

DIDACTIC DESIGN OF NATURAL SCIENCES LEARNING ABOUT WATER CYCLES IN 5TH GRADE ELEMENTARY SCHOOL

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Abstract. This research is motivated by the findings of learning barriers experienced by students in Classes V and VI of elementary school from the results of a preliminary study. Students do not yet understand the concept of the occurrence of water cycle so students find it difficult to work on identifying learning obstacles in the water cycle topic. This obstacle is caused by learning that does not pay attention to the nature of natural science learning and meaningful learning for students. Students are not actively involved in finding a concept but instead only receive information. Therefore, students' understanding of the water cycle topic is not built because the learning process is meaningless. This research aims to design a didactic design consisting of a lesson design which pays attention to the science process skills, the nature of natural science learning and meaningful learning. This didactic design has been validated by experts to get a better didactic design. The research method used is qualitative research methods while the data collection techniques used are observation, interviews, and documentation. This research produced three lesson designs from the results of the learning obstacle research analysis, namely: lesson design 1 understanding the role of water for living creatures, lesson design 2 introducing water elements and processes, and lesson design 3 understanding caring attitudes towards water conservation

Keywords: Didactical Design, Learning Obstacles, Natural Science, Science Process Skill.

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INTRODUCTION

Natural Sciences (IPA) is a group of sciences, which has special characteristics, namely studying factual natural phenomena, either in the form of reality or events and their cause and effect relationships. (wisudawati and sulistyowati, 2014, p. 22). This research focuses on the content of the material which will increase students' mindset in elaborating on a concept either in science learning or in other learning activities as well as making students have an increase in learning motivation.

Meanwhile, according to Trianto (2015, p. 136), science is knowledge that is structured systematically, and its use is generally limited to natural phenomena. Its development is not only marked by a collection of facts, but by the existence of scientific methods and scientific attitudes. In line with the author's statement and previous research theory, it can be concluded that science is a systematic collection of theories, its application is generally limited to natural phenomena, born and developed through scientific methods such as observation and experimentation and demands scientific attitudes such as curiosity, openness, honesty, etc.

The teacher's ability to plan and implement learning determines the success of a lesson, which is demonstrated by the achievement of learning objectives by students. As an educator, we should create learning that allows students to achieve the goals they have set. In general, the task of an educator in learning is as a facilitator whose job is to create a learning situation that allows the learning process to occur within students.

The various components contained in learning activities, especially teachers and students, will be able to work optimally if there is something that encourages them to do this, namely motivation. As facilitators we are able to create things that can make it easier for students in the learning process, such as providing teaching materials, learning media, practicums and others, so that they can provide student learning motivation.

Based on a preliminary study in the form of conventional learning and a test on class VI students, various kinds of obstacles to learning or understanding the concept of a topic were found for each student who were observed either in the learning process or test results. There were 36

students who took part. The learning process was carried out conventionally, adapting to previous educators' teaching methods and was the most basic way in formal learning to find out learning obstacles that students experienced in the water cycle material and then carry out a test after learning. The obstacles experienced were 22 out of 36 students or around 65% of students experienced obstacles in understanding the water cycle material.

There are many incorrect but considered correct understandings of the concepts contained in the water cycle, resulting in students having difficulty studying the concept of the water cycle which is basically a cause-and-effect event. In a preliminary study of conventional teaching, students only understood the concept of the water cycle so they did not know that it was closely related to the previous material. When conducting a basic understanding test, the researcher gives a number of interrelated questions so that basically, if students forget some terms, they can be helped by having interrelated questions, such as in question No. 3 "what is the role of the sun in the water cycle? explain!" with the expected answer "the sun acts as a source of heat energy where sunlight radiates to the earth which results in the process of evaporation of water on the surface".

