

How Do Science Content Misconceptions Occur in Primary School Teachers with Teaching Certificates?

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Abstract. Misconceptions are understandings of concepts that are not in accordance with scientific concepts. Teachers have the potential to experience misconceptions and misconceptions that occur in teachers can result in students also experiencing misconceptions. Research that examines science misconceptions in elementary school teachers is still rare, so there is a need for research examining science misconceptions in elementary school teachers, especially in elementary school teachers who are certified educators. Therefore, this study aims at determining whether science misconceptions occur in elementary school teachers with teaching certificates or not and how much misconceptions are experienced and the misconceptions occurred. This study employs descriptive quantitative by involving 17 certified elementary school teachers who are classroom teachers teaching several subjects in elementary schools including science subjects. Data collection was done by conducting a four tier misconception diagnosis test and the result was analyzed using by referring to four tier test concept developed by various researchers. The findings indicated that primary school teachers possessing teaching certificates exhibited science misconceptions at a rate of 22%, placing them in the low category of scientific understanding at 66%. Despite the relatively low occurrence of misconceptions, it is advisable for certified primary school teachers to further enhance their grasp of the concepts they impart to prevent any potential hindrance to the learning process.

Keywords: Educator Certificate, Misconception, Natural Science, Primary School, Teacher.

1. Introduction

Science is one of the subjects that must be taught. Science subject has an important role, especially in improving students' scientific knowledge, and skills in everyday life (Kanlı & Yavaş, 2021; Ozkan & Topsakal 2021). With the content of science lessons, students are expected to be able to think critically and scientifically and be able to solve the problems they face (Arnold et al., 2021; Maryani et al., 2021; Baysal et al., 2022).

Understanding knowledge concepts is an important part of the science learning process (Sari & Abduh, 2022; Munastiwi et al., 2022). It cannot be taught only by memorizing and listening to teacher's explanations. The selection of appropriate and effective learning strategies must be carried out by teachers to develop students' conceptual understanding and avoid misconceptions (Mubarokah et al., 2018; Kulgemeyer et al., 2020). An effective form of learning that is appropriately used in science learning is active learning, which consists of observation, experimentation, and simulation to invite students to think critically and be actively involved during the learning process (Schalk et al., 2019; Cherbow et al., 2020; Hamna & Ummah BK, 2022). If the content of science lessons is only carried out by memorizing and listening to teacher's explanations, it might cause misconceptions because students are less active in the learning process (Kulgemeyer et al., 2020).

Misconceptions are misunderstandings of scientific concepts or understandings that are not in accordance with the explanation of scientific concepts (Vasconcelos, 2023). Misconceptions can occur in various subject contents including science. Misconceptions are difficult to change and will be carried for a long time (Bayuni et al., 2018; Tapia et al., 2019). Misconceptions can be an obstacle for students in learning science because they are unable to understand the

concepts they learn, cannot solve problems and learning objectives will not be achieved (Halim et al., 2018; Nurjani et al. 2020; Resbiantoro et al., 2022). The indicators that cause misconceptions consist of five indicators, namely students themselves, books, context, teachers, and teaching methods (Gusmalini, 2020).

Teachers have an obligation to reduce and remediate misconceptions experienced by students (Qian et al., 2019; Reydon, 2021; Resbiantoro et al., 2022). Primary school teachers are teachers who teach all subject content in primary schools (Kikas, 2004; Aningsih et al., 2022), so they must have a good understanding of concepts. They must be able to understand scientific topics and concepts well and correctly so that students can have a good understanding, because they are a key factor in developing students' thinking skills (Banawi et al., 2019).

1.1. Problem Statement

Misconceptions are often experienced by students, but it does not rule out the possibility that teachers also experience misconceptions. According to Härmälä-Braskén et al., (2020) and Fauzan et al., (2023) there are several studies that show that misconceptions are not only experienced by students but also teachers. Factors causing misconceptions in teachers include a low level of reasoning, lack of learning resources, limited information, lack of mastery of the field, and cumulative misconceptions experienced by teachers while still in school (Potvin & Cyr, 2017; Hala et al., 2018; Resbiantoro et al., 2022). Misconceptions that occur in teachers can cause students to also experience misconceptions (Yates & Marek, 2014; Tapia et al., 2019; Taban & Kiray, 2022) and if misconceptions occur at the elementary school level, it will cause continuous misconceptions at the next level (Sari et al., 2019; Tapia et al., 2019).

