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Identification and remediation of science misconceptions in elementary school teachers using the P2OC2R model

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Abstract

This study aims to identify the conceptions of elementary school science teachers on 40 science concepts that were found to have misconceptions in the field. Identification of the teacher's conception using the three tiers instrument that had been developed previously, then remediation was carried out using the P2OC2R learning model. Forty science concepts were then tested on eleven teachers. Initially the three tiers instrument was launched to the participants, then the test results were mapped in the form of a conception profile describing the distribution of respondents who understood the concept, did not understand the concept and misconceptions. The next stage, the teachers were carried out learning using P2OC2R learning with the stages of exploring the teacher's initial conception using probing questions, testing the teacher's initial conception through observation of concept examples, negotiating and confirming the conception and reflection for 40 concepts. Furthermore, respondents were tested again using three tiers instruments. The results showed that there had been a change in conception from not understanding the concept and misconceptions to understanding the concept reaching 75.5%. The implication of this research is the action to remediate misconceptions because this research has been able to find the reliability and effectiveness of P2OC2R.

Abstrak

Penelitian ini bertujuan untuk mengidentifikasi konsepsi guru IPA SD pada 40 konsep IPA yang ditemukan miskonsepsi di lapangan. Identifikasi konsepsi guru menggunakan instrumen three tiers yang telah dikembangkan sebelumnya, kemudian dilakukan remediasi dengan menggunakan model pembelajaran P2OC2R. Empat puluh konsep IPA kemudian diujicobakan pada sebelas guru. Awalnya instrumen three tiers diluncurkan kepada peserta, kemudian hasil tes dipetakan dalam bentuk profil konsepsi yang menggambarkan sebaran responden yang paham konsep, tidak paham konsep dan miskonsepsi. Tahap selanjutnya guru melaksanakan pembelajaran menggunakan pembelajaran P2OC2R dengan tahapan menggali konsepsi awal guru menggunakan pertanyaan probing, menguji konsepsi awal guru melalui observasi contoh konsep, negosiasi dan konfirmasi konsepsi serta refleksi untuk 40 konsep. Selanjutnya responden diuji kembali dengan menggunakan instrumen three tiers. Hasil penelitian menunjukkan bahwa telah terjadi perubahan konsepsi dari tidak memahami konsep dan miskonsepsi menjadi memahami konsep mencapai 75,5%. Implikasi dari hasil penelitian ini adalah adanya kemudahan dalam melakukan remediasi miskonsepsi dengan adanya model remediasi yang disebut Model P2OC2R.

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A. Introduction

Concepts are the basic building blocks of every science. The relationship between concepts that make up explanations and or predictions is called theory (Ibrahim, 2012). A theory that has been consistently tested true is a law or principle. The description implies that the concept has a strategic position in science. The truth of the concept will determine the truth of the theory and the laws it builds. On that basis, mastery of concepts for a teacher, especially elementary school teachers, is a necessity.

Research conducted by researchers found that misconceptions occur at almost all levels of education. Ibrahim (2019); Puja (2011) found that conceptual errors (misconceptions) and misunderstandings occurred among elementary school teachers. Meanwhile Kartimi et al. (2021); Faridah et al. (2020); Munawaroh & Falahi (2016) found misconceptions in elementary school students, Ariandini et al. (2013) found misconceptions in junior high school students. Wulandari et al. (2021); Fauzannur et al. (2022) found misconceptions in senior high school students. Murni (2003); Hermita et al. (2016); Ainiyah et al. (2018) found misconceptions in students.

When elementary school teachers experience misconceptions, the impact is that students also experience misconceptions (Farida et al., 2020; Mawaddah et al., 2020; Kartimi et al., 2021). A survey on misconceptions has been launched in 2021 on elementary school teachers spread across 25 provinces, who are currently students in the Teacher Professional Education (PPG) study program at Nahdlatul Ulama University Surabaya (Unusa) totaling 268 people. Referring to the consistency of the results of research conducted by researchers regarding the existence of misconceptions in teachers and students, it is strongly suspected that this misconception also occurs in the teachers of the Cooperation Partner School of Nahdlatul Ulama University Surabaya, namely elementary school teachers in the Krembung district of Sidoarjo.

