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ANALYSIS OF STUDENTS' MISCONCEPTIONS IN ANSWERING MULTIPLE CHOICE QUESTIONS ON MAGNETIC MATERIAL WITH THE HELP OF THE CERTAINTY OF RESPONSE INDEX METHOD

Fadilla Shafa Alyada Rahma[1*], Nur Ngazizah[2], Titi Anjarini[3]
[1.2.3]Universitas Muhammadiyah Purworejo, Indonesia
[1]fadilla@students.umpwr.ac.id

Abstract
The continuity of the learning process in elementary schools cannot be separated from students' understanding of basic concepts, especially in Science. One of the important topics in science is magnetism. However, many students face difficulties in understanding this concept, which is often caused by misconceptions or misunderstandings related to magnetic phenomena. This study aims to analyze students' misconceptions in answering multiple choice questions on magnetic material with the help of the Certainty of Response Index (CRI) method as a measuring tool. This research approach is descriptive qualitative with the subject of 22 grade VI students from one of the private schools in Purwodadi District. The results showed that 27% of students experienced misconceptions in magnetic material as a whole, with the highest misconceptions found in the indicator of determining materials that can be attracted by magnets at 55% and how to make magnets at 59%. In this study, the use of the CRI method can identify the level of understanding and misconceptions of students so that teachers can develop more effective strategies. The application of experiment-based learning and the use of interactive visual media can help reduce misconceptions and improve understanding of the concept of magnetism at the elementary school level.
Keywords: *CRI; IPA; Magnet; Misconceptions*

Abstrak
Keberlangsungan proses pembelajaran di sekolah dasar tidak dapat dipisahkan dari pemahaman siswa terhadap konsep-konsep dasar, khususnya dalam pelajaran Ilmu Pengetahuan Alam (IPA). Salah satu topik penting dalam IPA adalah kemagnetan. Namun, banyak siswa menghadapi kesulitan dalam memahami konsep ini, yang sering kali disebabkan oleh adanya miskonsepsi atau pemahaman yang salah terkait fenomena magnetik. Penelitian ini bertujuan untuk menganalisis kesalahpahaman siswa dalam menjawab soal pilihan ganda materi magnet dengan berbantuan metode *Certainty of Response Index* (CRI) sebagai alat ukur. Pendekatan penelitian ini adalah deskriptif kualitatif dengan subjek 22 siswa kelas VI dari salah satu sekolah swasta di Kecamatan Purwodadi. Hasil penelitian menunjukkan bahwa 27% siswa mengalami miskonsepsi dalam materi magnet secara keseluruhan, dengan miskonsepsi tertinggi ditemukan pada indikator menentukan bahan yang dapat di tarik magnet sebesar 55% dan cara pembuatan magnet sebesar 59%. Pada penelitian ini penggunaan metode CRI dapat mengidentifikasi tingkat pemahaman dan miskonsepsi siswa sehingga guru dapat menyusun strategi yang lebih efektif. Penerapan pembelajaran berbasis eksperimen serta penggunaan media visual yang interaktif dapat membantu mengurangi miskonsepsi dan meningkatkan pemahaman konsep magnetisme di tingkat sekolah dasar.
Kata Kunci: CRI; IPA; Magnet; Miskonsepsi

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Introduction

Science education is a fundamental part of the basic education curriculum that aims to build students' understanding of scientific concepts and their application in everyday life (Maryani & Atmojo, 2024). Science not only teaches facts and theories, but also develops critical thinking, problem solving, and evidence-based exploration skills that are essential for students' intellectual development (Nurulwati et al., 2024). At the elementary school level, science education plays an important role in forming initial concepts that will be the basis for understanding more complex material at the next level of education (Fajriyanti & Sayekti, 2022). Therefore, students' understanding of basic concepts in science must be obtained accurately so as not to cause misunderstandings that can hinder further learning. In line with the opinion of Harefa et al., (2020) that science education is included in important learning for students starting from elementary school because it emphasizes direct experience. This means that students not only learn about theory and product aspects, but also learn about processes through practice or experimentation.

