

FINDINGS OF AN EQUATION TO RESOLVE TEMPERATURE CONVERSION PROBLEMS ALL KINDS OF THERMOMETERS (BEST PRACTICE DISCOVERY LEARNING MODEL)

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ABSTRACT

Temperature conversion is a way of changing the temperature value of a thermometer to the size of various types of thermometers. In the process of conversion this temperature has many difficulties experienced by students. This difficulty is due to the many equations that must be mastered by students to convert the temperature of one thermometer to the other thermometer. There are 4 thermometers namely Kelvin, Celsius, Reamur and Fahrenheit. To be able to convert 4 different thermometers, students must control 12 types of equations. This is, what is the main cause of students has difficulty converting temperature. Through Discovery Learning-based learning, the author uses empirical methods originating from his experience in finding an equation that can be used for temperature conversion of various thermometer. The discovery of an equation that can be used for the temperature conversion of all kinds of thermometer is certainly very important because until now in textbooks or journals, the equation for temperature conversion is still a lot and confuses students. After using an equation to convert the temperature of all thermometers then mastery learning the material only takes one hour for the lower class and half an hour for the upper class.

Keywords: *Discovery Learning, Thermometer, Temperature Conversion.*

I. INTRODUCTION

One of the important materials learned by junior high school students is temperature conversion. It is written in the learning objectives of the latest curriculum that students can make a temperature scale, measure temperature with a scale thermometer, and compare measurements with a recognized temperature scale thermometer. Temperature conversion is listed in the discussion of temperature measurement with a scale thermometer.

Student learning outcomes on temperature material are still low. The low result of daily tests on temperature material caused by students has difficulty remembering and applying the formulas of temperature conversion contained in the book. The temperature conversion formula

has a certain pattern so that the temperature conversion table can be made. By using the temperature conversion table, it is expected that students are easier to study temperature conversion material. Temperature conversion props in the form of a temperature conversion table is a solution to improve learning outcomes. This is based on the study that has been done, the existing temperature conversion props in the form of formulas contained in the package book.

In general, learning media are a tool for teaching and learning processes. Everything that can be used to maximize thinking, ideas, attention and abilities or skills. So it can encourage the learning process. Learning media is a physical means to join the content / learning

material such as, books, films, videos. In the world of education, the use of learning media often uses the principle of cone experience, which requires media such as textbooks, learning materials made by teachers and audio visuals.

Temperature conversion is a way to declare the temperature of an object from one scale into another scale. To convert temperatures from one scale to another can use the established formula.

However, due to too many formulas or equations to convert thermometer units to other thermometers, students will find difficulties and saturation in resolving the problem of temperature conversion. Not yet working on just a lot of students who complain sometimes even lazy to see the temperature conversion table consisting of many formulas or equations.

As an effort to overcome these problems, the author has found a way, precisely an equation or formula that can be used in converting the temperature of all kinds of thermometer through Discovery Learning models.

II. THEORETICAL BASIS

Definition of Discovery Learning Model

In general the model is interpreted as an object or concept used to present something. Something real and converted for a more comprehensive form.

According to Sani learning models are a conceptual framework in the form of a systematic procedure pattern developed based on theory and is used in organizing the teaching and learning process to achieve learning goals. Arends in Trianto stated that:

"The Term Teaching Models Refers to A Particular Approach to Instruction That Includes its Goals, Syntax, Environment, and Management System".

Which means, the term learning model is a term referring to a special approach

to instructions that cover the purpose, environment, syntax and management system.

Of the some opinions it can be concluded that the learning model is intended as a pattern of student interaction with teachers in the class concerning strategies, approaches, methods and learning techniques applied in the implementation of teaching and learning activities in the classroom. In order for Islamic religious education to be absorbed properly by students, in addition to learning strategies, teachers also need to have methods and learning models that are deemed appropriate and in accordance with the condition of students.

