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Analysis of Student Misconceptions on the Solar System Material Using the Four-Tier Test Instrument

Fitriyani[1], Idam Ragil Widianto Atmojo[2], Sri Yamtinah[3]

[1, 2] Postgraduate Program Elementary Teacher of Education, Sebelas Maret University, Indonesia
Correspondence: E-mail: fitriyanifitriyani@student.uns.ac.id

ABSTRACT

Misconception is a misunderstanding or inaccurate understanding of a certain concept or information. Category misconceptions are still common in elementary school sixth grade students, the occurrence of misconception can be due to several factors. This research aims to identify and discredit misconceptions of elementary school sixth grade students in the eye of solar system material IPA lessons. Data collection method using four-tier test instruments. The approach used in the research is a quantitative approach. The research was carried out at the State SD 2 Nadi Bulukerto district. The population in the study was class VI students. The study sample is 16 students who have studied the material of the Solar System. Data from the research was analyzed using descriptive quantitative analysis. The results of the study showed that misconceptions that occurred in elementary school students belonged to the "Medium" misconception category with a percentage of 53,125%. Students experienced the highest misconcept on the following four concepts: 1) planetary arrangement in orbit; 2) planetary identification based on its characteristics; 3) elements on Saturn's planetary rings; and 4) celestial objects that include stars.

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1. INTRODUCTION

Education is a deliberate and organized effort to establish a favorable environment for learning, enabling students to actively cultivate their potential in areas such as religion, self-discipline, personality, intelligence, moral values, and the necessary skills for themselves and society. Education encompasses the imparting of specialized skills, as well as the intangible yet profound transmission of knowledge, consideration and wisdom (Pristiwanti et al., 2022). This kind of education can be created in primary school through IPA learning Where students will learn natural phenomena, develop knowledge, and develop self-skills. IPA invites students to learn to formulate concepts based on realities in the field. So that we can combine the experience of the scientific process and the understanding of the product of science through direct observation (Siwi & Setiawan, 2021).

In general, IPA or science is understood as the science that is born and developed through the steps of observation, the formulation of problems, the preparation of hypotheses, the testing of hypothetics through experiments, the drawing of conclusions, and the discovery of concepts or theories so that the values of science that can be embedded in the learning of science are: (1) the ability to work and think systematically and regularly according to the measures of scientific methods; (2) the skill and competence in holding observations; (3) have the scientific attitude necessary in solving problems both in relation to the lessons of science and in life (Fatimah & Kartika, n.d.).

Misconception is a condition when a person has conceptual ideas different from the generally accepted scientific consensus. Misconceptions or misconcepts occur when one has concepts or understandings that do not correspond to the scientific or acceptable understanding of experts in his or her field. In some cases, misconception can be caused by incomplete understanding or simple IPA concepts expressed by many pupils. Misconceptions can be an obstacle in understanding the correct science concept, if misconcepts are left behind and not dealt with, pupils may experience more serious misconcept that will be more difficult to correct (Mubarok, 2023).

The factors that cause the student to experience misconception come from the student: lack of knowledge of the student, incorrect or incomplete intuition, educators who lack mastery of the material, teachers who and textbooks, monotonous teaching methods of educators (Sari & Rohman, 2020). Misconceptions do not always come from the student, sometimes because the wrong teacher uses the language in delivering the material can lead to misconception in the student. Causes of misconcept can come from a student's wrong initial concepts, errors in the book, mistakes in the explanation and may come from teachers who do not understand the material (Nurfiyani et al., 2020).

One of the concepts in IPA learning that is closest to everyday life and problems is the concept of the solar system. According to Suparno (2013), students at the middle school/MTs level experience misconceptions in every sub-material of learning about the concept of light. Misconceptions can hinder student understanding and have a negative impact on student learning outcomes. Misconception is a problem that must have been remedied. The purpose of misconception remediation is to in still the correct concepts in students and maximize student learning results. Diagnostic assessment is carried out as a form of initial information excavation of students' knowledge (Maulana et al., n.d.), so that the diagnostic assessment activities are implemented at the beginning of learning. A diagnostic test is a test performed in order to diagnose or identify learning difficulties, detect the factors causing them and determine ways to solve problems found (Irianti, 2021). In the case of misconception, these assessments or diagnostic tests are used to identify

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misconceptions experienced by students, because in some cases students who experience misconcept do not mean they are unable to understand a concept, but the concept they understand is an inappropriate concept.

