The effect of creative problem-solving models on students’ higher level thinking skills in linear programming

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Abstract. The purpose of this study was to determine the effect of Creative Problem Solving (CPS) on Higher Level Thinking Skills of Grade XI students in High Schools in Linear Programs. This research was carried out in SMA Negeri 5 Palembang. This research method is quantitative with only a control group posttest design. Regarding the experimental class will be given with Creative Problem Solving while the control class will be given with cooperative learning. High-level Thinking Skills are postal measurements and data will be analyzed by t-test. The results of the study said higher-order thinking skills in the experimental class were higher than the control class. This means that CPS influences Higher Level Thinking Skills in Class XI of SMA Negeri 5 Palembang in linear programming.

1. Introduction

Along with technological and economic developments, schools are required to develop higher-order thinking skills to prepare a quality 21st-century workforce [1, 2]. To be a quality human resource, students must have the ability to make decisions, have good thinking, formulate strategies, reasoning, and problem-solving collaboratively [1-3]. This is supported by the Ministry of Education and Culture Regulation No. 103 of 2014 concerning learning in primary and secondary schools that discusses learning in the 2013 curriculum emphasizing 21st-century skills and higher-order thinking skills. Referring to the Ministry of National Education Regulation No. 22 of 2006 concerning content standards regarding higher-order thinking skills also has priority in learning in school, especially in mathematics.

High order thinking skill is a higher level of thinking than thinking higher and making something with the facts. Adapting, understanding, categorizing, manipulating, then uniting it in a new way (creating) and applying it when searching for new solutions to new problems [4].

Table 1. PISA and TIMSS ranks for Indonesian students [5-7].

| Years | Rank | Participant Country | Years | Rank | Participant Country |
|-------|------|---------------------|-------|------|---------------------|
| 2009  | 60   | 65                  | 2007  | 32   | 49                  |
| 2012  | 71   | 72                  | 2011  | 37   | 42                  |
| 2015  | 64   | 72                  | 2015  | 35   | 48                  |
Based on the table above, it can be seen that Indonesian students have a high level of thinking ability that is classified as low. The low PISA results of Indonesian students are caused by weak non-routine or high-level problem-solving abilities [8, 9]. High-level thinking ability can be improved through problem-solving learning models, this is because problem-solving learning models can provide opportunities for students to solve problems by using his own strategy (creating) [10]. One characteristic of problem-solving models is using non-routine problems. Creativity or creation is a type of capital that is important for individuals, organizations, and social development that can be increased through appropriate teaching and training [11, 12]. Creative Problem Solving (CPS) model is the most effective tool to facilitate individual creativity [11]. The Creative Problem Solving Model is the development of the Problem Solving Model. This learning model is not like the problem-solving learning model in general, this learning model involves convergent-divergent thinking that focuses on the ideas given, then students can postpone their completion [13, 14]. According to Pepkin [15], there are 4 steps in implementing the CPS model, namely clarification of problems, aiming to ensure students' understanding of the given problem. Brainstorming (expressing opinions), students discuss and express their opinions about various strategies that can be used in solving problems. Evaluation and Selection, in this stage students, discuss while sorting and choosing the right strategy to solve the problem. Implementation, applying the strategy chosen so that it gets the right solution. By using the CPS model in increasing the ability to think at a higher level, it is expected that when solving a problem, students can think creatively, critically, skillfully and motivated so that it does not only depend on the sample questions given by the teacher [16].

In line with statement [17] based on the results of interview research conducted by Akbar in 2017 on the mathematics teacher of class XI IPA 1 MAN PAKEM shows that students can solve linear programming problems well, students only use the method given by the teacher alone, this means students have not yet reached the stage of creating in the high-level thinking process [17]. Therefore, to overcome this, researchers are interested in applying the Creative Problem Solving (CPS) model to see the effect of the CPS model on students' higher-order thinking skills in linear programming.