Basically, the question above is a fundamental question from the concept of the water cycle, and is closely related to the law of changes in the state of substances. When a substance is subjected to heat energy pressure with its respective volume, one of the processes of changing the state of the substance, namely evaporation, will occur. Where evaporation is a physical change in a liquid that spontaneously becomes a gas. According to Adnan (in Rahmawati, 2019, p. 29) evaporation of water or drying is the process of reducing the relative humidity of the air by circulating hot air around the material, so that the water vapor pressure of the material is greater than the water vapor pressure in the air. This pressure difference causes the flow of water vapor from the material into the air.

In line with the expression above, the beginning of the water cycle is the process of evaporation of water on the surface of the earth. However, in fact, the student's response in answering the basic question on the same question as above was beyond the researcher's expectations by answering "The sun rotates around the earth, rainwater flows to the sun." This answer lacked the use of connecting words so that the answer could not be understood by the teacher or reader.

In fact, the students' responses above when given a test to understand the basic concepts of the water cycle material turned out to have many errors like the picture above, which proves that students cannot explain the cause and effect from one concept to another. Because the role of the sun in the water cycle is a cause and effect of the presence of heat energy which is able to change a substance into an event. And this proves that students experience a Learning Obstacle, this is supported by the statement of Bachelard and Piaget (in Brousseau, 2002. P. 64) Mistakes are not only the result of neglect, uncertainty, and coincidence as mentioned in empirical learning theory or behaviorism, but rather the impact of previous knowledge that was thought to be correct but turned out to be wrong. It can be concluded from this incident that the learning flow provided by previous educators did not pay attention to the Ontogenic aspect, namely students' readiness to accept new concepts because previous knowledge acts as a condition for readiness to accept the next theory or concept.

Based on the description above, the researcher intends to develop a design for learning by creating a student learning trajectory (Learning Trajectory) that pays attention to students' flow of thinking in understanding the concept of the water cycle, so the researcher thinks this will make things easier for teachers and students during the learning process.

METHOD

The didactic design is based on Learning Obstacle and Trajectory. Suryadi (2013) describes several formal steps in conducting didactic design research which are organized into three activity stages, among others: a) Didactic situation analysis before learning which takes the form of a hypothetical didactic design including ADP, b) Metapedadidactic analysis, namely analysis of teacher abilities which includes three integrated components, namely unity, flexibility, and coherence. c) Retrospective analysis, namely analysis that links the results of the analysis of

hypothetical didactic situations with metapedadidactic results. The stages carried out in this research are as follows:

Preparatory stage/Didactical situation analysis

1. Determine the science subject matter that will be used as research material.
2. Analyze the facts that occur in the field
3. Search for literature as material for data from the material that has been determined.
4. Study and analyze the characteristics of the material that has been selected for research
5. Create an initial instrument to determine the learning obstacles that exist on the topic chosen for research.
6. Select the participants who will be the subjects of the learning obstacle test
7. Conduct trials and analyze learning obstacles
8. Develop and consult on and improve the learning trajectory that has been created
9. Analyze the character of the students who will be used as research subjects
10. Develop, create and consult on initial didactic designs based on analysis of learning obstacle and learning trajectory tests

Implementation stage/Metapedadidactic analysis

1. Conduct initial didactic design trials. By carrying out the validation stage with experts who are relevant to the material that has been determined.
2. Analyze and evaluate the initial didactic design for deficiencies by validating it with relevant experts.

Data processing and analysis stage/Retrospective analysis

1. Reorganize and perfect the initial didactic design from the results of the evaluation that has been carried out and carry out validation consultations again with the experts.
2. Prepare a report on the results of the research that has been carried out based on the implementation of the initial didactic design that has been prepared.
- 3.

RESULTS

Before preparing a didactic design for the water cycle material, the researcher first searched for data regarding students' learning experiences in passing test questions on the water cycle material in class V of elementary school. The test is carried out to identify any learning obstacles that students experience in studying the cycle. Apart from the test, researchers conducted observations to identify teachers' methods for teaching the water cycle in class. The observations carried out aimed to identify the relationship between learning obstacles experienced by students and the teacher's method of teaching the water cycle material.