This kind of condition requires immediate treatment so that the impact of teacher misconceptions can be eliminated or at least reduced. The concept that is owned by the teacher and then teaches it to students can have a "snowball" impact, which is getting more and more people experiencing misconceptions. To deal with the problem of misconceptions and lack of understanding of science concepts, it is carried out by downstreaming the results of previous research, namely (a) developing diagnostic instruments to determine teachers' conceptions of certain concepts (Mujizatul et al., 2017) and (b) developing learning models for changing the teacher's conception of science (Ibrahim, 2019). Using the results of research (a) a mapping of the science conceptions of elementary school teachers at Unusa's partner schools will be carried out. Through the diagnostic test, teachers are grouped into teachers who master the concept, do not understand the concept and experience misconceptions, so that a science conception profile of elementary school teachers is produced. Furthermore, using the results of research (b) remediation will be carried out on teachers who do not understand the concept and experience misconceptions. Based on the description above, the objectives of this study are: (1) to describe the conception profile of elementary school teachers about 40 science concepts before and after learning using the P2OC2R model (2) to describe the shift in the conception of respondents before and after learning using the P2OC2R model. The research was carried out in two stages (1) Identification of the teacher's initial conception (participants) and (2) Remediation of misconceptions experienced by participants.

B. Material and Method

This research is a quantitative descriptive study, firstly describing the concepts owned by the respondents using the three-tier diagnostic test (Ainiyah et al., 2018) for concepts that are suspected of having misconceptions (Ibrahim, 2012). This test consists of three parts, namely a statement about the concept, a choice of True or False answers related to the statement given, and a confidence level of 1-5, where the number five indicates very sure the answer is correct, while a score of one means very unsure of the correctness of the answer given. . This diagnostic test covers 40 concepts, involving all class teachers who teach science, which are eleven people. Furthermore, remediation learning is carried out using P2OC2R learning with the following stages in Table 1 (Ibrahim, 2019).

The next step is to do a final test related to the 40 concepts that have been studied. Based on the results of the initial and final tests, the participants' conception profiles before and after remediation were determined in the form of a distribution of concepts (a) understood the concept, (b) did not understand the concept, and (c) misconceptions in the participant-concept matrix. Determination of participants' conceptions is determined using the following rubric.

Table 1 P2OC2R Learning Stages

Stages	Describtion
Probing	The tutor uses the probing questioning technique to collect information about the participants' initial conceptions regarding the 40 concepts that have been tested on them. The implementation is carried out one by one concept.
Present previous conception	Participants presented their conceptions including: understanding, attributes, examples, value (benefits) of related concepts. The tutor records the participants' responses on the blackboard.
Observation	Participants were asked to observe the examples of concepts provided. For this purpose, examples of related concepts are presented using the help of powerpoint slide media.
Confirmation	The tutor guides the participants to confirm the correctness of the answers (conceptions) they gave in the second step.
Clarification	Participants clarify to determine which conception is correct
Reflection	Participants are guided to reflect on the process of changing their conceptions

Participants' conceptions determination rubrix:

1) **Understand the concept:** if the response given is correct and very sure of the truth of the response with a confidence level > 2.5.
2) **Do not understand the concept:** if the response given is correct and the confidence level is low < 2.5 or the response is incorrect with a low confidence level < 2.5.
3) **Experiencing misconceptions:** if the response given is wrong, but the level of confidence is high > 2.5.

This profile will provide information about each participant's conception of each concept being tested. The success of remediation is determined based on the results of the shift/change in conception in a positive direction. Change in a positive direction: what is meant is a change from not understanding concepts and or misconceptions to understanding concepts.

C. Results and Discussion

Conceptions that are misconceived include the following 40 science concepts.

