instead of this drawing (showing the student answer sheet). Can you explain this picture?
R: .... (thinks a while) Look, fishermen want to catch fish in the sea so the wind is blowing from land to sea.
P: at the time of fishermen to the sea, the temperature and the pressure on land and sea like what?
R: mainland hotter, colder ocean. Significant pressure on land rather than at sea.

The answer given by the students in written tests and interviews indicated that if the factors that influence students' conceptions are accompanied by an understanding that the textbook is a theoretical structure. Students answer tests written by drawing what is remembered in the book and interview students during the test to identify images based on opinion. Pictures given to these students showed that students remember what's in the textbook, and the explanations given were mistakenly included in the structure factor as a theoretical understanding.

In the learning process, students are not only a source of knowledge that the teacher explains the material but also textbooks that students hold true at any time. Textbooks used to go through the process of selecting the right so that the students understand of the material. According to Banowati (2011), selecting textbooks needs to consider various things. The main ones are the advantages of textbooks as a source of information. Giving a stimulus when needed, given the specific presentation of the material, may affect the reader's attitude. Mistakes can lead to the selection of textbooks and students' misconceptions about the material being taught.

The research results have proven a misconception because the students cannot explain the mechanism of onshore wind on number 2. The case that happened in number 2 is in line with that expressed by Amiruddin & Supriyatman (2013) that students are only able to memorize concepts without being able to develop process skills science in solving the problems faced in everyday life. Sözbilir (2003) mentions that the phenomenon of misconceptions on this matter is not surprising because humans have built a knowledge base based on experiments on temperature and heat from an early age. This difficulty can arise from several sources, including the terminology used. In everyday life, often use words that have different meanings when the word is used in schools.

Knowledge is a theoretical structure that becomes another factor in forming students' conceptions. The studies conducted by Vosniadou (1994) concluded that individuals construct various alternative conceptions to interpret new problems in theory. However, the interpretation still does not following the scientific outlook. Indication and a parallel alternative conception in students because of the theory can be determined by conducting interviews. If the student answers the basis of the theory, but the theory/beginning of the mistaken assumption, then the conception of an alternative or parallel indication in the student because the student theoretical structure factors can be known.

It can be concluded that knowledge as a theoretical structure is an effort by the students to interpret the situation or problems encountered into a theoretical framework. This theoretical framework is some of the false theories in students. As happened in the matter of the number 2 on the mechanism of occurrence of onshore wind. Students said the wind was blowing hard from land to sea and onshore winds there during the night.

In addition to the factors already mentioned, one more factor causes students to have a conception. These factors are conceptual changes. Some students experienced conceptual change as students gave different answers when the written test and interview. Conceptual changes also occur from class VII to VIII featured. Conceptual changes experienced by students of class VIII seed due to degradation factor due to the influence of time thinking skills. The material is on temperature and heat the material in class VII. Conceptual changes that occur in superior grade students are presented in FIGURE 4.

