IDENTIFICATION OF THE STAGES OF STUDENTS' FIELD-INDEPENDENT CREATIVE THINKING PROCESS IN MATHEMATICS PROBLEM SOLVING

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Abstract:

The purpose of this study was to describe the creative thinking process of students' field-independent cognitive style in solving mathematical problems related to the circumference of a flat shape. The method used was descriptive qualitative. The subjects of this study were class VIII students who had a field-independent cognitive style based on the Group Embedded Figure Test (GEFT). Data were obtained through tests, documentation, observation, and interviews. Data analysis was carried out using four creative thinking processes developed by Graham Walla, namely preparation, incubation, illumination, and verification. The results indicated that students could understand the problem well, tend to be quiet to find solutions, could design solutions that would be done by choosing ideas to be solved by modifying the knowledge they already have and applying designed ideas to solve problems. Therefore, students seemed to understand mathematical operations related to the circumference of plat shapes.

Abstrak:

Tujuan penelitian ini adalah untuk menyajikan proses berpikir kreatif gaya kognitif field-Independent siswa dalam memecahkan masalah matematika berkaitan dengan keliling bangun datar. Metode yang digunakan adalah kualitatif deskriptif. Subjek penelitian ini merupakan siswa kelas VIII yang memiliki gaya kognitif field-independent berdasarkan hasil tes Group Embedded Figure Test (GEFT). Data diperoleh melalui tes, dokumentasi, observasi, dan wawancara. Analysis data dilakukan menggunakan empat proses berpikir kreatif yang dikembangkan Graham Walla, yaitu persiapan, inkubasi, iluminasi, dan verifikasi. Hasil penelitian menunjukkan bahwa Siswa dapat memahami masalah dengan baik, cenderung pendiam untuk mencari solusi, dapat merancang solusi yang akan dilakukan dengan memilih ide untuk diselesaikan dengan memodifikasi pengetahuan yang telah dimiliki, dan menerapkan ide yang dirancang untuk menyelesaikan masalah. Oleh karena itu, siswa tampak memahami operasi matematika yang berkaitan dengan keliling bangun datar.

Keywords:

Creative Thinking Process, Field-Independent, Problem-solving

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INTRODUCTION

One of the components measured in the Program for International Student Assessment (PISA) shows the importance of creative thinking (Kaur, Zhu, & Cheang, 2019; Leksmono, Sunardi, Prihandoko, & Murtikusuma, 2019; Retnawati & Wulandari, 2019). Competing in various sectors of work in the 21st century requires creative thinking skills (Anazifa & Djukri, 2017; Nur, Zubaidah, Mahanal, & Rohman, 2020). Creative thinking skills are also needed in generating innovative ideas in various activities (Ramdani, Artayasa, Yustiqfar, & Nisrina, 2021). In education, creative thinking must be developed to produce highly creative human resources (Astuti, Waluya, & Asikin, 2020). Students who can provide the results of problem-solving in the form of creative solutions or answers mean through the process of creative thinking (Leikin & Pitta-Pantazi, 2013).

