Mathematics Instructional Package Based on Creative Problem Solving to Improve Adaptive Reasoning Ability and Creative Thinking Ability

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Abstract. This study aims to produce a valid and effective mathematics instructional package using creative problem solving (CPS) models for improving adaptive reasoning ability and creative thinking ability in mathematics. The instructional package development model used was to modify the Borg and Gall model, and refer to the Dick and Carrey instructional design model. The sample in this research was Chemical Engineering students at State Polytechnic of Sriwijaya. Data collection instruments used were expert validation sheets and tests of adaptive reasoning ability and tests of creative thinking ability in mathematics. The data collected is in the form of data about the quality of the product being developed, namely validity and effectiveness, as well as potential effects of the use of learning packages that have been produced. The instructional package framework developed consists of an introduction, problem exploration, concept strengthening, information extraction, problem solving, concept development, summary, and evaluation, emphasizing freedom of opinion and material developed based on CPS learning. The results showed that the instructional package developed had met the criteria of expected validity and effectiveness. The results of the study using the instructional package showed an increase in creative thinking abilities and adaptive reasoning abilities.

1. Introduction

The development of science and technology, humans, are required to have the ability to think critically, systematically, logically, creatively, reasoning, and collaborate effectively so that it can develop in this globalization period. Creative thinking competence for students is very important in the era of global competition because of the level the complexity of the problems in all aspects of modern life is increasing. Creative thinking is thinking that leads to the acquisition of new insights, new approaches, new perspectives, or new ways to understand something [1]. Creative thinking is different thought, different thinking is the process of creating many ideas about a particular topic in a short time [2]. Creative thinking is a blend of logical and divergent thinking based on intuition, divergent thinking produces ideas for finding solutions. Creative thinking gives meaning to how an idea is developed and grown into new ideas that are an alternative to solving a problem [3]. While creative thinking in mathematics is a combination of logical thinking and different thoughts based on intuition, but in the awareness that takes into account authenticity, flexibility and fluency, and novelty [4]. The ability to think creatively in mathematics can also be interpreted as the ability to solve problems and develop
structured thinking that refers to the logical, didactic nature of the field of knowledge and adjust the connection to mathematical content [5].

Seeing how important the creative thinking ability, should be creative thinking ability in mathematics learning is developed and gets attention from the teaching staff. But the reality in the field shows that students creative thinking ability is not optimal, the low ability of students to think creatively is suspected because all this time the teacher has not tried to explore students' knowledge and understanding of creative thinking. Based on the research results of Kashefi, et al it can be seen that the cause of creativity in mathematics learning cannot develop optimally because students are too accustomed to thinking procedurally so that they are prevented from responding and solving problems freely [6]. Students who think procedurally like this are accustomed to following a pattern of behavior and behavior as the pattern developed by their environment. Mathematical creative thinking ability of students cannot develop well if in the process of teaching and learning activities, the learning method used in schools is still teacher-centered which does not involve students actively in the formation of concepts [7]. The lack of mathematical creative thinking skills of students is also caused because most students still cannot decide and express varied ideas. The low ability is a result of the learning process that most students only act as recipients, less active in finding or seeking new information to solve a problem.

Creative students can be produced by involving them to be active in learning. Until now the involvement of students in learning has not been optimal. This is caused by learning that leads to teacher centered. In addition, learning is carried out more dominated by questions or tasks in the form of closed questions both in the process and in the results. This results in students being patterned and directed to choose one correct answer so that students' potential cannot be explored and developed [7]. This is in line with Craft & Wegerif thought, which states that optimal development of the ability to think creatively is closely related to the way of teaching. The ability of creative thinking of children will develop on their initiative if the learning atmosphere is not authoritarian and children are given the opportunity to work in accordance with their interests and needs [2].

In addition to the creative thinking ability, mathematical reasoning has a very important role in students' thinking processes in learning mathematics. Students' skills in solving mathematical problems are influenced by their abilities in understanding mathematics. The ability to reason plays an important role in understanding mathematics. The reasoning is a habit of thinking, and like a habit, then reasoning must be a consistent part of each student's mathematical experience. Besides that mathematics has one special characteristic which is its nature which emphasizes on deductive processes which require logical and axiomatic reasoning. In the process, students must be able to provide solutions to mathematical problems using their intuitive abilities, and then the solutions are proven and strengthened using steps with analysis or justification. Adaptive reasoning itself is the capacity to think logically about the relationship between concepts and procedures that are generalized in a sensible way so that they can demonstrate possibilities in problem solving, and enable differences of opinion to be resolved in a reasonable way [8]. Adaptive reasoning not only emphasizes students to solve a problem, but students are required to think logically that is reasonable and uses reasoning correctly. This is based on previously known facts and considers that the settlement procedure is in accordance with the applicable rules [9]. Thus adaptive reasoning is a necessary part to support success in the learning process of mathematics that must be continuously trained and developed so that mathematics learning becomes more meaningful and achieves the expected learning goals. Through adaptive reasoning, students will be able to solve problems quickly, precisely and students will build their minds to master the whole mathematical concepts both for now, later and become the foundation of students in acting logically in mathematical activities or other daily activities.

