

# The Level of Creative Thinking Skill in Graph Theory Application Course

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**Abstract:** Graph theory can be applied to solve various life problems such as optimization of distribution cost, minimum time routing, and project scheduling. In the Graph Theory Application course, one of the student's project tasks was a field survey to the industry / institution / company. From problems found, they identified and solved problems, modelled problems in graph, and developed the solution design. The purpose of this study was to identify the students' level of creative thinking in posing the problem and designing for the problem solving. To measure the level of creativity, Terrace Test of Creativity Thinking (TTCT) was adapted. Data of the students' creativity dimensions (fluency, flexibility and novelty) in solving the problem of graph theory were used to analyse the creative thinking level of students (very creative, creative, creative enough, less creative, and not creative). From the data analysis, the students' creative thinking level in the Graph Theory Application was dominant in level of creative thinking 3 i.e. the student was able to show fluency and novelty or fluency and flexibility in problem posing and problem solving. For the creative thinking level 4 (very creative) and level 1 (less creative) were in small percentage, and no student with creative level 0 (not creative).

## 1 INTRODUCTION

In facing the era of globalization and the challenges of 21st century education, it is necessary to have a learning pattern that makes students have high skills that involve critical, systematic, logical, and creative thinking. Similarly to the challenges of the working world that job seekers need to have are the ability to work together in teams, master the technology, able to communicate effectively and the most important is to have problem-solving ability. Learning innovation is needed to develop those abilities and meet the demands of skills needed in the 21st century.

Graph theory is one of course in Mathematics study program, State University of Malang, which has wide application field in real life. The learning achievement of graph theory application is a) able to understand the problem and develop problem solving algorithm, b) able to design mathematical model, complete the model, and interpret the obtained solution, c) able to plan and control the optimization process in industry, decision making, and business. (Catalogue of FMIPA UM, 2017). Characteristic of the content of Graph Theory Application course is the content can be used to solve a number of real-world

problems, hence the problem solving ability can be incorporated into this course.

According to (Pehkonen, 1997) problem solving is one way to encourage creativity as a product of creative thinking because problem solving is useful in developing cognitive skills, motivating learning math applications, and encouraging creativity of thinking. Some researchers linked the effects of problem solving to creative thinking, such as (Kandemir, M and Gür, 2009; Nozari and Siamian, 2014; Dostal, 2015; Kirmizi, Saygi and Yurdakal, 2015; Rodzalan and Saat, 2015). Problem solving skills are also needed to face the challenges of 21st century education (Greiff *et al.*, 2014).

In addition to problem solving, some researchers suggest that assigning problem posing tasks can be used to measure creativity of thinking (Leung, no date; Stoyana and Ellerton, 1996; Silver, 1997). Problem posing activity is also needed in mathematics learning, as stated by (Akay and Boz, 2009; Cildir and Sezen, 2011; Şengül and Katranci, 2012; Kunimune and Niimura, 2014).

Creative thinking ability can be measured by several criteria. According (Silver, 1997) to assess creative thinking ability in adults can be done with

The Torrance Test of Creative Thinking (TTCT). The creativity dimension consisting of the three main components considered in TTCT is fluency, flexibility and novelty. Fluency refers to the number of ideas created in response to a command. Flexibility appears in the approach changes when responding to commands. Novelty is the originality of an idea created in response to a command. Some researchers are adapting TTCT to identify the level of creative thinking that is (Rababah *et al.*, 2013; Turkey, 2018). (Siswono, 2011) develops students' creative thinking level in the mathematics classroom.

This article discusses about how to identify the students' level of creative thinking in graph theory application course. The method used adapted (Siswono, 2011; Rababah *et al.*, 2013; Turkey, 2018).

## 2 METHOD

The type of this research was descriptive qualitative. The research data source was 25 students who followed the lectures of the Graph Theory Application in even semester of 2017-2018 academic years. To identify student's creativity level, the following methods were used. 1). Formation of field survey groups and selection of applied graph materials, 2). Preparation of survey proposals to industry / institution, 3). Acquisition of field data, 4). Formulation / modelling problems, 5). Create problem-solving designs with various appropriate algorithms.

The creativity level of students was identified based on the creativity dimension (fluency, flexibility and novelty). This level of student creativity was observed from the problem posing and problem solving they made based on the results of field surveys. The level of creativity of students is described as very creative, creative, creative enough, less creative, and not creative.

## 3 RESULT AND DISCUSSION

### 3.1 Field Survey in Graph Theory Application Course

Field survey conducted by students related to material of graph theory application course. The main subjects

include are (1) Algorithm in the Traveling Salesman Problem (TSP) variant and its application, (2) Matching, matching in bipartition network, matching in no bipartition network, and its application; (3) Maximum flow, maximum flow algorithms and its application, (4) Minimum cost flow, minimum cost flow algorithms and their application, (5) Vehicle Routing Problem (VRPPD), Vehicle Routing Problem with Time Windows (VRPTW), Vehicle Routing Problems with Simultaneous Deliveries and Pick-ups (VRPSDP), Multiple Trip Vehicle Routing Problems (MTVRP) and their implementation, and (6) Network implementation for project scheduling (FMIPA UM catalogue, 2017).