Understanding concepts in science has a key role in the success of learning in elementary school. A good understanding of science concepts allows students to develop better scientific reasoning and be able to connect theories with phenomena around students (Darmastuti & Desstya, 2024). However, in practice, many students experience difficulties in understanding scientific concepts due to various factors, such as less interactive learning approaches, lack of direct experiments, and teaching materials that are not delivered contextually (Mariyadi & WA, 2023). Misunderstandings that persist in students can develop into misconceptions, which if not corrected immediately, will affect the way they understand other scientific concepts (Theobald & Brod, 2021).

Misconceptions are students' understanding that is not in accordance with academically accepted scientific concepts (Abdurahman et al., 2024). One area of science that often experiences misconceptions at the elementary school level is the concept of magnetism. Many students misunderstand the properties of magnets, how magnetic fields work, and the interaction between magnets and various types of materials (Muzakki et al., 2023). Several previous studies have shown that misconceptions in science can be long-lasting and difficult to correct, especially if learning is only text-based without exploratory activities that support concrete understanding (Wright et al., 2022). Therefore, it is important to identify and analyze students' misconceptions early on in order to design more effective learning strategies.

One method that can be used to analyze student misconceptions is the Certainty of Response Index (CRI). This method allows the measurement of students' level of confidence in the answers they give, thus revealing whether the wrong answers come from ignorance or deeply embedded misconceptions (Yolanda, 2021). This approach is superior to conventional evaluation methods because it not only assesses correct or incorrect answers, but also identifies students' mindset in understanding a concept (Jusniar et al., 2020). Thus, the use of CRI in this study is expected to provide deeper insight into the level of students' misconceptions about the concept of magnetism and provide a basis for developing more effective learning methods.

In this study, CRI was used as a diagnostic tool to identify students' misconceptions in the concept of magnetism. By measuring the level of confidence in students' answers, this method can distinguish between students who really understand the material and students who only answer randomly or have a wrong understanding. The results of the study are expected to provide deeper insights into the factors that contribute to misconceptions and the best ways to overcome them. By understanding the patterns of misconceptions that occur in students,

teachers can design more effective and evidence-based learning strategies to reduce misconceptions and improve students' overall conceptual understanding.

Research Methods

This study used a qualitative descriptive approach to analyze students' misconceptions in understanding the concept of magnetism. The selection of schools and classes was based on the consideration that this school has a representative curriculum and students with varied academic backgrounds. In addition, the selected class was grade VI with a total of 22 students because magnetism material has been taught in this level of curriculum and is often a source of misconceptions among students. The data collection methods used include interviews, documentation, and assessment.

The interview was conducted by the researcher with the subject under study, there is a question giver and the one who answers the question. Interview data collection in this study will be carried out to improve the clarity and accuracy of findings on students who experience misconceptions. The interview technique used is a structured interview using an interview sheet instrument. Furthermore, documentation is done by collecting data related to the documents used by students in answering questions on magnetic material using the Certainty of Response Index (CRI) method. The assessment in this study used a test sheet instrument, where the test sheet contained a multiple choice test of 16 questions, equipped with the Certainty of Response Index (CRI) confidence level.

In this study, the triangulation method was carried out by comparing the results of multiple choice tests equipped with the Certainty of Response Index (CRI) with student interviews and documentation. This approach ensured that the misconceptions identified were not only derived from the test answers, but also confirmed through direct interviews with students to understand the reasons behind their answers. Documentation in the form of written notes and pictures was also used to strengthen the research findings by providing visual evidence of how students understood the concept of magnetism.

This study used CRI to test the learning process regarding students' confidence in their capacity to select and apply the information that students get, which requires students to show their level of confidence in the answers that students choose according to the criteria outlined in Table 1.

Table 1. CRI Value and Criteria

CRI Value	Criteria
0	Overall Guessing Answer
1	Some Answers Guess
2	Not Sure
3	Sure
4	Almost Understand
5	Very Understand

Source. (Yolanda, 2021)

In the criteria above, the number 0 indicates that the student does not know the material at all, while the number 5 indicates that the student understands and is sure that the answer is correct according to the concept. This CRI shows when students answer questions at the same time students measure their level of understanding of the questions given. If the CRI value is low (0-2), then the answer chosen by guessing and indicating that the student does not understand the concept. If the CRI is high (3-5), the confidence in the answer that students give

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means high and sure. For this, if the student's answer is correct, then the student has high confidence in their mastery of the concept they are learning. If it is wrong, this will be assessed as an error in understanding the concept, this is what is identified as a misconception. This CRI takes place as long as students answer the test with the option of confidence in the correctness of the answer in each item. The results of the test will be processed with existing provisions and criteria.

