IDENTIFYING OF ELEMENTARY STUDENTS' MENTAL MODEL on GRAVITY CONCEPT

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IDENTIFYING OF ELEMENTARY STUDENTS' MENTAL MODEL on GRAVITY CONCEPT

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Abstract

This study aims to analyze fourth grade elementary school students' mental models on gravity concept in one of elementary school in Pekanbaru, Indonesia. The method in this study was descriptive quantitative research methods with instruments test in the form of an understanding level test which is divided into three concepts, the subjects in this study consisted of 34 students. The results showed that students' mental model related to gravity concept 11.76% of students categorized the scientific mental model on the first concept in level understanding test, the highest average was obtained by the synthetic mental model 79.41% in second concept, and there was a drastic increase in the initial mental model in third concept by 55.88%. Understanding of students is based on daily life experiences, but participants can reason according to several components of scientific concepts. So that a reconstruction of learning is needed that can connect the experience of students with the concepts to be learned.

Keywords: *mental model, gravity concept, fourth elementary students*

1. Introduction

Humans memorize a variety of experiences that are processed into systems of thought so that they become their identity. According to [1] research on cognitive science, science education, and psychology over the past decade has shown that children and adults build an intuitive understanding of the world based on their daily life experiences. Children's understanding based on daily life experiences is the key word so that learning at school can be easily reflected by referring to their real experiences. But in science learning, students often find this learning difficult and complicated. This is because learning science in students' eyes means learning something abstract. Students tend to develop their own concepts because the lessons learned have not been able to connect between scientific concepts with real life. According to [2] this representation of everyday life becomes a structural analogy of a situation or process, its role is to explain the reasoning of individuals both when they try to understand discourse and when explaining and predicting the real world.

This representation is supported by the ability to think. The ability to think of a person in solving problems is passed through the process of combining various perceptions by reasoning, analyzing, and identifying so as to form strategies in problem solving. Strategy

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in solving this problem is reflected in a person as a mental model. According to [3] students' thinking ability and memory in the development and conceptual reasoning of science requires representation stored in working memory, this mental representation is described as a mental model. Meanwhile, mental models are built based on the knowledge students have from daily life, form perceptions, and make them problem solving strategies [4]. Every students solve their problem using the process of reasoning, predicting a phenomenon, and explaining phenomena, which is why mental models must be built so that scientific theory can be understood [5].

Mental Model is a explanation of what students reason about confident conditions that can be seen in the way they convey their reasons and explanations [6] [7] [8] [9]. [10] [11] also said that the mental model is a description of someone in understanding and clarifying a phenomenon. Mental models are also used to support someone's understanding and explanation of logic about certain situations and shaped impulsively when distributing with certain conditions, but mental models can also be stowed as long-term memory [12]. Students' mental models are constructed when they study new theories and make networks between material got, either in the form of script or pictures [13] [14]. Stains & Sevian opinion that mental models can be designed when someone faces a precise problem [15]. Gentner & Stevens said that mental models are made due to convinced methods and confident situations that are repetitive [16]. This suggests that the mental model may vary according to students' experiences and understanding.

2. Methodology

The research method used in this research is quantitative descriptive method. The instrument used was a level understanding test which was divided into three concepts, each concept consisting of point a, point b, and point c. Expressed as a concept because each item is mutually sustainable, here is one example of the problem given;

a. Every object near to earth will get the gravity, try to describe the definition of gravity!

b. Why does the fruit on the tree come off the stem when it falls to the ground? Explain!

c. Try to draw the direction of the earth's gravity acting on the fruit that is hanging on his tree!

The three questions above have described the level of understanding, for example at point a asking for reasoning about the scientific concept of gravity, point b about the effect of gravity on falling fruit, then point c is a derivative of a matter of descriptive understanding level where reasoning requires a description related to the direction of gravity on the fruit hanging on the tree. To express the mental model is done by first analyzing the level of descriptive understanding contained in point a and point b, while for the level of visual understanding contained in point c. Categorizing the level of understanding and mental models using rubric references by Kurnaz (2015). The rubric of descriptive understanding level is contained in the following table;

Evaluation Rubric for Descriptive Responses

Level of Understanding (LU)	Criteria
Sound Understanding (SU)	The response contains all of the components that can be scientifically accepted.