Studies related to misconceptions are fundamental considering that misconceptions is not just a learning obstacle but can be a starting point in conceptual improvements for learning, determining appropriate learning strategies, and advancing the field of educational research (Maskiewicz & Lineback, 2013; Lewis, 2021). Previous studies have examined many science misconceptions that occur in students and prospective teachers, but rarely found research that examines misconceptions in elementary school teachers. This was also revealed by Desstya et al. (2019a) in their research that research examining misconceptions in elementary school teachers is still very rare. Based on the results of searches related to science misconceptions in elementary school teachers in various research journals and various keywords, there are only a few studies that examine science misconceptions in elementary school teachers, so research examining misconceptions in elementary school teachers is important to do.

The assumption that many elementary school teachers have poor science content and low understanding of scientific concepts (Kikas, 2004; Awad & Barak, 2018; Novak & Wisdom, 2018; Anggoro et al., 2019; Fokides et al., 2020; Chen & Mensah, 2022), makes the reason in this study involving educator certified teachers, because they have better performance than those who are not (Tjabolo & Herwin, 2020). In other studies, it is said that teachers with teaching certificates have professional competence, namely being able to master the content of the lesson well and have a complete understanding of the concepts (Hermita et al., 2019; Huda et al., 2021; Daga et al., 2023). Although there are studies that say that certified teachers master the concept well and have a complete understanding of the concept, there has not been any studies examining science misconceptions in elementary school teachers with teaching certificates, thus conducting research on misconceptions among elementary school teachers with teaching certificates is crucial.

1.2. Related Research

Research on this study includes a study by Laksana et al. (2017), revealing that elementary school teachers exhibited misconceptions at a rate of 31%, possessed a mastery of scientific concepts at 25.5%, and 43.6% lacked proficiency in the material. A study by Widodo et al. (2017) reported that elementary school teachers engaged in a professional certification program had misconceptions at 42.4%, mastered scientific concepts at 36.5%, and lacked understanding of the concepts at 21.2%. Additionally, Desstya et al. (2019b) conducted research indicating a prevalence of science misconceptions among elementary school

teachers at 80.12%. Furthermore, various other studies delve into the examination of science misconceptions among elementary school teachers.. In addition, other existing studies have been conducted on elementary school teachers who are currently participating in a professional certification program so that they are not yet certified educators. The difference between this study and previous ones is that this study focuses on examining science misconceptions in educator-certified elementary school teachers who have taught as educator-certified elementary school teachers.. Research on science misconceptions in elementary school teachers with teaching certificates helps determine if teachers with teaching certificates have science misconceptions and to what extent they experience them.

1.3. Research Objectives

Considering the previous studies highlighting science misconceptions among elementary school teachers, poor science content and low understanding of scientific concepts in many teachers, it becomes relevant to investigate whether certified teachers also encounter science misconceptions. If so, understanding the extent of these misconceptions and their underlying causes is crucial. This study aims to determine whether primary school teachers with teaching certificates experience science misconceptions, the extent of science misconceptions experienced, its description. The expected result of this research is as a motivation for teachers to continue improving their competence, especially in mastering the material so that they can avoid misconceptions.

2. Theoretical Framework

2.1. Educator Certified Teachers

Educator certified teachers are teachers who have participated in a certification program designed by the Indonesian government to improve teacher professionalism and passed the performance and knowledge tests (Faisal & Martin, 2019; Suyatmini et al., 2020; Fatimah et al., 2021). Teachers who are certified educators can be said to be professional teachers (Purwantiningsih & Suharso, 2019; Soenarto et al., 2021; Firmansyah et al., 2022). Professional teachers have four competencies, namely pedagogical, personality, social, and professional competencies (Kartowagiran, 2020; Daga et al., 2023). Teachers' professional competencies include being able to master the content of the lesson well (Wiener et al., 2018; Daga et al., 2023), characterized by having a complete understanding of concepts, laws, principles and principles and free from misconceptions (Hermita et al., 2019).

