Enhancement higher order thinking skills in algebra by The PINTER mathematics learning model

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Abstract. This study aims to determine the enhancement of students' high-level thinking skills in algebra material through the application of the PINTER mathematics learning model. The PINTER mathematics learning model was developed with the learning stages: Presentation to real life, Investigation, Team Activities, Explanation & Reasoning, and Reinforcement. This research instrument uses tests to determine the effectiveness of learning, observation to see the feasibility of the model, practicality questionnaires to determine whether the model is easy to apply, Practicality questionnaires to determine whether the model is easy to apply, and student questionnaire responses to determine student responses to the learning process. This research was conducted in 4 Junior High School (SMP) in Purworejo Regency. The stages of the study were carried out in 5 meetings where each meeting was reflected and corrected to be carried out at the next meeting. Research results show: 1) The PINTER mathematics learning model is effective for improving students' high-level thinking skills on algebra material, 2) The PINTER mathematics learning model is practically or easy to apply by teachers, 3) the PINTER mathematics learning model gets good responses from students. Thus, PINTER's mathematics learning model has the potential to be applied to mathematics learning, especially in efforts to enhance higher-order thinking skills.

1. Introduction

1.1. Background
Higher-order thinking skills or high level thinking skill is one of the abilities that must be developed in the learning process in the classroom, especially mathematics. In Indonesia, high-level thinking skills began to be raised in the National Examination questions in 2018 although in a small proportion. But in 2019, the proportion of the number of high-level thinking questions has been increased. Starting from this, the awareness of teachers in Indonesia began to emerge to apply mathematics learning which refers to the enhancement of higher-order thinking skills. This is consistent with the results of research which states that currently, teachers in many countries have shown efforts to contribute to enhance the quality of education [1,2,3].

The Government of Indonesia has given sufficient attention to enhance students' higher level thinking skills. This can be seen by the amount of training that is intended for teachers to create a learning process that leads to higher level thinking skills. In addition, there was also a lot of training
on the preparation of higher order thinking questions. However, the results of students' National Examinations in Purworejo Regency still show unsatisfactory results, this result can be observed in the following table.

| Statistics | Indonesian | English | Mathematics | Science |
|------------|------------|---------|-------------|---------|
| Average    | 79.85      | 57.79   | 62.41       | 63.57   |
| Min Score  | 32         | 22      | 17.5        | 22.5    |
| Max Score  | 98         | 100     | 100         | 100     |

Source: Puspendik.kemdikbud.go.id

The government states that the National Mathematics Examination has increased compared to the implementation of the National Examination in 2018. Therefore, although the mathematics scores show no better results than other subjects, the efforts that have been made so far need to be increased because they are in the right direction.

| No | Material Tested | Regency | Province | National |
|----|-----------------|---------|----------|----------|
| 1  | Number          | 50,92   | 43,64    | 39,71    |
| 2  | Algebra         | 60,88   | 54,96    | 51,24    |
| 3  | Geometry        | 51,77   | 45,23    | 42,27    |
| 4  | Statistics      | 67,65   | 60,86    | 55,60    |

Source: Puspendik.kemdikbud.go.id

The table above shows that the percentage of students who answered correctly on each material tested was still quite low (under 70%). Therefore, this research will look at the effect of learning to think at a higher level in algebra material. Algebra becomes an interesting material to be studied because almost all material will involve the concept of algebra, such as variables, coefficients, and constants. In addition, algebraic manipulation is also very important for students to master in solving various mathematical problems. Based on some of the above, it is necessary to do mathematics learning that it can enhance higher-order thinking skills, especially algebra material.

1.2. Higher Order Thinking Skill
Bloom's revised taxonomy (Remember, Understand, Apply, Analyze, Evaluate, and Create) are used as the basis for the division of thinking skills into lower-level thinking and higher level thinking. The three higher levels of Bloom’s (analyze, evaluate, and create) require higher level cognitive skills [4,5]. Another definition of higher level thinking skills is characterized by the ability to solve non-routine problems by presenting non-procedural, complex, multiple solution solutions, and allows for the emergence of uncertain or unexpected solutions [6,7]. Non-routine problems as contextual problems involving or situations where one or more appropriate solutions are not yet known directly to the answer [8]. Giving non-routine problems to students consistently, can spur students to use various mathematical thinking such as analogies, reasoning, analyzing, evaluating, creating, critical and creative to solve the problems given. Did not rule out the possibility of creating divergent thinking skills that produce many alternative solutions.