Students' learning obstacles or learning obstacles are divided into 3 types, namely ontogenic (difficulties related to children's learning readiness), epistemological (limitations of concepts being studied) and didactical obstacles (teacher teaching situations) which can occur in the learning process, Brosseau (in Suryadi, 2019 p. 24). After analyzing the data obtained periodically, the author can conclude that the learning difficulties or learning obstacles experienced by students in learning science on the Water Cycle material are found in epistemological obstacles and didactical obstacles.

Learning Obstacle Water Cycle Material

Students' learning obstacles or learning obstacles are divided into 3 types, namely ontogenic (difficulties related to children's learning readiness), epistemological (limitations of concepts being studied) and didactical obstacles (teacher teaching situations) which can occur in the learning process, Brosseau (in Suryadi, 2019 p. 24). After analyzing the data obtained periodically, the author can conclude that the learning difficulties or learning obstacles experienced by students in learning science on the Water Cycle material are found in epistemological obstacles and didactical obstacles. The following are the learning difficulties that the author found.

Related category A learning objectives explain the role of the elements of the water cycle in the process. Based on students' answers from the identification of learning obstacles, researchers found that students had learning difficulties in explaining the role of the water cycle elements in

the process. Analyze students' answers to the fundamental question "What role does the sun play in the water cycle?", below the researcher describes the results of the analysis into a table:

Table 1. Epistemology Obstacle Type A

Student Answer Type	Many Students
"The sun revolves around the earth rainwater falls on the sun"	1
"Evaporation of water in the ocean"	3

The student's learning obstacle in student answer type number 1 is the student's misunderstanding in receiving knowledge about the existence of water evaporation caused by solar heat energy, so that students have the concept that evaporated water gathers in the sun. This condition can be caused by 1) Students' imperfect understanding of the causes and effects of heat energy emitted by the sun on a substance, 2) Students' direct experience of seeing a rainy situation, namely the cloudy sky covering the presence of the sun due to the result of water vapor covering the sun.

Type of student answer number 2 is students' incomplete understanding when accepting new concepts. Basically, the sun causes evaporation events or evaporation of water on the surface of the earth, not just the sea. Evaporation occurs in various waters and from other living creatures, especially plants, but students only mentioned sea waters. This condition can be caused by the incomplete initial concept that students receive. As a result, the fact that students have from direct experience is that coastal/ocean areas tend to be hotter than other areas, so students have the concept that evaporation is possible only in the ocean.

Learning obstacles category B is related to explaining the cause and effect of a situation so that the water cycle process occurs. Based on students' answers from identifying learning obstacles, researchers found several obstacles to students' learning in explaining the causes and effects for the water cycle process to occur. Analysis of students' answers to the basic question "Can the evaporation process occur at night?", here the researcher describes the results of the analysis in a table

Table 2. Epistemology Obstacle Type B

Student Answer Type	Many Students
"This occurs because sea water evaporates at night"	1
"From the clouds back to the sea from the sea back to the clouds, Turnover"	2
"The process of evaporation occurring at night is not, because the temperature at night is higher than in the morning/afternoon"	1

The obstacles to students' learning or learning obstacles in answer types number 1 and 2 that the researchers found had the same common thread, namely that students misunderstood the concept of cause and effect of evaporation, thereby stating that at night the evaporation process could occur. The night situation can only result in the process of evaporation of water to surrounding objects that can be seen in the morning, namely dew. This condition can be caused by 1) students' lack of understanding regarding changes in the state of matter due to energy in the form of matter. 2) students' lack of understanding of the events that occur in each term of the water cycle process.