Student misconceptions can be identified by using an interview instrument, an open test, a double-choice test, and a two-tier diagnostic test (Gurel et al., 2015). Each test instrument has its advantages and disadvantages. Interviews provide in-depth information and flexibility in asking questions. The open test gives respondents the opportunity to answer questions in their own words. Respondents can also give new answers that researchers have not thought of before. Regular double-options have the advantages of saving time in administration, scoring can be instantly determined, proof of validity strong and applied to many subjects. When it comes to double choice, the two levels have all the advantages that the ordinary double choice test has, as well as the opportunity to identify false positive and false negative. In the three-level double choice there are all advantages in the two-level multiple-choice test. Then the determination of the answer given at the first two levels is due to misconception, error or lack of understanding.

The priorities of the four-tier diagnostic test are: (1) teachers can distinguish between the degree of confidence in the answer and the degree in the confidence of the reason selected by the student so that they can learn more about the strength of the understanding of the student's concepts, (2) teachers may diagnose misconceptions that occur in the student further, (3) teachers are able to determine the various parts of the material that need to be reviewed, and (4) teachers could plan better learning in order to reduce the occurrence of misconception to the student (Fariyani & Rusilowati, 2015).

Here are some previous studies conducted in analyzing students' misconceptions in science subjects: 1) research entitled "Analysis of Misconceptions of Grade VI Elementary School Students in Science Learning on Gravitational Force Material" proves that 66.7% of students experience misconceptions or misunderstandings when learning about gravitational force in science. To overcome this misconception, teachers must create models and media that can increase motivation and encourage learning in the field of Science, especially those related to gravitational force (Mariyadi & Wa, 2023); 2) research entitled "Analysis of Students' Learning Difficulties on the Concept of Buffer Solution Using Four-Tier Multiple Choice Diagnostic Test" The survey revealed that students had a low level of understanding of the concept of buffer solutions, with only 32.3% showing understanding. In addition, 38.1% of students had no understanding at all, while 20.6% had misconceptions. These results indicate that the level of difficulty for students in understanding the material on buffer solutions is quite high, with a percentage level of 67.7% (addition of TPK + MK + Error) (Firdaus et al., 2022); 3) research with the title “Misconception Profile On Photosynthesis by Using Four-Tier Diagnostic Test on Twelve Grade Students of Senior High School” Based on the results of the research on the profile of students' misconceptions in the photosynthesis submission using a four-tier diagnostic test can be concluded that students experience misconceptions by 45.5%, students understand concepts by 28%, and students who do not understand the concept is 26.5%. As much 46.7% of students had high misconception, 29.8% of students had moderate misconception, and 23.5% of students had low misconception (Aristyasari & Yuliani, 2021); 4) research entitled "Identification of Student Misconceptions on Force and Motion Material Using Certainty of Response Index (CRI) in Elementary Schools" concluded that 34.92% of students understood the concept, while 16.51% did not understand it, and 48.57% experienced misconceptions (Arruum & Desstya,n.d.).

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2. METHODS

The research carried out using a quantitative approach. The research is carried out in the full semester of the 2023/2024 lesson. The population in the study is a student of the 6th grade SD Negeri 2 Nadi Bulukerto district Wonogiri. Sampling research using purposive sampling techniques. The sample consisted of 16 students who had already studied the Solar System material. The data collection instrument used in the research is a four-tier diagnostic test instrument consisting of 10 questions about the concepts of the solar system. Each item of the question consists of four levels as follows: 1) tier-1 is a question with multiple options; 2) tier-2 is a degree of confidence in the answer to tier-1; 3) tier-3 is a basis for choosing an answer to tier-1; 4) tier-4 is a level of faith in reason to tier-3

