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JPPIPA 9(1) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Guided Discovery Learning Model Using Concept Map Strategy to Improve Students' Metacognition and Critical Thinking Skills

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Received:
Revised:
Accepted:
Published:

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Abstract: This study aims to improve students' metacognition and critical thinking skills in learning physics through the implementation of *the guided discovery learning model* with a concept map strategy. This research is a classroom action research, with stages: (1) planning, (2) implementation, (3) observation and evaluation, and (4) reflection. The subjects of this study were 30 students of class XI IPA MAN 3 Central Lombok. The research instrument consisted of metacognition skill assessment sheets and critical thinking tests, which were declared valid and reliable. Data analysis was carried out in a quantitative descriptive manner. The results of this study are: (1) students' metacognition skills experienced an increase in scores in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III) ; (2) students' critical thinking skills also experienced an increase in scores in the high and very high categories with a percentage of 63.33% (cycle I), 76.66% (cycle II), and 86.67% (cycle III). thus, the implementation of the guided discovery learning model with a concept map strategy can improve students' metacognition and critical thinking skills in learning physics.

Keywords: Guided Discovery Learning (GDL), Concept Maps, Metacognition Skills, Critical Thinking

Introduction

Critical thinking and metacognition are two important aspects that overlap (Asy'ari, Ikhsan, et al., 2019; Asy'ari & Rosa, 2022; Fitriani et al., 2019) , and are components of 21st century innovative skills (Muhali, 2019) , which must be taught continuously to students because it is a demand in the world of education today and in the future. Teaching both of them requires certain strategies for educators considering the many indicators of critical thinking according to experts, while metacognition in learning must take place naturally by students. Educators as a determinant of student learning success play an important and very large role in learning (Sukaisih & Muhali, 2014) , and the process of understanding students and their various ways of learning is one of the challenges (Arends, 2012) . Therefore, educators must continue to seek and find solutions in an effort to improve the quality of the learning process so that students' learning success becomes better and optimal.

Various attempts have been made by researchers to train students' critical thinking skills

How to Cite:
Example: Susilawati, S., Doyan, A., Muliyadi, L., & Hakim, S. (2019). Growth of tin oxide thin film by aluminum and fluorine doping using spin coating Sol-Gel techniques. *Jurnal Penelitian Pendidikan IPA, 1*(1), 1-4. https://doi.org/10.29303/jjppipa.v1i1.264

and metacognition by applying the *problem solving model* (Sukaisih & Muhali, 2014) , the problem solving model with cognitive conflict strategies (Sukaisih et al., 2020) , the inquiry model (Asy'ari , Ikhsan, et al., 2019) , and its development is in the form of an active inquiry-based model (Prayogi & Muhali, 2015) , as well as a metacognitive reflective learning model (Muhali et al., 2019) , which in general can improve students' critical thinking and metacognition . Along with the development of curriculum and learning at the high school/MA level, especially science learning, and the development of the characteristics of students at this time, learning is more emphasized on learning by discovery or guided discovery learning (GDL). Therefore, it is important in learning science, especially physics, to train students with GDL learning.

GDL model learning is a series of learning activities that optimally involve all students' abilities to seek and investigate systematically, critically, and logically so that they can find their own knowledge, attitudes and skills as a form of behavior change (Nasruddin et al. , 2020) . GDL in its implementation students carry out experiments or demonstrations by observing the pictures and writing down the data produced in worksheets and answering questions given by the teacher in an effort to find concepts based on the data obtained and compare with the theory contained in the module or book lesson. GDL is a model learning which in practice gives problems to students, provides guidance to students in the form of observations, and solves problems with teacher guidance, and learning is assisted by worksheets. GDL Learning in this study there were 5 stages according to Bruner (Muhali et al., 2021) , namely: (1) Stimulation , the teacher instructs students to pay attention to the pictures on the LKS and gives questions that stimulate students' critical thinking, this stage is the most important stage. appropriate to encourage students to read books and think in preparation for problem solving. (2) problem statement, the teacher gives students the opportunity to identify as many problems as possible that are relevant to the subject matter, this stage greatly influences students' understanding in formulating problems to make hypotheses (3) data collection, students conduct experiments or observations to prove whether the hypothesis is correct or not. (4) data processing and verification , the teacher gives evaluation questions to each group and performs verification together, with the provision of evaluation questions, it encourages students to better understand the concept of material (5) generalization / make conclusions , students make conclusions on the problems that have been formulated according to the data and information obtained during the discovery process.