1) All living things eat.
2) Connecting and sticking are examples of artificial vegetative reproduction.
3) Plants absorb nutrients from the soil.
4) The food chain is an event of eating eating according to a certain order.
5) Examples of food vitamins, minerals.
6) Foodstuffs, food, and food substances are the same terms.
7) Osmosis is the process of moving molecules of a substance from low to high concentration.
8) Respiration is basically the same as breathing.
9) Anaerobic respiration is respiration that does not require oxygen.
10) Plants breathe only at night.
11) Breathing plants absorb carbon dioxide (CO2).
12) The cat's body is covered with fur.
13) Monocot stems are unbranched.
14) The distinctive feature of birds is that they can fly, have wings and beaks.
15) The leaves of monocots are parallel, whereas dicots are pinnate.
16) Cashew nuts are examples of open seed plants (Gymnosperms).
17) Sweet potato tubers include root tubers.
18) 18. Beautiful color on the kana flower (the flower of Tasbih and Bogenvil is the crown).
19) Photosynthesis only occurs during the day.
20) Green plants photosynthesize during the day and breathe at night.
21) The fruit on peanuts includes root tubers because it comes from the roots.
22) Animals that live in water breathe with gills.
23) Generative reproduction is reproduction that uses sex cells.
24) Herbivores are the same as herbivores.
25) Shoots are the same as sprouts.
26) Characteristics of animals giving birth, have ears.
27) An object immersed in a liquid loses weight.
28) If a liquid is put into a container, its shape changes according to the shape of the container.
29) Air in motion has greater pressure.
30) In the process of seeing, the eye emits light that hits the object being seen.
31) The image formed by a concave mirror is always inverted.
32) When light travels from air to water, in water it bends.
33) When a pencil is dipped in water, it bends, because the pencil is refracted.
34) Lenses are always made of glass which is symmetrical in shape.
35) When two objects with different weights are dropped in a vacuum, the heavier object will reach the bottom faster than the lighter object.
36) Weight is a force.

37) A student pushes the wall with all his might, even though the wall does not move, but the student has made an effort.
38) Changes in the shape of the moon into a crescent, semi-circle, full moon, because it is covered by the earth.
39) The occurrence of day and night events because there is a revolution of the earth about the sun.
40) People on earth can see all the surface of the moon, because the moon rotates.

The results of this study are in the form of a participant-concept matrix, which maps the distribution of each student's conception of each concept being tested. Participants' initial conception profiles related to 40 science concepts can be seen in Table 2.

Table 2 Participants' Initial Conception Profile

Concept Number	Participants' Number										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1.	-	-	-	-	-	-	-	-	-	-	-
2.	-	-	-	-	-	-	-	-	-	-	-
3.	-	-	-	√	-	-	-	-	√	-	-
4.	-	-	-	-	-	-	-	-	√	-	-
5.	-	-	-	√	√	-	-	√	-	√	-
6.	√	√	-	√	√	√	√	√	-	√	-
7.	-	√	√	×	-	×	×	-	-	-	-
8.	-	-	-	-	-	×	-	-	×	-	√
9.	√	√	×	√	-	×	-	-	-	-	-
10.	√	√	√	-	√	√	×	√	√	-	-
11.	-	-	-	-	-	-	-	-	-	-	√
12.	-	-	-	-	-	√	-	-	-	-	-
13.	-	-	-	-	-	-	-	√	-	-	√
14.	-	-	-	-	-	-	-	√	-	-	-
15.	-	-	-	-	-	-	-	-	-	-	-
16.	-	-	×	-	-	-	-	-	-	-	-
17.	-	-	-	-	-	-	-	-	-	-	-
18.	-	-	-	√	-	-	-	-	-	-	-
19.	-	-	-	-	-	-	×	-	-	-	-
20.	√	√	-	-	-	√	×	√	√	-	-
21.	-	-	-	-	-	-	-	×	√	-	-
22.	√	√	-	√	√	√	-	√	√	-	-
23.	-	-	-	-	-	-	-	-	-	-	-
24.	-	-	√	-	-	√	-	-	-	√	-
25.	-	-	-	-	-	-	-	-	-	√	-
26.	√	√	√		-	-	-	-	√	√	-
27.	√	√	-	√	-	-	-	√	-	√	√
28.	-	-	-	-	-	-	-	-	-	-	-
29.	-	-	-	√	-	-	-	-	×	√	-
30.	√	√	-	√	√	-	-	√	×	√	-
31.	-	-	×	-	-	-	×	-	-	-	-
32.	-	-	-	√	-	-	-	-	-	-	-
33.	-	-	-	-	-	-	-	-	-	-	-
34.	√	√	×	×	×	×	×	-	√	√	-
35.	-	-	-	-	√	√	×	-	-	-	-
36.	-	-	×	√	×	×	-	×	√	√	-
37.	-	-	-	√	-	-	-	-	-	-	-
38.	√	√	-	-	-	-	-	√	-	√	-
39.	√	√	-	-	√	-	-	√	√	√	√
40.	√	√	×	-	-	×	-	√	×	-	-

Information: √ = Understand the concept; - = Experiencing misconceptions; × = Do not understand the concept

Based on Table 2, it was found that there were no concepts understood by all participants, there were seven concepts (1, 2, 15, 17, 23, 28, and 33) that all participants had misconceptions about. There are 15 concepts that are not understood by at least 1 participant. If we calculate the percentage of concept participant cells, we get data from 440 "concept participant" cells. The profile shows that only 21.6% (95 cells) indicate that the teacher understands a certain concept. 5.5% (24 cells) did not understand the concept, while the largest number 72.9% (321 cells) experienced misconceptions. The Conception Profile of Participants after Remediation is shown in Table 3.