2. Method
This research uses quantitative methods with a true experiment type of posttest only control group design. The design of this study only looked at the posttest values of the experimental and control classes. The study was conducted at SMA Negeri 5 Palembang, the sampling technique used purposive sampling technique based on teacher recommendations. The sample is 35 students of Class XI Science 5 who will be treated with the Creative Problem Solving (CPS) model and 26 students of Class XI Science 1 who will be taught with conventional learning models. Before conducting the research, the researcher made preparations for the study by making 2 lesson plans, a students worksheet containing 2 questions and 3 test questions validated by expert validators. Then all the instruments were tested in the pilot class, to see the instrument's appropriateness and correct things that were lacking in the instrument so that it could be used as a tool to measure students' higher-order thinking skills. Higher-order thinking skills can be integrated into the CPS Model, which is then linked to student learning outcomes in the linear program material, as can be seen in the following Table 2.

During the implementation process, both classes practiced Higher Order Thinking Skills (HOTS) only except that the treatment was different. The last stage is data analysis, the researcher measures students' high-level thinking skills through test questions to see the effect of the CPS model on groups that are treated with groups that are not treated. Data from the test results will be analyzed by t-test using the help of IBM SPSS Statistics 21 software on condition that the data are normally distributed and come from homogeneous variance.
Table 2. Linkages between CPS, HOTS and student learning outcomes in the linear program material.

| CPS                  | HOTS | Learning Outcomes                                                                 |
|----------------------|------|------------------------------------------------------------------------------------|
| Clarification of the Problem | Analyze | Students can collect and explore various information on the questions              |
| Brainstorming/Expression of Opinion | Evaluate | Students can discuss and express opinions as widely as possible from the information about the problem and then write it into the mathematical model |
| Evaluation and Selection | Evaluate | Students can determine the point of constraints of the mathematical model that will be used in drawing graphics |
| Implementation       | Create | Students can solve problems by drawing graphs, then determine the area of resolution and find the optimum value using corner points. |

3. Result and Discussion

The research was conducted using Pepkin's Creative Problem-Solving steps, namely problem clarification, brainstorming, evaluation and selection, and implementation. Based on the test results, the percentage of high-level thinking ability indicators of the experimental class students is higher than the control class, as can be seen in the following Table 3.

Table 3. Percentage of test result high-level thinking ability indicators of the experimental class students is higher than the control class.

| No | Analyze |       | Evaluate |       | Create |       |
|----|---------|-------|----------|-------|--------|-------|
|    | Experiment | Control | Experiment | Control | Experiment | Control |
| 1  | 97.14%   | 99.03% | 90%      | 83.65% | 72.85% | 56.73% |
| 2  | 59.28%   | 31.73% | 29.28%   | 4.8%   | 17.85% | 0%    |
| 3  | 73.57%   | 56.73% | 44.28%   | 38.46% | 32.14% | 22.11% |

Of these three problems students have difficulty when creating, this is in line with research [18, 19] which says that students are easier to work on analyzing and evaluating indicators than creating creative problems that require the incorporation of information to generate new ideas in its completion. To see the effect of the CPS model on students' high-level thinking skills, a data normality test was conducted using the Kolmogorov Smirnov method using IBM SPSS Statistics 21. It turned out that the data were normally distributed with a significant value of 0.2. After the data is normally distributed then parametric statistics are performed with two independent sample t-tests, with decision-making criteria if Sig. 2 tailed > 0.05 then $H_0$ is rejected and $H_1$ is accepted. If Sig. 2 tailed <0.05 then $H_0$ is accepted and $H_1$ is rejected. t-test analysis table with the help of SPSS 21, can be seen in the following Table 4.

In the Equal Variance Assumed section the Sig value is known. (2-tailed) value of 0.018 < 0.05 means that the Creative Problem Solving (CPS) model can affect students' high-level thinking skills. This is supported by [20] that the CPS model can stimulate students' critical thinking skills where critical thinking is also an indicator of higher-level thinking skills. Learning with a monotonous model makes students bored, therefore in CPS-based learning students are formed in several groups so that they can freely exchange ideas in choosing problems and solving them. To motivate students to work on problems, need the help of learning resources that can involve students actively and stimulate students' thinking processes. Therefore, the research team made CPS-based LKPD with HOTS criteria...
which turned out to make students enthusiastic to work on this problem because the themes raised in LKPD could attract students’ interest in completing it.