The implementation of the GDL model in this study was integrated with the concept map strategy. Concept maps are a strategy that displays information in the form of concepts in a systematic and interconnected manner. According to Katagall (2015) , concept maps are visual representations of key ideas that are interconnected and used to show the position of the relationship between the concepts being taught so that the subject matter is easier for students to follow. Concept maps are characterized as a way of showing the concepts and propositions of a field (Baliga et al., 2021) , such as fields of study, both physics, chemistry, biology, and mathematics (Machado & Carvalho, 2020) . With a concept map students in learning can see the field of study more clearly and study it more meaningfully. Concept maps clearly show the main concepts of a material or topic and how the relationships or relationships between existing concepts. Concept map strategy in its implementation, students are asked to make concept maps and the teacher is in charge of helping students. Students are asked to freely make a concept map of a material before discussing it, students are asked to read the material at home, and in class are asked to make their own concept maps, and explain the concept maps that are made and the relationships that exist.

Based on the descriptions, the formulation of the problem in this study is how the implementation of the GDL model with a concept map strategy can improve students' critical thinking skills and metacognition in science learning? Several studies believe that the GDL model can teach conceptual understanding well and has a significant influence (Aprilia et al., 2020; Vivanti et al., 2020) , the GDL model can teach students' critical thinking skills (Batubara, 2019; Fadillah et al. al., 2018; Noer, 2018) , and the GDL model for teaching conceptual understanding and critical thinking (Muhali et al., 2021; Yuliani & Saragih, 2015) . Thus, the purpose of this study was to determine the increase in students' critical thinking skills and metacognition in physics learning which were taught through the GDL model with a concept map strategy.

Method

This type of research is Classroom Action Research (CAR), which is research conducted with the aim of improving students' critical thinking skills and metacognition by applying GDL learning with a concept map strategy in physics learning, especially material about Newton's Laws. The subjects of this study were 30 students of class XI IPA MAN 3 Central Lombok. This research was conducted in 3 (three) cycles with 3 (three) meetings in each research cycle. Each cycle consists of stages: (1) planning, (2) implementation, (3) observation and evaluation, and (4) reflection. The description of activities at each stage is described as follows.

Planning stage

The planning stage is an activity carried out in order to make all the preparations and completeness that support the implementation of the action. The activities carried out at this stage are: (1) compiling a GDL-based lesson plan (LP) with a concept map strategy, (2) compiling LKPD (student worksheets), (3) compiling AS (assessment sheet) of the implementation of learning, (4) preparing ASs for students' learning activities, (5) preparing instruments for assessing critical thinking skills, and (6) preparing AS instruments for metacognition skills.

Implementation stage

The implementation stage is the activity of carrying out learning in class by applying GDL-based learning with a concept map strategy with a series of activities as stated in the lesson plan. The activities carried out at this stage are: (1) the implementation of learning by educators according to the GDL-based RPP with a concept map strategy, and (2) the implementation of learning activities by students according to LKPD.

Observation and evaluation stage

This stage is the stage of monitoring and evaluating the process and results of the implementation of the action. The activities at this stage are: (1) observing and assessing the implementation of learning, (2) assessing metacognition skills according to the results of filling out the LKPD, and (3) assessing students' critical thinking skills.

