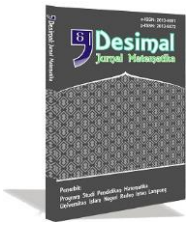
Desimal: Jurnal Matematika Vol 4 No 2 (2021) 113-122

Contents lists available at DJM

DESIMAL: JURNAL MATEMATIKA

p-ISSN: 2613-9073 (print), e-ISSN: 2613-9081 (online), DOI 10.24042/djm

http://ejournal.radenintan.ac.id/index.php/desimal/index



Dispersive thinking process to construct self-regulated learning ability in a "conceptual embodied" world

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ARTICLE INFO

Article History
Received : 02-08-2020
Revised : 25-01-2021
Accepted : 26-04-2021
Published : 30-06-2021

Keywords:
Reflective Thinking; Creative Thinking; Dispersive Thinking; Self-Regulated Learning.

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Doi:
10.24042/djm.v4i2.6949

ABSTRACT

Dispersive thinking is a process of expanding knowledge through reflective thinking, followed by creative thinking and producing various alternative solutions / answers that are unique, new, and appropriate. This research aims to describe students' dispersive thinking processes in constructing their self-regulated learning in a "Conceptual Embodied" world. Data collection methods are non-routine tests (problems) related to flat shapes, interviews, and think out loud. The results showed that students' dispersive thinking processes in constructing self-regulated learning in the "Conceptual Embodied" world consisted of the following stages: experiencing confusion (presence of experience), identifying problems, synthesizing ideas, building ideas, implementing ideas. The researcher recommends that the construction of a flat concept in the "Conceptual Embodied" world should focus on the development of the students' dispersive thinking stages.

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INTRODUCTION

Dispersive comes from the word dispersion. Day & Underwood (2012) used a prism to describe the dispersion of light, where white light becomes a spectrum. This definition of light dispersion provides research ideas regarding one's thinking process in problem solving. In the process of light dispersion, a beam of light enters the prism and then deflects (refracts) the light. This bending of light shows a situation of confusion or conflict that students experience in dealing with problems. Prayitno et al. (2016); Rodgers (2002) argue that the situation of confusion or conflict experienced by students in facing unique problems is a supporting factor for reflective thinking. Hidajat et al. (2019); Lyons (2010); Reichenberg & McVee (2019) emphasized that the role of this confusing and dubious situation can encourage the involvement of students' reflective thinking by

conducting repeated investigations. This inquiry process is based on making hypotheses that lead to problem solving (Ricks, 2011). In making a hypothesis, a person experiences a movement from reflective thinking to creative thinking. This is important to examine, because this research can contribute knowledge in developing research in the field of students thinking processes, where students need to have the opportunity to develop their creative thinking through reflective thinking.

Creative thinking acts as a prism that spreads a beam of white light into a spectrum, where the various colors that together make up the white color can be identified separately. In the creative thinking process, students synthesize or combine ideas / previous experiences with current experiences (non-routine problems). Students then build ideas based on the results of the student's synthesis and then apply the ideas they have built (Lince, 2016; Siswono, 2011; Wheeler et al., 2002). The process of reflective thinking which is continued by creative thinking to produce unique, new, and appropriate answers is called the dispersive thinking process. The dispersive thinking process can be illustrated in Figure 1.