Furthermore, calculating the percentage of research results from the criteria of guessing, almost guessing, not sure, sure, almost correct, correct on each indicator using the formula:

$$P = \frac{f}{n} \text{ x } 100\%$$

Description:

P = percentage number (%)

f = number of students in each group

N = number of groups (total number of students who were used as research subjects)

After calculating the percentage of misconceptions, researchers calculated the average of each indicator. Furthermore, the results were grouped based on the assessment categories in Table 2.

Table 2. Percentage of Misconception Assessment

Percentage	Tiers
0-30%	Low
31-60%	Medium
61-100%	High

Then the researcher describes it based on the calculation results obtained.

Results and Discussion

The study categorized the results of a multiple-choice exam supplemented with CRI into four different groups. Grade VI students answered the magnetic material questions with 14.5% guessing, 38.1% showing understanding, 20.5% lacking understanding, and 27% showing misconceptions. The proportion of misconceptions is clearly visible from each indicator of the question being assessed. The proportion of student test results on magnetism in grade VI is presented in Table 3.

Table 3. Persentase Hasil Tes Siswa Table 3
Percentage of Student Test Results with CRI

No	Questions Indicator	MN%	PK%	TPK%	M%
1	Explain the meaning of magnetism and its propertie	9%	23%	27%	41%
2	Identify types of magnets, including natural and artificial magnets.	27%	45%	18%	9%
3	Identify the strength of magnetic attraction.	14%	50%	14%	23%
4	Explain the concept of north and south poles in magnets.	14%	32%	23%	32%
5	Identifying magnetic poles that attract and repel each other.	27%	45%	9%	18%
6	Mentioning materials that can be attracted by magnets.	5%	23%	18%	55%
7	Classify objects based on magnetic attraction.	27%	73%	0%	0%
8	Analyze the interaction of magnets with various materials.	23%	73%	5%	0%

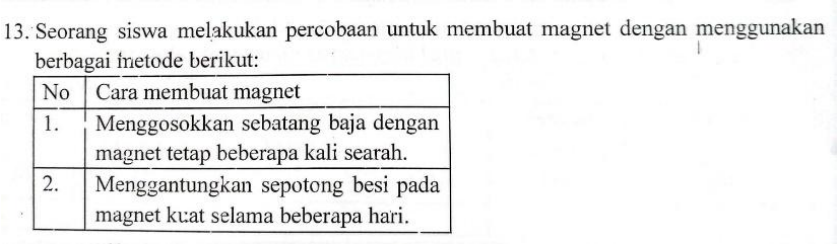
9	Draw a magnetic field and magnetic lines of force.	0%	14%	41%	45%
10	Explains how a magnetic field is formed around a magnet.	32%	23%	23%	23%
11	Explains the effect of a magnetic field on surrounding objects.	5%	23%	36%	36%
12	Explains the relationship between electrical energy and magnetism.	23%	45%	14%	18%
13	Identify ways to make magnets, such as rubbing, induction, and using electric current.	0%	5%	36%	59%
14	Analyze the process of making a simple magnet.	14%	36%	27%	23%
15	List the uses of magnets in everyday life, such as compasses, electric motors, and electronic devices.	9%	55%	9%	27%
16	Explain the benefits of magnets in technology and industry.	5%	45%	27%	23%
	Total	**14,6%**	**38,1%**	**20,4%**	**27%**

Table 3 shows the level of student misconceptions on magnetic material based on the indicators compiled. Grade VI students on average experienced misconceptions categorized as low, concept understanding categorized as moderate, concept understanding categorized as low, and the ability to guess answers categorized as low. Although the percentage of misconceptions is categorized as low, almost all students have a good understanding of magnetic material. Many factors, including self, teachers, books, learning media, and learning approaches.