Reflection stage

This stage is an activity to review the learning process that has been carried out by looking at the results of observations and evaluations that have been achieved. This activity was carried out with a team of observers (colleagues), to: (1) see the achievement of the learning process, student activities, critical thinking skills, and students' metacognition skills, (2) look for and find weaknesses in the process and results achieved, (3) seek and find solutions as alternative improvements, and (4) determine corrective solutions to be implemented in the next cycle of learning.

All of these stages are carried out in each research cycle by considering the reflection results at the end of each activity, until an indicator of learning achievement is obtained with a classical completeness percentage of 85%. The research design can be illustrated in Figure 1 as follows.

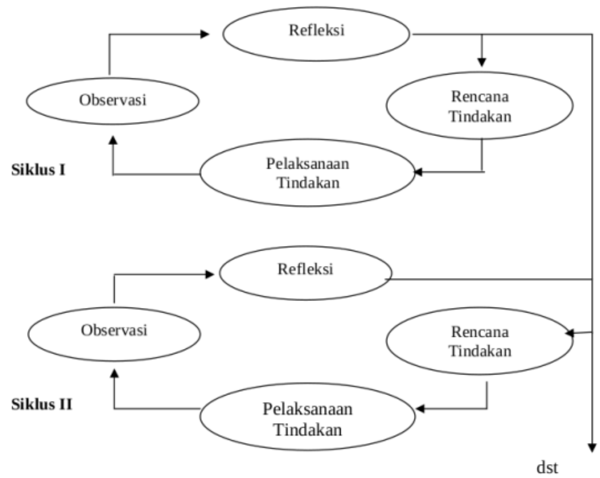

Figure 1. Flow of Classroom Action Research (CAR)

The instruments in this study included: (1) instruments for assessing the implementation of learning in the form of learning implementation AS, (2) instruments for assessing learning outcomes in the form of critical thinking skills tests, and AS for metacognition skills. Instruments for the implementation of learning include all learning activities carried out by educators listed in the lesson plans which consist of an introduction (apperception), this activity (stimulation, problem statements, data collecting, data processing and verification, and generalization), closing activities, enthusiasm in learning, and Time Allocation. The critical thinking ability instrument is a description of 6 (six) questions in each cycle containing indicators of critical thinking according to Ennis (2011), namely focus, reason, inference, situation, clarity, and overview. The metacognition skill instrument in the form of a performance appraisal sheet includes indicators according to Muhali et al. (2019) , namely formulating general and specific learning objectives, formulating problem formulations and hypotheses, planning problem solving, carrying out planning systematically, observing the process of carrying out planning in groups and individually, examining the process of carrying out planning in groups and individually, recording or collecting data, and evaluate results.

Instruments to obtain instruments that are valid and reliable so that they can be used to measure the achievement of learning processes and outcomes. Validation was carried out through the validator's assessment of 3 (three) experts in the field of science education at Mandalika University of Education. The assessment includes content and construct validity (r_{α}) and reliability (*Cronbach's Alpha, a*), validation results are analyzed with the equation according to Malhotra (Muhali et al., 2020) , and the results of the analysis are listed in Table 1.

Table 1. Research Instrument Validation Results

No.	Instrument	Validity Value (r α) and Reliability (α)				r table
		Fill	α	Construct	α	
1	LP of Learning Implementation	0.751	0.858	0.739	0849	0.497
2	Metacognition Skills LP	0.793	0.884	0.840	0.913	0.532
3	Critical Thinking Ability Test	0.746	0.855	0.839	0.912	0.532

Data collection techniques were carried out using observation techniques, performance appraisals, and tests. Observation techniques to obtain data on the implementation of learning at each meeting conducted by observers using the LP on the implementation of learning, by giving a mark (√) in the score column for each activity according to what is observed. Performance appraisal techniques are used to obtain student performance data during carrying out learning activities at each meeting, carried out by the assessment team (teachers and observers involved) at each meeting from the results of filling in the LKPD. The assessment is carried out with reference to the LP's metacognitive skills, and the results of the assessment are data on students' metacognitive skills. The test technique for obtaining data on students' critical thinking skills is carried out at the end of each cycle, and is then evaluated by referring to the grid of questions, and the scores obtained are data on students' critical thinking abilities.