Data analysis begins with checking the respondent's answers. Then group the categories of students according to their understanding of the concepts of the solar system. Category 1) Understanding concepts (scientific conception), students understand concepts of the solar system; category 2) Lack of knowledge, lacking understanding or partial understanding, is where students answer correctly have the right reason but are not sure. 3) False positive or positive error (false positive), students are categorized experience false positive when answering correctly but giving the wrong reason or in other words students answer true but are correctly having the wrong understanding of the concept and confident with the answer; 4) False negative or negative error (fake negative), students were categorized experiencing false negative when responding incorrectly but providing the correct reason or with another word students have the correct understanding but still giving the incorrect reason. 5) Misconception, is where students give the wrong answer for reasons that are wrongly convinced but with both. 6) Mistake is where students do not answer one or more indicators or are often called errors. After the student's understanding is categorized based on the given answers, the next step is to determine the large percentage of each student's understanding. Analysis activities using Microsoft Excel, according to Sudijono (Sheftyawan et al., n.d.) percentage of student understanding can be searched with the following equations:

$$P = \frac{f}{n} \times 100$$

Description:
P : value of student response percentage
F : frequency of student answer
N : number of students or samples studied

Student understanding categories viewed based on table Four-tier diagnostic test results (Gurel et al., 2015). Students are said to understand the notion that Tier 1 answers correctly, Tier 2 believes, Tier 3 gives the right reason, and Tier 4 believes the reason. Students say lack of knowledge or understand (part of understanding) when answering correctly but not believing the answer, can also be said to lack of knowledge when students answer unwillingly but have the correct reason. The student is said to have false positive when answering right at Tier-1, giving the wrong reason at Tier-3 and believing in both. False negative when responding wrong at Tier-1 gives the right reason to Tier-3 as well as believing at Tier-4 and Tier-4, whereas the student who answers wrong at Tier-1, giving a wrong reason on Tier-3 but giving the correct reason to believe at Tier-2 and Tier-4 is

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categorized as having a misconceptional understanding. More clearly, decision-making with four-tier diagnostic test instruments is shown by **Table 1** as follows.

Table 1. Student Understanding Categories Based on Answer Choices

1 st tier	2nd tier	3nd tier	4th tier	Decision for four tier test
Correct	Sure	Correct	Sure	SC
Correct	Sure	Correct	Not Sure	LK
Correct	Not Sure	Correct	Sure	LK
Correct	Not Sure	Correct	Not Sure	LK
Correct	Sure	Wrong	Sure	FP
Correct	Sure	Wrong	Not Sure	LK
Correct	Not Sure	Wrong	Sure	LK
Correct	Not Sure	Wrong	Not Sure	LK
Wrong	Sure	Correct	Sure	FN
Wrong	Sure	Correct	Not Sure	LK
Wrong	Not Sure	Correct	Sure	LK
Wrong	Not Sure	Correct	Not Sure	LK
Wrong	Sure	Wrong	Sure	MSC
Wrong	Sure	Wrong	Not Sure	LK
Wrong	Not Sure	Wrong	Sure	LK
Wrong	Not Sure	Wrong	Not Sure	LK

Description
SC : Scientific Conception
LK : Lack of Knowledge
FP : False Positive
FN : False Negative
MSC : Misconception
MTK : Mistake

While the percentage of student misconceptions is categorized into three levels, the student misconception categories are low, medium, and high. According to the Suwarna (in Sheftyawan et al., n.d.) it can be seen in **Table 2**.

Table 2. Percentage Categories of Misconceptions

Percentage Categories of Misconceptions	
Persentase	**Kategori**
0% - 30%	Low
31% - 60 %	Medium
61% - 100%	High

3. RESULTS AND DISCUSSION

The data collected and discussed indicates that primary school kids who have already studied material on the solar system still have misconceptions. Students who demonstrate comprehension of concepts in the Low category, students who lack understanding of concepts in the Lower category, learners who exhibit errors in the low category, and

students who possess a grasp of the concepts transition to the Staging category. Percentage categories of students' understanding of the concepts of the solar system are more clearly shown in **Table 3** as follows.