Table 3 The Conception Profile of Participants' after Remediation

Concept Number	Participants' Number										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1.	√	√	-	√	√	√	√	-	√	-	-
2.	√	√	-	√	√	√	√	-	√	-	-
3.	√	√	√	√	√	√	√	-	√	-	-
4.	√	√	√	√	√	√	√	-	√	-	-
5.	√	√	√	√	√	√	√	√	√	√	-
6.	√	√	√	√	√	√	√	√	√	√	-
7.	√	√	√	√	√	√	√	-	√	-	-
8.	√	√	√	√	√	√	√	-	√	-	√
9.	√	√	√	√	√	√	-	-	√	-	-
10.	√	√	√	√	√	√	√	√	√	-	-
11.	-	-	-	√	√	√	√	-	√	-	√
12.	√	√	√	√	√	√	√	-	√	-	-
13.	√	√	√	√	√	√	√	√	√	-	√
14.	√	√	√	√	√	√	√	√	√	-	-
15.	√	√	√	√	√	√	√	-	√	-	-
16.	√	√	√	√	√	√	√	-	√	-	-
17.	√	√	√	√	√	√	√	-	√	-	-
18.	√	√	-	√	√	√	√	-	√	-	-
19.	√	-	√	√	√	√	√	-	√	-	-
20.	√	√	√	√	√	√	√	√	√	-	-
21.	√	√	√	√	√	√	√	×	√	-	-
22.	√	√	√	√	√	√	√	√	√	-	-
23.	√	√	√	√	√	√	√	-	√	-	-
24.	√	√	√	√	√	√	√	-	√	√	-
25.	√	√	√	√	√	√	√	-	√	√	-
26.	√	√	√	√	√	√	√	-	√	√	-
27.	-	-	√	√	√	√	√	√	√	√	√
28.	√	√	√	√	√	√	√	-	√	-	-
29.	√	√	√	√	√	√	√	-	√	√	-
30.	√	-	-	√	√	√	√	√	√	√	-
31.	√	√	-	√	-	-	√	-	√	-	-
32.	√	√	-	√	√	√	√	-	√	-	-
33.	√	√	√	√	√	√	√	-	√	-	-
34.	√	√	√	√	√	√	√	-	√	√	-
35.	√	√	√	√	√	√	√	-	√	-	-
36.	√	√	√	√	√	√	√	×	√	√	-
37.	√	√	√	√	√	√	√	-	√	-	-
38.	√	√	√	√	√	√	√	√	√	√	-
39.	√	√	-	√	√	√	√	√	√	√	√
40.	√	-	-	√	√	√	√	√	√	-	-

Information: √ = Understand the concept; - = Experiencing misconceptions; × = Do not understand the concept

Based on Table 3, it was found that 39 concepts were understood by at least 70% of the participants; only one concept was understood by 60% of the participants. There was only one participant who still did not understand two concepts. The following is the final condition of each participant.

1) Participant 1: Concept eleven remains a misconception, Concept 27 becomes a misconception, previously understood, besides that there was a shift to understanding concepts
2) Participant 2: Concept eleven remains a misconception, concepts 27 and 30 become misconceptions
3) Participants 3: Concepts 1, 2, 11, 30, 31, 32, 39, and 40 remains a misconception.
4) Participant 4: is complete, meaning that all concepts are understood
5) Participants 5 and 6: only have one concept that is misconceived, namely the image formed by a concave mirror.
6) Participants 7: only had one concept of experiencing a misconception, namely the concept of anaerobic respiration.
7) Participant 8: did not experience any change from the situation in the initial test, namely twelve concepts had been understood, two concepts were not understood, and 26 concepts still had misconceptions.
8) Participant 9: 40 concepts have been understood (completed).
9) Participant 10: Still twelve concepts are understood, the rest have misconceptions

10) Participant 11: Did not take the final test, so the conception profile remained.

Overall the shift occurred significantly. Most of the responses have understood (understand the concept), only two concepts that have not been understood by one participant.

