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STUDENTS' CREATIVE THINKING SKILLS ON HEAT PHENOMENA USING POGIL LEARNING MODEL

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***Abstract**: This research aimed to analyze the improvement of students' creative thinking skills on the matter of heat and its transfer using the POGIL model. The topic concerning heat and its transfer has some characteristics that enable students to carry out practicum and trigger them to develop their higher-order thinking skills. The method used in this research was pre-experimental with one group pretest-posttest design. A total of 32 seventh grade students at SMPN 1 Jaten Karang Anyar, Central Java, were randomly selected as the participants in this research. To measure the increase in students' creative thinking skills, a multiple-choice test had been developed based on the indicators of creative thinking skills. Based on the results of data analysis, the values of N-gain on the indicators consisting of fluency, flexibility, originality, and elaboration were 0.56, 0.60, 0.46, and 0.53 respectively. Those numbers meant that creative thinking was in the medium category. Further analysis shows that, by using the POGIL model on the topic of heat and its transfer learning, students' creative thinking skills can be increased, especially on the indicators of fluency and flexibility.*

Keywords: *active learning, creative thinking, POGIL model*

INTRODUCTION

The development of information, technology, and digitalization in the 4th era of the industrial revolution have created a new paradigm in education (21st-century learning). In the new era of education, teachers must be able to facilitate students to think critically and creatively and to have communication skills as well as good collaboration (Griffin, Care, & McGaw, 2012; Shidiq & Yamtinah, 2019; Trilling & Fadel, 2009).

The focus of this research is to improve one of the skills needed by students in the 21st century, namely creative thinking skills. According to Kampylis & Berki (2014), creative thinking is defined as a thinking process that allows students to apply their imagination to produce ideas, formulate questions and hypotheses, conduct an experiment with alternatives, and evaluate ideas, processes, and final products. Creative thinking is essentially related to the discovery of something, and concerning the things that produce something new by using something that has already existed (Daryanto, 2009).

Creative thinking has many conceptualizations. Some experts see it as a process that occurs through stages. Other experts see creative thinking in terms of creative products and creative people. Some of those who see it as a process are Isaksen and Treffinger (Treffinger & Isaksen, 2005); and Torrance (Phillips & Torrance, 1976; Torrance, 1968, 1973; Torrance & Aliotti, 1969; Torrance & Hansen, 1965). They are experts in the fields of education and creativity (Freeman, 1999).

The term, creative thinking skills, refers to a constellation of general mental abilities that are considered a creative achievement. Many educators and psychologists prefer to call this ability

"divergent thinking", "productive thinking", or "imagination". Some scientists prefer to use the term "creative " only to refer to a rare, particular, and substantive capacity (Torrance, 1968).
Creative itself is the process of being sensitive to problems, deficiencies, gaps in knowledge, missing elements, and disharmony; identifying difficulties; finding solutions, making predictions, or formulating hypotheses about deficiencies; testing and re-examining hypotheses and maybe modifying them; and finally communicating the results (Almeida, Prieto, Ferrando, Oliveira, & Ferr, 2008; Kim, 2006; Torrance, 1968).

Creative thinking is still difficult to define in the context of natural science learning, but researchers believe that it is part of a cognitive process that can be developed through adequate learning design (Scott, Leritz, & Mumford, 2004). Creative thinking skills can influence and be influenced by lots of aspects. The study conducted by Yanti (2016) showed that creative thinking skills can be improved through the application of problem-based learning (hereafter as PBL) model (Yang, Lee, Hong, & Lin, 2016). However, Ayyildiz & Tarhan, (2018) revealed some obstacles in the application of PBL model in that it requires more time to solve the problems, has difficulty in doing an objective assessment, and gives a great responsibility to the teacher, so that both teacher and students are expected to be familiar with the types of problems in PBL model (Ayyildiz & Tarhan, 2018). Also, a digital learning module can be used by students in practicing problem-solving skills, but due to the limitation of students' facilities, this module is not effective for the use (Mulhayatiah et al., 2019).