Table 3. Average percentage of student understanding

Average Percentage of Student Understanding	
Kategori	**Persentase**
SC	30,625%
LK	8,75%
FN	5%
MTK	2,5%
MSC	53,125%

The percentage of misconception experienced by students was 53.125%. The percentage of student misconception on each item is shown by **Figure 1** as follows.

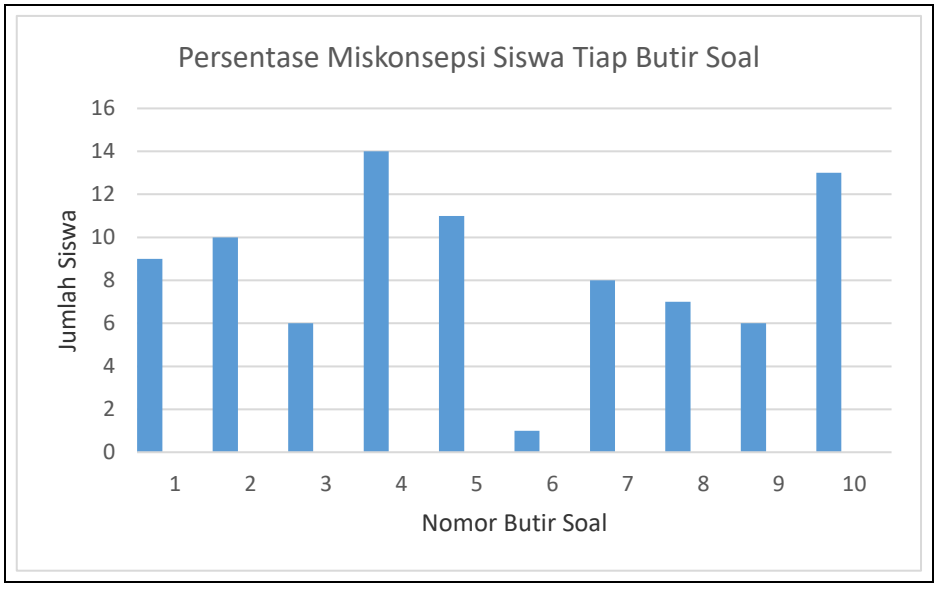

Figure 1. Percentage of student misconceptions of each topic

After data analysis, students who experienced misconception on each item had a variable percentage, Categories of misconceptions per item are shown by **Table 4** as follows.

Tabel 4. Category Student Misconceptions on Every Detail

Question Number	Misconception	Percentage	Categori
1	9	56,25	Medium
2	10	62,5	High
3	6	37,5	Medium
4	14	87,5	High
5	11	68,75	High
6	1	6,25	Low
7	8	50	Medium
8	7	43,75	Medium
9	6	37,3	Medium
10	13	81,25	High

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Table 4 shows that all respondents had misconceptions, it can be shown that 40% of respondents experienced misconception in the high category with a variable percentage of mis-concept, 50% of the respondents suffered mis-conductions in the moderate category, and 10% of those responding experienced mis-conception in the low category. Based on the diagnostic results, the description of student misconception is shown by **Table 5** as follows.

Tabel 5. Description of Student Misconceptions on The Solar System Concept

No.	Misconceptions	Description Misconceptions
1	M1	Venus belongs to the Star because it is called the Planet of the Dawn Star
2	M2	Comets emit light like falling stars
3	M3	A meteorite is a celestial object that floats in space and reaches the earth.
4	M4	The long difference between day and night is due to the rotation of the earth
5	M5	Planets rotating in order
6	M6	Saturn's rings are formed because the planet is dust, grass, and ice.
7	M7	Asteroids are celestial objects that fly freely like meteoroids.
8	M8	A solar eclipse occurs because the moon covers the sun
9	M9	A partial eclipse occurred because the moon cut a line
10	M10	The earth turns from the east to the west, for the sun rises from the eastern side and sets in the west.
11	M11	Planets with the most satellites

