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The Analysis of Problem Solving Ability in Terms of Cognitive Style in Problem Based Learning Model with Diagnostic Assessment

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Abstract

The background of this research is the findings on learning difficulty by students in learning mathematics. The purposes of this research are (1) to describe the effectiveness of problem based learning model with diagnostic assessment in improving problem solving ability, (2) to describe follow-up activities from diagnostic assessment result toward the achievement of problem solving ability, and (3) to describe the pattern of mathematical problem solving ability of students in terms of cognitive style. This is a mixed method research type concurrent embedded. The population in this research is students grade XI MIPA (Mathematics and Natural Science) State Senioe High School 1 Bojong. Data sampling of cognitive style uses GEFT test, while sampling of mathematical problem solving ability uses a test. The effectiveness was analysed based on mean test, completeness test, difference of means test, and difference of proportions test. The result of this research shows that a learning using problem based learning model with diagnostic assessment is effective. Diagnostic assessment result is followed-up by providing appropriate treatment where students find difficulties which include repeating learning, giving particular guidance, giving assignments, asking and answering questions, and optimizing peer tutors. Problem solving ability owned by field independent students is better than that of field dependent students. Field independent subjects are able to master four problem solving indicators according to NCTM, which are: developing new mathematical knowledge through problem solving; solving problems in mathematics and other fields; applying and adjusting various appropriate strategies to solve problems; observing and enhancing mathematical problem solving process, while field dependent subjects are less able to master the indicators that have been mentioned.

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INTRODUCTION

Education is important for the progress of a nation. Permendikbud (Regulations of Education and Culture Minister) Number 21 Year 2016 regarding education standard content asserts that mathematics subject must be given to students starting from Elementary School. This is because mathematics is very useful in all aspects of life (Akinmola, 2014).

According to NCTM (2000), mathematical ability standard that must be achieved are mathematical reasoning, mathematical representation, mathematical communication, mathematical ideas association, mathematical problem solving. Problem solving plays an important role in mathematics, and it must have significant role in mathematics education (Vandiagris, Junaedi & Masrukan, 2015). Problem solving is the focus of school mathematics, thus it is important to enhance problem solving ability (Karatas & Baki, 2013).

National Council of Teacher Mathematics (NCTM, 2000) states that in mathematics learning, students are expected to be able to develop new mathematics knowledge through problem solving; to solve given problems by involving mathematics in other contexts; to apply and adjust various strategies which are suitable to solve the problems; and to observe and develop the process of solving problems. The importance of mathematics problem solving ability has not yet been balanced with Indonesian achievements in mathematics. It can be seen from the result of Indonesian participation in main international scale assessment that is PISA (Programme for International Student Assessment) and TIMSS (Trend in International Mathematics and Science Survey).

The result of International Survey Pogramme for International Student Assessment (PISA) in 2012 showed that Indonesia ranked 64 out of 65 countries which participated in PISA (OECD, 2012). In 2015, Indonesia ranked 56 out of 65 countries participating PISA in terms of the ability of calculating, reading, and science (OECD, 2015). Meanwhile, the result of international survey TIMSS (Trend in International Mathematics and Science Survey) showed that Indonesia ranked 49 out of 53 countries participating TIMSS. Based on TIMSS survey result (2015), mathematical problem solving ability of students in Indonesia was still below international standard.

Students' low ability of mathematical problem solving based on PISA and TIMSS study has been stengtened by the real situation in schools. The result of initial observation conducted in State Senior High School 1 Bojong proved that students still find difficulties to complete given questions related to mathematical problem solving, students find difficulties to complete and comprehend story matters with contextual substance, students are not able to determine suitable steps which must be used as the strategy to solve given problems. According to Joseph (2011), the difficulties in solving problems found by students are caused by lack of understanding of the problems, lack of solving strategy knowledge, and inability to interpret given problems into mathematical formula.

To solve mathematical problems, every individual has their own unique characteristics which are not owned by other individuals. Characteristic difference from each individual in responding information is called individual congnotive style. Cognitive style can be defined as the way how an individual receives, memorizes, and thinks, or the specific ways in receiving, keeping, forming, and utilizing information (Vendiagrys, 2015). Cognitive style covers stable attitude, options, or habitual strategy which differentiate individual style to feel, memorize, think, and solve problems (Saracho, 1997). According to Witkin, et al. (1997), cognitove style in learning mathematics covers field independent and field dependent.

An innovative learning in needed in order to develop problem solving ability.