When viewed from the matrix of concept test participants, out of 440 cells, it was understood: in 106 (24.1%), still experiencing misconceptions, two cells (0.5%), did not understand the concept and 332 cells (75.5%) had understand the concept. Forty concepts were tested as in the appendix.

The results of the diagnostic test to record the participants' initial conceptions, have found that most of the participants (72.9) experienced misconceptions. This condition supports the findings of previous studies (Ibrahim, 2012; Ainiyah et al., 2017; Mawaddah et al., 2020; Naz & Nasreen, 2013; Gültekin & Topsakal, 2014; Köse 2008). Thus, during the last ten years (2012-2022) there has not been a significant change in the condition of the misconceptions of the concepts tested. Various efforts have actually been made, for example through writing books on concepts and misconceptions and how to learn them (Ibrahim, 2012), teacher training through various projects including the Science Education Quality Improvement Project in collaboration with the Germany government. Reconstruction of misconceptions has also been done (Taufiq, 2012; Chairunnisa et al., 2016; Sutrisno et al., 2018; Dosinaeng et al., 2021). However, conceptual errors still occur to teachers, students, and even teacher and student handbooks.

Conceptual errors in book writing are strongly suspected (1) the author of the book reads another equivalent book as a reference. For example, a teacher writes a book, referring to a similar book written by someone else. There has not been an optimal effort to dig up information from higher quality sources that are used as a reference for writing books. (2) There has been no maximum effort to try to confirm the truth of concepts with facts in nature, even though it is an open secret that facts are the judges who determine the truth of a concept, especially the science concept. (3) Each concept consists of five elements, namely the name (label), understanding (definition), characteristics (attributes), examples (example), and value (value/benefit).

Conceptual errors experienceed by elementary school book writers, teachers, and students are in understanding, on characteristics, or on examples (Ibrahim, 2012). The understanding made is often not confirmed with other concepts that have been declared as truth, thus causing a conflict with other concepts that have been declared true and there is no attempt to criticize the errors that occur, because they may not be realized. For example, anaerobic respiration is respiration that does not require oxygen. This understanding must be considered as a misconception, because it contradicts other concepts which state that respiration is a reduction and oxidation reaction. It is well recognized as a correct conception that oxidation requires oxygen.

In other cases, errors arise because the author of the book and also the teacher/student uses characteristics that are easily visible, when asked about the characteristics of a concept. Take for example: if asked what are the characteristics of birds, it is almost certain that the teacher/student will say that the characteristics of birds are wings, can fly, beak, lay eggs, etc. In the iPad research, it is true that what is mentioned is a characteristic possessed by birds, but what is not understood is that not every characteristic can be a characteristic (attribute) of a concept. The characteristics (attributes) of the concept are differentiator of a concept with other concepts. Characteristics are found in all examples of the concept and are not found in non-examples of the concept. Winged birds are true, but not a feature, because wings are also owned by other animals that are not birds. Can fly is characteristic of most birds, but there are other animals that also fly like butterflies, while there are members of birds that cannot fly such as ostrich, cassowary, etc.

The findings of the two studies are related to the effectiveness of the P2OC2R learning model. This learning is effective because it starts from the participants' own conceptions, namely when they are asked about their conceptions of certain concepts. Then they are guided to test their conception with facts. It's possible that when they are shown facts they still haven't changed their conception, but when other consistent facts are shown, they end up changing their conception. One of the properties of misconceptions is resistance. People who experience misconceptions really believe that their conception is correct and therefore they are difficult to change and always try to defend their wrong conception. In P2OC2R resistance can be reduced by inviting observations on some examples of concepts.

The implication of the results of this study is the need to change the concept learning strategy. So far, learning concepts using a concept acquisition model that is carried out inductively from examples often occurs, because students find it difficult to find attributes of the concepts they

learn because they require observation on more examples. By doing concept learning using P2OC2R is more effective, because it starts from the conception of the learner. If there is a wrong conception, it is enough to show evidence/argument that the conception is wrong and show the right thing so that it does not require addressing in many examples.

D. Conclusion

Based on the facts obtained from this study, it can be concluded that there are still misconceptions among elementary school teachers in Krembung Sidoarjo district, related to 40 science concepts. In addition, it can also be concluded that remediation using the P2OC2R model has been able to change the participants' conceptions in a positive direction, namely from misconceptions and not understanding the concept to understanding the concept, although it was found that there were participants who still persisted for one or two of their conceptions.

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