On **Table 5** is a description of eleven misconceptions of students, while the scientific concepts are correct as follows: 1) a celestial object called a star is a celeste that can emit its own light, the star is not a star, but a planet that reflects the light from another star and looks shining in the sky like a star; 2) a comet appears to shine like a Star not because the comet can emit the light itself, but because it is a meteoroid that is attracted by the earth's gravity and then shakes with the Earth's atmosphere, this friction causes the light as if it were a twist; 3) a meteorite is the remainder of the sky of comets burning in the atmosphere; 4) the long difference between day and night is the result of the earth revolution, whereas the consequence of the rotation is the occurrence of the day and the night; 5) each planet has its own orbital path that is formed by the gravitational interaction of each planet with the gravity of the sun, 6) rings on the planet Saturn are formed because of outer objects such as rocks, dust, and ice that are trapped when Saturn's planet orbits; 7) unlike meteoroids, asteroids are sky objects smaller than the planet but larger than the meteoroid, an asteroid consisting of rocky and metal elements, most of the Asteroids orbit in the asteroidal belt; 8) solar eclipses occur because the sun's light turns to the Earth's surface blocked from the Moon; 9) lunar eclipse occurs because the Earth is not entirely blocking the moon from sunlight, this happens because the Moon is in the penumbra area, so there is still a portion of sunlight that reaches the surface of the Moon, 10) Earth's rotation is the movement of the earth at its axis, where the earth rotates from west to east, which causes the sun to be seen rising from the east; 11) the planet with the most satellites is Jupiter, whereas the blue planet is Neptune.

Based on the eleven misconceptions of students on the concepts of solar systems, the following researchers describe the three concepts that have the highest misconception, the greatest disconception on the concept of "planets in the solar system" where the subject is presented in the following form is shown by **Figure 2** as follows.

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4. Perhatikan gambar di bawah ini!

1) Susunan planet yang jaraknya terdekat dari matahari adalah ….
   a. Merkurius, Venus, Bumi, Mars, Yupiter, Uranus, Saturnus, Neptunus
   b. Merkurius, Venus, Mars, Bumi, Yupiter, Saturnus, Uranus, Neptunus
   c. Merkurius, Venus, Mars, Bumi, Yupiter, Uranus, Saturnus, Neptunus
   d. Merkurius, Venus, Bumi, Mars, Yupiter, Saturnus, Uranus, Neptunus
2) Apakah kamu yakin dengan jawabanmu?
   c. Yakin
   d. Tidak Yakin
3) Alasanmu:
   ……
4) Apakah kamu yakin dengan alasan yang kamu tulis?
   c. Yakin
   d. Tidak Yakin

Figure 2. Instruments for Four-Tier Test No. 4

After analysing the student's answers, out of 16 students, only one student with the Understanding category, 1 student with Partial Understanding, and 14 have misconceptions, of the 14 students who have this misconception they can answer tier-1 questions correctly, believe the answer, but have inadequate reasons, and believe the reasons. In the fourth item, related to the concept of planetary arrangement in the solar system, students were asked to show the order of planets from the closest to the sun. Students were able to demonstrate the ordering of the planets of the nearest the sun but they had not yet understood why these planets were arranged in such a way, they believed it happened just for no reason, just in accordance with what was delivered by the teacher, and according to the book. The students did not understand whether the arrangement of the planetary system occurred as a result of each planet having its own orbit that formed an ellipse. The orbit is influenced by the gravity of the sun and the planet itself. This is because of the teacher's lack of detailed explanation and lack of the student's thinking skills.

The second highest misunderstanding is in the concept of "the largest number of satellites on this planet" in edition number 10 which is shown in **Figure 3** as follows.