Partial Understanding (PU)	The response contains several components that can be accepted scientifically
Partial Understanding with Alternative Conception (PU-AC)	Responses indicate that concepts can be understood but are formed from alternative concepts
Alternative Conception (AC)	Responses contain illogical or incorrect information, and cannot be accepted scientifically
No Understanding (NU)	There is no response / blank.

Whereas the level of visual understanding is contained in the following table;

Evaluation rubric for Visual Response

Level of Understanding (LU)	Criteria
Correct Depicting (CD)	The image reflects all of the components of scientific depiction.
Partial Correct Depicting (PCD)	The image reflects several components of scientifically.
Correct Drawings reflecting also Non-scientific Depicting (CD-ND)	Images reflect a scientific picture but cannot be accepted scientifically, or partially.
Incorrect Depicting (ID)	The picture does not reflect the scientific picture.
No Depicting (NO)	There is no picture / blank.

After getting the descriptive and visual understanding level categories on the representation of students' answers, then the categorization of mental models was analyzed using the rubric of mental model categories in the following table;

Evaluation rubric for Mental Models

Level of Understanding	Content
Scientific	Perception coincides with scientific knowledge: Answers rated (PU or PCD) or (SU or CD)

Synthetic	Perceptions that coincide and some that coincide with scientific knowledge
Initial	Perceptions which do not coincide with scientific knowledge; answers at the level (NU or ND), (AC or ID), (PU-AC or CD-ND).

3. Results and Discussion

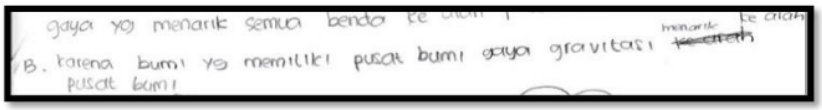
The results of mental models in this study describe fourth grade students' the mental models in three concept. In the first concept, the question asked requires an identification of scientific conceptual reasoning about the definition of gravity. Then point b requires reasoning that reflects an explanation related to the effect of gravity on the fruit falling down, and at point c requires a reasoning that is represented through an image related to the direction of the fruit that hangs on various sides of the hemisphere. The results of mental models in the first concept are summarized in the table below;

Level of Understanding	Amount obtained	Total (f) (%)
Scientific	4	11,76%
Synthetic	25	73,52%
Initial	5	14,70%
Total	34	100%

Only 11.76% of students have a scientific mental model, students at the scientific level can reflect an answer that is categorized into a level of descriptive understanding at the level of SU (Sound understanding) and PU (Partial understanding). And the level of visual understanding at the level of CD (Correct Depicting) and PCD (Partial Correct Depicting). Students' answers to point a that reflect the scientific mental model in the first concept are like the following picture

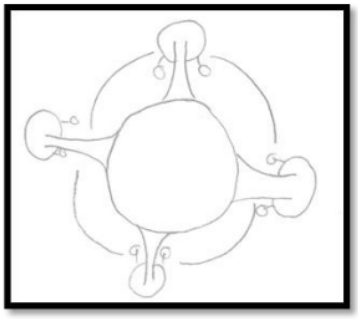
The student already has an understanding in accordance with the scientific concept of the definition of gravity, namely that the gravity is the force that pulls every object on the surface of the earth towards the center of earth. Whereas at the level of understanding of PU (Partial Understanding), the student's perspective has the tendency that the gravity is the force that pulls all objects towards the center of the earth, this is oriented with scientific concepts, but has a lack of accentuation of the gravitational pull which is actually only on objects that are near the surface of the earth. So it can be justified that students' understanding only has a few scientific components, but it cannot be said that their understanding is entirely a scientific concept, which is why they are at the level of PU (Partial understanding) understanding. Following is an example of student answers at the level of PU:

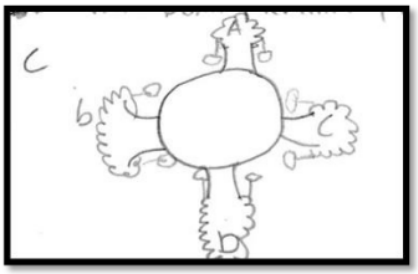
When students were asked about the influence of gravity on fruit events that always fall towards the bottom, students can represent an answer at the SU level that the gravity that has the center of the earth makes the gravity pull the fruit towards the center of the earth, reflecting the answer as shown below;



While students who are categorized into PU level has not yet formed a scientific concept, but students can reason the influence of gravity on daily life events based on several scientific components. Students' answers in general are that the event of a fruit falling from a tree will always lead to the center of the earth, students do not explain the most important scientific component, namely because of the gravity that causes the direction of fruit falling down is always towards the center of earth, not only that the perspective of students also states that the event of a fruit falling from a tree due to the gravity, the answer is correct, but students do not explain the direction of the pull of gravity. Students only have a few scientific components that underlie their answers. Following is an example of student answers at the PU level;

The students picture to reflect their reasoning on fruit that depends on each side of the hemisphere, categorizes the level of understanding of CD as follows:





Some scientific components that are intended are the location of the tree on the side of the hemisphere in accordance with scientific concepts, but the direction of the dependent fruit does not exert gravity.

The results of the mental model on the second concept are related to the reasoning for the direction of the gravity acting on the object at point a, then the effect of gravity on the event of the ball being thrown vertically at point b, and the description related to the direction of the gravity on the ball thrown vertically upwards at point c, summarized in the following table this

Level of understanding	Amount obtained	Total (f) (%)
Scientific	0	0
Synthetic	27	79,41%
Initial	7	20,58%
Total	34	100%

Seen from the table above the synthetic mental model dominates with an average of 79.41%. Student understanding is a mixture of components at the level of descriptive and visual understanding. Students who are categorized into the level of understanding PU, stated that the direction of the gravity acting on objects towards the center of the earth, this raises ambiguity, namely about the direction of the gravity acting on objects that lead to the center of the earth whether towards the side, up, or down, the answer that should put forward most scientific concepts is that the direction of the gravitational force acting on mass objects always goes downward (Vertical towards Earth's gravity). The following is one example of student answers at the PU level;

a. 

b. 

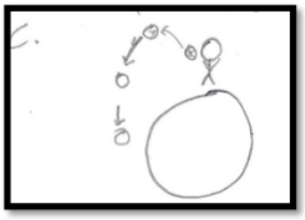
Whereas for students at PU-AC level, students' state that the direction of gravity acting on objects at the center of the earth, this understanding cannot be accepted scientifically, the pull of gravity is not at the center of the earth, it can be justified that the concept is an understanding alternative to the attributive force of gravity. Following are the answers categorized into PU-AC level;

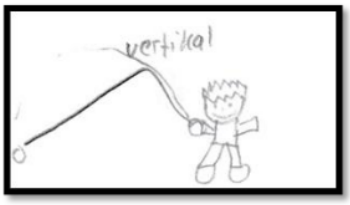
students who are at the level of understanding SU, students' perspective that the direction of the gravity acting on objects "downward" as shown below

Although these answers only stimulate the direction of the gravitational force without an explanation of the scientific concept, but this is also due to questions from questions that do not ask to be explained, it can be said that students' understanding of the direction of gravity acting on objects already has the most important element of scientific concepts.

