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The identification of students abductive types in science learning using an abductive inquiry model with connected integration type

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Abstract. In recent years, there has been an increasing interest in student thinking skills. Many researchers argue that reasoning skills are one of the most important skills for the students, one of which is abductive reasoning. Therefore, the study aims at identifying various students' abductive types in science learning by applying the integrated type of abductive inquiry learning model on global warming topic. This research was a qualitative study, utilizing an audio recording of student and teacher dialogues during learning and an observation sheet. The subjects in this study were 30 students of grade VII selected by convenience sampling technique. The results showed that the abductive types of students in learning science varied between groups. These types included theoretical abductive, existential abductive and legal or regulatory abductive.

1. Introduction

Determination of learning objectives is always done by the teacher when designing their instruction [1]. This is important because the determination of learning objectives will lead teachers to use the appropriate assessment methods and teaching techniques [2]. One of the objectives in learning science based on the 2013 curriculum is the development of reasoning ability in analytical thinking by using the concepts and principles of science to explain various natural events and solve problems both qualitatively and quantitatively [3]. The science learning process requires students not to be separated from the process of thinking or reasoning [4,5]. Reasoning is an activity of thinking specifically to draw conclusions [6]. So that students' thinking activities will have certain characteristics in drawing a conclusion as a truth which lead to produces new knowledge [7].

Acquisition of knowledge is based on human thought processes. There are three types of human thought processes so as to produce a conclusion that is deductive, inductive and abductive [8]. Deductive is a form of reasoning which patterned from general to specific, inductive is a form of reasoning that is patterned from specific to general. While abductive aims to deduce an unobservable cause or explanatory reasoning for the observed event [9]. Based on these three thought processes, abductive reasoning is a more complex thought process compared to other. It should be sharpened through learning specifically the learning of natural sciences.

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Abductive is the process of forming explanatory hypotheses for the results that have been observed [10]. The teacher's role is to guide students in formulating relevant hypotheses and choosing the reasons that make the most sense according to the criteria. Abductive conclusions are made by reducing or selecting some of the possible answers obtained through observation to produce the best hypothesis that can be accepted [11,12]. So the process of argumentation is also important in finding conclusions [13].

The formulation of conclusions begins with observing the facts, then followed by the preparation of the most reasonable hypotheses or answers[14]. When someone goes through a process like this, he is basically carrying out abductive inquiry [15,16]. Abductive inquiry is seen as an iterative process that involves observers' prejudices or assumptions followed by a process of studying the truth of a theory related to the facts of phenomenon and then shaping it into the best answer (Martaleta). In the process of abductive inquiry learning students are given the opportunity for students to construct new knowledge through problems in the experiment, then formulate some possible answers, select some of the possibilities that have been previously formulated until finally selecting the best answer that makes the most sense to explain the problem. The purpose of this abductive inquiry learning model is to facilitate or facilitate students to discover their own concepts. When students are in such a learning process, then learning will be more meaningful, so students are more receptive to and absorb what they get, compared to students receiving verbal teacher explanations.

Previous studies have shown that the implementation of inductive inquiry on earth science materials has been shown to be able to improve students' abilities in problem solving and hypothesis formulation [17]. Improve students' ability in terms of hypothesis formulation, learning performance and student memory [18]. Furthermore, it is also able to improve the critical thinking skills of prospective physics teachers on terrestrial and space science [7]. There is a development in students' thinking and mastery of concepts by applying abductive inquiry models, this is because students are given a real problem or phenomenon in daily life, then students look for information and solve these problems using critical, logical and scientific thinking skills [19]. even though not very significant. This is because the teacher does not yet know the abductive types of students. Therefore this study aims to identify the abductive types of students. The novelty of this study is the connected type integrase model which is considered to make it easier for students to practice the abductive way of thinking.