One of learning models which can be applied to develop problem solving ability is problem learning based model (PBL). Hmelo-Silver (2004) assert that problem based learning is a learning model where students learn to solve given problems. It is similar to research result conducted by Abdullah, *et al.* (2015), and Noriza, *et al.* (2015) which states that problem based learning is able to develop mathematical problem solving ability. The application of Problem Based Learning consists of five steps. They start from students' orientation on the problem and end with students' presentation and work analysis. The five steps are: (1) students' orientation on the problems; (2) organizing students in learning; (3) guiding group observation; (4) improving and presenting works; (5) analyzing and evaluating problem solving process (Dzulfikar, 2012).

Basically, every learning whether using conventional learning model or Problem Based Learning, there will always be obstacles during learning process. One of the obstacles is that students still find difficulties in learning, so they are not able to achieve learning completeness. To overcome the difficulties, it needs to conduct a diagnostic test at the end of learning to analyse where the difficulties are. Diagnostic test is a test given in order to discover the difficulties found by students during learning process including misconception, while summative test is given at the end of learning to determine the success of students, so by knowing students' difficulties, teachers can take actions for the next learning process (Suwanto, 2013). Zhongbao Zhao (2013) says that diagnostic test is mainly to determine the strength and weakness of students and to give suggestions for teachers as well as students to make decisions related to development of learning process. Satoto (2013) suggests that a teacher must know and understand his/her students well, and understand their strength and weakness. It is in line with the opinion of Khaerunisak, *et al.* (2017) that state that a teacher should analyse students' difficulties before s/he continues to the next subject material. The result of diagnostic test can provide information about concepts that have been understood and those that have not yet been understood.

After knowing students' difficulties, a teacher must assist the students to overcome the difficulties, that is by conducting a follow-up on diagnostic test by giving appropriate treatments based on students' difficulties (Kartono, 2016) which in this matter is called improvement learning. According to Mulyadi (2010), improvement learning is a particular teaching which aims to improve students' ability to overcome the difficulties.

The research questions in this study are (1)How is the effectiveness of the problem based learning model with diagnostic assessment to develop problem solving ability? (2) What are the follow-up activities from the result of diagnostic test in the achievement of mathematical problem solving ability? (3) How is the pattern of mathematical problem solving of students in terms of cognitive style in learning applying problem based learning model with diagnostic assessment?

This study aims to (1) describe the effectiveness of problem based learning model with diagnostic assessment in developing problem solving ability; (2) describe follow-up actions from the result of diagnostic assessment in the achievement of problem solving ability; and (3) describe the pattern of mathematical problem solving ability of students in terms of cognitive style.

METHOD

This research is conducted in State Senior High School 1 Bojong particularly in grade XI MIPA (Mathematics and Natural Science) academic year of 2017/2018 with specific material of linier program. The population in this research is all students grade XI MIPA State Senior High School 1 Bojong. The research samples are XI MIPA-4 as class control and XI

MIPA-5 as class experiment. The subject in this study is taken from class experiment (XI MIPA-5) that is grouped based on cognitive style field independent and field dependent. The chosen subjects are three students with cognitive style field independent, three students with cognitive style field dependent having the highest, average, and the lowest score of GEFT test.

This research uses a mixed method model concurrent embedded. Reseach method mixed method is research approach which combines or connects qualitative and quantitative research methods (Creswall, 2014). Combination method concurrent embedded is a research method which combines between qualitative and quatitative research methods by mixing the two unevenly (Sugiyono, 2015).

Data sources in this study are GEFT test to determine students' cognitive style, observation sheets of learning implementation, answer sheets of diagnostic test, answer sheets of TKPM, students' interview result, and students' response sheets. The data is used for describing mathematical problem solving ability of students in terms of their cognitive style.

Data collection technique used in this study is test, questionnaire, assessment, observation, and interview. Test technique is used for obtaining data of mathematical problem solving ability of students by using mathematical problem solving test. Questionnaire test is used for collecting data of students' responses. Interview technique is used for obtaining data which are deeper and more accurate on how students' mathematical problem solving ability is. Meanwhile, observation is used for obtaining deeper data to assess students' performance in learning process.

This research starts from conducting an introductory study stage to identify problems that occur in the field by conducting an interview and observing one of mathematics teachers in State Senior High School 1 Bojong during a specific learning process, arranging theories which are related to problems that will be observed, and arranging learning instruments and research instruments wich are Silabus, RPP, eaching materials, studets' worksheets, diagnostic test, mathematical problem solving ability test, interview guidance, observation sheets on learning implementation, observation sheets on students' activities, and questionnaires on students' responses. Afterwards, the researcher conducts an expert validity test for learninig instruments as well as research intruments, and conducts a try out on TKPM questions. The criteria used to determine whether or not the research instruments are feasible to use is when the instruments are considered valid. The result of research instruments validiation must at least include good criteria.

