Analysis of problem solving on project based learning with resource based learning approach computer-aided program

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Abstract. This study aimed to reveal the effectiveness of Project Based Learning with Resource Based Learning approach computer-aided program and analyzed problem-solving abilities in terms of problem-solving steps based on Polya stages. The research method used was mixed method with sequential explanatory design. The subject of this research was the students of math semester 4. The results showed that the S-TPS (Strong Top Problem Solving) and W-TPS (Weak Top Problem Solving) had good problem-solving abilities in each problem-solving indicator. The problem-solving ability of S-MPS (Strong Middle Problem Solving) and (Weak Middle Problem Solving) in each indicator was good. The subject of S-BPS (Strong Bottom Problem Solving) had a difficulty in solving the problem with computer program, less precise in writing the final conclusion and could not reflect the problem-solving process using Polya’s step. While the Subject of W-BPS (Weak Bottom Problem Solving) had not been able to meet almost all the indicators of problem-solving. The subject of W-BPS could not precisely made the initial table of completion so that the completion phase with Polya’s step was constrained.

1. Introduction
Mathematics is one of science branch that can make human resources to be qualified. Reflecting on the purpose of mathematics in schools was to equip students to face ever-evolving life through actions based on logical, rational, critical, accurate, honest, effective, and efficient thinking [1]. Furthermore, by studying mathematics students were expected to apply mathematical science thinking in daily life and used it as a basis for studying other science.

The universities had great responsibilities and obligations, especially in creating intellectual resources, which were expected to contribute to the improvement of the nation's human resources [2]. Learning and mathematical thinking in college had been the concern of the Mathematical Association of America (MAA) through the Committee on the Undergraduate Program in Mathematics or CUPM, which recommended among others that learning of mathematics in the classroom should involve activities that supported all students to improve and developed analytical and critical reasoning skills, problem solving, and communication, also achieved habitual (habit) of mathematical thinking [3]. In addition, CUPM also recommended that classroom learning should present key ideas and concept from multiple perspectives, such as presenting a range of examples and applications to motivate and illustrate material, promoting mathematical connections to other disciplines, developing the ability of each student to apply mathematical material to the discipline, introducing current topics of mathematics and
its applications, and improving students' perceptions of the vital role and importance of mathematics in today's world [3].

Mathematics materials at universities were different from when they were in school. Mathematics learning in college was becoming increasingly difficult to learn. Mathematics learning was often rated negatively by students and they had considerable difficulty with some mathematical processes such as reasoning, non-routine problem solving and proving [4-5]. Ability to solve problems was considered a very important learning activity in formal education from primary education to college [6-8]. Further, the changes from elementary thinking to advanced mathematical thinking involved a significant transition, i.e from describing to defining, from convincing to logically proving based on a definition [9]. One of the courses that had complexity and difficulty also required solving management problem abilities was Operations Research.

Operations Research was one of the subjects in the mathematics course that belongs to the applied science group. Operations Research was related with optimal decision making and modeling of the deterministic and probabilistic systems derived from daily life [10]. Solving the problem in Operations Research required the right strategy and considerable calculation.

The development of science and technology encouraged people to use it in various fields. The digital era did not only change the quality of resources and information but also included significant potential for using various resources in a variety of ways, one of them in educational field [11]. Learning that utilized various resources was usually called Resource Based Learning. Through Resource Based Learning students were able to build their own knowledge, created thinking strategies, and helped the problem-solving process [12].

Analysis and calculation of the problem of more and more optimization in Operations Research required the use of computer programs so that learning did not tend toward only the concept of understanding. The use of computer programs in learning could overcome negative feelings that impacted on motivation and provided positive effects and could support students during lectures and in professional life in the future [13-14]. One of the computer programs that could be used was Solver (add in Microsoft Excel) and Microsoft Project [15].

A learning model that could drive real-world problem-solving management in operations research is Project Based Learning. Project Based Learning provided a broader view of how and what was obtained with mathematics [16]. Project-Based Learning (PjBL) was an innovative learning model that emphasizes contextual learning through complex activities [2].

Computer-supported problem solving on collaborative work would be more efficient than individual work [17]. Science and technology both of them taught knowledge, scientific method in science and design on technological aspect, while solving the problem of both aspects [18].

Based on the description, in this study tested and analyzed the effectiveness of Project Based Learning method through computer support Resource Based Learning approach and described the characteristics of problem-solving skills of mathematics students in terms of students initial ability problem-solving.