2.2. Misconception

Misconceptions are misunderstandings of scientific or understandings of concepts that are not in accordance with the explanation of scientific concepts (Vasconcelos, 2023). Misconceptions can occur in various subject, one of which is science . Misconceptions that are increasingly developing in students will be difficult to be corrected and might be carried for a long time (Bayuni et al., 2018; Tapia et al., 2019). Misconceptions in students can hinder the learning process and students' scientific understanding, therefore students cannot solve problems in everyday life (Halim et al., 2018; Nurjani et al. 2020; Resbiantoro et al., 2022). Misconceptions can occur to anyone including teachers (Kikas, 2004; Fauzan et al., 2023). Misconceptions experienced by teachers can potentially lead to the development of similar misconceptions among students. (Yates & Marek, 2014; Tapia et al., 2019; Taban & Kiray, 2022). Teachers must diagnose misconceptions before carrying out learning (Resbiantoro et al., 2022; Taban & Kiray, 2022), so that if teachers experience misconceptions, efforts can be made considering teachers as the key factor in developing students' scientific thinking skills who have obligations to reduce and remediate misconceptions experienced by students (Banawi et al., 2019; Qian et al., 2019; Reydon, 2021; Resbiantoro et al., 2022).

3. Method

3.1. Research Design

This study employs descriptive quantitative research. Descriptive quantitative research allows a researcher to describe a particular situation through numerical data and describe a particular data sample (Johannesson & Perjons, 2014; Roni et al., 2019). The form of descriptive quantitative research is to display research results through graphs, bar charts, or tables to display very detailed data (Johannesson & Perjons, 2014). In accordance, this study aims to describe the misconceptions of educator-certified primary school teachers through numerical data and describe the misconceptions that occur in educator-certified primary school teachers.

3.2. Respondent

The population in this study were educator-certified primary school teachers. The samples were determined using purposive sampling. Purposive sampling is a sample determined by certain criteria by the researcher for purposes relevant to the research (Andrade, 2021). Purposive sampling is very useful in situations where researchers need information for a specific target group (Stockemer, 2018). The researcher plans to select certified elementary school teachers from grades 4, 5, and 6 for the study. This decision is based on the fact that, under the 2013 curriculum, science lessons in grades 1, 2, and 3 are integrated with other subjects, and the independent curriculum with dedicated science content for each grade level has not been fully implemented yet. With these considerations, high accuracy data would be obtained. This study was conducted in the city of Surakarta with a sample of 17 educator-certified primary school teachers from several primary schools from 5 different sub-districts. Of the 17 certified primary school teachers, all were classroom teachers who taught a variety of subjects in primary schools including science.

3.3. Data Collection

Data collection in this study was carried out by giving a written misconception diagnosis test to the participants using the four tier test. The four tier diagnosis test is the most powerful misconception measurement tool than other measurement tools and has a fairly high accuracy because it measures the confidence of answers on content and reasoning so that it can distinguish between misconceptions and lack of knowledge (Caleon & Subramaniam, 2010; Kaltakci-Gurel et al., 2017; Anam et al., 2019; Kiray & Simsek, 2021). The Four tier misconception diagnosis test has 4 levels, namely the first level contains multiple choice content (responses), the second level contains the level of confidence in the answer at the first level, the third level contains the reason for choosing the answer at the first level (conceptual), and the fourth level contains the level of confidence in the answer at the third level (Kaltakci-Gurel et al., 2017; Istiyono et al., 2022).

The development of the misconception diagnosis test in this study was carried out in several stages. The initial stage of development was carried out by dividing the science subject matter based on the content standards stipulated in the Regulation of the Minister of Education, Culture, Research and Technology of the Republic of Indonesia. The next stage is to compile indicators of misconception diagnosis test presented in Table 1. The next stage is to look for material in students' textbooks that has the opportunity to have misconceptions and link it to scientific research journals indexed by WoS, Scopus, and Google Scholar and then compile materials that have might lead to misconceptions into a four tier misconception diagnosis test.