Learning to enhance higher level thinking skills cannot be done without habituation. This means that familiarizing students with non-routine problems in learning activities is important to help students get used to solving new problems, make decisions, and make links about certain problems with other problems [4]. Many attempts have been made by researchers and teachers to enhance higher-order thinking skills. Problem Based Learning can help students enhance the ability to analyze, synthesize, and evaluate so that it can bring up the habit of instilling activities that support higher level thinking skills [9,10]. The characteristics, strategies, and methods applied in Contextual Learning can enhance higher-order thinking skills [11,12]. Group discussion to solve complex problems related to various materials in a learning process is an important thing for students to practice thinking skills to a
further level [13]. The steps or learning sequences to empower higher level thinking skills include: 1) determine learning objectives, 2) teach through questioning, 3) practise before assessment, 4) review, refine, and enhance, dan 5) provide feedback & assessment of learning [14].

1.3. PINTER Mathematics Learning Models

In this study, efforts to enhance higher order thinking skills were carried out through the application of the PINTER Mathematics Learning Model. The PINTER math learning model is a mathematical learning model developed to build students' cognitive structures so as to create meaningful learning experiences through the creation of contextual, friendly, comfortable, motivates, and friendly learning environments through the habituation of group discussion activities and the provision of non-routine problems with the aim to enhance high-level thinking skills. The syntax of the PINTER math learning model is as follows: Presentation to real life, Investigation, Team Activities, Explanation & Reasoning, and Reinforcement.

| No | Syntax                        | Strategies                                                                                     |
|----|-------------------------------|-----------------------------------------------------------------------------------------------|
| 1  | Presentation to real life     | a. Presenting contextual problems                                                           |
|    |                               | b. Using learning media related to the material                                              |
|    |                               | c. Give students the opportunity to solve a given problem                                    |
| 2  | Investigation                 | a. Enhance understanding of concepts through learning activities with the Concrete-Pictorial- |
|    |                               | abstract approach                                                                           |
|    |                               | b. Resolving problems with the Bar model                                                    |
| 3  | Team Activities               | a. Provide non-routine problems                                                              |
|    |                               | b. Internal group discussion                                                                 |
|    |                               | c. Give open-ended student worksheet                                                         |
| 4  | Explanation & Reasoning       | a. Present the results of group work                                                         |
|    |                               | b. Discussion between students in 1 class                                                    |
| 5  | Reinforcement                 | a. Giving individual problems                                                                |
|    |                               | b. Review, refine, and feedback                                                             |
|    |                               | c. Draw conclusions of learning activities                                                  |

The strength of PINTER's mathematics learning model is that it emphasizes the creation of students' cognitive structures so as to create meaningful learning. A mental representation of the given information depends on three cognitive processes namely: Generalizing, Synthesizing and Abstracting [15]. In the PINTER mathematics learning models, generalizing is done by connecting between material concepts through the use of concrete objects. For example, given the following questions: Mother shopped 1 mango chopper and 4 mangoes. This can be done by giving a basket picture and a picture of 4 mangoes. Next defined basket is a variable "x". So that the algebraic form $x + 4$ is obtained.

Synthesizing is done by introducing the concept of algebraic operations (addition, subtraction, multiplication, and division) by using pictorial forms. For example, I shop 2 baskets of mango and 4 mangoes. Then he bought back 3 baskets and 5 mangoes. How much are you shopping for? Thus, the concepts of variables and constants that have been mastered previously are linked and acted through understanding more complex concepts.

Abstracting is done by presenting problems using word problems. At this stage, students will use all information / knowledge that has been previously mastered to solve non-routine problems that are given.

Through the learning process, it is hoped that the cognitive structure of students will be formed and strengthened through discussion activities and the habit of presenting non-routine problems. Discussions between students in teams activities and discussions between students can strengthen the
cognitive structure of students due to the exchange of a lot of information / knowledge. Non-routine problem solving will guide students to use conceptual understanding, reasoning, and various problem solving strategies. Thus, higher order level skills will be formed, especially in algebra material.