Learning experiences gained in the classroom can be arranged depending on the scenario used by the teacher in accordance with the lesson plan (Faour, Hammoudeh, & Ghamdi, 2012; King & Bauer, 1986; Qureshi & Ullah, 2014) Currently, various learning models are applied to help teachers to accommodate students in developing creative thinking skills, such as the use of contextual learning with module (Kurniasari, Sukarmin, & Sarwanto, 2018) and project-based learning (Diawati, Liliasari, Setiabudi, & Buchari, 2018). However, the model has not been focused on student activities in the classroom. Students who are actively involved in learning in the classroom to improve creative thinking skills are important. One of the solutions to overcome such problems is by applying the Process Oriented Guided Inquiry Learning (hereafter as POGIL) model. This model can get students involved in terms of activities and work together (Haryati, 2018; Walker & Warfa, 2017).

This model is based on the principle of constructivism which can trigger students to actively learn through interactions in groups to solve problems. According to Hanson, D. (2010) POGIL is student-centered learning and group-work or teamwork learning to master concepts but not memorizing. The study conducted by Rosadi (2018) showed that the natural science learning model grounded in POGIL can improve analytical thinking skills and students' learning outcomes. With this model, students can develop creative thinking skills, metacognition, communication, teamwork, and management. The teacher's task in learning only provokes students to solve problems and do things to practice their creativity. Therefore, it becomes a novelty that differs from previous researches to use the POGIL model in learning physics to improve students' creative thinking skills. This is offered as an answer to the problems that have been identified previously.

Specifically, the purposes of this study are to analyze the improvement of students' creative thinking skills on the

topic of heat and its transfer using the POGIL model. This research is expected to contribute to the novelty of the teacher learning model to improve students' creative thinking skills on the topic of heat and its transfer.

METHODS

Research design

The method used in this research was a pre-experimental method with one group pretest-posttest only design (Fraenkel, 2012). The selection of the research method was based on the learning objective intended to quantitatively analyze the improvement of the creative thinking skills of junior high school students. The research flows can be seen in Figure 1.

This research began with the identification of problems, preliminary research to find the best way to deal with the problems, and implementation of the alternative solution proposed. This research focused on the assessment of students' creative thinking skills on the heat and its transfer topic. Subsequently, the POGIL learning model was applied during several meetings. At the end of the lesson, the test was given again to see the improvement of students' creative thinking skills. The design of the chosen research method can be seen in Table 1.

Table 1. Research design

Pretest	Treatment	Posttest
X_1	POGIL Model	X_2

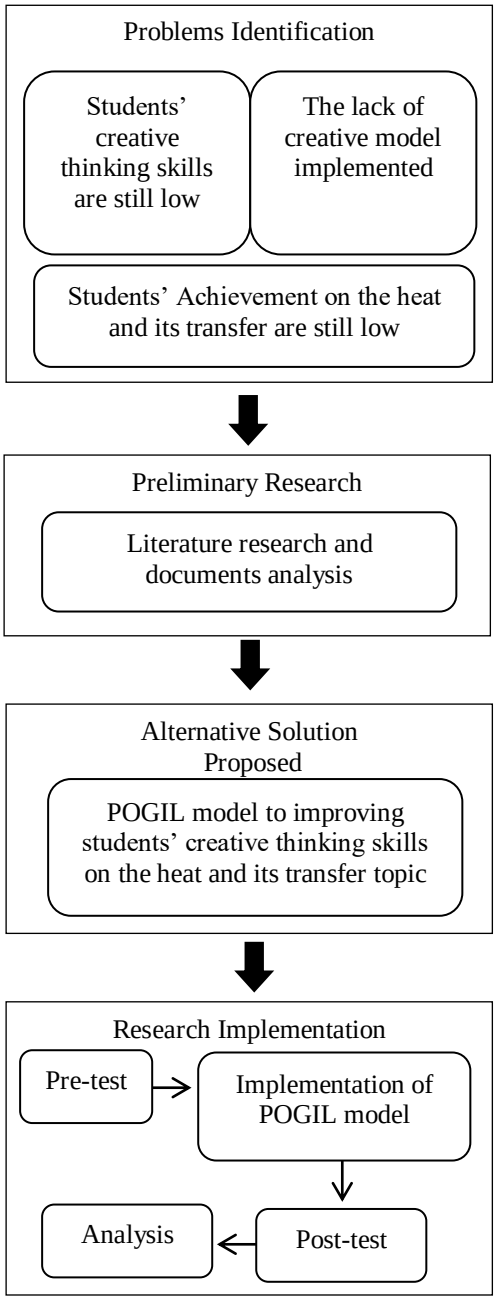

Figure 1. Research flow

Research participants and locations

The sample selection technique used in this research was random sampling so that 32 junior high school students in grade VII were obtained as the samples. The research was conducted at SMPN 1 Jaten, Karanganyar, Central Java.