Table 1. Indicators of Misconception Diagnosis Test

No	Content Standards	Diagnosis test indicators
1.	Living Things and Life Processes	Able to understand how living things obtain food
		Able to understand animal classification
2.	Objects and their Properties	Able to understand the concept of mass in objects

		Able to understand concepts related to changes in the form of objects
3.	Energy and its Changes	Able to understand the concept of Earth's gravitational force
		Able to understand the concept of sound
		Able to understand the concept of heat transfer
4.	Earth and Universe	Able to understand the Earth's revolution
		Able to understand the characteristics of planets in the solar system

3.4. Data Analysis

Data in the form of teacher answers that have been obtained from the results of the four tier misconception diagnosis test were categorized according to the decisions put forward by Istiyono et al. (2022), Kiray & Simsek, (2021), and Taban & Kiray, (2022) which are presented in Table 2.

Table 2. Four Tier Test Decision Making for Misconception Diagnosis

Decision	Answer			
	First level	Second level	Third level	Fourth level
Scientific understanding	True	Sure	True	Sure
False Negative	False	Sure	True	Sure
False Positive	True	Sure	False	Sure
Misconceptions	False	Sure	False	Sure
Lack of Knowledge	True	Sure	True	Not sure
Lack of Knowledge	True	Not sure	True	Sure
Lack of Knowledge	True	Not sure	True	Not sure
Lack of Knowledge	True	Sure	False	Not sure
Lack of Knowledge	True	Not sure	False	Sure
Lack of Knowledge	True	Not sure	False	Not sure
Lack of Knowledge	False	Sure	True	Not sure
Lack of Knowledge	False	Not sure	True	Sure
Lack of Knowledge	False	Not sure	True	Not sure
Lack of Knowledge	False	Sure	False	Not sure
Lack of Knowledge	False	Not sure	False	Sure
Lack of Knowledge	False	Not sure	False	Not sure

Misconceptions involve believing an incorrect answer is right, contradicting scientific concepts; In a four-tier misconception diagnosis test, individuals are considered to have misconceptions if they confidently choose incorrect answers in the first and third levels but correctly answer the third and fourth levels. Uncertain responses are classified as a lack of knowledge. (Taban & Kiray, 2022). False positive is categorized as an incorrect conception with a correct response. False negative is categorized as a correct conception with a wrong response.

Furthermore, the categorized were calculated using the formula proposed by Prodjosantoso et al. (2019):

$$\% = \frac{\sum k \text{decision category}}{\sum \text{sample}} \times 100\%$$

The findings data were presented in the form of a percentage graph. In addition, the percentage of misconceptions obtained were analyzed based on the misconception magnitude category according to Prodjosantoso et al. (2019) presented in Table 3.

Table 3. Misconception magnitude level

Category	Misconception percentage
Low	0% – 30%
Medium	31% – 60%
High	61% – 100%

Furthermore, the scientific concepts and misconceptions experienced by teachers were be analyzed descriptively.

3.5. Validity and Reliability

The validity and reliability tests of the research instrument in the form of a four tier misconception diagnosis test were carried out through several methods. Testing the four tier test can be done by expert validity, Pearson, false positive & false negative, and factor analysis for validity testing; meanwhile reliability tests are performed by Cronbach alpha, KR-20, and Pearson (Kaltakci-Gurel et al., 2017; Kiray & Simsek, 2021; Taban & Kiray, 2022; Çelikkanlı & Kızılıçık, 2022). In this study, the validity test was carried out using expert validity, Pearson, and false positive & false negative tests, while the reliability test was done using KR-20.

The expert validity test in this study involved 1 expert. Pearson validity test was conducted by correlating the correct answer score and the confidence score (Kaltakci-Gurel et al., 2017; Kiray & Simsek, 2021), so three different correlations were calculated, namely between the correlation of the first and second level answer scores with the result of 0.561, the correlation of the third and fourth level answer scores with the result of 0.576, the correlation of the first third level answer score and the second fourth level with the result of 0.573. The recommended validity of false positives and false negatives is the probability of false positives and false negatives less than 10% each (Arslan et al., 2012; Kiray & Simsek, 2021). The false positive score obtained was 7%, while the false negative score was 1%.

Reliability test KR-20 was calculated based on the reliability coefficient of scientific knowledge and misconceptions (Kiray & Simsek, 2021; Taban & Kiray, 2022), the results obtained were 0.728 and 0.636, respectively. Four tier tests to diagnose misconceptions are different from normal tests. In a normal test, the KR-20 reliability coefficient should be higher than 0.70, while this number may be lower to determine misconceptions (Kiray & Simsek, 2021). The reliability coefficient of misconceptions in this study is acceptable because it is above 0.50 (Kiray & Simsek, 2021).