Analysis of learning implementation data was obtained in the form of scores with a range of 1–4, with categories 1 = not good, 2 = not good, 3 = good, and 4 = very good. The score for each aspect obtained from all the meetings that have been carried out in each cycle , the average is calculated, then interpreted in the form of a score as follows.

Table 2. Average Score Interval and Learning Implementation Criteria (Ratumanan & Laurens, 2011)

Average score interval	Average score criteria
1.00 – 1.8	Not good (K)
1.9– 2.7	Good enough (C)
2.8 – 3.6	Good (B)
>3,6	Very good (SB)

Learning success is achieved if a score is obtained for all activities in each cycle of 85% in the good and very good categories (Muhali, 2018). Data analysis of students' critical thinking skills (CBC) and metacognition skills (KM) of students is carried out using the following equation.

$$CBC\ or\ KM = \frac{Score\ obtained}{Maximum\ score} x100$$

The scores obtained are then grouped according to criteria and categories as shown in the following table.

Table 3. Criteria and Categories of Students' Critical Thinking Ability and Metacognition Skills (Muhali et al., 2019)

Mark	Category
80 – 100	Very high
66–79	High
56–65	Enough
40 – 55	Low
30 – 39	Very low

Students' critical thinking skills and metacognition skills are said to be successful in learning if ≥ 85% of students get scores in the high and very high categories (Muhali et al., 2019) .

Result and Discussion

The results of this study consist of the implementation of learning using the GDL model with concept map strategies, metacognition skills, and students' critical thinking skills which are presented in each cycle, described in full as follows.

Implementation of Learning Using the GDL Model with a Concept Map Strategy

Data on the implementation of learning was obtained from the results of peer observations on the implementation of a series of learning activities that had been listed in the GDL-based lesson plan using a concept map strategy. The complete observation results are listed in Table 4.

Table 4. Learning Implementation Data in Each Cycle

No.	Steps/Learning Activities	Average and Category of Learning Implementation in cycle to:					
		I	Category	II	Category	III	Category
1.	apperception	3.00	B	3.50	B	4.00	SB
2.	Stimulation	3.00	B	3.00	B	4.00	SB
3.	Formulation of the problem	2.75	CB	3.00	B	4.00	SB
4.	Collecting data	2.67	CB	2.75	CB	3.00	B
5.	Processing and Data Verification	2.50	CB	2.83	B	2.83	B
6.	Generalization	3.00	B	3.50	B	4.00	SB
7.	Closing activities	4.00	SB	4.00	SB	4.00	SB
8.	Enthusiasm	3.50	B	3.50	B	3.50	B
9.	Time Allocation	2.50	CB	3.00	B	3.00	B
	Average	**2.99**	**B**	**3.23**	**B**	**3.59**	**B**

Information: *SB = Very Good, B = Good, and CB = Fairly Good.*

The implementation of the GDL model with the concept map strategy in learning in each cycle experienced an increase in the average score of cycle I = 2.99, cycle II = 3.23, and cycle III = 3.59, but all three were in the good category. The percentage of learning implementation according to Table 4 above, in cycle I was 55.56%, cycles II and III were 88.89% and 100% in the good and very good categories. This means that in general the GDL model with a concept map strategy can be implemented properly in learning physics. This learning requires students to learn through a series of scientific processes by formulating problems, making hypotheses, conducting experiments in order to collect data, process and analyze data, and draw conclusions as a form of justification for the final decision. This is in accordance with the opinion of Arends (2012) and Fitriani et al. (2022) , through GDL students learn to find patterns in various concrete and abstract situations so that they can explain and predict the additional information presented. Yerimadesi et al. (2022) stated that GDL helps students develop readiness and mastery of skills in cognitive processes. Furthermore, Yuliani and Saragih (2015) state that the GDL model is a model by presenting questions or problems to direct students to think, observe, formulate conjectures, explain and analyze in discovering new knowledge. In line with this opinion, Fadillah et al. (2018) states that students' explanatory abilities can grow and develop after going through the stages of stimulation or giving stimulation, identifying problems, collecting and processing data as well as verification and generalization as stages in implementing the GDL learning model.