Instrument

The quantitative data in this research were garnered from the use of multiple-choice test instruments to measure the improvement of students' creative thinking skills. The instruments used were 10 items on the topic of heat and its transfer. The indicators of creative thinking skills used were adapted from Guilford (Guilford, 1988) that entailed;

a. Fluent thinking (Fluency); the ability to generate many ideas, answers, problem-solving, or questions.
b. Flexible thinking (Flexibility); the ability to generate various ideas from information that has been obtained.
c. Original thinking (originality); the ability to generate notions or ideas that are new and different from the prior ones.
d. Elaborate thinking (elaboration); the ability to develop and add ideas in detail so that they become more interesting.

Data analysis technique

The technique of data analysis was undertaken by tabulating the data that had been obtained, then calculating the percentage score of each component of the questions consisting of 10 questions with regard to creative thinking skills having been given to 32 students of class VII, and then calculating the percentage score of each aspect by using the following formula:

$$\text{Ps} = \frac{Ni}{N} \qquad (1)$$

Ps is the percentage score; Ni is the number of scores obtained, and N is the maximum number of the score for each aspect. The results of the percentage score of each component are indicated by criteria according to Shriki (2013). This category is shown in Table 2:

Table 2. Criteria for average values in creative thinking profile scores

Percentage	Category
< 55 %	Low
≤ 55% - ≤75%	Medium
> 75 %	High

The analysis used to determine the effectiveness or increase (gain) of the creative thinking skills of the students whose learning processes applied the POGIL model was Gain score. The gain score is also called a score increase or difference that indicates the difference between the pretest and posttest scores in one sample group. Meltzer, D.E. (2002) states that the Gain scores can be obtained by using the following formula:

$$N\text{-}Gain = \frac{Tpost - T_{pre}}{T_{maks} - T_{pre}} \qquad (2)$$

T_{post} is average *posttest* score; T_{pre} is the average *pretest* score, and T_{max} is the maximum ideal score. The N-gain score obtained from the formula above can be categorized using the gain score interpretation table conforming to Table 3.

Table 3. N-gain category

N-gain (g)	Category
(g) > 0,7	High
0,3 < (g) ≤ 0,7	Medium
(g) ≤ 0,3	Low

RESULTS AND DISCUSSION

The purpose of this study was to analyze the improvement of students' creative thinking skills on the topic of heat and its transfer using the POGIL model. The POGIL model was implemented with the syntax developed by Hanson, D. (2006)as shown in Table 4. In the meantime, the creative thinking skills used in this research referred to Guilford (Guilford, 1988)

Some of the main frameworks that have been established in creative thinking skills include the creative thinking framework proposed by Guilford, Perkins, and Torrance (Guilford, 1988; Perkins, 1984; Sadler-smith, 2014; Torrance, 1961). This research adopted Guilford's creative thinking skills. Aside from being in line with this research objective, this framework also has several advantages including having a complete description of creative thinking, namely operations, content, and production (Anoiko, 2011) and distinguishing between convergent and divergent thinking processes (Anoiko, 2011; Costa, 1991).

The data on students' creative thinking skills were obtained by giving 10 multiple-choice test items in which each represented 4 aspects of creative thinking skills. The example of a critical thinking instrument is presented in Table 5. Differences in scores obtained by students before and after learning using the POGIL model are presented in Table 6.