According to Hamdani Discovery Learning is a mental process where students are able to assimilate a concept or principle, where the mental process is observing, explaining, grouping, making conclusions and so on.²

Hosnan suggests the Discovery Learning model is a model to develop the way students learn actively by finding themselves, investigating themselves, so the results obtained are more meaningful, durable and not easily forgotten by students.³

According to Jerome Bruner discovery is a process, a way of way in approaching problems instead of a product or certain knowledge item.⁴

Basically Discovery Learning is not much different from Inquiry's learning, but on Discovery Learning problems faced with students a kind of problem engineered by the teacher, so students do not have to mobilize all their thoughts and skills to get the findings in the matter through the research process.⁵

Hanafiah in the concept of the learning strategy suggests that Discovery Learning is a series of learning activities that involve the

¹ Ridwan Abdullah Sani. *Inovasi Pembelajaran*. (Jakarta: Bumi Aksara, 2013). 89

² Hamdani. *Strategi Belajar Mengajar*. (Bandung: CV Pustaka Setia. 2011). 185

³ Hosnan, *Pendekatan Saintifik Dan Kontekstual Dalam Pembelajaran Abad 21*, (Jakarta: Ghalia Indonesia, 2014). 282.

⁴ Heruman. *Model Pembelajaran Matematika Di Sekolah Dasar* (Ramdhani Boyke, Ed). Bandung : PT Remaja Rosdakarya. 2008. 4

⁵ Materi Pelatihan Guru Kemendikbud. *Implementasi Kurikulum 2013*. (Jakarta: Kementerian Pendidikan dan Kebudayaan. 2013)

maximum entire ability of students to find and investigate systematically, critically and logically so that they can find their own knowledge, attitudes and skills as a manifestation of behavioral changes.⁶

As the opinion of Jerome Bruner quoted by Lefancois in the Ministry of Education and Culture, that:

"Discovery Learning Can Be Defined as the Learning That Takes Place When The Student Is Not Presented With Subject Matter in the Final Form, but Rather is Required to Organize It Him Self".⁷

Of the opinions of experts above it can be concluded that the Discovery Learning model is a learning model that encourages students to find themselves and transform complex information, check new information with those already in their memory, and develop into information or capabilities that are in accordance with the times.

Purpose Discovery Learning Model

Each learning model has the objectives to be achieved. As Bell expressed in Hosnan several specific objectives of learning with a discovery model including:⁸

- In the discovery of students have the opportunity to be actively involved in learning. The fact shows that students' participation in learning increases when discoveries are used.
- Through learning with discovery, students learn to find patterns in concrete and abstract situations, as well as many students predictive (extrapolate) additional information provided.
- Students also learn to formulate a question and answer strategy that is not incompetet

and use a question and answer to obtain information that is useful in finding.

- Learning with discovery helps students form a way of effective shared work, divide information, and hear and use other people's ideas.
- There are several facts that show that skills, concepts and principles learned through more meaningful discoveries.
- The skills learned in the learning situation in several cases, is more easily transferred for new activities and is applied in a new learning situation.

The purpose of the Discovery learning model according to Azhar is:⁹

- The ability to think to be more responsive, careful and train nalar power (critical, analysis and logical).
- Foster and develop an attitude of wanting to know better.
- Develop cognitive, affective and psychomotor aspects.
- Developing attitudes, student skills in deciding something appropriately and objectively.

Based on the opinion of the expert above, researchers concluded that the purpose of the Discovery Learning model was creating active and independent students in finding solutions to problems in learning activities, and practicing students' thinking skills and confidence skills in deciding something objectively.

Characteristics of Discovery Learning Models Discovery Learning learning model Some characteristics or main characteristics. The characteristics of the Discovery Learning learning model according to Hosnan are:¹⁰

- Explore and solve problems to create, combine and generalize knowledge.
- Learning.
- Activities to combine new knowledge and existing knowledge.

⁶ Hanafiah dan Cucu Suhana, *Konsep Strategi Pembelajaran*, (Bandung: Refika Aditama, 2009).77

⁷ Kementrian Pendidikan dan Kebudayaan, *Materi Pelatihan Guru Implementasi Kurikulum 2013 SMA/SMK Pendidikan Agama Islam dan Budi Pekerti* (Jakarta: BPSDM Pendidikan dan Kebudayaan dan Penjamin Mutu pendidikan, 2014). 89-94

⁸ Hosnan, *Pendekatan Saintifik Dan Kontekstual Dalam Pembelajaran Abad 21*, (Jakarta: Ghalia Indonesia, 2014). 284.