Creative thinking is the ability to create different, uncommon, original ideas with correct and appropriate results (Hanipah, Yuliani, & Maya, 2018). Creative thinking is closely related to alternative problem solving (Larasati, Santosa, & Sari, 2018). Creative thinking in mathematics learning is an ability that allows students to find various solutions or ideas to solve problems, not only mathematical problems but the creativity needed in work (Kulsum, Hidayat, Wijaya, & Kumala, 2019). The essence of learning mathematics is creative thinking (Idris & Nor, 2010). Creative thinking is needed in interpreting problems and planning problem-solving steps (Anggareni & Hidayat, 2019). Having the creativity to think allows solving problems and finding alternative solutions or optimum solutions (Arikan, 2017). Students' creativity in solving problems is determined based on their fluency, flexibility, and authenticity (novelty) answers to solve problems given (Nadjafikhah & Yaftian, 2013; Yaftian, 2015). According to Munandar (2004), there are three characteristics of creative thinking, namely (1) Fluency is the ability to generate many relevant opinions or answers, (2) Flexibility, namely being able to change different ways or approaches and ways of thinking, (3) Novelty is the ability to answer unusually and the answers given were different from most people. This is in line with the results of Siswono, Tatag, & Kurniawati (2004) which saw that problem-posing ability as a creative ability. The problem-posing product is reviewed using creativity criteria, namely fluency, flexibility and originality, as well as on aspects of the creative process which emphasizes the cognitive aspect of students when solving and posing problems. The results showed that in the creative thinking process, each student in the creativity level group, namely the creative, less creative and non-creative group had different characteristics in each stage of the thinking process. The research provides empirical evidence of the relationship between creative thinking and mathematical problem solving and proposing.

Teachers must be facilitators in developing students' creative thinking skills (Astuti, Waluya, & Asikin, 2020). For this reason, teachers need to design learning so that they need information related to students' thinking processes. Knowing more about students' creative thinking processes will increase the teachers' effectiveness (Huang, Kuo, & Chen, 2020; Sumarni & Kadarwati, 2020). Wallas in Siswono, Tatag, & Kurniawati

(2004) explains the four stages of the creative thinking process, namely: (1) Preparation, gathering information relevant to a problem, formulating a problem, and making an initial effort to solve it; (2) Incubation, a period in which no attempt is made directly to solve a problem and attention is shifted for a moment to something else; (3) Illumination, obtain an idea or plan for solving the problem; (4) Verify, implement and test the ideas or understanding obtained and make a solution.

Creative thinking has a relationship with students' cognitive style (Masalimova, Mikhaylovsky, & Grinenko, 2019). Sternberg in Risnanosanti, 2010 suggested that creativity is a meeting point between three psychological attributes: intelligence, cognitive style, and personality (character) or motivation. Description related to the creative thinking process experienced by students (Sari, Ikhsan, & Saminan, 2017) and their cognitive styles (Jantan, 2014) are useful for designing various actions in learning to increase student creativity, so it needs to be a concern for teachers (Suharto, Widada, & Susanta, 2021). Students' cognitive styles influence creative thinking of problem-solving, namely Field-Dependent (FD) and Field-Independent (FI).

There are differences between FD and FI in responding to the context of the problem (Umah, 2020). Someone with FI cognitive style tends to approach problems and solve them analytically, so problem manipulation does not easily influence him/her. Meanwhile, someone with FD cognitive style tends to approach problems and solve them generally by focusing the problem on the environment as a whole so that he/she have perceptions that are easily influenced by situation manipulation (Nuswantoro, Siswono, & Khabibah, 2020). FI individuals have better problem-solving skills (Motahari & Norouzi, 2015). Someone with a field-independent cognitive style is considered capable of creative thinking. FI individuals have the habit of organizing and processing information (Xin, Jingyao, & Liuqing, 2019) and solve problems in a structured and organized way (Pathuddi, Budayasa, & Lukito, 2019). Azlina, Amin, & Lukito (2018) suggested that FI individuals meet the activity indicators, namely fluency, flexibility, and novelty. Thus, this study aimed to describe the creative thinking processes of Field-Independent (FI) students in solving mathematical problems.

RESEARCH METHOD

This study was descriptive qualitative research. Data were obtained through tests, documentation, observation, and interviews with respondents. Subject selection was taken based on the results of students' works from the GEFT test and belonged to the field-independent cognitive style. Group Embedded Figure Test (GEFT) is a set of psychometric tests developed by Witkin in 1971. GEFT is commonly used to classify students' cognitive styles into field-dependent (FD) or field-independent (FI).