1.4. Research Problem
According to some of the above, the objectives of this study are as follows: a) How is the implementation of the PINTER mathematical learning model in improving thinking skills at a high level of algebra material? 2) How is the attachment of high-level thinking skills to algebraic material after obtaining learning with the PINTER mathematics learning model?

2. Research Method
This research uses quantitative and qualitative research methods. Quantitative research is carried out with a One Group Pretest-Posttest research design, while qualitative research is carried out using descriptive methods. The research was conducted on 4 junior high schools (SMP) in Purworejo Regency, including SMP 4, SMP 6, SMP 31, and SMP 33. The research was conducted in 5 meetings in each school. In each meeting activities are carried out: 1) planning, 2) implementation and observation, 3) and ending with an evaluation for enhancement in the next meeting. The study was conducted by involving teachers / instructors who carry out learning and 2 observers who saw the implementation of the PINTER mathematics learning model.

Quantitative research is conducted with the aim to find out the enhancement of students' higher order thinking skills. For this reason, in each school a pre-test was conducted first, then treatment was given with the PINTER Mathematics Learning Model in 5 meetings, and it was finished with the post test. The test given is in the form of 10 multiple choice questions and 5 description questions. Data analysis using Paired Sample t-test.

Qualitative research was conducted with the aim to know how the PINTER mathematics learning model works in improving students' higher-order thinking skills. To find this out, observation sheets on the implementation of learning, interviews, practical questionnaires on the implementation of learning models, student learning response questionnaires, answer sheets of high-level thinking skills test. Observation sheets, interviews, practicality questionnaires, and student learning response questionnaire were used to find out the learning process of learning with the PINTER mathematics learning models, while the test results were used to find out how to enhance pupils' higher thinking skills marked by pupils' ability to present some unique completion procedures for math problem given.

3. Research Result and Discussion
The analysis of this study includes: 1) Application of the PINTER mathematics learning model, 2) enhancement of higher-order thinking skills, and 3) analysis of student learning outcomes. The analysis is based on interviews, classroom observations, and results of students work.

3.1. Implementation of PINTER Mathematics learning model
At the initial meeting, the teacher still had a little difficulty in applying the PINTER mathematics learning model. Difficulties experienced by the teacher include: a) the unfamiliarity of teachers and students in using teaching aids so that the guided inquiry process is not going well, b) the teacher is not accustomed to delivering material with the Concrete-Pictorial-Abstract approach, c) the teacher is not accustomed to solving problems with a Bar model d) the teacher still has difficulty managing group activities because there are still many passive students, and e) the teacher has difficulty managing class discussions. However, the teacher firmly believes wholeheartedly that the PINTER mathematical learning model provides a huge opportunity to enhance learning outcomes in algebra material.

To overcome these difficulties, enhancements were made through the activities of Group Discussion Forums (GDF). This activity is carried out through classical meetings with several teachers and researchers meeting with individual teachers in their respective schools. The GDF activities
produced several learning activities as an enhancement from the learning that had been carried out.
The researcher strongly emphasizes the application of the Concrete-Pictorial-Abstract approach and
delivery with the model Bar because this approach is not yet familiar to teachers. The results of
observations of the implementation of the PINTER mathematics learning model at each meeting of 4
teachers can be seen from the graph as follows.

![Graph showing implementation of PINTER model](image)

**Figure 1.** The Graph of the Implementation of the PINTER Mathematics Learning Model

The graph above shows that at first, teachers had difficulty in applying the PINTER mathematics
learning model. However, with various enhancements made, it appears that teachers can enhance the
implementation process so that at each stage of learning increases at each meeting. This shows that the
PINTER mathematics learning model has been implemented well by the teacher. This is supported by
the results of interviews with teachers in each school that shows that teachers have been able to apply
the PINTER mathematics learning model. One of the results of an interview with the teacher can be
seen as follows:

Researcher : Do you understand that PINTER's mathematics learning model can help students
develop students’ higher-order thinking skills?

Teacher : I understand very well. I can see that this learning model has been presented with
various strategies for achieving higher-order thinking skills.

Researcher : Are you having difficulty in implementing this model?

Teacher : At first I had a little difficulty because I was not used to this learning model.
However, with some enhancement in the reflection activity at the end of learning, I
can begin to understand how this learning model should work. Finally, I quite
enjoyed the learning process at each stage.