Table 4. Process-oriented guided inquiry learning (POGIL) syntax

No	Syntax	Activity Components
1	Identification of learning needs	An interesting issue is presented. An answer to the question formulation of the problem is given. Learning objectives and competency indicators are defined.
2	Linking prior knowledge	A question on the issue is raised and students predict the answer. Prerequisite material is defined.
3	Exploration	A model and assignment are given, and the source of the material is defined. Students explore models or assignments in response to critical thinking.
4	Understanding and concept formation	Critical thinking questions will lead to identifying and understanding concepts to be built.
5	The practice of applying knowledge	Students work on problems to apply directly from the knowledge and concepts gained.
6	Applying knowledge to new contexts	Students work on problems with different contexts and higher levels.
7	Reflection in process	The completion of the problem and the answer to the question are validated and integrated with the concepts and performance of students during learning assessed.

Table 5. The example of creative thinking instrument

Basic Aspect of Creative Thinking	Indicator	Question
The authenticity of thinking (originality)	Providing ideas for finding new solutions related to heat and its transfer	Provided: glass bottles, plastic bottles, bamboo, cloth, cork. If you don't have a flask, how do you make a mock-up of a flask from the device provided so you can store hot water for a long time? a. load a flask from a plastic bottle, put it in bamboo until there are no gaps between the two, and make the lid from the cork b. make a flask from a glass bottle, put it in bamboo until there is no gap between the two, and make it from cork c. make a flask from a glass bottle, put it in bamboo and make a gap between the two, insert a cloth between the glass walls, and cover it with cork d. make a flask from a plastic bottle, put it in bamboo and make a gap between the two, insert a cloth between the glass walls, and cover it with cork

Table 6. Descriptive statistics of the obtained scores of students' creative thinking skills

Descriptive statistics	Pretest				Posttest			
	Aspect				Aspect			
	A	B	C	D	A	B	C	D
Total score	58	34	25	24	97	52	43	45
Maximum score	128	64	64	64	128	64	64	64
Percentage	45%	53%	39%	37%	76%	81%	67%	70%
Category	Low	Low	Low	Low	High	High	Medium	Medium

Note: A: Fluency; B: Flexibility; C: Originality; D: Elaboration

In general, Table 5 shows the scores in every aspect of creative thinking obtained by students before and after they were taught by using the POGIL model. Before the POGIL model was applied the students' creative thinking skills were in a low category, and after the POGIL model was applied, the students' creative thinking skills were in the medium and high categories. The increase in students' creative thinking skills was due to the application of the learning model that provided opportunities for students to think. POGIL model applied three learning cycles composed of exploration, discovery or formation of concepts, and application.

In the POGIL model, students were also facilitated in implementing their knowledge through problems, learning to communicate, and most importantly being able to do a reflection process to improve their process skills. Hence, the POGIL model was considered capable of accommodating students in developing creative thinking skills. This can be seen in Figure 2.

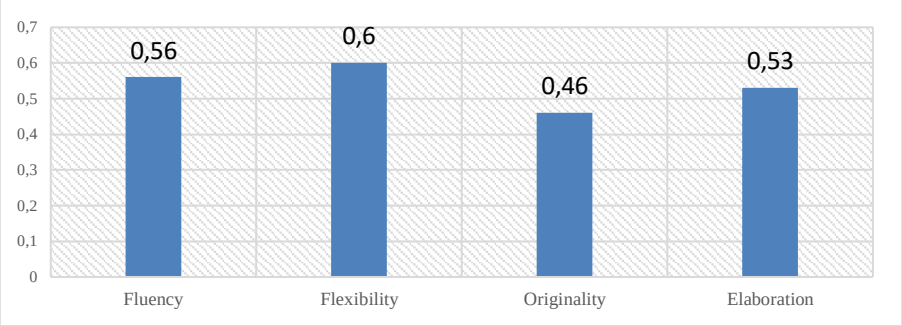

Figure 2. N-gain of students' creative thinking skills

The value shown in the graph indicates that the obtained N-gain for each aspect was in the medium category. This meant that through the POGIL model, students' creative thinking skills could adequately be developed. The Fluency aspect had an N-gain value of 0.56.

The fluency aspect allowed us to assess the students' ability to come up with ideas, be able to propose many answers, and be able to put forward problem-solving. On the topic of heat and its transfer, the teacher presented the example of a problem about how it was that if traveling during the day, the students would not feel hot. The answers and solutions to this question reflected on the aspect of fluency because students were required to provide their ideas along with the supporting reasons.