4. Findings

Based on data obtained from research on science misconceptions using the four tier misconception diagnosis test, it shows that certified primary school teachers experienced science misconceptions with the results presented in Figure 1.

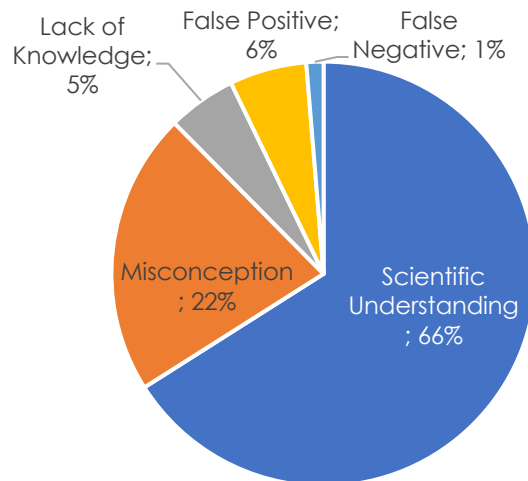


Figure 1. Percentage of Natural Science Misconceptions Among Certified Elementary School Teachers

Figure 1 above reports that primary school teachers with teaching certificates experienced science misconceptions of 22% with scientific understanding of 66%, false positive of 6%, false negative of 1%, and lack of knowledge of 5%. The most misconceptions were in the content standards of energy and its changes as much as 8%, while the smallest misconceptions occurred in the content standards of the Earth and the universe as much as 1%. In the content standards of Living Things and Life Processes, there were 3% and in the content standards of Objects and their Properties were 7%. The results of the misconception diagnosis test using the four tier test, scientific answers and misconceptions in primary school teachers with teaching certificates are presented in each content standard as follows:

4.1. Living Things and Life Processes

In this content standard, two misconception diagnosis test questions are presented. In the first question, the teachers were given questions related to how plants obtain food. In the second question, the teachers were given questions related to the classification of living things that do not belong to the fish species. The diagnosis test questions were developed based on the material contained in the learner textbook or student book. The results are described in Table 4.

Table 4. Scientific Answers and Misconceptions in the Content Standards of Living Things and Life Processes.

No	Scientific Answers		Misconception	
	Response	Reason	Response	Reason
1.	Plants obtain food through the process of photosynthesis	Plants obtain food in the form of glucose by making it themselves through the process of photosynthesis; plants can cook their own food through the process of photosynthesis with the help of sunlight; photosynthesis is the process of plants making their own food with the help of sunlight.	Plants obtain food from water and nutrients that they absorb through their roots; plants obtain food from water that they absorb through their roots.	Water and nutrients are the main food for plants; without water and nutrients plants will die because plants do not get food.
2.	Whales are not a type of fish	Whales belong to the mammal class; whales breathe with their lungs, give birth and nurse their calves	Eels are not a type of fish	Eels can live in mud; eels don't look like fish; eels don't have the characteristics of fish.

4.2. Objects and their Properties

In this content standard, two misconception diagnosis test questions are presented. In the first question, the teachers were given questions related to the meaning of mass in objects to reveal the teacher's understanding of the difference between mass and weight in objects. In the second question, the teachers were given questions related to the change in the form of objects, namely the change in the form of crystallized objects that occur in ice flowers in the freezer or refrigerator. The text form of the second question is presented narratively, "Someone puts meat in the freezer and after a few days the meat is filled with ice flowers, what changes in the shape of objects occur in ice flowers?". The diagnosis test questions were developed based on the material contained in the learner textbook or student book. The results are described in Table 5.

Table 5. Scientific Answers and Misconceptions in the Content Standards of Objects and their Properties.

No	Scientific answer		Misconception	
	Response	Reason	Response	Reason
1.	Mass is the amount of matter possessed by an object	Mass is the amount of substance or material that makes up an object and mass is the material or substance contained in an object; mass is different from weight because mass is the amount of substance that makes up an object and if the mass of an object is more, the object will be heavier.	Mass is the weight of an object	Mass is the weight of an object, mass is not affected by the size of an object; mass is the size of an object.