Researcher : After applying learning with the PINTER mathematical model, do you feel that this
learning model is easy to apply?

Teacher : I feel that this learning model is easy and convenient to apply. I feel that this model
can be applied to other material.

Difficulties that arise in teachers in applying the PINTER mathematics learning model can be
understandable given the teacher is not accustomed to learning that is directed at the achievement of
higher-order thinking skills. Learning with the aim to improve HOT is very difficult or challenging
enough to be applied in the classroom [16,17,18,19,20,21]. In fact, some teachers do not pay special
attention to higher-order thinking skills. Attention to higher-order thinking skills has only emerged in
the last 2 years because it was raised on the National Examination. This is in accordance which states
that in most classrooms, higher order thinking receives little or no attention [22].

The success of the teacher in applying each stage of learning from the PINTER mathematical
learning model certainly can encourage the achievement of the objectives of the application of this
learning model, namely to enhance higher-order thinking skills. The instructional strategies that
teacher uses can motivate students to learn and think on higher levels [23]. This can explain that the
achievement of higher-order thinking skills will depend on the implementation of the learning being
carried out. The teacher feels that the application of the mathematics learning model is quite practical
or easy to do. This is indicated by the results of the practical value of the model obtained from 4
teachers as follows.
Figure 2. Graph of practicality of PINTER mathematics learning model

The graph above shows that the PINTER mathematics learning model can be applied practically / easily. Some completeness of the model such as: RPP model manuals, teaching aids, student learning activity sheets, and student worksheets can be used easily by the teacher. The practicality of a model is very important to note. This will make it easier for teachers / users who are not familiar with the new learning model to adopt it easily. Practicality is an important key so that teachers are willing and able to apply the learning model well. In some cases, teachers find it difficult to implement new / innovative models for various reasons, for example: not having enough time to learn new learning models, busy with administrative tasks, lack of support from peers, already comfortable with learning models that have this is used. This was also mentioned who stated teachers in high poverty, diverse schools do not have the time or the energy they need to figure out how to teach in new ways, including teaching higher-order thinking skills [24]. Thus, it is very important to present a learning model that can be applied easily / practical. In learning practices, learning models and learning tools should be arranged in a simple way. This is in accordance with states that Another characteristic of high-quality interventions is that end-users (for instance the teachers and learners) consider the intervention to be usable and that it is easy for them to use the materials in a way that is largely compatible with the developers' intentions [25].

The PINTER mathematics learning model also received very good responses from students. This response was obtained from a student response questionnaire that was distributed on 2 occasions, namely at the end of meeting 2 and the end of meeting 5. Student responses can be observed in the following graph.

Figure 3. Graphic Student responses to the PINTER mathematics learning model

From this graph, it can be seen that students give good responses to the implementation of the PINTER mathematics learning model. This is also supported by learning observations where students show interest and they are very enthusiastic in participating in each stage of learning. Students feel happy with the use of teaching aids and it shows a positive attitude in group activities by contributing ideas / ideas to solve the problems given.

3.2. Increased higher-order thinking skills

The application of the PINTER mathematics learning model can have an influence on improving students' higher-order thinking skills on algebra material. This can be seen from the results of the pre-test and post-test in the table below.
Table 3. Result of Pretest and Posttest

| Paired Differences | Mean | Std. Deviation | Std. Error | 95% Confidence Interval of the Difference | Mean | Std. Deviation | Std. Error | t | Df | Sig. (2-tailed) |
|--------------------|------|----------------|------------|----------------------------------------|------|----------------|------------|----|----|----------------|
| Post_Test - Pre_Test | 19.903 | 12.805 | 1,150 | 17.62 | 7 | 22.179 | 17.309 | 123 | .000 |

The table above shows that $t_{stat} = 17.309 < 1.657 = t_{tab}$, so $H_0$ rejected. Thus, it can be concluded that an increase in high-level thinking skills in students after being given learning with the PINTER mathematics learning model.

This increase in higher-order thinking skills is marked by the emergence of students' ability to solve non-routine problems. This can be interpreted that when students are able to solve non-routine problems, then students already have high-level thinking skills. Non-routine problem solving can bring up various procedures for solving the problem given through the reasoning process and using the knowledge that has been previously owned. This is in line with state that HOTS is implemented in the assessment framework so that students can assess their abilities to solve higher-order questions [26].