10. Perhatikan Tabel pernyataan di bawah ini!

No.	Ciri – ciri
(1)	Berwarna hijau kebiru - biruan
(2)	Atmosfernya terdiri dari hidrogen, helium dan metana
(3)	Memiliki 27 satelit
(4)	Satelit terbesarnya yaitu Oberon, disusul Titania, Umbriel, Ariel dan Miranda

1) Nama planet yang ciri-cirinya ditunjukkan dalam tabel tersebut adalah ….
   a. Jupiter
   b. Saturnus
   c. Neptunus
   d. Uranus
2) Apakah kamu yakin dengan jawabanmu?
   a. Yakin
   b. Tidak Yakin
3) Alasanmu:
   ……
4) Apakah kamu yakin dengan alasan yang kamu tulis?
   a. Yakin
   b. Tidak Yakin

Figure 3. Instruments for Four-Tier Test No. 10

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After the analysis of the question, it was stated that 13 students had misconceptions and 2 students understood the concept while 1 student understoods partly, students who had misconsceptions on question number 10 occurred because students underanalyzed the characteristics of planets in the solar system, this occurred due to students lack critical thinking skills.

The next misunderstanding is the concept of "the sky includes stars and Venus is the stars" in question number one which is in **Figure 4** as follows.

2. Perhatikan gambar di bawah ini!

1) Benda langit yang berhasil mendarat sampai ke permukaan bumi disebut ….
   a. Meteorit
   b. Meteoroid
   c. Meteor
   d. Asteroid
2) Apakah kamu yakin dengan jawabanmu?
   a. Yakin
   b. Tidak Yakin
3) Alasanmu:
   ……
4) Apakah kamu yakin dengan alasan yang kamu tulis?
   a. Yakin
   b. Tidak Yakin

Figure 4. Instruments for Four-Tier Test No. 2

After the analysis of question number two, it can be concluded that 10 students have misconceptions and 4 students understand the concept while 2 students understand partly, students who have a misconception on question number 2 with the concept of "differences between meteoroids, meteorites, meteors, and comets) occurs because students can't distinguish the difference between meteorids, meteorites, meteorits, comets because they have similar names and within the scope of 1 object, this happens because of the lack of use of learning media.

According to the results of the study (Rachmawati & Susanto, 2017), students suffered misconceptions on the concepts of 1) the occurrence of ocean rushes, 2) the rotation of the Earth; 3) the Earth's revolution; 4) the Sun as a Star; 5) the Sun that has energy; 6) the phases of the moon; 7) the concept of rotation and the revolution of the Moon; 8) the differences in observing the stars in urban and rural areas; 9) the asteroid concept; 10) the third law of Kepler; 11) the various types of planets and their orbital velocities; 12) the second law of kepler; 13) the gravitational styles between the sun and planets; 14) the law of Newton's gravity. Previous research carried out (Jumadi, n.d.) was student misconceptions about: 1) the conception of the Solar System; 2) the sun as a star; 3) the order of the nearest to the furthest planets from the sun; 4) the characteristics of planets based on images, and; 5) the understanding of satellites.

Although it relates to everyday life and has a direct impact on human activities, the concepts of the solar system are generally abstract and often misunderstood, requiring a deeper understanding. Moreover, the material of the Solar System is not directly accessible to the human senses because of the limited human sense. So, in the process of learning, it

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needs a medium that matches the characteristics of students and current technological developments. The science (IPA) learning media is also expected to serve to convey abstract material into more real material, thus minimizing the occurrence of misconceptions in elementary school students. The media that can be used is the digital media that utilizes technology to make the materials abstract because they are taught with images and texts, turning into material that is concrete and interesting for students because of the presence of real visualization (Maisarah et al., 2023).

4. CONCLUSION

Research shows that students experience misunderstandings about the concepts of solar systems even though students have already studied the material of the solar system at school. The results of data analysis with four-tier diagnostic test instruments showed that students experienced misconception in the medium category with a percentage of 53,125%. Students experienced missconception on any conception of solar system matter. It shows that students come to school with preconceptions and sometimes preconception is misconceptional. The preconceptions that students have come from experience, interaction with the environment, language, books, even teachers can also be a cause of misconception. If a misconception has been inherent in the student's understanding then it will be very vulnerable to the students' subsequent understanding, it needs to be a concern for teachers and other layers of education in order to identify misconceptions to further take conception remediation action so as to minimize misconcept material.

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