The type of student answer number 3 that the researchers found was students' mistakes in understanding the verbs used to mean a temperature in hot or cold situations. So students stated that the temperature at night was higher than during the day

Learning obstacle C is related to explaining one of the terms from the stages of the water cycle. Based on students' answers from identifying learning obstacles, researchers found several obstacles to students' learning in completing sentences that explain one of the water cycle processes. Analyze students' answers to the basic fundamental question "Evaporation or _____ is the process of changing ___ molecules into ___ molecules, this causes water to rise which has

turned into ___ up or into the atmosphere." Below the researcher describes the results of the analysis into a table:

Table 3. Epistemology Obstacle Type C

Student Answer Type	Many Students
"Evaporation or evaporation is a process of large molecular changes into small molecules, this causes the water which has turned into gas/steam to rise upward or into the atmosphere"	1
"From the clouds back to the sea from the sea back to the clouds, Turnover"	2
"The process of evaporation occurring at night is not, because the temperature at night is higher than in the morning/afternoon"	1

Students' learning obstacles or leaning obstacles in answer type number 1 are students' misunderstandings in understanding the factors that vary in weather in a region. This question gives students the opportunity to analyze the differences between Oceanic and Mountainous regions. Basically, students will know the lowlands and highlands of an area. The statement "2 climates" that students gave to the question of differences in rainfall in two regions shows students' mistakes in understanding the context of the question. This condition can be caused by students' imperfect understanding of the evaporation process in the water cycle.

Type of answer number 2 is that students make a mistake in writing a cause and effect event from the water cycle process. This is proven by two sentences that are parallel to each other in the student's answer 1) 'when it evaporates in Bogor' this shows that students understand well the many evaporation processes that occur in the Bogor area. Evaporation that occurs in highland areas tends to experience more evaporation because there is water and more transpiration processes occur. 2) "When it rains in Lombok", this leads to students not fully understanding every process of the water cycle. Lombok is a low-lying area, so this sea area has quite arid temperatures and winds. This is because the direction of the evaporating water vapor is shifted by the large number of wind gusts, causing the water droplets to fall again in other areas. Evaporation that occurs in highland areas tends to experience more evaporation because there are waters and more transpiration processes occur, the amount of rainfall in highland areas means that the temperature in highland areas tends to fall more quickly which is caused by the production of fresh air from the abundance of forestry, so that water vapor that collects in the atmosphere will fall back down to that area more quickly.

Answer type number 3 is a misunderstanding that occurs in category A answer type number 1 and category C number 3, namely students' misunderstanding of the concept of the water cycle. This condition can be caused by 1) students not fully accepting the concept of the water cycle, so they are mistaken in concluding a real situation, 2) Students' direct experience of seeing a rainy situation, namely the cloudy sky covering the presence of the sun because the result of water vapor covering the sun causes the Bogor area to always rain, 3) students are fixated on a general fact, namely "Bogor is a rainy city".

Didactical Obstacles

1. Related category A learning objectives explain the role of the elements of the water cycle in the process

Student Answer Type	Many Students
Evaporate	1
Heater	3
Globalization	1

Student answer type number 1 was one word "evaporate" which caused the researcher to draw the conclusion that the student was unable to explain his understanding of the role of the sun in the water cycle. Learning obstacle B is related to explaining one of the terms from the stages of the water cycle.

Student Answer Type	Many Students
Evaporation or condensation is the process of changing water molecules into vapor molecules, this causes the water which has turned into clouds to rise upward or into the atmosphere.	4

The learning barrier in the answer above is that students misunderstand the terms in the stages of the water cycle. The type of question that completes a paragraph is created so that researchers can find out the extent of students' understanding of the definition of a term in the water cycle. Researchers draw the conclusion that, this condition can be caused by 1) students' lack of communication at each stage of receiving and understanding new material, 2) students not having the opportunity to be trained to pronounce terms frequently, 3) learning situations that do not involve students in looking for facts from terms. -terms of the stages of the water cycle.