Some field surveys conducted by students in even semester of 2017-2018 are: Optimizing the Distribution of Newspapers Using Dynamic Traveling Salesman Problem in Radar Malang, Optimization of Employee Assignment in "Adi Bungsu" Cigarette Factory using Bipartition Matching Graph, Maximum Flow Implementation for Distributing Product in PT Gatra Mapan Malang, optimization route of newspaper distribution in radar malang by using Vehicle Routing Problem With Time Window (VRPTW), Implementation of Network Analysis for Solving Project Scheduling Problem in PT. Kharisma Menara Abadi Malang, Distribution of Sosro Products Using Minimum Cost Flow Method at PT Sinar Sosro Malang, Optimization of "Walls" Ice Cream Distribution Using Capacitated Vehicle Routing Problem at PT Lukindari Permata Malang.

An example of a graph model of a problem and the result of a solution on a student assignment is shown in Figure 1, 2, and 3.



Figure 1: Example of graph model of goods distribution.

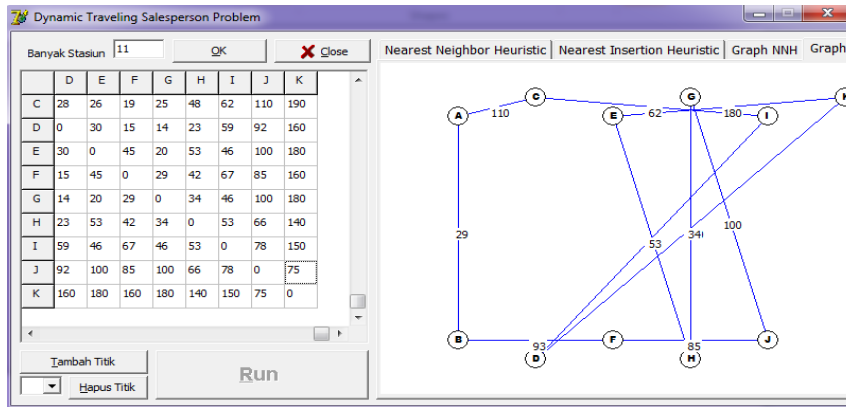


Figure 2: Solving TSP in software.

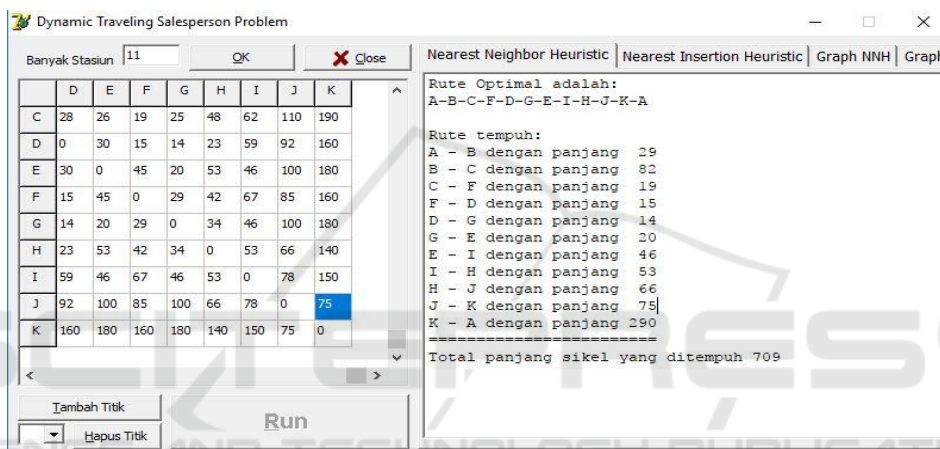


Figure 3: Example of TSP solution.

The Figure 1, 2, and 3 shows the model of the route of newspapers distribution to a number of agents in several areas in Malang. Searching of minimum length route which passed all agents is examined with Nearest Neighbor Heuristic Algorithm, Nearest Insertion Heuristic Algorithm and Cheapest Link Algorithm. In the modeled case, the Cheapest Link algorithm provides better results than the other two algorithms.

### 3.2 Creativity Dimension in Problem Posing of Survey Result

Problem posing of survey results is a task for students to create or formulate problems obtained from real survey results, which then modeled and solved. The steps taken are the students doing field survey, finding problems, formulating the problem, and making the draft solution. Problem posing and problem solving can be used to measure the ability of

creative thinking (Silver, 1994, 1997). The dimension of creativity can be measured from three components of creativity products, i.e. fluency, flexibility and novelty.