The determination of the research subject was based on the results of the GEFT test, which classified students into two cognitive styles, namely independent-field and dependent-field. The GEFT test determines students' cognitive styles based on their psychological differences. Students were given a creative problem-solving test in the field-independent, which was then analyzed further through in-depth interviews to see students' creative thinking processes based on the creative thinking process developed by Graham Walla, namely preparation, incubation, illumination, and verification. Then, the creative problem-solving test was given to students with the field-independent cognitive style.

The steps for selecting research subjects were: (1) Establishing research classes, namely class VIII in even semester of 2018/2019 school year; (2) Grouping students according to GEFT results based on FI; (3) Giving a creative problem-solving test to students who got FI and FD categories; (4) students who were selected as research subjects were students with the FI cognitive style and completed the creative problem-solving test according to the indicators of creative thinking.

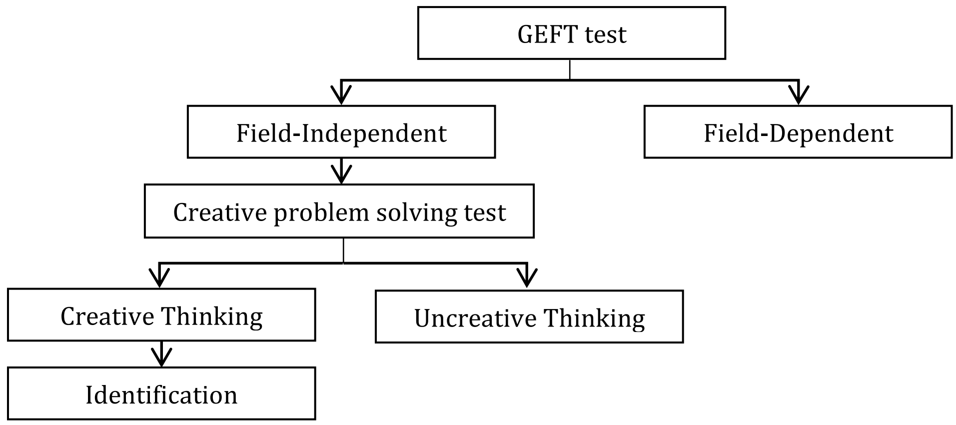

Figure 1. Research Stages

RESULTS AND DISCUSSION

The analysis was carried out on the creative problem-solving test. The problem given was a geometry problem. Students were asked to be creative in making answers by drawing as many flat shapes as possible under certain conditions. One of the questions given was as follow:

> *A rectangle has four sides (PQRS) with 20 cm length and 5 cm width. Make flat figures as many as possible with the same perimeter but different areas of the rectangle PQRS (perhaps by combining two or more plane figures). Show your answer.*

The researchers obtained data related to students' thinking process of FI based on analysis results of the several questions that students did when doing creative problem-solving tests. The results were also strengthened by interviews based on the stages of the creative thinking process, namely preparation, incubation, illumination verification.

This study focused on the students' creativity and creative thinking processes of field-independent in solving mathematical problems. The determination of the research subject was based on the results of the GEFT test, which classified students into two cognitive styles, namely field-independent and field-dependent. Then, the creative problem-solving test was given to students' field-independent. The subject in this study was a student who was given the initial FI1. His/her answer met three creativity categories: fluency, flexibility, and originality. FI1 was then interviewed to see the creative thinking process in producing creative answers based on the Wallas stages, namely preparation, incubation, illumination, and verification. FI1's answers when solving the problem was as follow:

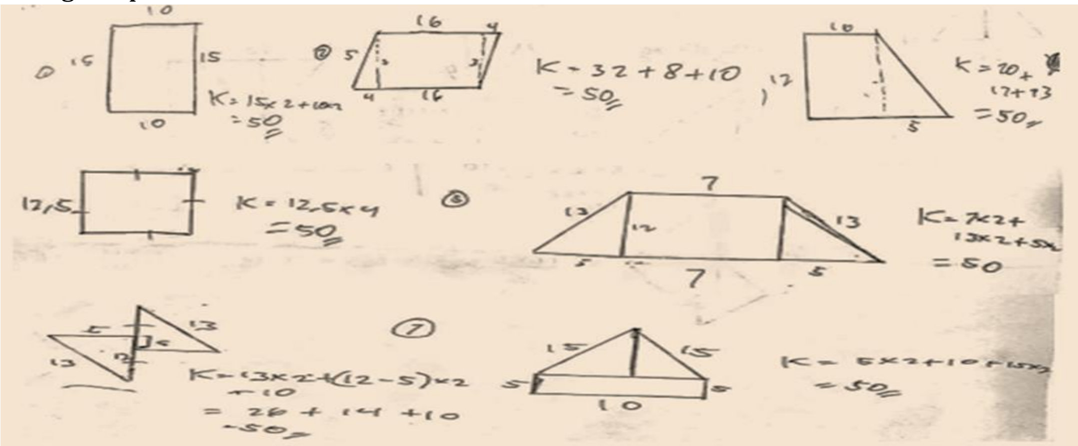

Figure 2. FI1's Answer Sheet

As stated by Siswono (2011), fluency in solving mathematical problems was seen from the ability of students to give many correct answers. Based on Figure 2, the fluency category was met as seen from a student's answer who could draw seven plane shapes with the same area as the rectangles on the creative problem-solving test. There were seven correct answers that students could give. The student's correct answer met the flexibility category by using seven different ways or ideas. Figure 2 illustrated the shape of a plane figures (1) rectangle, (2) parallelograms, (3) right trapezoid, (4) square (5) a combination of one rectangle two triangles, (6) a combination of two triangles, (7) a combination of two triangles and one rectangle. Those answers indicated that students could draw several plane figures in many ways. The originality category was fulfilled as seen from FI's answer sheet in Figure 2 forms 5, 6, and 7. Students could give correct "unusual" answers at the same level of knowledge and give such answers first.

The creative thinking process was based on four stages designed by Wallas, namely, preparation, incubation, illumination, and verification. In the preparation step, FI1 read the problem. He/she found that the problem was drawing several plane figures with the same perimeter as the rectangle on the question, but it was not for the area. In line with Puspitasari (2019), FI1 showed that students collected the information obtained to complete. FI1 understood that the rectangle PQRS with length 20 cm and width 5 cm also became information that could solve the problem where it meant that the circumference and area of the rectangle were 50 cm and 100 cm2. Thus, FI1 knew that the material about the circumference, area of the plane figure, and Pythagoras was needed to solve the problem.

The incubation step was experienced twice by thinking of how to make an unusual shape fulfilled the condition of the problem. The circumference was 50 cm, and the area was 100 cm^2. FI1 scribbled on another paper, trying to find a form that could be a solution. FI1 thought while trying again to draw on another paper. The second incubation, with the same action, was experienced by FI1 when he/she was about to find the last form (form 7 in Figure 2).

FI1 entered the illumination stage by getting new ideas about shapes with two congruent triangles then combining them in such a way. The second illumination experienced by FI1 after the second incubation, FI1 got a new idea by making two different flat shapes with each circumference to be modified to merge so that the circumference became 50 cm.

The last, FI1 applied new ideas obtained at the previous illumination stage in the verification stage. In form 6 in Figure 2, FI1 drew a shape consisting of two congruent triangles with a base of 5 cm, a height of 12 cm, and a hypotenuse of 13 cm. Then, FI1 squeezed the two together so that each of the triangles met each other on the 5 cm side (form 6 in Figure 2). FI1 did it to ensure that the circumference of the shape could be 50 cm. In the end, FI1 found a shape with a circumference of 50 cm. As a form of application of the ideas found in the previous stage, FI1 made a rectangle with 5 cm and 10 cm side lengths. He/she also made an isosceles triangle with a base of 10 cm following the length of the rectangle made previously, then the other two sides were 15 cm. FI1 combined the two flat shapes between the sides of a 5 cm rectangle with a triangular base of the same length. Thus, FI1 made a new shape with a circumference of 50 cm.