⁹ Azhar Arsyad. *Media Pembelajaran*. (Jakarta: PT. Raja Grafindo Persada Companies, Inc, 1995).99

¹⁰ Hosnan, *Pendekatan Saintifik Dan Kontekstual Dalam Pembelajaran Abad 21*, (Jakarta: Ghalia Indonesia, 2014). 284.

There are a number of characteristics of learning processes that are highly emphasized by constructivism, namely as follows:¹¹

- a. Emphasizing the learning process, not the teaching process.
- b. Looking at students as the creator of the will and goals to be achieved.
- c. Viewing that learning is a process, not pressing on results.
- d. Encourage students to be able to conduct an investigation.
- e. Provide opportunities for students to build new knowledge and understanding based on real experience.

Based on the characteristics of the constructivism learning, its application in the class as follows:

- a. Encourage the independence and initiative of students in learning.
- b. The teacher asks open questions and provides opportunities for some time to students to respond.
- c. Encourage high-level students.
- d. Students are actively involved in dialogue or discussions with teachers or other students.
- e. Students are involved in the knowledge that encourages and challenges the discussion.
- f. The teacher uses raw data, main sources, and interactive material.

From the theory of cognitive learning and the characteristics and application of the constructivism theory can give birth to the Discovery Learning model.

Operational Steps for Learning Implementation with Discovery Learning Models

A. Step Preparation of Discovery Learning Model

The steps prepared by the teacher before carrying out the learning process are as follows:

- 1) Determine learning objectives.
- 2) Identify the characteristics of students (initial capabilities, interests, learning styles, and so on)
- 3) Choosing the subject matter to be learned.
- 4) Determine the topics that must be learned by students inductively (from generalizational examples).
- 5) Develop learning materials in the form of examples, illustrations, duties, and so on to learn students.
- 6) Adjust the topic of lessons from simple to complex, from the concrete to abstract, or from the delicious stage, iconic to symbolic.
- 7) Conduct the process assessment and learning outcomes of students.

B. Discovery Learning Model Application Procedure

According to Shah in applying the Discovery Learning model in class, there are several procedures that must be carried out in general teaching and learning activities as follows:¹²

- 1). Stimulation (stimulation / giving stimulus)

First of all at this stage students are faced with something that causes its confusion, then continues not to generalize, so that the desire to investigate itself. In addition, the Furu can start the teaching and learning process activities (PMB) by asking questions, recommending reading books and other learning activities that lead to problem solving preparations. Stimulation at this stage serves to provide conditions for learning interactions that can develop and help students in exploring materials. In this case Bruner gives a stimulation using aquires of asking, namely by asking questions that can confront students in internal conditions that drive exploration. Thus a teacher must master the techniques in giving stimulus to students so that the purpose of activating students to explore can be achieved.

¹¹ Hosnan, *Pendekatan Saintifik Dan Kontekstual Dalam Pembelajaran Abad 21*, (Jakarta: Ghalia Indonesia, 2014). 284.

¹² Muhibbin Syah, *Psikologi Pendidikan Suatu Pendekatan Baru*, (Bandung: Remaja Rosda Karya, 2004). 244

2). Problem statement (statement / identification of problems)

After the stimulation the next step is that the teacher provides the opportunity for students to identify as many organizations as possible to the subject of the lesson, then one of them is selected and formulated in the form of a hypothesis (interim answer to the problem question). Whereas according to the chosen problem, it must be formulated in the form of a question, or hypothesis, the statement as a temporary answer to the question asked. Providing the opportunity for students to identify and analyze the problems they face, is a technique that is useful in building students so that they are accustomed to finding a problem.

3). Data Collection (Data Collection).

When the exploration takes place teachers also provide opportunities for students to collect as many relevant information to prove the right or not hypotheses.¹³ This stage serves to answer questions or prove the absence of hypotheses, thus students are given the opportunity to collect relevant information, read the literature, observe objects, interviews with resource persons, conduct their own trials and so on. The consequences of this stage are students to learn actively to find something related to the problems faced, thus accidentally students connect problems with the knowledge they have had.