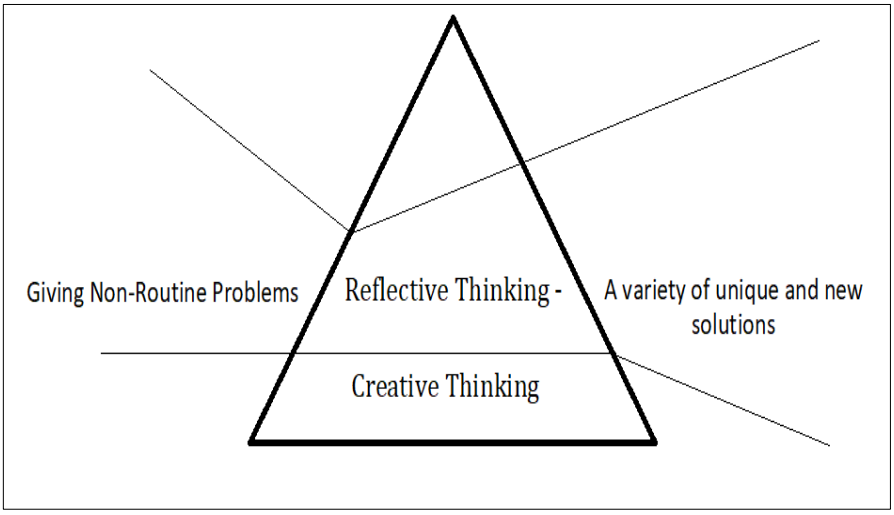


Figure 1. The Process of Dispersive Thinking

Regarding the occurrence of reflective thinking, Dewey (1933); Prayitno et al. (2016); Rodgers (2002) mention two components in reflective thinking, namely confusion (perplexity) and repeated investigation. Confusion is the difficulty, uncertainty, or conflict that an individual experiences in solving a problem. Investigation is a person's attempt to plan or create a hypothesis that leads to problem solving.

Ricks (2011); Rodgers (2002) mentioned four stages in the reflective thinking process. First, there are experiences that make confusion, doubt, and curiosity. Second, identify the problem. Third, planning / making hypotheses that lead to problem solving solutions. Fourth, applying hypotheses to obtain solutions. The process of reflective thinking that is done properly, can help a person move towards the next higher level of thinking, namely creative thinking.

Creative thinking is high-level thinking that is shown by a person in producing new and original products / things and providing accurate and unusual solutions in problem solving. A person's creative thinking can be seen from his creative thinking process in mathematics problem solving (Glassner & Schwarz, 2007; Krulik et al., 2003; Muhtadi &

Sukirwan, 2017; Posamentier & Krulik, 2009; Sitorus & Masrayati, 2016). Krulik & Rudnick (1999); Siswono (2011) stated that the creative thinking process includes 4 stages, namely synthesizing ideas, building (generating) ideas, and implementing ideas. Synthesizing ideas means forming or combining ideas (ideas) that you have, which can be sourced from learning in the class and daily experiences. Building ideas means bringing up ideas related to a given problem as a result of synthesizing previous ideas. Implementing ideas means implementing or using a planned idea to solve a problem.

Problem solving through reflective thinking which is continued to creative thinking can provide maximum solutions by the process of constructing the ability of self-regulated learning. Self-regulated learning can improve student learning outcomes (Van Alten et al., 2020). Self-regulated learning can help students find new and creative solutions (Mulyadi et al., 2016).

Several researchers have studied reflective thinking as a process towards creative thinking, among others: reflective thinking is the basis for developing higher-order thinking, especially creative thinking (Zachariades et al., 2013). Fisher (2009); Hannigan (2018) stated that creative thinking is the result of sensible thinking and reflective results that focus on developing various alternative ideas or quality thoughts. Rich & Weisberg (2004) also argue that creative thinking is characterized by the process of obtaining new ideas from the results of various ideas and experiences gained when reflecting on problem solving. This shows that reflective thinking is an important key to creative thinking. However, this research has not provided an overview of how the reflective thinking process is continued with creative thinking, so as to obtain various alternative answers that are unique, new and appropriate. Therefore, this article examines the reflective thinking process, followed by creative thinking, and then obtains various alternative answers that are unique, new, and appropriate. This process is called the dispersive thinking process.

Based on the description above, this article would like to examine more deeply the students' dispersive thinking processes in constructing their self-regulated learning abilities based on the "Conceptual Embodied" way of thinking. Conceptual Embodied (Tall, 2008) is a person's way of thinking which is based on the embodiment of euclidean, non-euclidean, or all physical manifestations.