The findings suggest that students who have misconceptions can be identified using the CRI technique. Students are evaluated using the CRI technique based on how confident students are in answering and how accurate students' answers are. Sixth grade students usually have some misconceptions about magnets. The reason behind this is because many students use their own knowledge to answer the questions given, but end up giving wrong answers. Students with themselves after filling out the question sheet, even though they had given the wrong answer. The number of students who answered the questions confidently were students who chose a high CRI (3-5).

Confidence on the part of students is a problem in the CRI method. Students with low CRI levels will be paired with students who make incorrect guesses. Students just happen to guess the right answer, or students really understand the subject but are not sure how to answer it. Some students lacked confidence in answering the multiple-choice questions given.

Question 13 (Figure 1), which asked students to name methods to create magnets, such as rubbing, induction, and electric current, ranked highest in the misconception category. Students' incorrect answers and high CRI levels indicated misconceptions for 13 out of 22 students.


13. Seorang siswa melakukan percobaan untuk membuat magnet dengan menggunakan berbagai metode berikut:

No	Cara membuat magnet
1.	Menggosokkan sebatang baja dengan magnet tetap beberapa kali searah.
2.	Menggantungkan sepotong besi pada magnet kuat selama beberapa hari.

No	Cara membuat magnet
3.	Memanaskan sepotong baja hingga merah, kemudian mendinginkannya di medan magnet kuat.

Berdasarkan metode yang dilakukan siswa tersebut, manakah di antara cara-cara tersebut yang benar untuk membuat magnet?

a. Hanya cara 1 yang benar
b. Hanya cara 2 yang benar
c. Cara 1 dan 2 benar
d. Semuanya benar

CRI (*Certainty of Response Index*):

Menebak (0)	Hampir Menebak (1)	Tidak Yakin (2)	Yakin (3)	Hampir Benar (4)	Benar (5)

Figure 1. Highest Misconception Example

Based on Figure 1, students only answered the first method of making magnets correctly, while in the second method, many had misconceptions. The interview results show that students assume that hanging a piece of iron on a strong magnet for several days will not produce a new magnet. In fact, conceptually, this method is known as an induction way to make a magnet. This is in line with the opinion of Putri & Desstya (2024) that if students' initial understanding is wrong, it will result in students answering the wrong questions.

The induction method is one way to make a magnet by bringing or attaching ferromagnetic materials, such as iron or steel, to a permanent magnet without direct contact. In this process, the magnetic domains in the iron will be affected by the magnetic field of the permanent magnet, causing the domains to be organized and producing magnetic properties in the iron. However, the effectiveness of this method depends on the duration and strength of the applied magnetic field. In line with Kolan & Rondonuwu (2022) added that magnetic induction can use a coil of wire that is electrified from a battery. The current from the battery flowing on the wire coil will produce a magnet. Conversely, the magnet that hits the wire coil will generate an electric current.

Figure 2 shows question number 6, which is the second highest category of misconception. This question asks students to mention what materials can be attracted by a magnet. The misconception percentage of 55% indicates that 12 out of 22 students have misconceptions.