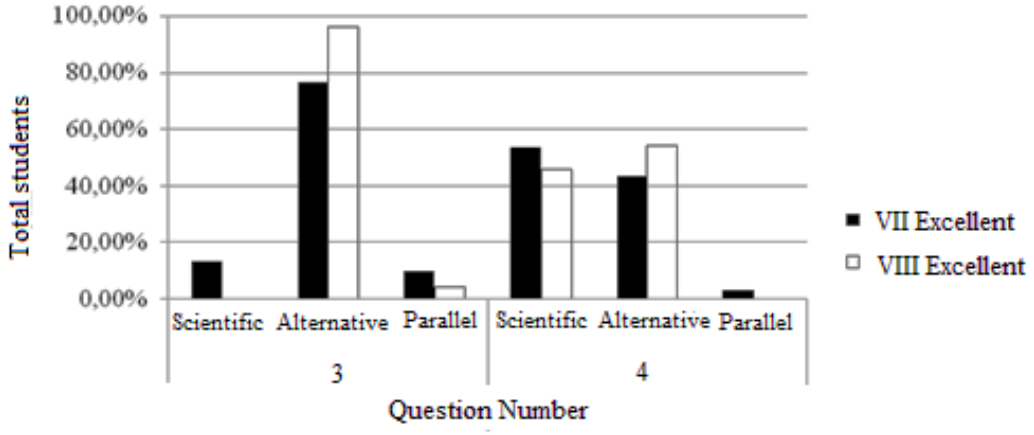


FIGURE 4. Description of Conceptual Changes in the Excellent Class

Owned conceptual change featured eighth-grade students included in the form of status change. As understanding of the research carried out pre-concepts of students losing their status, a new concept got their status because it is easier to understand, accept, and see as more useful by students. Conceptual changes are not seen as a situation in which the concept of the student is deleted or lost from the mind. So the conceptual changes experienced by students in the form of changes in the conception of the written tests and interviews to test the differences between the shape conceptions of class VII and VIII featured included in the activity of conceptual change. This is consistent with the opinion (Küçüközer & Kocakülah 2008).

CONCLUSION

Students' conceptions about the specific heat at a grade of 33.33% featured VII to scientific conceptions, alternative conceptions by 60%, and the conception of the parallel of 7%. VII grade students' conceptions of 24% to regular scientific conceptions and 76% for alternative conceptions. Whereas class VIII featured a scientific conception by 23%, amounting to 75% of alternative conceptions, and to 2% of parallel conceptions.

Conceptual changes that occur in the Excellent VIII Class is in a degraded state due to the influence of time thinking skills seen from the decline in the percentage of the scientific conception of the students of class VII featured by 33.33% while the seed VIII grade of 23%. In addition, it is also an increase in alternative conceptions of class VIII to class VII seed from 60% to 75%.

REFERENCES

A'yun, Q, Harjito & Nuswowati, M 2018, 'Analisis Miskonsepsi Siswa Menggunakan Tes Diagnostic Multiple Choice Berbantuan Cri (Certainty Of Response Index)', *Jurnal Inovasi Pendidikan Kimia*, vol. 12, no. 1, pp. 2108-2117.

Amiruddin, K & Supriyatman 2013, 'Pengembangan Perangkat Pembelajaran Fisika bagi Siswa SMP Negeri di Daerah Tertinggal', *Jurnal Pendidikan Fisika Indonesia*, vol. 9, no. 2, pp. 99-105.

Akmam, A, Anshari, R, Amir, H, Jalinus, N & Amran, A 2018, 'Influence of learning strategy of cognitive conflict on student misconception in computational physics course', *IOP Conference Series: Materials Science and Engineering*, vol. 335, no. 1, p. 012074, https://doi.org/10.1088/1757-899X/335/1/012074.

Banowati, E 2007, 'Buku Teks dalam Pembelajaran Geografi di Kota Semarang', *Jurnal Geografi*, vol. 4, no. 2, pp. 147-158.

Halim, A, Soewarno, S, Elmi, E, Zainuddin, Z, Huda, I, & Irwandi, I 2020, 'The Impact of the E-Learning Module on Remediation of Misconceptions in Modern Physics Courses', *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, vol.6, no.2, pp. 203-216.

Hidayatullah, Z, Jumadi, J, Nadhiroh, N, Kartika, E, Nuha, A & Erlangga, S 2020, 'Identifikasi miskonsepsi dan konflik kognitif fisika: kasus terkait perubahan konseptual', *EDUSAINS*, vol. 12, no. 1, pp. 64-71, https://doi.org/10.15408/es.v12i1.13504.

Julianto, E, Hartono & Wiyanto 2011, 'Pembelajaran Fisika untuk Menumbuhkan Kemampuan Berpikir Hipotetikal Deduktif pada Siswa SMA', *Jurnal Pendidikan Fisika Indonesia*, vol. 7, pp. 17-22.