2. Learning obstacles type C, related to explaining the differences in the water cycle based on the type of area

Student Answer Type	Many Students
Due to differences in regional factors and natural factors	3
Because in Lombok there is little evaporation	1

Learning obstacles in the two types of answers above have something in common, namely that students cannot describe well the consequences that occur in an event. This leads the researcher to the conclusion, 1) students experience limited vocabulary, 2) students are unable to restate based on their understanding of a concept.

DIDACTICAL DESIGN FOR WATER CYCLE MATERIAL

A design of teaching materials prepared by the teacher based on research regarding learning objectives of material in science learning produces a didactic design. In this case, learning obstacles are closely related to learning trajectory, namely the flow of children's learning to achieve certain goals which are facilitated through a series of learning activities that suit their abilities. The design process is carried out by carrying out a validation process from experts, the following is a description of the validation results:

Learning Trajectory :

Revision of expert lecturer validation : Add science process skills that can be developed in every line of thinking.

Hypothetical trajectory

Class teacher validation revision :

1. The gap between KKO in basic competencies and KKO in indicator items
2. Pursing the sun's heat source in the form of radiation

Revision of expert Lecturer Validation :

Add science process skills that can be developed in every line of thinking

Lesson plan

Class teacher validation revision:

The gap between KKO C3 and C4

Revision of Expert Lecturer validation:

Arrange the purpose of using the CABD formula

Didactical Design (Teaching Materials)

Class Teacher validation results:

1. Provide the title "Didactical Design of the Water Cycle" on the cover page of the teaching materials

2. Image modeling: students label an image at each stage of the water cycle
3. Provide lesson design information for each didactic situation in the teaching materials

Expert Lecturer validation results:

1. Arrange the purpose of using the CABD formula
2. Providing similar concepts of heat energy between the sun and stove fire (mini practicum) to represent the same concept of evaporation results.
3. Provides information on each stage of the water cycle

CONCLUSION

Lesson Design is a learning plan that uses one teaching material completely, in which there are several components, consisting of didactic situations, student responses, teacher assistance and instructions. Based on the results of the class teacher's validation regarding the readability and use of the flow of teaching materials in the learning process, there are several suggestions, namely:

Pursing the sun's heat source in the form of radiation

In the presentation of material regarding the element of water, there is a shift in concept from the didactic situation which states that the source of solar heat can influence changes in a substance and the didactic situation in the practical stage of using the heat of a stove to change the form of a substance. This purification of material aims to equate the concept of heat sources which can influence changes in substances in water. The characteristics between the sun and Fire are different. The sun's heat energy is in the form of radiation, and does not require a medium to conduct the heat. Meanwhile, stove fire is a source of heat energy that requires a medium to conduct the heat. Even though the two have differences in conducting heat, the characteristics of water/hydrogen, when exposed to heat energy, the molecules that are interconnected will become looser and their mass will become smaller and lighter, the lighter molecules will fly into the air and appear to be very small particles like gas. . Therefore, the direction of the arrow showing signs of evaporation is pointing upwards.

Provide information on the teaching material page for each didactic situation

Provide descriptions of the pages contained in the teaching materials for each stage that occurs during learning. This happened when the validator checking the connection between the lesson design and the teaching materials experienced confusion because there was no water cycle teaching material page related to the didactic situation in the lesson design. Therefore, the researcher added page descriptions to each learning flow that were adapted to the flow of the water cycle teaching materials created.

Didactic Design (teaching materials)

The design compiled consists of 12 worksheets. The first worksheet (p.1) instructs students to write down daily activities related to water. The aim is for students to remember various activities that use water. The preparation of this design or worksheet is adapted to the Enactive Stage proposed by Jerome Bruner, namely 'knowing an aspect of reality without thinking'. This worksheet is given at the beginning of the lesson (activity 1). Meanwhile, the second sheet, (p.2) contains instructions 1) to write down the various types of living creatures on earth, 2) to write down each living creature's need for water. The goal is for students to achieve aspects of learning with Science Process Skills - observing and the enactive stage of Jerome Bruner's theory. The Observation stage occurs after students have gone through the enactive stage, namely the facts that students already have and then observe them to classify the needs of various types of creatures for water.