2.	The change in the form of objects that occurs in ice flowers in a freezer or refrigerator is a change in the form of objects in a crystallized manner.	Water vapor undergoes a process of changing the form of objects in a crystallized manner to form ice flowers; water vapor changes its form to form ice flowers; and water vapor (gas objects) changes its form to ice flowers (solid objects) so that the process of changing objects occurs in a crystallized manner.	The change in the form of objects that occurs in ice flowers in a freezer or refrigerator is a change in the form of objects by freezing; condensing	Meat that is put into the freezer changes its form by freezing to form ice flowers; meat that is put into the freezer condenses into liquid and then the liquid freezes.
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4.3. Energy and its Changes

In this content standard, three items of misconception diagnosis test questions are presented. In the first question, the teachers were given a question related to the gravitational force of the earth, namely two objects, namely "a stone and a tissue dropped in a vacuum at the same height, what will happen?". In the second question the teachers were given a question related to heat with the question "Why can a jacket keep the body warm?". In the third question, the teachers were given a question related to the source of the sound of the gallon when taking drinking water from the gallon through the dispenser. The diagnosis test questions were developed based on the material contained in the learner textbook or student book. The results are described in Table 6 below.

Table 6. Scientific Answers and Misconceptions on Energy and its Changes Content Standard

No	Scientific answer		Misconception	
	Response	Reason	Response	Reason
1.	When the stone and tissue are dropped simultaneously from the same height in a vacuum, the stone and tissue will reach the bottom simultaneously.	If there were no air resistance, both would reach the bottom at the same time; because there is no air resistance, the stone and tissue will fall to the surface at the same time.	When the stone and tissue are dropped simultaneously at the same height in a vacuum the stone will reach the bottom first.	The mass of the stone is greater than the tissue so it falls faster; the stone is heavier than the tissue so it falls faster; because the tissue is very light, the tissue will float before falling; the tissue is held by the air.
2.	Jackets can reduce the release of heat on the human body	By wearing a jacket, the release of heat in the human body can be reduced because the jacket acts as an insulator; the jacket can hold the heat out of the body into the air with a low temperature because the jacket acts as insulation; the heat in the body does not escape to a colder place because it is blocked by the jacket because the jacket insulates the air; the jacket traps air so that the release of heat in the human body can be reduced.	Jackets have the property of keeping the body warm; they prevent the transfer of cold air into the human body.	Jackets can make the body warm; jackets can warm the body; jackets function as insulators that prevent the transfer of cold and hot air.

3.	The source of the sound when taking drinking water from the gallon through the dispenser is the vibration of the water and the air cavity in the gallon.	Sound comes from vibrating objects; vibrations in water and air can produce sound.	Air pressing on the water in the gallon; air pressure in the gallon; collision between air, water, and gallon	Pressure can produce sound; collisions between particles can produce sound
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4.4. Earth and the Universe

In this content standard, two misconception diagnosis test questions are presented. The first question is related to the time required by the Earth to orbit the Sun or the Earth's revolution in the form of days. The second test question is related to the characteristics of the planet, namely the planet Venus as the hottest planet in the solar system. The results are described in Table 7.

Table 7. Scientific Answers and Misconceptions in the Earth and Universe Content Standard

No	Scientific answer		Misconception	
	Response	Reason	Response	Reason
1.	The time it takes Earth to orbit the Sun is 365.25 days	The time required for the Earth to orbit the Sun is 365.25 days, the calendar lists 365 days therefore every 4 years on the calendar there is a leap year with the number of days in a leap year being 366 days.	The time it takes the Earth to orbit the Sun is 365 days	It takes 1 year or 365 days to revolutionize the Earth.
2.	Venus is the planet that has the hottest temperature because it is surrounded by a very thick atmosphere	Venus' thick atmosphere makes Venus very hot; Venus' thick atmosphere causes a greenhouse effect on Venus, making Venus the hottest planet	Mercury is the planet that has the hottest temperature because it is closest to the sun	Mercury's proximity to the Sun makes it the hottest planet in the solar system