Julianto, E, Nugroho, SE & Marwoto, P 2013, 'Perkembangan Pola Pemecahan Masalah Anak Usia Sekolah dalam Memecahkan Permasalahan Ilmu Pengetahuan Alam', *Jurnal Pendidikan Fisika Indonesia*, vol. 9, no. 2, pp. 151-162.

Küçüközer, H & S. Kocakülah 2008, 'Effect of Simple Electric Circuits Teaching on Conceptual Change in Grade 9 Physics Course, *Journal of Turkish Science Education'*, vol. 5, no. 1, pp. 59-74.

Laliyo, LAR 2011, 'Model Mental Siswa dalam Memahami Perubahan Wujud Zat', *Jurnal Penelitian dan Pendidikan*, vol. 8, no. 1, pp. 1-12.

Linuwih, S 2011, 'Konsepsi Paralel Mahasiswa Calon Guru Fisika pada Topik Mekanika', *Disertasi Universitas Pendidikan Indonesia*.

Mosik & Maulana, P 2010, 'Usaha Mengurangi Terjadinya Miskonsepsi Fisika melalui Pembelajaran dengan Pendekatan Konflik Kognitif', *Jurnal Pendidikan Fisika Indonesia*, vol. 6, pp. 98-103.

Munawaroh, A, Wilujeng, I & Hidayatullah, Z 2020, 'Physics Learning Instruction Based on the Conceptual Change Model for Senior High Schools', *Advances in Social Science, Education and Humanities Research*, vol. 541, pp. 441-446.

Pujayanto 2012, 'Miskonsepsi IPA (Fisika) pada Guru SD', *Jurnal Materi dan Pembelajaran Fisika (JMPF)*, vol. 1, no. 1, pp. 22-24.

Septiyani, E & Nanto, D 2021, 'Four-Tier Diagnostic Test Assisted Website for Identifies Misconceptions Heat and Temperature', *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, vol. 7, no. 1, pp. 35-42.

Setyadi, E 2012, 'Miskonsepsi tentang Suhu dan Kalor pada Siswa Kelas 1 di SMA Muhammadiyah Purworejo, Jawa Tengah', *Berkala Fisika Indonesia*, vol. 4, no. 1&2, pp. 46-49.

Simangunsong, IT & Sani, RA 2012, 'Analisis Pemahaman Konsep dan Kemampuan Pemecahan Masalah Fisika dengan Menggunakan Model Problem Based Instruction (PBI) dan Direct Instructin (DI)', *Jurnal Online Pembelajaran Fisika*, vol. 1, no. 2, pp. 50-57, [Online] Tersedia di http://dikfispasca.org/ika-trisni-simangunsong-dan-ridwan-a-sani-50-57 [diakses 2 Februari 2014].

Sözbilir, M 2003, 'A Review of Selected Literature on Students', *Misconceptions of Heat and Temperature*, Boğaziçi University Journal of Education, vol. 20, no. 1, pp. 25-41.

Sugiyono 2012, 'Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D', Bandung: Penerbit Alfabeta.

Suratno, T 2008, 'Konstruktivisme, Konsepsi Alternatif dan Perubahan Konseptual dalam Pendidikan IPA', *Jurnal Pendidikan Dasar*, vol. 10.

Vosniadou, S 1994, 'Capturing and Modeling the Process of Conceptual Change', *Jurnal Learning and Instruction*, vol. 4, pp. 45-69.

Walsh, C, Quinn, K, Wieman, C & Holmes, N 2019, 'Quantifying critical thinking: Development and validation of the physics lab inventory of critical thinking', *Physical Review Physics Education Research*, vol. 15, no. 1, p. 010135.

Wilujeng, I & Hidayatullah, Z 2021, 'Alternative learning model in physics learning: Effect of the conceptual change model with cognitive conflict on critical thinking skill', *Momentum: Physics Education Journal*, vol. 5, no. 2, pp. 111-120.