Given the problem as follows: Anne read a fairly thick novel in 4 days. On the first day she read $1/3$ part. The second day she read the remaining half. The third day she read the remaining $3/4$. The fourth day she read 44 pages. What is the total page of the novel?

The following are some of the results of student work

Examples of student work results mentioned above show the emergence of several different completion procedures. Figure 4 shows that the problem was solved using the Bar model or pictorial model, while Figure 5 shows that the problem was solved using algebraic manipulation. The use of the Bar model in solving problems is greatly influenced by the use of the Concrete-Pictorial-Abstract approach at stage 2 of Investigation. Thus, the Bar model can help students to solve problems.

Problem solving with the bar model is very likely to bring up various alternative solutions to the problem. Even the solutions shown can be beyond what the teacher thinks. Completion with abstract manipulation, is very possible when students already have a good understanding of concepts and are confident to use algebraic manipulation in abstract terms. This difference between problem solving shows that students provide different interpretations of the problem given, so the resolution algorithm used is also different. This is consistent with the opinion that the concept of HOTS as non-algorithmic, complex, yields multiple solutions, requires the application of multiple criteria, self-regulation, and often involves uncertainty [6].
This PINTER math learning model is able to encourage students to enhance higher order thinking skills. This is because at each stage of learning (syntax) directed at the formation of cognitive structures that are interrelated between material and learning activities so as to form higher-order thinking skills. The development of higher order thinking skills in this model is strengthened through the provision of non-routine problems, both at the Investigation stage which is strengthened at the Team activities stage. In a group, each person contributes his or her own experiences, values, attitudes, and personalities, and based on these individual contributions, discussions can activate certain kinds of learning opportunities [27]. Therefore, in a learning activity, it is very necessary to do learning activities that involve group activities in the form of collaboration or cooperative learning.

3.3. Analyze the results of student assignments

The learning tasks in the PINTER mathematics learning model are presented in the form of giving open-ended student worksheets at the Team Activities stage. Open-ended student worksheets contain non-routine problems that must be solved in groups. The purpose of giving assignments in groups is to bring about the exchange of knowledge, so as to help the formation of students' cognitive structures. In addition, through group work it is possible to bring up various problem solving strategies. The results of the assessment of the open-ended student worksheet can be seen as follows.

![Image](image_url)

*Figure 6. Results of an open-ended student worksheet assessment*

The graph shows that, the score of the completion of the open-ended student worksheet has increased at each meeting. This happens because the discussion that occurs in each group in solving the problem given runs constructively. That is, discussions can produce a variety of problem solving procedures. This shows that the provision of open-ended tasks is very effective in encouraging discussion among students in group activities. Students must also receive challenging tasks, encouraging to stay on task when grappling with open-ended questions [28]. Open-ended student worksheets provide challenges and opportunities for students to think divergently, so that some completion procedures can be obtained. This is in line with states that Open-ended and challenging tasks that build on students' prior knowledge are conducive to discussions because they encourage students to think collaboratively and build upon one another's ideas [29].

Increased students' higher order thinking skills can occur because indeed each stage of learning in the PINTER mathematical model has been arranged to enhance higher order thinking skills. At the Presentation to real life stage, learning begins by giving problems related to the real world. The purpose of presenting a real-life problem situation in an open-ended student worksheet is so that students can rediscover information and develop it into new knowledge so as to lead to meaningful learning. Situations from real life are not just used to prepare students for solving applied problems [30]. The main function of real-life situations is to offer a conceptual basis for reinventing the mathematics the students are to learn. The process of reinventing / reinvention is what will encourage students to have the ability of reasoning.

4. Conclusion

The results above show that the PINTER mathematical learning model can enhance students' higher order thinking skills on algebra. Observations on the implementation of learning indicate that the
teacher has been able and easy to carry out learning the PINTER model. This is also supported by the response of students who are enthusiastic and motivated during the learning process. The results of the analysis of tests and assignments have indicated that students have higher-order thinking skills because they have been able to solve non-routine problems. Students have also been able to display some unique, unexpected, and non-procedural solutions even though they are still limited to certain students.

The results of these studies provide opportunities for teachers and other researchers to adopt the learning model in other materials and levels of education on it. It will be interesting to see how this PINTER model is associated with other media based on information technology.

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