5. Discussion

Based on the findings presented in Figure 1, primary school teachers with teaching certificates experienced science misconceptions of 22%. This figure shows that the science misconceptions experienced by primary school teachers with teaching certificates are low (Prodjosantoso et al., 2019). When compared with existing research examining science misconceptions with a mixed population of both teachers who are certified educators and teachers who have not been certified educators, the misconception rate in this study by only taking certified educators, the numbers of misconceptions that occur were lower and the numbers of scientific conceptions were also higher. In previous studies with a mixed population of both primary school teachers who have been certified educators and who have not been certified educators with more dominated by primary school teachers who have not been certified educators, the number of misconceptions occurred in the range of 40%-80% which was included in the category of moderate to high misconceptions, with a scientific understanding level of 14%-55%.

Although the science material in elementary school is quite simple, this study revealed that there are certified teachers who experienced misconceptions and lack of knowledge in teaching, even though the concepts tested in this study are contained in the students'

textbooks. Another study mentioned that school teachers have the same misconceptions as children aged 6-12 years (Härmälä-Braskén et al., 2020). The misconceptions experienced by teachers in this study and the actual scientific concepts cited from various studies are presented in the paragraphs below.

The misconception experienced by teachers on the concept of plants obtaining food is that teachers assume that plants obtain food from the soil, and water and minerals taken from the soil. The correct scientific concept of plants obtaining food is that plants make their own food through the process of photosynthesis, while plants obtain food from the soil, and water and minerals taken from the soil is a wrong conception (Woldeamanuel et al., 2020; García-Fernández, 2022; Mekonen & Kelkay, 2023). Photosynthesis is the process by which plants produce their own food in the form of glucose (Hoogerheide et al., 2019; Woldeamanuel et al., 2020; Wanselin et al., 2023). The process of photosynthesis occurs in chloroplasts with the scheme $\text{water} + \text{carbon dioxide} + \text{light} \rightarrow \text{glucose and oxygen}$ (Hoogerheide et al., 2019; Woldeamanuel et al., 2020).

Misconceptions experienced by teachers on the concept of animal classification, teachers assume that whales are a type of fish, besides that the teacher thinks that eels are not a type of fish. Scientifically, whales are not a type of fish, because whales are a type of mammal (Berta, 2015; Shields, 2020). Categorizing whales as fish is a misconception (Jung, 2020; Ntshalintshali & Clariana, 2020; Dellantonio & Pastore, 2021; Kucuk, 2022). Whales are categorized as mammals because they have the characteristics of mammals, namely warm-blooded, lung-breathing, haired, giving birth, and nursing their young (Johansson, 2021; Chakraborty, 2021), while fish breathe with gills (Johansson, 2021). Eels are often considered not to be a group of fish because their body shape does not look like a typical fish. Scientifically, eels are a type of fish (Drouineau et al., 2018; Chakraborty, 2021).

The misconception experienced by teachers on the concept of mass is that teachers think that mass is the weight of an object. Scientifically, mass is the amount of material possessed by an object (Stein et al., 2015; May, 2023). Simply put, mass is the amount of material that makes up an object. Objects that have a greater mass (building blocks) will have a greater weight. Mass is different from weight (Stein et al., 2015). The definition of weight itself is a measure of the gravitational force acting on an object (Tural et al., 2010; Stein et al., 2015).

The misconception experienced by teachers on the concept of changes in the form of objects is that teachers think that the changes in the form of objects that occur in ice flowers in the freezer are changes in the form of objects by freezing, besides that there are also teachers who think that changes in the form of objects occur by condensing. Scientifically, the cause of ice flowers in the freezer is actually the change of water vapor to freeze through the desublimation process (Malik et al., 2020; Hermes et al., 2021). Desublimation is the process of changing the form of objects from water vapor to ice without going through the liquid phase (Jitendra et al., 2022; Qi et al., 2022). The water vapor comes from the humidity of the object stored in the freezer and when opening the freezer door. Water vapor is included in gaseous objects and ice flowers are included in solid objects, so the change in the form of objects that occurs is a change in the form of objects in a crystallized manner.