2. Method

This study used a qualitative research approach [20]. A total of 30 VII grade students in Bandung are involved in this research selected by convenience sampling technique. This study used two types of data namely audio data and student observation sheet data. Audio data collection is done by recording during learning while the data on the observation sheet is observed by the observer. The observation sheet used was adopted from Shurc (2008) [9]. Student audio data is analyzed and observation sheets are used to map the abductive types of students

3. Result and Discussion

The data used to determine the abductive type of students is the flow of student reasoning taken from the dialogue footage of teachers and students in each sub-subject of global warming. The following are the results of students' abductive types in learning science.

3.1. Atmosphere Layers

The group analyzed for its abductive type in the Atmosphere layers topic is group two. The teacher displayed the phenomenon of the temperature of the Earth during the day and night. The phenomenon was emitted sun's light, some are reaching the surface of the Earth and some are reflected out space. Students analyzed that it is caused by the layer of Earth's atmosphere, but they are not sure of the evidence that supports it. They even mention it by "ozone layer". This can be shown through the dialog below.

T : "Afrilia, explain what happened in the video!"

S_2 : "There is the sun's heat reaching the surface of the Earth and there is the sun's heat that has not yet reached the surface of the Earth but has already been reflected"
T : "Why?"
S_2 : "Because there is an ozone layer that holds too much heat, ma'am"
T : "Okay then what else? Gazila, give your answer"
S_{11} : "The sun's heat reaching the surface of the Earth is reflected back into space, but there is heat retained in the Earth"
T : "Well, why do you think it can be held back, I want Jesica to answer"
S_{14} : "Because there was no ozone layer"

After gathering information and extending the theory at the testing phase, the students finally understood what caused the phenomenon displayed by the teacher. It was due to the atmosphere layer. This can be seen in the dialog below:

S_{26}: " why does not all of the Sun's heat reach the surface of the Earth ? because in my opinion there is a layer of atmosphere that is blocking it, so there is heat that can enter and there is heat that does not enter the Earth's surface"
T : "Why did you mention because of the atmosphere"?
S_{26}: "Yes ma'am, because the atmospheric layer serves to protect the Earth from the sun's heat which is harmful to the Earth, for example UV light, so that UV light does not reach the Surface of the Earth, but is reflected by the ozone layer contained in the atmosphere"
T : "Now the question is when the Earth receives heat from the sun, it re-radiates that heat. Can all the reflected heat get out of the surface of the Earth? I want to be answered by Susi "
S_{30}: "No, ma'am,"
T : "Why?"
S_{30}: "Because some of the heat reflected by the surface of the Earth is retained by the Atmosphere of the ma'am"

After going through the selection phase, students from group two explained their answers in full regarding the function of the atmosphere layer completely. From students' dialogues it is known that students apply their knowledge related to the function of the ozone layer to answer given phenomena, until students develop their theories regarding the atmosphere layer. Because the concept of the atmospheric layer is an abstract concept or cannot be proven through experimentation or direct observation, an analogy is used in the form of an illustration of the Sun that is radiating its heat to Earth. The results of abduction in the form of new rules with the concept of analogies and abductive are controlled by analogies along with background knowledge about the atmosphere layer. This line of reasoning is known as the type of existential abduction. The following is presented the type of existential abduction syllogism [9].

Exsistential Abduction

Theory's Background	: Ozone Layer resist harmful UV rays to the Earth so it does not reach the surface of the Earth
Explained Fact	: Not all of the heat emitted by the Sun reaches the surface of the Earth
Alleged abductive	: Earth has a layer of atmosphere that protects it from harmful rays and objects.

Students succeed in explaining that the preservation of the Earth from the heat of the Sun is too high and dangerous celestial bodies caused by the presence of atmospheric layers (explain with illustrations in the video). Illustration of the sun's heat reflected by the layers of the atmosphere shows that the heat does not enter the Earth's surface. Furthermore, there is heat from the Sun that enters the Earth's surface and the Earth reflects it back into space, but is held back by layers of the atmosphere. This analogy is used to explain that the same process occurs on our Earth in the presence of a layer of air that is transparent and invisible to the eyes.