METHOD

This qualitative research examines students' dispersive thinking processes (reflective thinking processes accompanied by creative thinking) to construct self-regulated learning abilities and obtain unique, new and precise solutions. The subjects were 4 of 8th grade junior high school students who had taken the flat shape material. These students come from SMP Negeri 1 Turen, SMP Laboratorium Malang, and SMP Negeri 8 Malang.

The subject selection procedure begins with selecting 55 junior high school students who are able to think out loud well in representing the results of their work. Furthermore, 18 out of 55 students were selected based on the results of their proper written work. In the end, 4 out of 18 students selected as research subjects were able to show a movement of reflective thought processes accompanied by creative thinking.

The data collection process is a test, interview, and think out loud. The test is in the form of a non-routine problem "wake up flat" (an adaptation of Siswono (2011) that students must complete. Students complete the test while explaining it verbally (Think Out Louds). Researchers also interview students when solving problems they are working on, if there are

things that are unclear. These tests, interviews, and think out loud determine the selection of research subjects by paying attention to students' thought processes that indicate the movement of reflective thinking to creative thinking (dispersive thinking processes) to construct their self-regulated learning.

The data analysis in this research are (1) reducing the raw data from 55 students to 4 students representing dispersive thinking; (2) presents an analysis of data descriptions; (3) provide conclusions from the stages of the student's dispersive thinking process.

Figure 2. Data Analysis Flowchart (Adapted from Creswell (2015))

The development of instruments from non-routine problems fulfills several characteristics, among others: first, the problems given are non-routine, allowing a person to experience confusion or difficulty (perplexity) / conflict in solving them. This provides an opportunity for students to examine more deeply the problems given by identifying problems, then allowing students to investigate the problems they face. Second, the problem given asks students to make at least 4 shapes with different backgrounds and has the same area as the trapezoidal shape.

This results in students conducting investigations by synthesizing ideas or combining current experiences with previous experiences, building ideas, and then applying them to obtain unique, new, and appropriate alternative answers. Based on the description above, these problem instruments allow students to carry out a dispersive thinking process, which is a process characterized by reflective thinking and creative thinking to produce various alternative answers that are unique, new, and precise.

RESULTS AND DISCUSSION

The students' dispersive thinking process in constructing self-regulated learning abilities in the "Conceptual Embodied" world consists of stages:

1. Experiencing confusion

Students are given complex problems (non-routine). These problems make students experienced confusion / difficulty. This is shown in the attitude of students who read the questions repeatedly. In addition, confusion appears at several other stages.

2. Identify the problem

At this stage, students convey their interpretations spontaneously regarding the problems given and examine more closely the clarity of the data collected. This is shown in the following interview transcripts.

> ***Researcher:*** *What do you see there?*
> ***Student:*** *Here I see a trapezoidal shape with 3 squares and two triangles.*
> ***Researcher:*** *What is the meaning of this question?*
> ***Student:*** *You are told to look for at least 4 flat shapes with different*

backgrounds and have the same area as the area of the trapezoid .... (Student is silent)

This shows that students seem to be confused about the new experiences given, namely problems related to flat shapes with non-routine types of questions. students seem a lot of silence and continue to try to understand the meaning of the problem by reading the questions repeatedly.

3. Synthesize ideas

Based on the stages of identifying the problem, students need to investigate the problems they face. Based on these investigations, it is possible to produce various alternative solutions. At this stage, students blend and combine current ideas or experiences with previous experiences. This is shown in the following interview transcript.

Researcher: *Then? What will you do?*
Student: *There are 4 rectangles*
Researcher: *Where are they?*
Student : *1, 2, 3 (students count the number of squares 1, 2, 3) and these triangles are combined with these. So there are 4 rectangles*

At this stage, students synthesize their ideas in a geometric way of thinking (Conceptual Embodied), which is combining one triangle with another, to form a rectangle.

4. Build ideas

At this stage, students learn independently and come up with ideas related to the problems given as a result of synthesizing previous ideas to obtain solutions. This is shown in the student's statement during the following interview.