The misconception experienced by teachers on the concept of Earth's gravitational force is that teachers assume that objects that have greater mass and weight if they are brought together simultaneously at the same height in a vacuum, objects that have greater mass and weight will reach the bottom first. Scientifically, Newton's law explains that where the time required for an object to fall if the resistance of the medium is ignored, the time required to fall depends only on the acceleration of gravity and distance (Syuhendri, 2019), meaning that in the motion of free-falling objects in both open space and vacuum, if objects with different masses are dropped simultaneously and from the same height, the objects will reach the bottom in relatively the same time, provided there is no air resistance (Anggoro et al., 2019). In a vacuum, there is no air resistance so that objects dropped simultaneously at the same height will touch the ground simultaneously regardless of their weight (Nussbaum et al., 2008). The

case in the problem above the stone and tissue are dropped in a vacuum, meaning that there is no air resistance, so that if the stone and tissue are dropped simultaneously at the same height, both will reach the bottom simultaneously.

Misconceptions experienced by teachers on the concept of heat transfer teachers assume that jackets prevent the transfer of cold air into the human body and there is also the assumption that jackets can warm the human body. Scientifically, heat moves from high temperature objects to objects that have lower temperatures (Rosebery et al., 2010; Hu et al., 2020) and heat can be released by an object that has heat energy to objects or areas that have lower temperatures (Rosebery et al., 2010; Åhman & Jeppsson, 2020). By wearing a jacket, it can reduce and prevent the release of heat in the human body (Rosebery et al., 2010; Hu et al., 2020; Permana & Kartika, 2021), because the jacket is actually an insulator made of materials that have excellent thermal insulation and low thermal conductivity (Lan et al., 2021). Jackets have body warming properties, meaning that jackets can produce heat and the heat will transfer to the human body so that the human body becomes warm, but scientifically this concept is wrong. Jackets do not produce heat but they can function as insulation in order to reduce and prevent the release of heat in the human body.

The misconception experienced by teachers on the concept of sound is that sound comes from air pressure and there is also an assumption that sound comes from collisions between particles. Scientifically, sound comes from vibrating objects (Pejuan et al., 2012; Volfson et al., 2021; Ferrando et al., 2023). In the case presented in the test, namely when taking water from a gallon through a dispenser, water will come out of the gallon and there will be air entering the gallon. The air will certainly rise to the surface. When the air rises to the surface, it will cause vibrations in the air cavity itself and in the water to produce sound.

The misconception experienced by teachers on the concept of Earth's revolution is that the time it takes for the Earth to orbit the Sun is 365 days. Scientifically, it takes 365.25 days for the Earth to orbit/revolve around the Sun (Goel et al., 2019). The Earth orbits the Sun takes 1 year and when converted into days the time required by the Earth is not 365 days as in the calendar, but 365.25 days. In the calendar the number of days listed is 365 not 365.25, therefore every 4 years there will be a leap year where the number of days in the leap year calendar is 366 days (Hanslmeier, 2023).

The misconception experienced by teachers on the concept of planetary characteristics in the solar system is that teachers assume that Mercury is the hottest planet in the solar system because Mercury is close to the Sun. Scientifically, the hottest planet in the solar system is Venus (Devecioglu-Kaymakci, 2016; Akcanca & Özsevgeç, 2020; Song et al., 2022). Venus' massive, CO₂-rich atmosphere creates a greenhouse effect that makes its surface the hottest in the Solar System on average (O'Rourke et al., 2023). Mercury is the closest planet to the sun, but it is not the hottest.

6. Conclusion

This study reveals that primary school teachers holding teaching certificates exhibit a 22% rate of science misconceptions, categorizing them in the low range, alongside a 66% proficiency in scientific understanding. Despite falling within the low category, rectifying these misconceptions is crucial, as they may potentially influence students and hinder the learning process. Certified elementary school teachers are encouraged to enhance their competencies, particularly focusing on mastering material concepts, to mitigate the occurrence of misconceptions in their teaching practices.

Limitation

The limitation of this study lies in the number of samples used because researchers have limited time so they cannot conduct research with more samples.

Recommendation

The researchers suggested that future research should examine the misconceptions of elementary school teachers who are certified educators using a larger sample with a broader scope of material and research to develop how the most effective method for reducing misconceptions in elementary school teachers, besides that the researcher also suggested that teachers continue to always deepen scientific concepts before teaching them to students.

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Conflict of Interest

There is no conflict of interest during this study and the publication of the article.

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