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3.2. Greenhouse effect

In greenhouse effect topic, the selected group for analyzed is the third group. They observed the three state of the Earth illustration, there are Earth covered with ice, the normal Earth and the Earth with increasingly high temperatures. Furthermore, the video shown also illustrated how the Earth reflecting the heat it receives, but there is heat trapped on Earth. This they can understand because the concept they had obtained at the first meeting was related to the function of the atmosphere. A dialogue occurs between the teacher and student as follows:

T : "According to Lamia what happened to the video?"
S_{15}: "There is an earth that is getting more and more white, ma'am"
T :"Well, what does that indicate ??"
S_{15}: "Ooo, the earth is covered with ice, because it's slowly white, it means the earth is coated with ice."
T : "Good. According to Nazla, why does the Earth be covered by ice?"
S_{22}: "Because there is no atmosphere, ma'am"
T : "What about the state of the Earth, Fhareal?"
S_{10}: "Normal Earth condition, which is warm or not too hot, means to be in state condition"

In the exploratory phase, students have found a problem to be investigated further regarding the causes of the Earth's ice-covered condition and the normal Earth's condition. In the testing phase, students discuss the related greenhouse effect. After conducting group discussions, students successfully understood the benefits of greenhouse gases and the process of the greenhouse effect to maintain temperatures on Earth. This is shown through the dialogue snippet below:

T : "According to Lamia what is the function of the greenhouse gas for life on Earth?"
S_{15}: "To keep the temperature of the Earth warm at night ma'am"
T : "How do you know that the greenhouse gas can keep the earth's temperature warm at night?"
S_{15}: "Because this greenhouse gas is in the atmosphere, bu, so the greenhouse gas also stores heat."
T : "Then?"
S_{15}: "So because there is heat stored by greenhouse gases and the heat is channeled back to Earth, so at night the temperature of the Earth remains warm"
T : "Now what do you think happens to Earth when there are no greenhouse gases?
S_{23} : "Cold ma'am, because no one absorbs it, it stores ma'am's heat. So for example the heat goes into Earth, then everything will go out into space again "
M : "So if there is a greenhouse gas what happened Nazla?"
S_{22} : "If there is a greenhouse gas, then there is a store of heat to maintain the temperature of the earth at night"

Students are able to select the best answers and explain in full the answers related to the greenhouse effect. If they had not yet collected information on the cause of the temperature of the Earth to be maintained, at this stage they were able to explain that the process of the greenhouse effect that causes the Earth's temperature to remain warm. They can also say that the greenhouse effect is closely related to the atmosphere and greenhouse gases, because it is the greenhouse gases in the atmosphere that absorb and store heat.

It was detected that students already had a background theory about the function of the atmospheric layers studied at the previous meeting. The results of the abduction of students in group 3 are not in the form of new rules, but students only expand the paradigm and understanding of the previous theory. The flow of students' reasoning is in accordance with the abduction of theoretical models [9]. The syllogism for the theoretical model abduction is shown below:

Theoretical Abductive
Theory's Background : Atmosphere layers function

Explained fact	: Earth covered with ice and Earth with temperatures rising during the day and night
Alleged abductive	: If there is no layer of atmosphere there is no heat trapped inside the Earth, if there is a layer of atmosphere then there is a store of heat in the Earth

3.3. Global warming

The fourth group discusses about global warming by watching a video of the phenomenon of the state of the Earth with increasingly high temperatures. Below is the dialogue between teacher and student:

T : "Now, I want to ask Anisa, try to explain what happened in the video!"
S_{21}: "There is a state of the Earth that is getting hotter or the temperature is increasing"
T : "Well, why can you say that the temperature of the earth is increasing?"
S_{21}: "First, because the illustration of the Earth is getting red and the temperature on the thermometer is getting higher"
T : "What about the others?"
S_9 : "Earlier Ma'am, the temperature of the earth was rising because more and more smoke from vehicles, factories and aircraft"
T : "What does that have to do with rising temperatures on Earth?"
S_9 : "The more smoke that is collected on Earth, the temperature will go up"

Group four understands that the cause of rising temperatures on the surface of the Earth is due to the amount of smoke produced by vehicles. But they do not yet know that these fumes will become greenhouse gas emissions that play a role in the greenhouse effect process. They have found a problem to be investigated further that is related to the process of global warming. In the testing phase, students discuss in groups until they successfully understand that increasing greenhouse gases in the atmosphere will cause the earth's temperature to increase or cause global warming.