Table 4. t-test analysis table with the help of SPSS 21.

|                          | Independent Samples Test |                          |
|--------------------------|--------------------------|--------------------------|
|                          | Levene's Test for Equality of Variances | t-test for Equality of Means |
|                          | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
| Hasil Belajar            |   |      |   |    |               |                |                    | Lower | Upper |
| Equal variances assumed  | 1.507 | .224 | 2.439 | 59 | .018          | 13.1216         | 5.3800             | 2.3561 | 23.8870 |
| Equal variances not assumed | 2.502 | 58.014 | .015 | 13.1216 | 5.2441 | 2.6245 | 23.6186 |

4. Conclusion
It can be seen from the percentage of high-level thinking skills clearly visible from the ability of students in the experimental and control classes. In analyzing, the control group was higher than the experimental group in question number 1, because some students in the experimental class did not make the final conclusions. At the level of analysis at number 2, the control group has not yet reached the level of creating this because the control group cannot analyze and compare well, it is related to the control group not working on the problem connecting in creating. While for other indicators, the experimental group was higher than the control group. After evaluating using statistics, it can be concluded that the CPS model affects higher thinking skills or apply the CPS model better than conventional models. Suggestions for other researchers to be able to apply the CPS model to measure other aspects of education.

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6. References
[1] Collins R 2014 *Curriculum & Leadership Journal* 12 14
[2] Warner S and Kaur A *Int. Electron. J. Math. Educ.* 12 193
[3] Lewis A and Smith D 1993 *Theory Into Practice* 32 131
[4] Thomas A and Thorne G 2009 *How to Increase Higher Order Thinking* (Metairie, LA: Center for Development and Learning)
[5] IEA 2011 TIMSS 2011 *international results in mathematics* online: [https://timssandpirls.bc.edu/timss2011/downloads/T11_IR_Mathematics_FullBook.pdf](https://timssandpirls.bc.edu/timss2011/downloads/T11_IR_Mathematics_FullBook.pdf)
[6] IEA 2015 TIMSS 2015 *international results in mathematics* online: [http://timssandpirls.bc.edu/timss2015/international-results/wp-content/uploads/filebase/full%20pdfs/T15-International-Results-in-Mathematics.pdf](http://timssandpirls.bc.edu/timss2015/international-results/wp-content/uploads/filebase/full%20pdfs/T15-International-Results-in-Mathematics.pdf)
[7] OECD 2019 *PISA 2015: PISA Results in Focus* (Boulogne-Billancourt: OECD Publishing)
[8] Stacey K 2010 *Journal of Science and Mathematics Education in Southeast Asia* 33 1
[9] Wu M 2011 *Journal of Research in Education Sciences* 1 67
[10] Suyitno A 2004 *Dasar-Dasar dan Proses Pembelajaran Matematika* 1 (Semarang: FMIPA)
[11] Tsai K C 2017 *Glob. J. Educ. Stud.* **3** 1

[12] Arvyati, Ibrahim M and Irawan A 2015 *International Journal of Education and Research* **3** 613

[13] Huda M 2013 *Model-Model Pengajaran dan Pembelajaran* (Yogyakarta: Pustaka Pelajar)

[14] Bishara S 2016 *Cogent Educ.* **3** 1

[15] Pepkin K L 2000 *Creative Problem Solving in Math* online: https://uh.edu/honors/Programs-Minors/honors-and-the-schools/houston-teachers-institute/curriculum-units/pdfs/2000/articulating-the-creative-experience/pepkin-00-creativity.pdf

[16] Manoy J T 2014 *Proc. Int. Seminar on Innovation in Mathematics and Mathematics Education* vol 1 (Yogyakarta: Departement of Mathematics Education Faculty of Mathematics and Natural Science Yogyakarta State University) p 289

[17] Prasetyo A M 2017 *Pengembangan lembar kerja siswa untuk membantu pemahaman siswa terhadap langkah-langkah menyelesaikan masalah program linier dengan metode titik pojok kelas XI IPA 1 MAN PAKEM tahun ajaran 2016/2017* Bachelor Thesis (Universitas Sanata Dharma)

[18] Nurhayati and Angraeni L 2017 *Jurnal Penelitian & Pengembangan Pendidikan Fisika* **3** 119

[19] Akmala N F, Suana W and Sesunan F 2019 *Jurnal Ilmiah Multi Sciences* **11** 67

[20] Supardi K I and Putri I R 2010 *Jurnal Inovasi Pendidikan Kimia* **4** 574