2. Methods

This research used combination method (mixed method) with sequential explanatory model that was combination of quantitative research method and qualitative method in sequence [19]. The first stage was done by quantitative method to obtain measured data and in the second phase was done by qualitative method to explore the findings obtained from the first stage. The research was conducted on the lecture of Operation Research of fourth-semester student of UNNES. The research activity began by determining the initial problem-solving ability by giving the initial test of problem-solving ability. Implementation of Project Based Learning method through computer support Resource Based Learning approach was implemented for five meetings. At the end of the learning activities students were given final tests of mathematical problem-solving skills and interviews were conducted. For each level of initial problem-solving ability, two students were taken as research subjects. Data analysis included
preliminary and final test of student problem-solving abilities for each subject at each level of initial problem-solving abilities according to Polya’s indicators of mathematical problem-solving ability [20].

3. Result and Discussion
The effectiveness of learning in this study was viewed from two aspects, they were: (1) Mastery of student learning achievement was if the percentage of students who reached the criterion B (score > 70) had exceeded 75% of the total subject of research; And (2) problem solving abilities achievement from before and after the learning of Project Based Learning method through computer support Resource Based Learning approach.

The result of proportion test showed that the proportion of students in the learning of Project Based Learning method through computer support Resource Based Learning approach that met the B score criteria reached more than 75%. While the result of comparison test of one paired samples showed the average problem-solving ability of student after the learning of Project Based Learning method through computer support Resource Based Learning approach more than the average of problem-solving ability of student before the learning of Project Based Learning method through computer support Resource Based Learning approach. Based on these two aspects, it was concluded that Project Based Learning method through computer support Resource Based Learning approach to students of 4th semester of Operations Research course was Effective.

A learning model that gave students an opportunity to investigate real-world topics and collaboratively gave a chance for them to design a process of determining solutions and to be responsible for accessing and managing information to solve problems. In line with English & Kitsantas [21], Project Based Learning, helped students become proficient in conducting investigation activities, thinking strategies, problem-solving, and gradually establishing student responsibilities. As explained by Vygotsky's theory that learning process would occur efficiently and effectively if students learned cooperatively with other students, supportive environmental atmosphere, in the guidance or assistance of more capable or more mature individuals, e.g. a student. Based on this problem, student problem-solving ability could be well built.

The results of this study indicate that the problem solving ability of TPS subjects in the indicators understand the problem on sub-indicators "know what is known and asked on the problem", "explain the problem according to the sentence itself", "collect data about the goals and constraints that affect the purpose" Create initial table of completion", is quite good. This is in accordance with the results of Lazakidou & Retalis [8] which shows that the process of solving can be done well-using computer support because it reduces the duration of problem-solving.

The subject of TPS category was able to understand the problem well and systematically. Subjects could write down what was known from the problem completely and correctly. Subjects were also able to write down sub-implied goals. Mathematical model which was written in TPS described the correlation between the input and the objectives to be achieved in the form of objective function. Plans that was prepared by the TPS were also complete and coherent. The subject of TPS could describe complex information from the encountered problems. Being able to analyze the mathematical model which was created and found solutions from the model using the program well. The written conclusions were easy to understand and to present because they used language that was easily understood.

At the re-check Problem Solving Problem, did not found on the TPS answer sheet, but this information was obtained by researchers after interviewing with the subject of TPS. Both S-TPS and W-TPS repeated reading every question to anticipate miss-information. Re-examine the purpose function and constraints in the mathematical model and checked the formulas in Solver. S-TPS at this step considered whether the obtained results were logical or not while W-TPS did not do so. Neither of them made an alternative answer. More detailed results on problem-solving skills of TPS students based on Polya's steps are presented in Table 1.
### Table 1. Problem Solving Ability of TPS student