The analysis of quantitative data is divided into two, which are initial analysis and final analysis. Initial analysis is taken from the result of Mid Semester Assessment (PTS) which aims to determine similarity of mean between class experiment and class control. Initial analysis uses normality test, homogeneity test, and two-means similarity test. Mathematical problem solving ability in both class experiment and class control has normal distribution, is homogenous, and has similar means. Meanwhile, final analysis is conducted after applying problem based learning model with diagnostic assessment by using mean test, completeness test, difference proportion test, and difference mean test. The analysis of qualitative data refers to Milles and Huberman opinion in Sugiyono (2015) which are data reduction, data presentation, and verification.

RESULT AND DISCUSSION

First thing to do in this research is arranging learning instruments that will be used. Based on validator assessment toward learning instruments, it is obtained that the mean of result score of learning instruments assessment is 4,25 which includes good criteria. The learning instruments are used for learning process in class experiment. Learning process conducted in class experiment applies problem

based learning model with diagnostic assessment, while learning process conducted in class control applies problem based learning model without diagnostic assessment.

The result of this research is elaborated in two stages, which are quantitative research and qualitative research. In quantitatve research stage, there are several tests to determine the effectiveness of learning applying problem based learning model with diagnostic assessment toward students' problem solving ability, they are (1) mean test; (2) classical completeness test; (3) difference mean test; (4) difference proportion test with prerequisite tests including normality and homogeneity tests. Meanwhile in qualitative stage, it needs to consider students' cognitive style to determine the follow-up result of diagnoctic assessment result and to determine students' problem solving ability.

Based on the analysis of initial data, it is obtained that sample thas has been taken is from normal distributed population, the population has homogenous variance, and there are no difference mean between samples of both classes. It proves tha the samples have similar initial condition.

From the result analysis of problem solving ability test, it is obtained that descriptively, the score mean of problem solving ability of students in class experiment is 77,03 calculated statistically using mean test with t-test. From the calculation, it is obtained $t_{calculation}$=6,722, while by using significance level of 5%, it is obtained t_{table}=1,70. It can be seen that $t_{calculation}>t_{table}$. Therefore, it can be concluded that the average problem solving ability of students in class experiment is more than KKM (68).

From the result analysis of problem solving ability, it is obtained that problem solving ability of students in class experiment achieves classical completeness. Descriptively, 29 out of 31 students can achieve minimum score of 68. It means that descriptively, the percentage of problem solving ability of students in class experiment reaches 93,5%. Statistically, it is analysed by using classical completeness test. From the calculation, it is obtained that $z_{calculation}$= 2,39, while by using significance level of 5% it is obtained z_{table}=1,70. It can be known that $z_{calculation}>z_{table}$. Therefore, it can be concluded that the proportion of students in class experiment reaches more than 75%.

Based on the result of difference mean test, it is obtained that $t_{calculation}$ = 4,11 while t_{table} = 1,67 thus $t_{calculation} > t_{table,}$ thus it can be seen that the average of mathematical problem solving ability of class experiment is better than that of class control. Meanwhile, based on the result of difference proportion test, it is obtained that $z_{calculation}$ = 3,79 and z_{table} = 1,64, so it shows that the completeness proportion of mathematical problem solving ability of students in class experiment is more that that of class control. From the result, it can be concluded that learning process applying problem based learning model with diagnostic assessment is effective in developing problem solving ability.

The effectiveness of learning process applying problem based learning model with diagnostic assessment in this research is supported by the previous research, such as the result of the research conducted by Noriza, M.N, Kartono, and Sugianto (2015) which shows that problem based learning model is effective toward problem solving ability and mathematical disposition. The result of a research performed by Setiawan T.Sugianto, & Junaedi (2012) also proved that learning process applying problem based learning model based on self directed learning oriented assessment is effective to develop mathematical problem solving ability of students. The research result conducted by Geni & Hidayah (2017) also shows that learning process applying problem based learning model nuanced ethnomathics is effective to develop mathematical problem solving ability of students. A research conducted by Munir, *et al.* (2012) suggests that problem based learning model is effective for linier program teaching.