4). Data Processing (Data Processing)

According to Syah data processing is an activity of processing data and information that students have obtained either through interviews, observation, and so on, then interpreted. All information on reading, interviews, observations, and so on, all are processed, randomized, classified, tabulated, even if necessary calculated in a certain way and interpreted at a certain level of trust. Data processing is also called categorization which functions as a concept and generalization formation. From the generalization students will get new knowledge of the alternative settlement that needs to get logically proof.

¹³ Muhibbin Syah, *Psikologi Pendidikan Suatu Pendekatan Baru*, (Bandung: Remaja Rosda Karya, 2004). 244

5). Verification (proof)

At this stage students carry out carefully examinations to prove the true or absence of the stated hypothesis with alternative findings, associated with the results of data processing. Verification According to Bruner, aiming for the learning process will run well and be creative if the teacher provides an opportunity for students to find a concept, theory, rules or understanding through the examples he encountered in his life. Based on the results of processing and interpretation, or existing information, the previous statement or hypothesis that has been formulated is then checked, whether it is missed or not, whether it is proven or not.

6). Generalization (draw conclusions / generalization)

The generalization stage / draw conclusions is the process of attracting a conclusion that can be used as a general principle and applies to all events or the same problem, taking into account the results of verification. Based on the results of verification, the principles underlying the generalization. After drawing conclusions students must pay attention to the generalization process that emphasizes the importance of mastery of lessons for the meaning and extensive rules or principles underlying a person's experience, and the importance of the regulation and generalization process of those experiences. Discovery Learning is a learning strategy that emphasizes students to learn to find and find themselves. In this learning strategy the presentation of lesson materials by the teacher is not in the final form, but students are given the opportunity to find and find themselves by using troubleshooting approach techniques. The learning process takes place by giving stimulus or stimuli that can encourage students to be involved and participate in learning activities, and more teacher roles as supervisors and facilitators.

Advantages and disadvantages of Discovery Learning Models

Hosnan suggests several advantages of the Discovery Learning model as follows:¹⁴

¹⁴ Hosnan, *Pendekatan Saintifik Dan Kontekstual Dalam*

- a. Help students to improve and improve skills and cognitive processes.
- b. The knowledge obtained through this model is very personal and effective because it strengthens the understanding, memory and transfer.
- c. Can improve students' ability to solve problems
- d. Help students strengthen their concepts, because they get Trust works with the others.
- e. Encourage the involvement of student activity.
- f. Encourage students to think intuition and formulate hypotheses themselves.
- g. Train students to learn independently.
- h. Students are active in teaching and learning activities, because he thinks and uses the ability to find the final results.

Hosnan put forward several disadvantages of the Discovery Learning model, namely:¹⁵

- a. Confiscate a lot of time because the teacher is required to change the habit of teaching which is generally an information provider to become a facilitator, motivator, and supervisor,
- b. Rational thinking skills of students are still limited. c. Not all students can take lessons in this way.

The author concluded that the advantages of the Discovery Learning model, which can involve students actively in learning. While the shortcomings of this model are taking a lot of time and not all students can follow learning with Discovery Learning mode.

Pembelajaran Abad 21, (Jakarta: GhaliaIndonesia, 2014). 287-288.

¹⁵ Hosnan, Pendekatan Saintifik Dan Kontekstual Dalam Pembelajaran Abad 21, (Jakarta: Ghalia Indonesia, 2014). 288-289.

III. DISCUSSION

A. Temperature concept

1. Temperature understanding

Temperature is a one magnitude to declare the size of the degree of heat or the cold of an object. Hot objects have higher heat degrees than cold objects. As an illustration of the temperature, when bathing uses warm water, we have to get the warm water by mixing cold water and hot water. When our hands touch cold water, then we say the water temperature is cold. When our hands touch hot water then we say the water temperature is hot. The size of the heat and cold degree of an object is expressed with temperature.