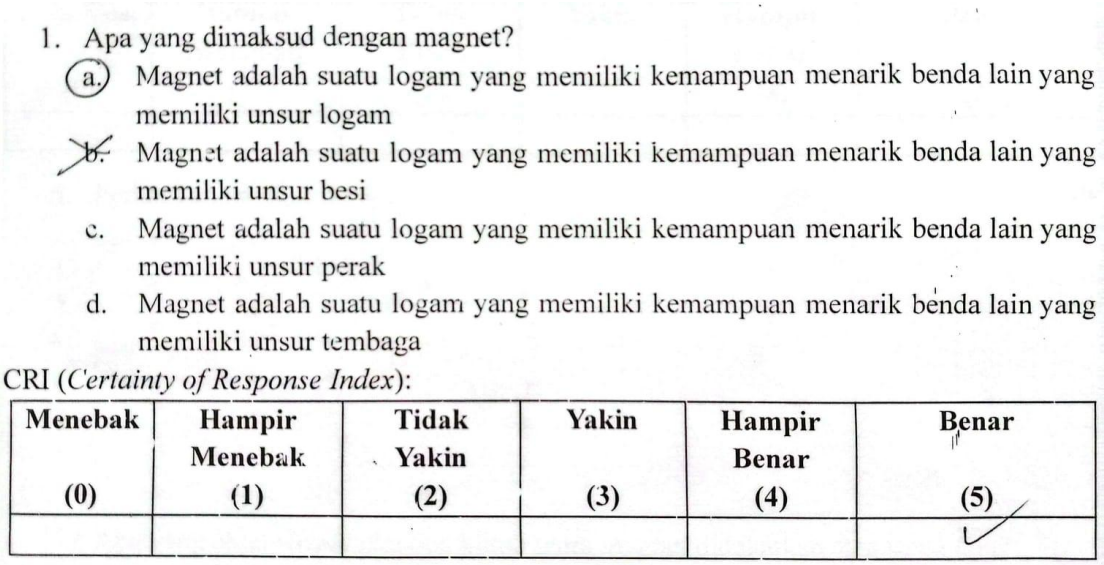
6. Bahan mana yang tidak dapat ditarik oleh magnet [redacted]?
   a. Besi
   b. Nikel
   c. Alumunium
   d. Kobalt

CRI (*Certainty of Response Index*):

Menebak (0)	Hampir Menebak (1)	Tidak Yakin (2)	Yakin (3)	Hampir Benar (4)	Benar (5)

Figure 2. Highest Misconception Example

Misconceptions about magnets are common among students in terms of scientific concepts. Cobalt is one of the materials that students choose as a solution because it is not attracted by magnets. Iron, nickel, steel, and cobalt are examples of materials that attract magnets, as illustrated in Figure 2. Cobalt is not understood or its appearance is not clear to students. Teachers can improve students' understanding of the idea through the use of interactive teaching methods, such as experiments, visuals, and discussions. In addition, research by Rosa & Nursa'adah (2023) also explained that understanding the sources of misconceptions can help in designing a more effective curriculum and provide students with a more effective understanding of science materials about materials that can be attracted by magnets. Students stated that nickel and cobalt cannot be attracted by magnets, based on interview data collected from indicators of magnetically attractive materials. This is because students tried to attach nickel to a magnet in an experiment, but were unsuccessful. The students mistakenly believed that iron has a stronger magnetic attraction than nickel and cobalt, despite the fact that these metals are actually attracted to magnets. Cobalt and nickel are ferromagnetic materials, which means they can be affected by magnetic fields. However, the difference in attraction strength between iron, nickel and cobalt is sometimes misunderstood.



1. Apa yang dimaksud dengan magnet?
   a. Magnet adalah suatu logam yang memiliki kemampuan menarik benda lain yang memiliki unsur logam
   b. Magnet adalah suatu logam yang memiliki kemampuan menarik benda lain yang memiliki unsur besi
   c. Magnet adalah suatu logam yang memiliki kemampuan menarik benda lain yang memiliki unsur perak
   d. Magnet adalah suatu logam yang memiliki kemampuan menarik benda lain yang memiliki unsur tembaga

CRI (*Certainty of Response Index*):