The facts in the field show that mathematics learning which has been done so far has not been in favor of adaptive reasoning and creative thinking of students, this can be observed in the learning model and teaching materials used. The teaching materials that have been used by the teacher in the classroom and the learning steps used have not taken sides in building adaptive reasoning and students' creative thinking skills, on the other hand in teaching teachers commonly using expository methods.
To overcome these problems, it is deemed necessary to choose and apply certain learning models that can facilitate students so that critical thinking skills and adaptive reasoning skills can develop. Based on the findings from previous studies, one learning model was obtained that was able to build adaptive reasoning, and students' creative thinking skills were Creative Problem Solving (CPS) learning models. Creative Problem Solving (CPS) learning model is a problem-solving learning model that emphasizes the discovery of various alternative ideas or ideas to find solutions in the form of the most efficient solution of a problem using the process of divergent and convergent thinking. Divergent thinking process to produce many ideas based on intuition in solving problems, while convergent thinking plays a role in making decisions on existing ideas [10]. Through divergent thinking in the CPS learning model trains the intuitive ability of students because the divergent thinking process exists based on intuition, while the convergent thinking process in the CPS learning model trains student reasoning skills. It is also seen from the CPS steps that aim to find the best solution through facts, concepts, procedures. The goal is closely related to adaptive mathematical reasoning that sees everything right and reasonable based on facts, concepts, and procedures. This CPS learning model is deemed able to develop and train students' mathematical adaptive reasoning because in this learning model emphasizes students to train and develop both inductive and deductive reasoning abilities involving intuitive abilities. Unlike problem solving methods in general, with CPS students are trained to identify a problem and then find a solution to the problem creatively collaborative (brainstorming) to produce many different ideas, ideas, thoughts, criticisms, suggestions in order to obtain the best solution [11].

Thus the stages in CPS can train students to spark many ideas in problem solving and provide many answers or ways to answer a question (fluency), providing opportunities for students to produce various problem solving ideas and can see a concept from the point of view different and present it in a different way (flexibility). CPS also allows students to provide new ideas in solving a problem or other answers from the usual way and make creative students in making unusual combinations of existing solutions. In addition, through the CPS model students are given space to develop or enrich ideas from others and add or specify ideas derived from the learning process so that the ideas are improved (elaboration) [12].

Based on the description above, then as an effort to facilitate students so that creative thinking skills and adaptive reasoning skills develop, it is deemed necessary to develop a mathematics engineering instructional package based on the CPS learning model that supports the improvement of creative thinking abilities and adaptive reasoning abilities. The development of instructional packages is a systematic way of identifying, developing, and evaluating a package of materials and strategies that are directed towards achieving certain educational goals [13]. The development of instructional packages is a management technique in finding solutions to learning problems or, at least, in optimizing the utilization of existing learning resources to improve education [14]. The result of the development of instructional packages is a learning system, namely material and teaching learning strategies that are developed empirically and consistently to achieve certain learning goals. Instructional packages that need to be developed are oriented towards developing creative thinking abilities, and adaptive reasoning abilities are instructional packages that are able to optimize the role of lecturers and students, condition learning activities well, and create a learning atmosphere that provides more opportunities for students to practice solving problems creatively, with learning models the right learning model in accordance with the characteristics and needs of students so as to make students learn effectively so that the goals of learning are achieved.

Research conducted by Vidal showed that learning using the Creative Problem Solving (CPS) model had a positive effect on students' attitudes in learning and was able to improve learning outcomes in mathematics [15]. Research conducted by Lin concluded that the application of CPS has a different impact on the ability of convergent thinking, divergent thinking, motivation, learning atmosphere and problem solving and creativity abilities [16]. Lin & Cho research concludes that learning using the CPS model provides better results for mathematical problem solving abilities than direct learning models [17]. Hamidreza Kashefi, et al concluded that mathematics learning techniques using...
CPS could support communication, teamwork, and problem solving skills of students [6]. Muin et al research resulted in the finding that the ability of students' mathematical adaptive reasoning applied by the CPS model was higher than the students' mathematical adaptive reasoning abilities applied to conventional learning models. Students taught using CPS are superior to intuitive-inductive and intuitive-deductive aspects compared to those taught using conventional learning models [18].