Researcher: *Then how is about that?*
Student : *So, there are 4 rectangles, then we can crack as much as we want, it's like playing centrical...*

This interview snippet shows that students appear to be constructing ideas geometrically by determining that 4 squares are needed to make other shapes.

5. Implement ideas

At this stage students implement / use the ideas they plan and build to solve problems geometrically. This is shown in snippets of interview transcripts & pieces of student work.

Researcher: *Which one is the first shape??*
Student : *First shape, this one is rectangle, there are 4 squares.*

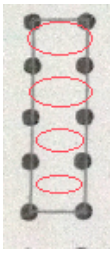


Figure 3 (a). First Subject Answer

Researcher: *Then, what is this?*
Student : *Ohh.. wrong ma'am*

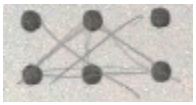


Figure 3 (b). Continuation of the First Subject's Answer

Researcher: *Why?*
Student : *It's okay Mom, I was wrong, I mean this one. Hehe....*

In this condition, Student appears to be confused, however, he can resolve it by recreating the other shapes appropriately.

Student : *These three squares and one rectangle are split into 2 triangles like this (pointing to 2 triangles in the second shape), so it's the same, there are 4 rectangles.*

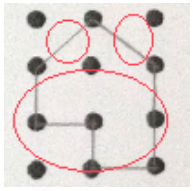


Figure 4. The Second Subject's Answers

Student : *Then square, there are also 4 rectangles. Then, this 1, 2, 3, 4 (students can count many squares).*

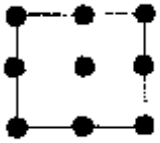


Figure 5. The Third Subject Answer

The student then makes another shape that is different based on many rectangular shapes, namely 4 squares.

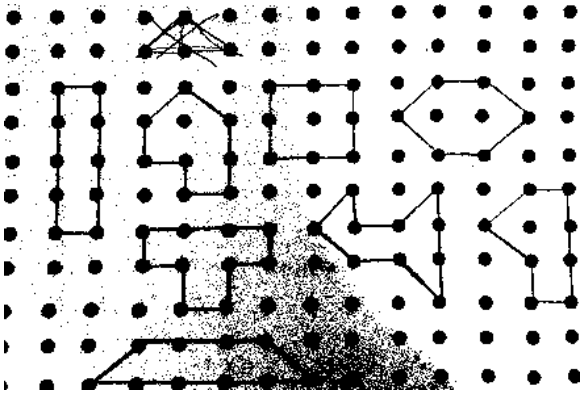
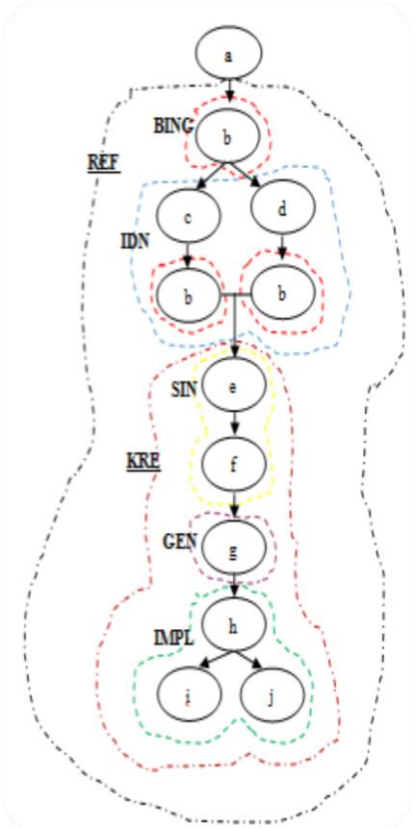


Figure 6. Fourth Student Overall Answer Results

Based on the answer results and interview excerpts, students seem to carry out all stages of the dispersive thinking process by means of "Conceptual-Embodied" thinking. The students' dispersive thinking process in the "Conceptual-Ambodied" world can be illustrated in Figure 7 below.