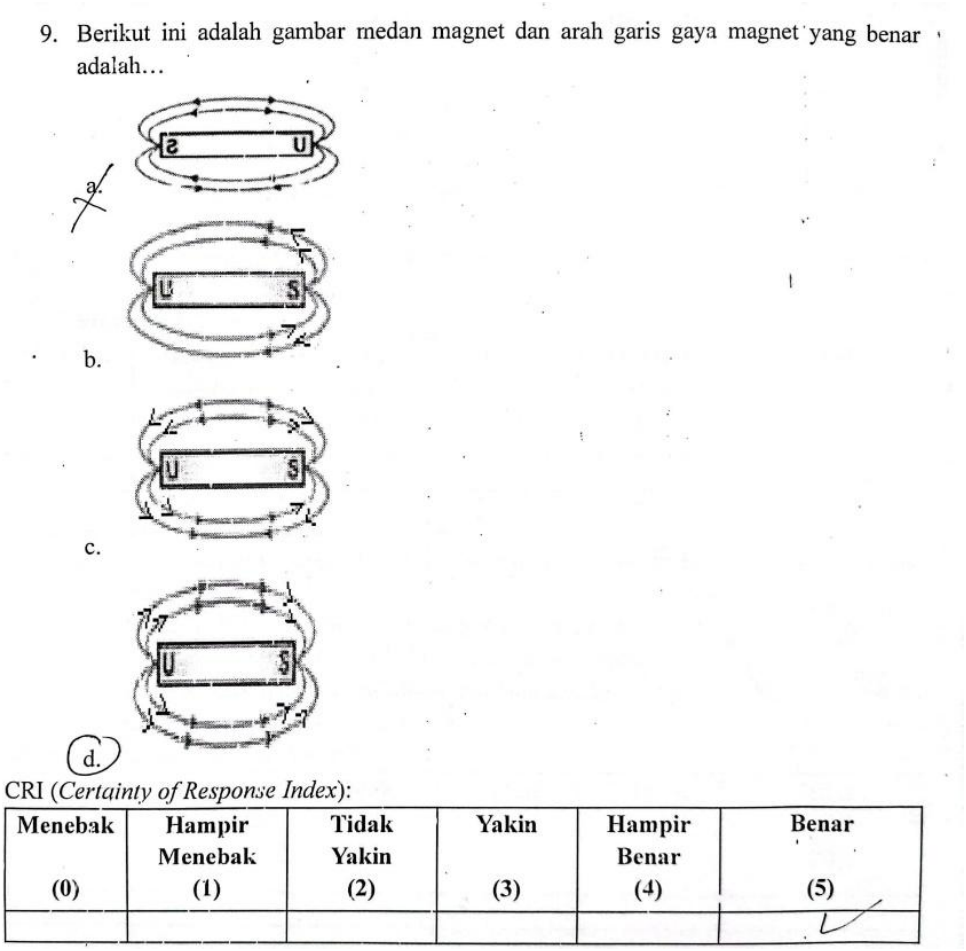
Menebak (0)	Hampir Menebak (1)	Tidak Yakin (2)	Yakin (3)	Hampir Benar (4)	Benar (5)
					✓

Figure 3. Example of Moderate Misconception

In Figure 3, it can be seen that students also answered incorrectly and chose a CRI confidence number of 5. Students answered that the definition of a magnet is a metal that has the ability to attract other objects that have iron elements. This shows that students do not understand that the ability of magnets to attract objects depends on the atomic structure of the material, especially on the magnetic domain in ferromagnetic materials. A magnet is a metal that has the ability to attract other objects that have metal elements, so not only iron elements can be attracted. Magnets do not attract all metal objects, but only certain ferromagnetic materials, such as iron, nickel, and cobalt. Other metals, such as aluminum, copper, or gold, are not attracted by magnets due to their diamagnetic or paramagnetic material properties. Based on the interview results, some students may state that all metals can be attracted by magnets or metals such as gold can also be attracted by magnets because they are metals. These statements indicate that students have misconceptions due to the generalization that all metals are magnetic. These misconceptions can be caused by learning that does not provide a thorough understanding of magnetic properties, or the lack of direct experiments that compare the

reaction of magnets to different types of metals. One of the efforts that can be made in improving the quality of education is by applying the right learning method (Akhmad Faizin, Nur Ngazizah, 2022). This is in line with Annisa et al. (2024) that teachers need to use appropriate methods in the learning process, namely methods that involve students directly so that they can actively participate in utilizing the natural environment as a learning resource, and students must research information about the materials used.

Another moderate misconception is found in the indicator of question number 9, which is about the image of the magnetic field and magnetic lines of force. The results showed that only 2 people had misconceptions. The form of student misconceptions in the form of incorrect answers to questions is shown in Figure 4 below.


9. Berikut ini adalah gambar medan magnet dan arah garis gaya magnet yang benar adalah...

a.

b.

c.

d.