The table contains icons as illustrations of various activities, objects that show the benefits of water for life on earth. On this comprehension sheet, students are given a stimulus first with questions found in Bubble Chat, 1) "where does water come from?", 2) "why does the water on earth never run out?". This question acts as a stimulus for students to practice students' critical thinking. The "Let's Read" activity is information carried out by teachers and students. The second

objective, this activity is to achieve the Science Process Skill aspect - Making Predictions and Communicating as stated by Tursinawati (in Sardinah, 2012 p.72).

Worksheet (p.4), there are 2 activities. First, write down students' experiences during rainy situations. This experience writing activity is an effort to train students in writing down an experience into words. The concept of "rain" questions is a learning process by linking a new concept with facts that students already have. This was stated by Ausubel in the Meaningful Learning Theory 'understanding a concept is always linked to other concepts, then a meaningful learning process will occur'.

Second, the activity of observing a picture and writing down every object in the picture. Then write down the students' opinions about the events that occurred in the picture. The aim is to get students used to putting their thoughts into writing in order to train students' skills in explaining an event. Image analysis activities are a student learning process at the Iconic stage, namely 'a collection of images to represent a concept' proposed by Jerome Bruner. This activity shows the 'ACTION' stage as an illustration that students experience an event without knowing the cause and effect of the event. This was stated by Suryadi (2006) in the Theory of Didactical Situation 'to encourage mental action, the learning process must begin with the presentation of problems that contain challenges for students to think'

The worksheet (p.5) contains students' activities to recognize the objects contained in the image analysis. This activity shows the formulation stage in the Theory of Didactical Situation as stated by Manno (2006). 'This stage gives students the opportunity to create their own models implicitly to express strategies in words that can be understood by other students'. As material for students' knowledge to remember the properties of objects that can cause an event. The goal is for students to analyze the cause and effect of an object meeting another object so that an event occurs. So that this learning process can achieve the science process skill aspect - Developing Tursinawati's hypothesis (in Sardinah, 2012 p. 72, as a product of Formulation activities, Suryadi (2006) in the Theory of Didactical Situation.

Worksheet (p.6) contains practical activities. The goal is for students to be able to prove and observe the process of changing the state of matter. 1) The column for filling in the function of practical tools and materials, the aim is so that students can hypothesize about what activities will be carried out. Practicum is carried out together with teacher guidance. 2) Filling in check marks by students in the practicum stage column, aims to ensure that students continue to follow the practicum process. 3) Any findings regarding events that occurred during the practicum are written in the "notes" column on the next worksheet (p.7).

Every finding and conclusion that students get in the practicum will be presented randomly. As stated by Lepiyanto (2014, p. 148) 'science process skills are observing, communicating and asking questions'. Filling in the questions after the practicum is an effort to assess the process to measure students' knowledge gained after doing the practicum. The worksheet (p.8) contains a series of interconnected processes to explain each water cycle process, equipped with pictures that can represent each cycle process consisting of Evaporation – Condensation – Precipitation – Runoff – Infiltration. Each stage contains 1) Terms without descriptions, aimed at being a stage for finding answers independently. 2) There are pictures with descriptions that are students' illustrations for the next process.

As has been done in the practicum, to find out the terms evaporation and condensation can be linked to the findings in the practicum. So students search for and analyze for themselves the relationship between practical findings and new knowledge (evaporation and condensation) to create a definition according to the hypothesis obtained which can then be confirmed by the teacher. This is in line with the theory of meaningful learning put forward by Ausubel (in Firmansyah, 2017, p. 15)

Worksheet (p.9) is an exposure activity carried out by the teacher. Providing stimulus in the form of presenting problems and explaining the factors inhibiting the water cycle. Student activities in understanding the factors aim to instill a caring attitude towards the importance of protecting and conserving water.

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