Problem based learning model with diagnostic assessment demands students activeness in completing individual or group tasks durig learning process, so the implementation of problem based learning model with diagnostic assessment can be done well. Padmavathy and Mareesh (2013) assert that teaching by applying problem based learning model is more effective that that of other models in terms of developing students activeness during learning process. Karsim, *et al.,* (2017) state that learning applying problem based learning model can train students to study independently, to study in a group in order to develop problem solving ability, to comprehend materials, and to enhance their knowledge. It is in line with a research conducted by Saputri M., Dwijanto, & Mariani S. (2016) which shows that studying activity can influence toward students' problem solving ability. It is also suitable with another research performed by Setiawan, T., Sugianto, & Junaedi (2012) which proves that students activeness in learning using problem based learning approach is able to develop students skill of higher order thinking.

Problem based learning model using diagnostic assessment also uses LKPD which concerns about the type of difficulties found by students. This is in line with the result of a research conducted by Mariya, *et al.,* (2013) which says that the use of LKPD enables students to become more enthusiastic to follow learning given by teachers. This is according to the result research performed by Lestari, *et al.,* (2016) and Sulistyoningsih, *et al.,* (2015) which suggests that the implementation of problem based learning model is effective in developing problem solving ability and learning independence of students. This is also what can be proved from a research conducted by Zakaria & Hidayah (2015) which asserts that mathematics learning using LKPD assisted scientific approach can develop honesty and problem solving in students.

Beside using problem based learning model, the effectiveness of problem based learning model with diagnostic assessment is also influenced by given diagnostic test which aims to determine the difficulties found by students in given materials. Basically, teachers plays similar role as doctors do, whereas doctors will strive to find out the cause of a disease suffered by patients through several intensive examinations (Kartono, 2016). After determining difficulties experienced by students, a teacher can take the appropriate actions or decide what next steps that must be taken during learning process (Suwarto, 2013).

In this study, a diagnostic assessment is given at the end of learning. From the result of the test, then it can be followed-up which actions are needed to take for students who still make mistakes or find difficulties. This activity is called improvement learning. According to Ministry of Education and Culture (Kemendikbud) (Hikmasari, 2017), the form of improvement learning includes (1) giving repeat learning; (2) giving special guidance; (3) giving assignments; (4) utilizing peer tutor; and (5) asking and answering questions.

The first meeting provides the material of systems of linear inequalities with two variables. From given diagnostic test, there are 3 students (E-02, E-19, and E-28) that make wrong answer in completing problem number 2 and there are 3 students (E-17, E-18, and E-26) who make wrong answer in completing problem number 3. Follow-up activity for students E-02, E-19, dan E-28 is to give a particular assignment related with drawing a graphic of systems of linear inequalities with two variables, while follow-up activity for students E-17, E-18, and E-26 is to give a particular assignment related with determining the completion area in systems of linear inequalities with two variables.

The second meeting provides the material of arranging mathematical model. From given diagnostic test, thera are 4 students (E-07, E-12, E-30, and E-31) who make wrong answer for problem number 4 and there are 3 students (E-02, E-28, and E-31) who make wrong answer for problem number 5. The follow-up activity for

students E-07, E-12, and E-30 is to give a particular assignment, while the follow-up activity for students E-02, E-28, and E-31 is to give a particular assignment and to give specific guidance related with arranging mathematical model from linear programming problem.

The third meeting provides the material of determining optimum value in linear programming by using corner point test. From the result of given diagnostic test, there are 2 students (E-23 and E-26) who make wrong answer for problem number 2 and there are 2 students (E-18 and E-19) who make wrong answer for problem number 3. The follow-up activity for students E-23 and E-26 is to give a particular assignment, while for students E-18 and E-19 is to give specific guidance related with arranging mathematical model from linear programming problem.

The fourth meeting provides the material of determining maximum value in linear programming problem by using critical line. From the result of given diagnostic test, there are 2 students (E-07 and E-31) who make wrong answer for problem number 1, and there are 2 students (E-02 and E-17) who make wrong answer for problem number 2. The follow-up activity for students E-07 and E-31 is to give specific guidance dan to utilize peer tutor, while for students E-02 and E-17 is to give a particular assignment related with determining maximum value in linear programming problem using critical line.

The follow-up results toward diagnostic assessment influence significantly toward the development of problem solving ability. It can be seen from the final test of problem solving ability (TKPM). From the final test of problem solving ability (TKPM), it is obtained that the mean of problem solving ability of students involved in learning applying problem based learning model with diagnostic assessment is 77,03, and 29 out of 31 students manage to reach score above KKM. This is in line with the result researches conducted by Kartono, *et al.,* (2016), fgef, *et al.,* (2016) and Hikmasari (2017) which state that giving follow-up activities in form of diagnostic assessment with improvement learning is effective to develop students' learning achiements. It agrees with a research conducted by Karibasappa (2008) which shows that students who are provided with improvement learning show significant development in terms of mathematica operational and skill. It is supported by a research performed by Saputra & Suhito (2015) which proves that Adaptive Remedial Tecahing Strategy based active-effective learning is able to overcome difficulties in mathematics learning.