Teachers must be able to design learning by giving more time to students. Simple interventions and the use of a planned framework can be done by the teacher to develop students' creative thinking skills so that there is a better change in classroom learning. Therefore, in an effort to facilitate students so that critical thinking skills and adaptive reasoning skills can develop, it is deemed necessary to conduct research in the form of developing a product that combines the advantages of CPS learning models with instructional packages.

This study aims to develop and produce a new product in the form of an instructional package for engineering mathematics based on creative problem solving learning oriented to enhance creative thinking abilities and adaptive reasoning abilities of students. Furthermore, the products produced were examined for their feasibility and effectiveness. The development of instructional packages is a systematic way in identify, develop, and evaluate a package of materials and strategies that are directed towards achieving certain educational goals [19]. In this study, the framework of the instructional package developed consisted of an introduction, problem exploration, concept strengthening, information extraction, problem solving, concept development, summary, and evaluation. The quality of the learning package developed in this study is based on the criteria proposed by Robert M. Gagne in [20], namely: validity and effectiveness. Valid criteria consist of content validity (relevance) and construct validity (consistent). The effectiveness of instructional packages developed in this study is measured based on the achievement of learning goals by using instructional packages developed. The effectiveness of learning packages can be seen from increasing the average score of thinking ability creative and adaptive reasoning abilities.

2. Research methodology

This development research is used to produce certain products and test the effectiveness of products. The instructional package development model used is to modify Borg and Gall's model [21] and refer to the Dick and Carrey instructional design model. The study was conducted in the Department of Chemical Engineering State Polytechnic of Sriwijaya. In this study, the framework of instructional packages developed consists of an introduction, problem exploration, concept strengthening, information extraction, problem solving, concept development, summary, and evaluation.

The quality of instructional packages developed in this study is based on the criteria of validity and effectiveness. Valid criteria consist of content validity (relevant) and construct validity (consistent). Valid learning packages mean that instructional packages are suitable for use. In terms of content, the learning package is said to be valid if the development process is based on the design development theory used as a guideline and in accordance with the characteristics of the learning model applied. Viewed in terms of construction, instructional packages are said to be valid if there is a consistent relationship between each component of instructional packages that are developed with the characteristics of the learning model applied. To see the construct validity of an instructional package, experts were asked for their opinions. The effectiveness of instructional packages developed in this study is measured based on the achievement of learning objectives by using instructional packages developed.

The effectiveness of instructional packages can be seen from: an increase in the average score of creative thinking ability and adaptive reasoning ability. Tests on the effectiveness of instructional packages were carried out through an experimental method with a pre-test and post-test control and treatment group design. The instrument used in this study was an expert validation instrument and creative thinking ability test instrument and a mathematical adaptive reasoning ability test consisting of the initial test (pre-test) and final test (post-test). The type of test used in this study is an essay test. Before using test kits validated by experts and tested to obtain valid and reliable instruments.
3. Research results and discussion

3.1. Results of instructional package development

Product development activities begin with the material/format and use of the media and curriculum and review the skills in mathematics. At this stage researchers sort and choose suitable material to be delivered, in terms of the learning objectives and characteristics of students to be taught. The material is prepared according to the CPS education and learning based learning objectives. The next stage is product development which is a design activity in accordance with previous planning. Early product development model used is Dick & Carey's instructional design model.

Furthermore, expert validation does not only apply the validity of instructional packages, validators and instrument validity to be used for experimental activities. Expert validation is carried out to obtain input, responses, suggestions, comments on products developed to be further carried out to improve product quality. Legitimate instructional packages are methods that are developed based on validation and also provide instructions for use. Especially for the test of creative thinking skills and adaptive ability tests during the trial, the conditions specified are: valid and reliable.

The instructional packages on based CPS learning that develops in this study has advantages such as: (a) the material is arranged with the appearance, content, and steps that are communicative according to user needs can be achieved effectively and efficiently; (b) material in instructional packages can be used sequentially or randomly; (c) the material applied in this instructional package in the Indonesia national qualification framework curriculum and needs analysis can enable users to achieve the specified educational goals; (d) instructional packages are equipped with tests and tests to measure cognitive, affective, and psychomotor learning outcomes to measure learning outcomes after using mathematics instructional packages with CPS learning models in the learning process; (e) learning can be controlled because in the use of instructional packages there are steps to the problem and allow different students to learn more quickly; (f) instructional packages can authorize students and lecturers in selecting problems related to topics in the field of chemical engineering with learning materials; In addition (g) steps have been taken in accordance with the steps of the model developed which can produce the needs carried out.