T : "Do you think human activity can increase greenhouse gases in the atmosphere?
S_{16}: "Yes ma'am, because the more people move to produce greenhouse gases, the amount of greenhouse gases will also increase"
T: "Okay, if the amount of greenhouse gases more in the atmosphere, how does it affect the temperature of the Earth? Anisa, Try to answer!"
S_4 : "Earth's temperature will get higher or higher, ma'am"
T: "Okay, why can you predict that the temperature of the earth will increase when there are more greenhouse gases in the atmosphere?"
S_4 : Hmmmm (think for a moment) Mom, when there is more gas in the atmosphere, more heat is absorbed, and more heat is reflected to the earth's surface"

At the selection stage, students choose the best answer and explain in detail the cause of the rise in surface temperature of the Earth, which is caused by the increasing amount of greenhouse gases in the atmosphere. It was detected that students could mention the cause of the phenomenon of rising temperatures on the surface of the Earth caused by the increasing amount of smoke from aircraft, vehicles and factories. Students can proposed hypotheses using previously known rules that are related to heat trapped in the Earth due to atmospheric layers. Students make initial assumptions that the increasing amount of smoke trapped on Earth causes the temperature of the Earth to rise. The results of abduction in the form of rules or legal abductions. In the type of legal abduction / abduction results in the form of empirical rules and also controlled by the implications of rules that are well known. The syllogism for legal / legal abduction is shown below:

Law/Rule Abductive

Known rule/law	: Atmospheric layers trap heat of the Earth
explained rule	: Greenhouse gases are increasing in the atmosphere
Alleged Abductive	: The increasing amount of greenhouse gases in the atmosphere the higher the temperature on Earth

During the testing phase students also discover new facts that are causing the rise in temperature on the surface of the Earth with the support of a theory known about the greenhouse effect. If in the previous stage they have not been able to mention that these fumes include greenhouse gases. So after gathering information and supporting theories, they can understand the associated greenhouse gases and their functions. They can also explain from the rules or theories they find that the increase in greenhouse gases resulting from human activities is the cause of global warming

Table 3. Student's Abductive type

Group	Topic	Abductives Type
2	Atmosphere layers	Existential Abductive
3	Greenhouse effect	Thereotical Abductive
4	Global warming	Law Abductive

The different abductive types shown by students in groups was caused by each group discussing or reviewing different topic. For example in atmosphere layers and the greenhouse effect topic which is an abstract concept that can be understood through the help of illustrations or analogies. Thus, the students' reasoning process or thought process will lead to the existential abductive type used to explain, support and strengthen their chosen hypothesis. While the global warming topic is more theoretical by explaining the facts that occur. Students' thought processes with the characteristics of the material will lead students to think more theoretically and explain their hypotheses by observing facts and and reinforced by theories. This is in line with what was conveyed by Schurz (2008) and also reinforced by Holyak and Thagard (1998) that important processes involved in abductive analogies or existentials are abstract concepts[21]. Thus the characteristics of the material discussed by students in learning will affect their thinking processes. When the material characteristics are abstract, students will tend to think of existential abductive types. Explain the material using examples or analogies. When the material characteristics discussed by students are more theories, students will tend to think of the abductive type of theoretical models. Students explain the material by developing their background knowledge. Furthermore, if the material discussed by students is more of a standard rule, such as studying / discussing laws, the student's thought process will tend to be in the abductive type of law / rule. This means that students' thinking processes are bound to the laws and rules that already exist and the rules obtained by students in the testing process.

4. Conclusion

The present study was designed to carried out the characteristics of students' abductive types in science learning. This study has shown that the abductive types of students differ in each concept. The different abductive types shown by students in groups was caused by each group discussing or reviewing different topic. The study, however, makes several noteworthy contributions to learning and teaching practice. By knowing the type of abductive types, it could help teachers to determine teaching techniques that appropriate to the concept or topic.

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