Cognitive test style is conducted by giving GEFT instrument sheet to students grade XI MIPA 5 State Senior High School 1 Bojong which amounts to 31 students. GEFT instrument is given in order to determine students' cognitive style, and is used for subject selection who will be interviewed regarding their ability to solve problems. Student grouping according to the cognitive style is conducted before learning starts. Students' cognitive style is classified into two categories, they are field independent and field dependent. Based on the result of GEFT test, it is obtained that 10 students can be classified into field independent cognitive style, while the other 21 are field dependent.

Data of students' problem solving ability according to cognitive style is data regarding the ability of students in completing TKPM which cover four indicators of problem solving according to NTCM that is to develop new mathematics knowledge through problem solving, to solve mathematical problems and other ones as well, to apply and adapt with various problem solving strategies, to monitor and reflect each process of mathematical problem solving. The following graphic is the score percentage for each problem solving indicators in terms of students' cognitive style.

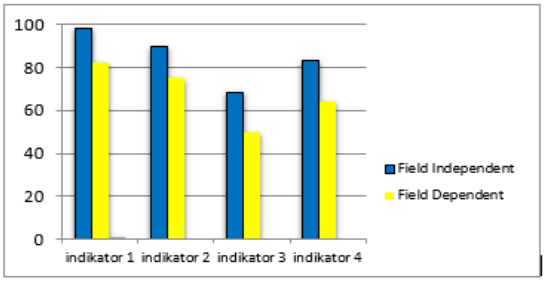

Figure 1. Diagram of Problem Solving Ability in Class Experiment Viewed from Students' Cognitive Style.

Figure 1 shows that students with dependent field independent style of cognitive are able to achieve problem slving indicators in a better way than students with field dependent style of cognitive. The third indicator is the indicator which is has the lowest achievement from both cognitives styles. Third problem solving indicator is applying and adapting various roblem sloving strategies, field independent and field dependent students are less able to make decision and choose different ways to solve problems. In terms of solving problems, it is showed that field independent students are able to solve given problems, but they are less able to arrange and apply various problem solving strategies. Meanwhile, field dependent students are able to solve problems quite well. However, they cannot arrange strategy comprehensively, so they tend to make wrong answers in completing given problems. They also cannot apply various problem solving strategies,

Field independent and field dependent subjects are able to comprehend the problems by determining given information and asked questions in the problems, field independent subjects tend to be more analytical, while field dependent subjects tend to write the information in the same way as written in the problems. In the stage of arranging problem solving plan, field independent subjects can take advantage of given information to solve the problems completely and systematically, while field dependent subjects write problem solving plan commonly and incompletely. In the stage of completing problems, field independent subjects are able to apply problem solving steps and arrange correct formulas and result in correct answer, while field dependent subject are less able to apply problem sloving steps that have been planned. In the stage of rechecking anwers, field independent subjects are able to write conclusions correctly and able to write problem solving plans in different steps, while field dependent subjects are lack of ability to recheck the plans and problem solving process because they tend to make many mistakes while calculating. This is in line with a research conducted by Prabawa & Zaenuri (2017) and Geni & Hidayah (2017) which assert that field dependent subjects are lack of ability to recheck and conclude their own work, and they are less able to write conclusions with correct answers.

CONCLUSION

Based on the result and discussion, the conclusion can be drawn as follow: (1) Learnings which apply problem based learning model with diagnostic assessment is effective toward mathematical problem solving ability, (2) The result of follow-up diagnostic assessment by giving diagnostic test which provides proper treatments based on difficulties found by students influence significantly in developing problem solving ability. It can be seen from the result of final test of problem solving ability (TKPM) that the mean of students' problem solving ability who are involved in learning which applies problem based learning model with diagnostic assessment is 77,03, and 29 out of 31 students are able to achieve score above KKM, (3) Problem solving ability of field independent subjects is better than field dependent subjects. Field independent subjects are able to master four indicators of problem solving according to NCTM (2000), while field dependent subjects are less able to master the indicators.

According to obtained conclusion, the researcher gives suggestions which are: (1) problem based learning model with diagnostic

assessment can be used as an alternative in learning which aims to develop mathematical problem solving ability by paying attention and following up difficulties found by students that is specifically in linear programming material and other materials as well; (2) Teachers should direct and encourage their students to solve given problems according to their cognitive style because different cognitive style influences toward how students solve problems. Teachers also should provide more guidance to field dependent students.

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