3.2. Description of creative thinking ability

Overall the average pretest score of students' creative thinking ability in the control class (17.33) was higher than the experimental class pretest score (16.93), but in the post test score it was precisely in the average experimental class score (23.23) higher than the average post test score in the control class (19.93). The difference in scores at the time before and after the lecture is from now on referred to as gain score, seen in the experimental class that uses the instructional package gain score is higher (6.3) than in the control class which only gets a gain score of 1.6.

Description of the data is presented in figures 1 and figure 2, while data from the pretest and posttest results of students were also analyzed to see the improvement of students' creative thinking skills before and after learning using CPS-based mathematics instructional packages. The t test between the posttest and pretest scores in the experimental class and in the control class using paired sample t test is presented in table 1. Testing the difference in the average posttest and gain score, the creative thinking ability between the experimental class and the control class after the lecture was done by an unpaired t test (independent t test) is presented in table 2.

If it is seen from table 1 it is obtained in the experimental class the result of t-test = 12.245 is greater than t-table at df = 23 and α = 0.05 that is 2.068, so Ho is rejected. This means that there is a significant difference in the means pretest and posttest scores. Thus in the experimental class, there is a change (increase) of students' creative thinking ability that is significant between before and after using instructional packages. Whereas in the control class obtained the value of t-te is 1.942 smaller than t table which is 2.068 so that Ho is accepted which means there is no significant difference between pretest scores and posttest scores.
Figure 1. Average score of pretest and posttest creative thinking ability.

Figure 2. Graph of difference in average gain score of creative thinking ability.

Table 1. T test results between pretest and posttest scores creative thinking ability.

| Paired Differences | Mean | Std. Deviation | 95% Confidence Interval of the Difference |
|--------------------|------|----------------|------------------------------------------|
| Pair 1 Pre test – Post test Experiment group | 6.300 | 2.618 | .514 | 12.245 | 23 |
| Pair 2 Pre test – Post test Control Group | 1.600 | 2.921 | .854 | 1.942 | 23 |

Table 2. Results of t test post test score and gain score creative thinking ability.

| t-test for Equality of Means | Levene’s Test for Equality of Variance | 95% Confidence Interval of The Difference |
|-----------------------------|---------------------------------------|------------------------------------------|
|                            | F       | Sig.  | t     | df | Sig.(2-tailed) | Mean Difference | Std. Error Difference |
| Post test experiment group and control group | Equal variances assumed | .021 | .886 | 8.241 | 46 | .039 | 4.300 | .522 |
|                            | Equal variances not assumed | 8.241 | 46 | .039 | 4.300 | .522 |
| Gain score experiment group and control group | Equal variances assumed | .174 | .678 | 2.060 | 46 | .044 | 1.500 | .728 |
|                            | Equal variances not assumed | 2.060 | 46 | .044 | 1.500 | .728 |

From table 2 it is obtained that the value of t-test = 8.241 is greater than t table at α = 0.05 and df = 46 is 2.013, so reject Ho. This means that the posttest score of creative thinking ability in the experimental class is higher than the control class, which means that students’ creative thinking ability scores after being given mathematics engineering lectures using instructional packages are higher than students who do not use instructional packages. Likewise, on the post-test-pretest gain score in the experimental class and control class, it was found that the score of 2.060 was greater than the t table of 2.013, so reject Ho. Thus it can be interpreted that the increase in the ability of creative thinking ability of students who use instructional packages developed is higher than students who do not use instructional packages. This shows that learning mathematics engineering through the use of CPS-based instructional packages can improve students’ creative thinking skills.
3.3. Description of adaptive reasoning ability

The average pretest score of students’ adaptive reasoning ability in the control class (23.25) was relatively the same as the experimental class pretest score (22.93), but at the posttest level, the experimental class average score (32.15) was higher than the average posttest score in the control class (27.14). Seen in the experimental class using the instructional package gain score is higher (9.22) than in the control class which only gets a gain score of 3.89.

Description of pretest and posttest scores and gain-score on adaptive reasoning ability are presented in figure 3 and figure 4.

![Figure 3. Average score of pretest and posttest ability adaptive reasoning.](image)

![Figure 4. Graph of difference in average gain score of adaptive reasoning ability.](image)

While the t test between the posttest and pretest scores of reasoning ability in the experimental class and in the control class using paired sample t test is presented in table 3. If seen from table 3 it is obtained in the experimental class the results of t-test = 16.885 is greater if compared with t-table at df = 23 and α = 0.05 which is 2.068, so Ho is rejected. This means that there is a difference in the mean pretest and posttest scores, in other words, there is a significant change (increase) in the adaptive reasoning ability of students in the experimental class after using instructional packages.