CRI (*Certainty of Response Index*):

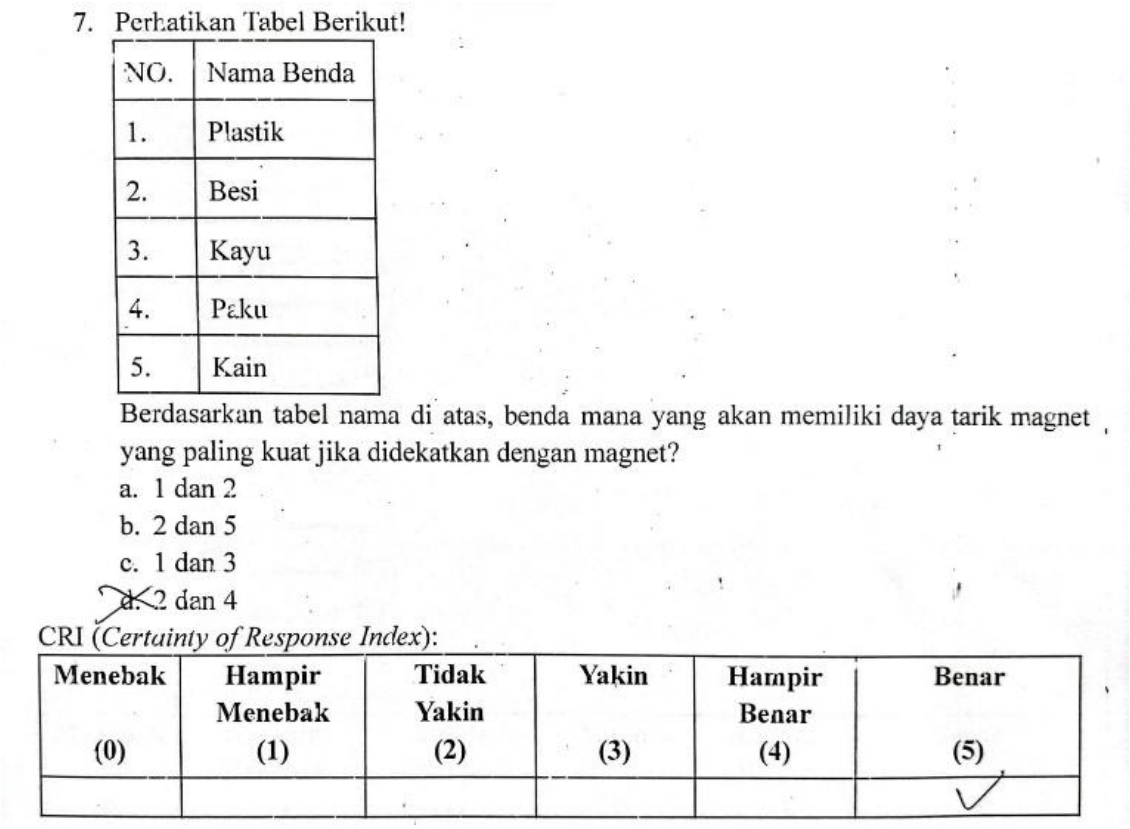
Menebak (0)	Hampir Menebak (1)	Tidak Yakin (2)	Yakin (3)	Hampir Benar (4)	Benar (5)

Figure 4. Example of Moderate Misconception

Figure 4 is a question that has a moderate misconception category regarding the image of the magnetic field and the direction of the magnetic lines of force. The magnetic field always leaves the north pole (N) and enters the south pole (S) outside the magnet, forming lines of force that curve from north to south. Some students chose the wrong answer but had a very high level of confidence. Students who chose the wrong answer had the misconception that the magnetic field flows in the same direction from the south pole to the north pole. Students were also confused about the direction of the arrow on the magnetic field lines of force. This error can occur if students only know the basic concepts of the north and south poles without an understanding of the nature of magnetic lines of force that always go out of the north and into the south. Based on the interview results, students experiencing this misconception have never

observed the magnetic field in a direct way, for example using iron powder or a compass around a magnet to see the direction of the magnetic lines of force. Direct experiments that cannot be done cause an understanding of the magnetic field to be abstract and prone to error.

Based on the research results, there are also indicators of questions that do not have misconceptions, such as numbers 7 and 8. The indicators of questions that do not have misconceptions are listed in Figure 5.