Information :
a = giving non routine problems
b = experiencing confusion (a lot of silence & reading questions repeatedly)
c = Mention what is known
d = State the thing being asked
e = Joining one triangle with another
f = Produces 1 rectangle
g = Stating: "there are 4 rectangles, then it can be broken apart as desired"
h = Applying (generate various alternative answers)
i = Mistakes form shapes
j = Form a variety of precise shapes

Component code

BING = experiencing confusion / perplexity
IDN = Identify the problem
SIN = Synthesize ideas
GEN = Build ideas
IMPL = Implement ideas

- - - - = There was confusion
- - - - = The process of identifying problems
- - - - = The process of synthesizing ideas
- - - - = The process of building ideas
- - - - = The process of implementing new and appropriate alternative answers
Ref = - - - - = Reflective thinking
Kre = - - - - = Creative Thinking

Figure 7. Dispersive Thinking Processes in a "Conceptual-Embodied" World

Figure 7 describes a schema of students' dispersive thinking in the "conceptual-embodied" world in problem solving related to flat shapes, where students experience the dispersion / distribution of reflective thinking processes, accompanied by creative thinking to obtain various alternative answers. Students' thinking process with "Conceptual-Embodied" begins when students experience confusion, because they are faced non-routine problems. This is supported by the statement of Tabach & Friedlander (2016) that students are not familiar with non-routine problems given. Students then identify the problem by stating that "there is a trapezoidal shape with 3 squares and two triangles and make at least 4 shapes with different backgrounds and have the same area as the area of the trapezoid. In the next step, students carry out an investigation to be able to solve the problem. In this case students carry out a reflective thinking process. Ricks, (2011); Rodgers (2002) stated that the reflective thinking process is characterized by experiencing confusion; identify problems; planning / making hypotheses to obtain solutions to

problems; apply the hypothesis to obtain the solution.

In the reflective thinking process, students carry out investigations by synthesizing ideas, namely combining one triangle with another to get a rectangle. Based on the results of the synthesis, students then built ideas using the concept of many squares (4 squares) to form other shapes with an area equal to the area of the trapezoid, and then apply them to obtain various alternative answers that are unique, new, and precise. In this case, students experience a creative thinking process. Krulik & Rudnick (1999); Siswono (2011) stated that the creative thinking process is characterized by synthesizing ideas, generating ideas, and implementing ideas.

Therefore, this research only reaches the description results of the stages of students' dispersive thinking processes, namely experiencing confusion (presence of experience), identifying problems, synthesizing ideas, building ideas, implementing ideas.

CONCLUSIONS AND SUGGESTIONS

The students' dispersive thinking process in constructing self-regulated learning abilities in the "Conceptual Embodied" world consists of 4 stages. First, students experience confusion / difficulty. The student confusion can be seen in the student attitudes who read the questions repeatedly and are silent a lot. Second, students then identify the problem more deeply by informing that "there is a trapezoidal shape with 3 squares and two triangles"; and then mention the things that will be solved, namely make at least 4 shapes with different backgrounds and have the same area as the area of the trapezoid. The third stage, students then carry out an investigation by synthesizing ideas on the "Conceptual-Embodied" way of thinking, which is combining one triangle with another to get a rectangular. Fourth, students seem to build ideas on the "Conceptual-Embodied" way of thinking, that is, students use the concept of 4 rectangles to form other shapes with the area of the trapezoid. Fifth, students apply the idea by forming other shapes whose area is the same as the area of the trapezoid.

Researchers recommend that the construction of self-regulated learning abilities in the "Conceptual Embodied" world with the concept of flat shapes should focus on the development of students' dispersive thinking stages. This shows that there is a research limitation that only reaches the description results of the stages of the dispersive thinking process of 8th grade junior high school students for flat shape material. Future research can develop this stage of the thinking process with a wider range of material and diverse subjects.

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