Siswono (2011) stated fluency in solving mathematical problems was seen from the students' ability to give several correct answers. FI1's answer met the fluency category of students who could draw seven flat shapes with a perimeter equal to the rectangle on the problem. The students could give seven correct answers. The flexibility category was met by the students' answers that could answer correctly using seven different ways or ideas. The originality category was fulfilled, as seen from the students' answers in figure 2 in forms 5 and 6. Students could give correct "unusual" answers at the same level of knowledge and give such answers for the first time. The result indicated that students could find new ideas by modifying or combining several previously known ideas (Edgar, Faulkner, & Franklin, 2008). Based on the level of evaluation (Siswono, 2011), FI was at the highest level, which meant that he/she was very creative.

FI1 was a subject with a field-independent cognitive style. Through visual ability in the preparation stage, FI1 could understand the problem given by reading. In the reading process, he/she remembered several problems that had been encountered before. It meant that FI1 called back the knowledge he/she had based on the learning experience stored in the memory. Experience in dealing with problems in the past was associated with problems encountered and contributed to decision-making in preparing the problem-solving process. This statement was consistent with the assumption that there was coordination between learning experiences and thought processes (Airasan, Cruikshank, & Mayer, 2001). In the preparation, FI1 found the information to be used in solving the problem as follows (1) PQRS rectangle with the sides' lengths of 20 cm and 5 cm, (2) the purpose of the problem was to draw flat shapes that had the same perimeter as PQRS but different area. Understanding the problem was seen based on the FI1's ability to re-express information on the problem and the conditions that must be met to solve the problem in his/her own words.

FI1 temporarily broke away from the given problem in the incubation stage. He/she focused on thinking of various types of flat shapes and determining the area and perimeter. At this stage, it might take a few seconds, minutes, or hours depending on the problem's difficulty (Maharani, Sukestiyarno, & Waluya, 2017). FI1 experienced another incubation by finding new ideas to draw shapes by combining two or more flat shapes or other ideas to determine the area of flat shapes. He/she experienced the incubation stage every time he/she wanted to draw a new form so that in one problem-solving process, the incubation stage repeatedly occurred (Guilford, 1979).

In designing the application of ideas, students choose certain ideas to solve problems faced (Siswono, 2011). In the illumination stage, FI1 found a planning idea for the settlement carried out. He/she used ideas obtained from the previous incubation stage. FI1 entered the illumination stage by finding ideas to combine the two forms of the flat figure and calculating the regular flat figure, the triangle. FI1 determined the combined perimeter of two triangles by subtracting the adjacent sides. It meant that FI1 could find new ideas by combining several previously known ideas (Edgar, Faulkner, & Franklin, 2008).

FI1 experienced the verification phase by applying new ideas found at the incubation stage and the previous illumination stage (Bahrudin & Siswono, 2020). FI1 drew two triangles that coincided with each other and looked for the circumference of the flat figure by analyzing the image to determine the solution to the problem.

CONCLUSION

The creative thinking process stages of field-independent (FI) students were preparation, incubation, illumination, and verification. The students could understand the problem well in the preparation stage. They got relevant information and explained it using easier sentences to be understood. The students tended to be quiet in the incubation stage but still thought of solutions. In other words, they remembered how to solve and find the right formula to use based on experience in solving previous problems. In the illumination stage, the students designed a solution that would be done by selecting ideas or getting new ideas to complete by modifying the knowledge they already have. Students applied designed ideas of the illumination stage at the verification stage to complete. They seemed understood mathematical operations and could modify completion at this stage. In addition, students also provided solutions and ways to solve new and varied problems. Researchers suggest that future teachers pay special attention to select questions or problems for students. To get students' creativity, teachers can use open-ended problems.

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