7. Perhatikan Tabel Berikut!

NO.	Nama Benda
1.	Plastik
2.	Besi
3.	Kayu
4.	Paku
5.	Kain

Berdasarkan tabel nama di atas, benda mana yang akan memiliki daya tarik magnet yang paling kuat jika didekatkan dengan magnet?

a. 1 dan 2
b. 2 dan 5
c. 1 dan 3
d. 2 dan 4

CRI (*Certainty of Response Index*):

Menebak (0)	Hampir Menebak (1)	Tidak Yakin (2)	Yakin (3)	Hampir Benar (4)	Benar (5)
					✓

Figure 5. Example of a Problem with No Misconceptions

In this question, students are asked to identify the object that has the strongest magnetic attraction among several choices, namely plastic, iron, wood, nails, and cloth. Based on the basic concept of magnetism, magnets will only attract objects made of ferromagnetic materials, such as iron and steel, which have magnetic properties. This is in line with Samara & Kotsis (2024) that magnets cannot attract objects with greater hardness, thickness, strength, or size than magnets. In the table, the objects that meet this criterion are iron (number 2) and nails (number 4), because nails are generally made of metals that can be attracted by magnets. The correct answers for this question are 2 and 4 and based on the CRI (Certainty of Response Index) indicator which is at level 5 (Correct), students show full confidence in their answers. This shows that students understand well and correctly that only ferromagnetic materials, such as iron or steel in nails, will experience magnetic attraction. The causes of misunderstandings that occur are learning media that are less interactive, do not allow students to experiment directly, and do not get enough explanation about the magnetic properties of metals. In addition, students' misconceptions are also caused by textbooks that are incomplete in providing information about magnetic concepts. For example, a book that only mentions that magnets attract metals can make students generalize that all metals will be attracted by magnets. In reality, only certain metals can be attracted by magnets. If the book does not explain in detail or uses language that

is not suitable for the level of understanding of elementary school children, students will misunderstand this concept and end up with misconceptions.

This research has important implications for curriculum design and teacher training. The science curriculum in primary schools needs to emphasize experiential learning to avoid rote learning. In addition, teacher training should emphasize misconception detection and correction strategies to address misconceptions early on. In line with research Agustina et al. (2024) teacher training needs to integrate the CRI method as a diagnostic tool that helps teachers understand student error patterns. In addition, the development of teaching materials that are more contextualized with daily life can strengthen students' understanding of science concepts.

This research is also in line with Darmastuti & Desstya's (2024) study which found that students often experience misconceptions in abstract science concepts if not supported by exploratory learning methods. In addition, research by Mariyadi & WA (2023) confirmed that misconceptions in science at the elementary school level often occur due to learning approaches that are too theoretical without direct practice.

However, the results of this study also show that the use of the CRI method can be an effective strategy to identify misconceptions, which has not been widely applied in previous studies. Therefore, further research can explore the effectiveness of CRI in various other science materials to improve students' conceptual understanding. Effective science learning must take into account how students construct their understanding. By identifying and analyzing students' misconceptions in depth, educators can design more effective learning strategies to improve conceptual understanding. In addition, implications for curriculum and teacher training show that an experiment-based approach, interactive visual media, and the CRI method can be a solution in reducing students' misconceptions about the concept of magnetism.

Conclusion

Analysis of the research data shows that grade VI students have varying levels of misconceptions in understanding the concept of magnetism. Overall, the level of misconceptions was in the low to moderate category, with the highest misconceptions found in indicators regarding materials that can be attracted by magnets (55%) and how magnets are made (59%). The main causes of misconceptions include the lack of direct experimentation, limited interactive learning media, and incomplete conceptual understanding from learning sources such as books. Teachers are advised to implement experiment-based learning strategies to improve students' conceptual understanding. The use of interactive visual aids, such as digital simulations and learning videos, can help reduce misconceptions. In addition, teachers need to provide more targeted feedback and guide students in correcting misconceptions through reflective discussions and inquiry-based learning. The integration of evaluation methods such as the Certainty of Response Index (CRI) in formative assessment can be a more effective approach in identifying and addressing student misconceptions early on. Thus, the use of CRI in this study is expected to provide deeper insight into the level of student misconceptions about the concept of magnetism and provide a basis for developing more effective learning methods.

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