The problem in point b indicates the students' reasoning towards the direction of the gravity on the ball being thrown vertically up. Students are not able to mention the reasons related to this, but students already have an alternative concept that bridges that there is indeed an influence of gravity and gravity on the event of throwing the ball. Following are some of the answers of students at the PU-AC level;

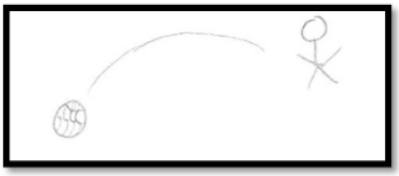
At the level of PCD understanding students describe the direction of the throw correctly is upward, then downward, but students do not include a sign for the direction of gravity in the event of the ball being thrown. The following are examples of student answers at the PCD level

a. 

b. 

As for the level of understanding of ND, students do not even know the vertical direction, most students describe the direction of throwing the ball horizontally. Here are some pictures on the answers to ND understanding level

a. 

b. 

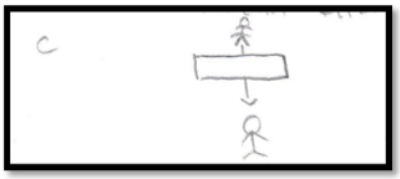
The results of the analysis of the third concept mental model related to scientific conceptual reasoning on the formula of the gravitational force in point a, reasoning the effect of gravity when submerged and landing on point b, and the description of the direction of the gravitational force when submerged and standing in the field c, are summarized into the following table;

Level of understanding	Amount obtained	Total (f) (%)
Scientific	0	0
Synthetic	15	44,11%
Initial	19	55,88%
Total	34	100%

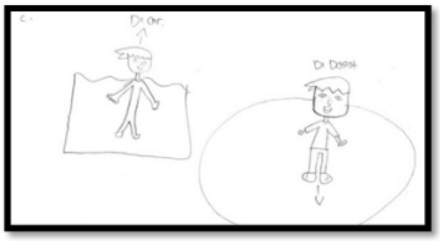
Initial mental model ownership dominates the third concept with an average of 55.88%, it is based on the categorization of students' answers in terms of descriptive and visual understanding refers to perceptions that do not coincide with scientific knowledge or at the level of NU (No Understanding,) ND (No Depicting), AC (Alternative

conception), ID (Incorrect Depicting), PU-AC (Partial Understanding with Alternative Conception) and CD-ND (Correct Drawings reflecting also Nonscientific Depicting).

At the AC level of understanding students have the perspective that the mass of objects multiplied by weight, this is of course very far from the actual scientific concept, and logically unacceptable, students do not know that the mass of objects is the meaning of objects that have weight. Students who are at the level of understanding PU-AC, students' answers at this level suggested that the influence of gravity on land and water will be different, when swimming his body will become lighter. This perspective reflects his experience in real life, so it is called an alternative concept. As for the level of AC understanding, many students cannot express answers even on knowledge that can be seen in everyday life. The depiction of the direction of gravity is not in accordance with scientific concepts, students describe the direction of the gravitational force towards the top, side, when standing or swimming, here is one example of students' answers at the ND level.

a.  b. 

As for students' answers at the PCD level, the depiction of the direction of the force of gravity when standing in the field downward, this is true in accordance with the scientific concept, but the direction of gravity when swimming cannot be scientifically accepted, so that only the direction of one component of the picture (the direction of the force of gravity when standing in the field) that can be scientifically accepted. Following is an example of an answer at the PCD level;



The result is scientific, synthetic, and initial levels of ownership the mental model is dominated by the synthetic mental model level, this can be seen from the test results of the concept understanding level 1 and 2 which have the highest average of 79, 41%. Only 11.76% in concept 1 had a scientific mental model, whereas in concept 3 there was a drastic increase in ownership of the initial mental model with an average of 55.88%.

Despite the fact that most students do not have a scientific mental model, scientific perceptions shown from synthetic mental models have actually implemented that students' understanding has relevant scientific information. Kurnaz (2015) states that students' perceptions will be related to alternative ideas, and therefore the nature of certain mental models may differ from scientific attributes.

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1	KURNAZ, Mehmet Altan and EKSİ, Cigdem. "An Analysis of High School Students' Mental Models of Solid Friction in Physics", İletişim Hizmetleri, 2015. Publications	106 words — 4%
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