2. Temperature measuring instrument

Temperature includes the main amount. In the SI unit (international system), the temperature is given a unit of Kelvin and berambolan with K. tool to measure the amount of the temperature of an object is a thermometer. The following is a type of thermometer based on its use:

a. Liquid thermometer

In general, objects in nature will lead (the size increases) if the temperature rises. This fact is used to make a thermometer of liquid. This liquid thermometer is a commonly used thermometer, liquid with its capillary pipe filler is mercury or alcohol. The liquid is used as a thermometer filler because the liquid will change volume if the temperature changes. Here are the advantages and disadvantages of thermometers of alcohol and mercury.

Excess tables and lack of fluid fillers thermometer.

Type of filler Thermometer	Excess	Lack
Mercury	1. Easy to be seen as shining. 2. Not moistening the wall. 3. Has a frozen point of 40 °C and 350 °C boiling point	1. Price is expensive. 2. Cannot measure very low temperatures. 3. Toxic substances so that it is dangerous if the tube breaks.

Type of filler Thermometer	Excess	Lack
Alcohol	1. The price is cheaper. 2. Have a frozen point - 114 °C and boiling point 78 °C so it can measure very low temperatures.	1. Has a low boiling point (78 °C) so the use is limited. 2. Colorless so it is difficult to observe. 3. Wet the glass wall.

Some thermometers that use liquid are as follows:

1) laboratory thermometer

The shape is long on a scale from -10 °C to 110 °C using mercury, or alcohol as shown in picture 3.1.



Picture 3.1. laboratory thermometer

2) body temperature thermometer

This thermometer is used to measure human body temperature. Scale written between 35 °C and 42 °C. The pipe at the bottom near the pumpkin is made narrow so the measurement is more careful due to mercury not immediately go down to the pumpkin / reservoir (picture 3.2).



Picture 3.2. body temperature thermometer

b. Bimetal thermometer

Pay attention to two metals which are different types and attached to one in picture 3.3. If the temperature changes, the bimetal will curve. Why? Because one metal leads longer than the other. It is used to make a bimetal thermometer.



Picture 3.3 Bimetal



Picture. 3.4. Bimetal Thermometer

c. Liquid crystal thermometer

There are liquid crystals whose colors can change if the temperature changes. This crystal is packed in thin tlastic, to measure body temperature, temperature aquarium, and so on (Figure 3.5).



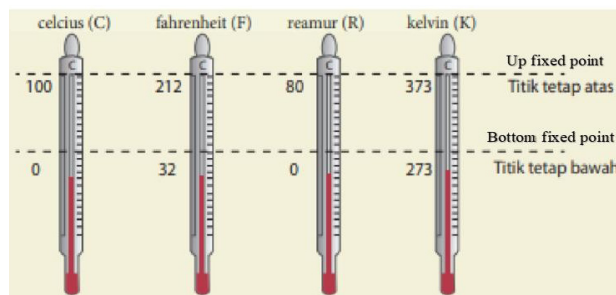
Picture 3.5. Liquid crystal thermometer

4. Scale of thermometer

The thermometer that we know today has a type of measuring scale, namely Celsius, Reamur, Fahrenheit, and Kelvin. The fourth difference of the type of thermometer scale can be seen in the following table.

Table of Thermometer Scale Type

No.	Thermometer Scale	Inventor	Fixed point		Scale	Unit
			Bottom	Up		
1.	Celsius	Andreas Celsius (Swedia)	0 °	100 °	100	°C
2.	Reamur	Reamur (Prancis)	0 °	80 °	80	°R
3.	Fahrenheit	Gabriel D. Fahrenheit (Jerman)	32 °	212 °	180	°F
4.	Kelvin	Lord Kelvin (Inggris)	273	373	100	K



Picture 3.6 Bottom Fixed point and Up fixed point on some temperature scale. The Celsius scale range, Fahrenheit, Reamur, and Kelvin are 100 consecutive 100, (212-32), 80, (373-273).

5. Temperature conversion

Temperature conversion has an understanding as a way of changing the temperature point of a size to another. In carrying out the temperature conversion process, of course, a special formula is needed.