### 3.3 Description of Students Creativity Level

Instruments to determine the level of students' creative thinking were adapted from Torrance Test of Creative Thinking (TTCT) (Silver, 1997), the level of creative thinking (Turkey, 2018), and level student's creative thinking in classroom mathematics (Siswono, 2011). Description of indicator of creative thinking ability used in this research is

- Fluency (able to model and solve problems with various problem interpretations or answers).
- Flexibility (able to solve problem and to discuss in various methods or algorithms), and

- Novelty (able to check or analyze a number of methods or algorithms, and to implement new algorithm or methods)

Of the indicator components above, the creative thinking level can be described as follow.

- Creative thinking level 4 (very creative)
- Students are able to demonstrate fluency, flexibility and novelty, or novelty and flexibility, in problem posing and problem solving.
- Creative thinking level 3 (creative)
- Students are able to show fluency and novelty, or fluency and flexibility, in problem posing and problem solving.
- Creative thinking level 2 (fairly creative)
- Students are able to demonstrate flexibility or novelty in problem posing and problem solving.
- Creative thinking level 1 (less creative)
- Students are able to show their fluency in problem posing and problem solving.
- Creative thinking level 0 (not creative)
- Students are unable to show the three aspects of the creative thinking indicators in problem posing and problem solving.

From the analysis result of students' creative thinking level in graph theory application course, the dominant percentage is the creative thinking level 3 (creative) ie the student is able to show fluency and novelty, or fluency and flexibility in problem posing and problem solving. As for the percentage of creative thinking level 4 (very creative) and the creative thinking level 1 (less creative) is very small. No student with creative level 0 (not creative).

The result of student creative thinking level analysis can be seen in Table 1 and Figure 4. In detail, components of students' creativity indicator shown in Table 2.

Table 1: Distribution of students' creative thinking level.

Creative thinking level	Number of students	Percentage
4 (very creative)	3	12 %
3 (creative)	14	56 %
2 (fairly creative)	6	24 %
1 (less creative)	2	8 %
0 (not creative)	0	0 %
Total	25	100 %

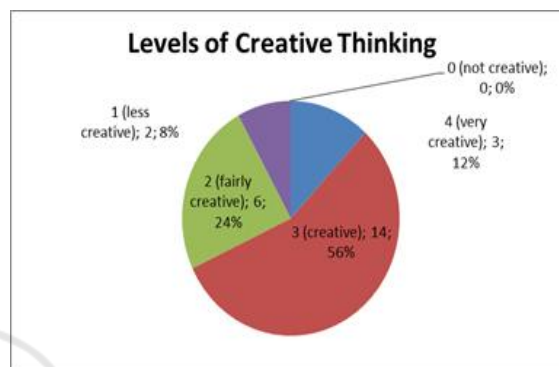


Figure 4: Proportion of students' creative thinking level.

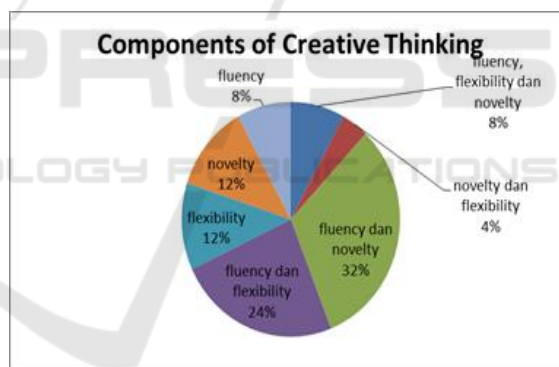


Figure 5: Proportion of students' creative thinking level based on its components.

Table 2: Distribution of students' creative thinking level based on its components.

Creative thinking level	Indicator components	Number of students	Percentage
4 (very creative)	fluency, flexibility and novelty	2	8 %
	novelty and flexibility	1	4 %
3 (creative)	fluency and novelty	8	32 %
	fluency and flexibility	6	24 %
2 (fairly creative)	fflexibility	3	12 %
	nnovelty	3	12 %
1 (less creative)	ffluency	2	8 %
0 (not creative)	-	0	0 %
	Total	25	100 %

Of three students in creative thinking level 4, only two students could show fluency, flexibility and novelty, and only a student could have novelty and flexibility in posing and solving problems.

Figure 5 showed depict distribution of creative thinking level, based on its indicator components.

## 4 CONCLUSION

In this research, most students of graph theory application course were in creative thinking level 3 (56%). They could present fluency and novelty, or fluency and flexibility in posing problem as well as solving problems. The rest in descending order are in level 2 (24%), level 4 (12%), and level 1 (8%). This showed that students were enthusiastic in the course that involved problem posing and problem solving, and they could have creative thinking skill which is really needed in work field afterthat.

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