| No | Indicators                                      | S-TPS                                                                 | W-TPS                                                                 |
|----|------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|
| 1. | Understanding the Problem                      | Complete and correct in writing down what was known of the problem.  | Complete and correct in writing down what is known of the problem.  |
|    |                                               | Obviously in writing the asked question in accordance with their own sentence. | Obviously in writing the asked question in accordance with their own sentence. |
|    |                                               | Write down the goals and constraints that were exist in the question completely. | Write down the goals and constraints that are exist in the question completely. |
|    |                                               | Was able to create completion initial table completely and correctly. | Was able to create completion initial table completely and correctly. |
| 2. | Devising the Problem Solving Plans            | Was able to write sub-goals that have not been implied in the question. | Was able to write sub-goals that have not been implied in the question. |
|    |                                               | Was able to write a mathematical model in the form of an equation that described the relationship between input and output and objectives to be achieved in the form of objective function. | Was able to write a mathematical model in the form of an equation that described the relationship between input and output and objectives to be achieved in the form of objective function. |
|    |                                               | Was able to develop a complete and coherent problem-solving plan.     | Was able to develop a complete and coherent problem-solving plan.     |
| 3. | Carrying out Problem Solving Plan             | Was able to answer the problem correctly because they were able to make a problem-solving plan correctly. | Was able to answer the problem correctly because they were able to make a problem-solving plan correctly. |
|    |                                               | Solved the problem using the program well in accordance with the earlier obtained model. | Solved the problem using the program well in accordance with the earlier obtained model. |
|    |                                               | Wrote the final conclusion well and correctly.                        | Wrote the final conclusion well and correctly.                        |
| 4. | Looking Back the Problem Solving Results      | Re-read the question and examine the purpose function and constraints in the mathematical model and checked the formula in Solver. | W-TPS did not consider whether the obtained results were logical or not, and did not make alternative answers. |
|    |                                               | Did not make alternative answers.                                    | Did not make alternative answers.                                    |

The problem-solving ability of MPS subjects based on Polya's steps on the sub-indicator knowing what was known and being asked on the problem, explaining the problem according to the sentence itself, collecting data on goals and constraints that was affecting the objectives, making the initial table of completion, were good. The subject of MPS could solve well the problem with Polya’s step from the step of understanding the problem until the step of rechecking the problem-solving result. Being able to analyze the mathematical model that was created and found solutions from the model using the program well. MPS could create a complete and precise completion table. This initial table made it easier for MPS to understand the problem. Making visual representations/early tables not only helps understand the problem, but can also guide the preparation of plans for better problem solving [22]. However, the written conclusions still did not explain the results clearly. The problem solving skills of MPS students based on Polya's step in more detail were presented in Table 2.
Table 2. Problem Solving Ability of MPS student

| No. | Indicators                  | S-MPS                                                                 | W-MPS                                                                 |
|-----|-----------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------|
| 1.  | Understanding the Problem   | Complete and correct in writing down what was known of the problem.   | Complete and correct in writing down what was known of the problem.   |
|     |                             | Obviously in writing the asked question in accordance with their own  | Obviously in writing the asked question in accordance with their own  |
|     |                             | sentence.                                                             | sentence.                                                             |
|     |                             | Write down the goals and constraints that are exist in the question    | Write down the goals and constraints that are exist in the question   |
|     |                             | completely.                                                           | completely.                                                           |
|     |                             | Was able to create completion initial table completely and correctly. | Was able to create completion initial table completely and correctly. |
| 2.  | Devising the Problem        | Was able to write sub-goals that had not been implied in the question. | Was able to write sub-goals that had not been implied in the question.|
|     | Solving Plans               | Was able to write a mathematical model in the form of an equation that | Be able to write a mathematical model in the form of an equation that   |
|     |                             | described the relationship between input and output and objectives to  | described the relationship between input and output and objectives to  |
|     |                             | be achieved in the form of objective function.                       | be achieved in the form of objective function.                       |
|     |                             | Was able to develop a complete and coherent problem-solving plan.     | Was able to develop a complete and coherent problem-solving plan.     |
| 3.  | Carrying out Problem        | Was able to answer the problem correctly because they were able to     | Was able to answer the problem correctly because they were able to     |
|     | Solving Plan                | make a problem-solving plan correctly.                               | make a problem-solving plan correctly.                               |
|     |                             | Solved the problem using the program well in accordance with the      | Solved the problem using the program well in accordance with the      |
|     |                             | earlier obtained model.                                              | earlier obtained model.                                              |
|     |                             | Wrote the final conclusion well and correctly.                        | Wrote the final conclusion well and correctly.                        |
| 4.  | Looking Back the Problem    | Repeated to re-read the problem and checked the purpose function and   | Repeated to re-read of the problem and checked the purpose function   |
|     | Solving Results             | constraints in the mathematical model and checked the formulas in     | and constraints in the mathematical model and checked the formulas in  |
|     |                             | Solver.                                                               | Solver.                                                               |
|     |                             | Did not consider whether the results obtained results were logical or  | Did not consider whether the results obtained results were logical or   |
|     |                             | not and did not make alternative answers.                             | not and did not make alternative answers.                             |

The information of rechecking the results of problem solving was found after interviewing with the subject of MPS. The subject of MPS, both S-MPS and W-MPS repeated reading every question to anticipate miss-information. Re-examine the purpose function and constraints in the mathematical model and check the formulas in Solver. Both of them did not consider whether the obtained results were logical or not. Neither do they make alternative answers.