Table of Thermometer conversion formula

	Celsius	Fahrenheit	Kelvin	Reamur
Celsius		$C = \frac{5}{9} (F - 32)$	$C = K - 273$	$C = \frac{5}{4} R$
Fahrenheit	$F = \frac{9}{5} C + 32$		$F = \frac{9}{5} (K - 273) + 32$	$F = \frac{9}{4} R + 32$
Kelvin	$K = C + 273$	$K = \frac{5}{9} (F - 32) + 273$		$K = \frac{5}{4} R + 273$
Reamur	$R = \frac{4}{5} C$	$R = \frac{4}{9} (F - 32)$	$R = \frac{4}{5} (K - 273)$	

B. Find an equation for conversion of the temperature of all kinds of thermometer.

As an effort to facilitate temperature conversion applications, it is necessary to obtain or found an equation that can be used

converts the temperature of one thermometer to the other thermometer.

Learning Discovery Learning form is one of the most suitable ways to find the equation. In accordance with this learning model, the steps that need to be done are as follows:

1). Stimulation (stimulation / giving stimulus)

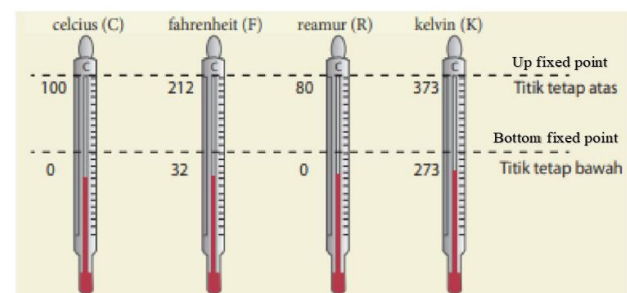
This step is done by agreeing with the definition of temperature, thermometer, temperature conversion and its benefits in everyday life.

2). Problem statement (statement / identification of problems)

This step is done by giving an overview of the problem of the thermometer diversity used to measure the temperature and the emergence of various similarities that exist to convert the temperature of one Thermometer to the other thermometer.

3). Data Collection (Data Collection).

Students are invited to observe and collect data from thermometer observations that are either through images or other data. For example by observing the following picture:



4). Data Processing (Data Processing)

Students are invited to practice to convert temperature using existing equations.

Then students are invited to practice to find an equation that can be used to calculate the temperature conversion of all kinds of thermometer as follows:

Forexample, to resolve the 50°C temperature conversion problem it becomes ... °K.

The steps taken are as follows:

$$\begin{aligned}
 t_i &= ((t_o - \frac{S_o}{S_i}) + B_{fi}) \\
 t_i &= ((80 - \frac{80}{100}) + 0) \\
 t_i &= ((80 - 0.8) + 0) \\
 t_i &= (79.2) + 0 \\
 t_i &= 79.2 \\
 \text{so } 280^\circ\text{X} &= 40^\circ\text{R}
 \end{aligned}$$

6). Generalization (draw conclusions / generalization)

The generalization of our students invited together concludes that after repeatedly testing either the unit of one particular thermometer to the unit of various other thermometers, it can be concluded that an equation that can be used to overcome the problem of temperature conversion of all kinds of thermometer or vice versa We have found or we can also say that a formula has been found to replace the various formulas to convert the temperature of one thermometer to another thermometer.

The equation is as follows:

$$\text{explanation : } t_i = ((t_o - \frac{S_o}{S_i}) + B_{fi})$$

t_i = Final point temperature (after conversion)
 t_o = First point temperature (before conversion)
 B_{fo} = First bottom fixed point

B_{fi} = Last bottom fixed point

S_i = Last thermometer scale

S_o = First thermometer scale

C. Conclusion

After applying an equation to introduce the problem of temperature conversion that can be applied to all types of thermometers, the process of understanding students becomes shorter. If you use a conventional equation it takes several meetings to take a temperature conversion material, then using an equation as above only takes 30-40 minutes for the upper class and 60-80 minutes for the Lower class.

Thus it can be concluded that an equation to convert the temperature of all kinds of thermometer is very necessary to be submitted to students. Even the equation should be written in the learning package books to replace all temperature conversion formulas that have been used.

By using only a formula to replace the various formulas, of course it will facilitate mastery of temperature conversion material for students and for all of us.

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