### Table 3. T test results between pretest and posttest scores adaptive reasoning ability.

| Paired Differences                        | Mean   | Std. Deviation | Std. Error of the Difference | t      | df  |
|-------------------------------------------|--------|----------------|------------------------------|--------|-----|
| Pre test – Post test Control Group        | 3.890  | 2.813          | .625                         | 6.223  | 23  |
| Pre test – Post test Experiment Group     | 9.220  | 2.726          | .546                         | 16.885 | 23  |

The difference between the average posttest score and the gain score difference between adaptive reasoning ability and the control class is also done with the unpaired t test (independent t test). The calculation results are presented in table 4. From table 4, it is found that the value of t-test = 3.833 is greater than t table at α = 0.05 and df = 46 is 2.013. This means that there is a difference in the average posttest score of students’ adaptive reasoning ability between the experimental class and the control class after being given Mathematics Engineering lectures. Likewise, the gain score in the experimental class and the control class obtained a significant difference because the value of t-test = 2.421 is greater than t table at α = 0.05 and df = 46 is 2.013, so reject Ho. This means that there is a significant increase in the value of adaptive reasoning ability between groups of students who are given lectures using instructional packages with those that do not use instructional packages.
Table 4. Results of t test post test score and gain score adaptive reasoning ability.

|                           | Levene’s Test for Equality of Variance | 95% Confidence Interval of The Difference |
|---------------------------|----------------------------------------|------------------------------------------|
|                           | F           | Sig. | t     | df | Sig.(2-tailed) | Mean Difference | Std. Error Difference |
| Post test experiment group and control group | Equal variances assumed | .024 | .872 | 3.833 | 46 | .031 | 2.000 | .522 |
|                           | Equal variances not assumed | | | | | | | |
| Gain score experiment group and control group | Equal variances assumed | .172 | .673 | 2.421 | 46 | .045 | 1.730 | .715 |
|                           | Equal variances not assumed | | | | | | | |

The increase in creative thinking skills and adaptive reasoning abilities after the use of CPS-based instructional packages can be explained as follows: Through the use of CPS-based instructional packages students are trained to think and act creatively, train students to design an invention by identifying and investigating and training students in interpreting and evaluating the results of problem solving, thereby stimulating the development of students’ creative thinking progress to solve problems appropriately. The stages in the CPS learning model provide an organized system. The use of the system involves applying productive thinking to deal with problems and opportunities, generating many varied and unusual ideas, and evaluating, developing, and implementing efficient solutions [22]. CPS learning is a system that contains the structure of a component, stages, levels, and tools and considers the involvement of a person, situation or context, the nature of the content or expectations of results [23]. Through CPS students are trained to find solutions through creative attitudes and thought patterns so as to produce many alternative solutions to problems, open in improvement, foster self-confidence, the courage to express opinions, divergent thinking, and flexibility in problem solving efforts. Creative aspects are needed in the CPS-based learning model, and because creative thinking is a combination of different thoughts based on intuition and logical thinking, the CPS model will train students to think differently based on intuition and logical thinking or convergence [23].

In addition, this CPS-based instructional package at the beginning of learning students is faced with problems that function as one of the stimuli and triggers of students to think. Students are faced with a variety of challenging problems that can present students' thinking activities in solving mathematical problems, involving students doing active math processes, restating the mathematical ideas in forming new understandings. Thus this CPS-based instructional package stimulates students to practice drawing logical conclusions, familiarizing students to provide explanations with models, facts, traits, and relationships as well as estimating answers and solution processes and training students to use patterns and relationships to analyze mathematical situations and study conjecture. Thus activities in CPS-based instructional packages train students to develop students' adaptive reasoning abilities.

4. Conclusion
The results showed that the instructional package developed had met the criteria of expected validity and effectiveness.

Valid is drawn from the results of the validator’s assessment where all validators state both contents and construct. In terms of content, instructional packages are said to be valid because the development process is based on a design development theory that is used as a guide or guideline and in accordance with the characteristics of the applied learning model. Viewed in terms of construction, instructional packages are said to be valid because there is a consistent linkage of each component of the instructional package developed with the characteristics of the learning model applied.

Based on the development process, it was found that the instructional package product developed which was composed of an introduction, problem exploration, concept strengthening, information ex-
traction, problem solving, concept development, summary and evaluation effectively improved the ability in creative thinking and adaptive reasoning ability for students.

5. References
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