The results of this study indicate that the problem-solving ability of BPS on S-BPS and W-BPS subject had some differences. Results of research on problem-solving ability of BPS students based on Polya’s step were presented in Table 3. BPS was able to write down the goals and constraints that exist in the problem completely. Differences between S-BPS and W-BPS started to appear in the W-BPS
which could not create the initial table of completion in accordance with the created mathematical model. The process of understanding the problem was an important aspect in problem-solving [23].

**Table 3. Problem Solving Ability of BPS student**

| No. | Indicators                        | S-BPS                                                                 | W-BPS                                                                 |
|-----|-----------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------------|
| 1.  | Understanding the Problem         | Complete and correct in writing down what is known of the problem.    | Was able to write down what is known of the problem.                   |
|     |                                   | Obviously in writing the asked question in accordance with their own sentence. | Was able to write down the asked question in accordance with their own sentence. |
|     |                                   | Writing down the goals and constraints that were exist in the question completely. | Writing down the goals and constraints that were exist in the question completely. |
|     |                                   | Was able to create completion initial table completely and correctly. | Not able to create completion initial table completely and correctly. |
| 2.  | Devising the problem-solving Plans| Was able to write sub-goals that had not been implied in the question. | Was able to write sub-goals that had not been implied in the question. |
|     |                                   | Was able to write a mathematical model in the form of an equation that describes the relationship between input and output and objectives to be achieved in the form of objective function. | Was able to write a mathematical model in the form of an equation that describes the relationship between input and output and objectives to be achieved in the form of objective function. |
|     |                                   | Was able to develop a complete and coherent problem-solving plan.       | Was able to develop a complete and coherent problem-solving plan.       |
| 3.  | Carrying out Problem-Solving Plan | Was able to answer the problem correctly because they were able to make a problem-solving plan correctly. | Not able to answer the problem correctly. |
|     |                                   | Was not able to solve the problem using the program for some questions. | Not able to solve the problem using Solver program for some questions. |
|     |                                   | Less precise in writing the final conclusion on some questions.         | Incorrect in writing the final conclusion on some questions.           |
| 4.  | Looking Back the problem-solving Results | Not repeating the reading problem. Not checking objective functions and constraints in mathematical models and check the formulas in Solver. | Repeating the reading problem. Trying to see the purpose function and constraints in the mathematical model and check the formulas in Solver. |
|     |                                   | Not considering whether the obtained results were logical and not able to make alternative answers. | Not considering whether the obtained results were logical and not able to make alternative answers. |

S-BPS was able to answer the problem correctly because it could understand the problem and made a well problem-solving plan because the table was made right. While W-BPS could not solve the problem because it was wrong in making the initial table of completion. In line with the opinion, S-BPS is able to choose the strategies and knowledge that must be used to make it able to solve problems better [24]. Although there were some problems that could not be solved by S-BPS because S-BPS still a little confused and not too sure in using Solver program. Students may be able to manage the strategy, but sometimes they were not sure how to implement the strategy to solve the problem [23]. Stepping W-BPS still needed guidance and explanation in using the program.

The conclusions made by BPS were still less precise and difficult to understand. S-BPS did not do re-checking the results of the problem because the time was less, as well as W-BPS because from the beginning was wrong with the initial table of completion.
4. Conclusion
Project Based Learning method through computer support Resource Based Learning approach was effective against students problem-solving abilities in the subject of Operations Research. Characteristics of student problem-solving skills were different when viewed from the initial problem-solving abilities. Students of TPS subject both S-TPS and W-TPS had good problem-solving ability. Strong problem-solving skills of S-MPS and W-MPS were also good although some problem-solving indicators were accomplished with few errors. The subject S-BPS had a problem in solving the problem with computer program, less precise in writing the final conclusion and could not reflect the problem-solving process using Polya’s step. While the Subject of W-BPS had not been able to meet almost all the indicators of problem-solving. The subject of W-BPS was not able to make the initial table of completion precisely so that the completion phase with Polya’s step was constrained.

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