The aspect of flexibility would be observed when students were able to see a problem from more than one point of view, and when they were able to link other disciplines to solve the problem at hand. Based on the N-gain value, this aspect had the highest value. That was because the POGIL model presented students with problems, and they could be solved in more than one way.

The aspect of originality referred to how students presented innovative problem-solving. Innovation from students' problem solving could be a modification of whatever existed or a presentation of something completely new. The aspect of originality had the lowest N-gain value because students found it difficult to create the solutions that had never been expressed before. However, this ability could still be honed because the POGIL model allowed students to explore and reflect on activities. Both of these activities could spur students to create new solutions.

The Elaboration aspect was an aspect of creative thinking that required students to enrich and explain in more detail the proposed solutions. POGIL invited students to think creatively starting from observing, hypothesizing, identifying models in the form of practicum about heat and its transfer, analyzing, and concluding through practicum activities.

Guided practice can improve students' ability to understand arguments and problems oriented towards certain abilities (Latifah, 2016). The use of practical tools in learning can also attract students' interest (Agustini. R & Suyatna, 2018; Wardani, Y,R, 2019). The application of the POGIL model is in accordance with the opinion of Doppelt, (2003) regarding active learning in constructivism-based teaching, whereby students will find it easier to find out and to understand concepts through active thinking and problem solving, and that the students learn in the realms of not only remembering but also conducting knowledge-building activities with exercises given by the teacher or homework contained in books (Doppelt, 2009). Students are responsible for learning events and learning outcomes. This is in line with the opinion expressed by Triwiyono, (2011), in that learning with guided experiments is more effective in improving students' higher-order thinking skills compared to conventional learning. The other study result which is in line indicates that laboratory inquiry can improve students' mastery of concepts and creative thinking skills (Suparman & Husen, 2015).

The POGIL model spurs the development of students' self-regulation (Şen & Yılmaz, 2015). The ability to work together is also homed in this model. The collaboration is formed through teamwork to identify and develop knowledge through data testing.

In this research, when learning took place, a team consisting of four students was formed. Each team comprised a manager, spokesperson, recorder, and strategy analyst. Each member had their respective duties. The aim was to improve the ability to work together in a team, work critically, be responsible, exchange opinions, draw conclusions, and solve problems. The group structure was carried out for each meeting. Collaboration between students will make them actively involved individually and also in group work (Sarwi & Liliasari, 2009). A similar notion is conveyed by Brown S. (2010) saying that the function of one's self-selected by the team to solve questions helps develop the key process skills such as critical thinking and communication.

Researchers have conducted many other studies to improve creative thinking skills, such as the use of worksheet and modules (Klieger & Sherman, 2015; Romli, Abdurrahman, & Riyadi, 2018), the use of inquiry learning models, STEM (Li, Li, Mo, & Li, 2018), project-based learning (Diawati et al., 2018; Mihardi, Harahap, & Sani, 2013), and problem-based learning (Yoon, Woo, Treagust, & Chandrasegaran, 2015). The use of PBL and other models has been carried out by other researchers to improve students' creative thinking skills. However, the POGIL model, besides being able to improve students' creative thinking skills, it also makes all students actively

involved in the learning process. This is the difference between this research and other studies.

The use of the POGIL model makes students happier, and they come to understand the things that often exist in everyday environments, for instance, the things about how to use a thermometer and stopwatch. Students learn with hands-on activities. Thus, students' scientific activities can influence their psychomotor development. The application of the physics learning model based on hands-on activities can foster the ability to think creatively, and it is demonstrated during learning (Yuliati, 2011).

CONCLUSION

Based on the results of data analysis, the values of N-gain on the indicators which consist of fluency, flexibility, originality, and elaboration are 0.56, 0.60, 0.46 and 0.53 respectively. Those numbers mean that creative thinking is in the medium category. Further analysis shows that, by using the POGIL model on the topic of heat and its transfer learning, students' creative thinking skills can be increased, especially on the indicators of fluency and flexibility.

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