Implementation of the GDL model at each stage of learning on solubility material and solubility product, the first stage (Stimulation), by asking students to pay attention to the pictures on the LKS and asking questions that stimulate their thinking processes. This activity is intended to encourage students to read books, think, and set goals in preparation for understanding and solving problems. This allows changes in the behavior of students to build a mental strength within themselves, generates the desire/motivation to explore information through literacy, connects prior knowledge with ideas of knowledge acquired.

The second stage (problem statement), provides an opportunity for students to identify as many problem agendas as possible that are relevant to the subject matter. This stage greatly influences understanding in formulating problems to make hypotheses. The ability of students to formulate problems and hypotheses depends on: (1) accuracy in identifying each problem from each presentation of the material at the stimulation stage, (2) the ability to understand, analyze, and relate the concepts presented, (3) the participants' thinking processes educate. The third stage (data collection), students carry out experiments or observations to collect data that is used to prove whether the hypothesis made is true or not. Student activities at this stage actively carry out experimental procedures, record observational data, and perform calculations on observed data. Through this activity, students can bring about changes in behavior by carrying out experimental activities carefully and correctly until appropriate information and data are obtained. GDL learning requires students to learn by experiencing not memorizing, so they are able to construct knowledge. Students are accustomed to solving problems, so they know what to learn and how to use the knowledge and skills acquired. According to the behavioristic view, this learning is suitable to be applied to acquire skills that require practice and habituation that contain elements of speed, spotty, and endurance (Arends, 2012) .

The fourth stage (data processing and verification), gives evaluation questions to each group as material for discussion, and asks each group to represent one of its members to read out the results and carry out joint verification. According to Skinner's view, a learning situation in which a response is made stronger due to direct reinforcement, and through continuous repetition and training can optimize the talents and intelligence of students who have been formed before (Biazus & Mahtari, 2022). With the provision of evaluation questions, it encourages students to better understand the concept and develop a mindset in analyzing questions. The GDL model provides opportunities for students to improve, expand, and apply their knowledge and skills in various activities. This helps students analyze their thinking processes and integrate newly acquired conceptual knowledge by asking them to rethink what is going on in their minds about the concept. This is in accordance with the opinion that the presentation of new problems or phenomena can direct students to carry out a more in-depth study of a concept being studied or known as the internalization process (Muhali et al., 2019) .

The fifth stage (generalization), students make conclusions in response to the formulation of the problems that have been made. This stage directs students to be able to read data, process and interpret data, connect data with existing concepts/knowledge to construct new knowledge as decisions or answers to learning problems. This is according to Asy'ari et al. (2019) that generalization is a process of drawing conclusions to be used as general principles that apply to all the same events or problems, after going through the process or results of verification . The implementation of the GDL model in this study was carried out with group discussions, this was intended to provide a shared learning experience to produce a series of scientific process skills, construction of students' knowledge through the ideas or knowledge of other students in their group.

Students' Metacognition Skills Learned Using the GDL Model with a Concept Map Strategy

Metacognition skills are obtained from assessing the performance of students in filling out the LKPD at each meeting in each learning cycle. Data on metacognition skills in each cycle can be seen in Table 5.

Table 5. Students' Metacognition Skills in Each Cycle

Value Intervals	Category	Acquisition of Students' KM Value (%)		
		Cycle I	Cycle II	Cycle III
80 – 100	Very high	0.00	0.00	0.00
66–79	High	33,33	80.00	86,67
56–65	Enough	50.00	13,33	13,33
40 – 55	Low	16,67	6,67	0.00
30 – 39	Very low	0.00	0.00	0.00

Based on the data in Table 5, there was an increase in the scores of students' metacognition skills in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III). These results indicate that learning with the GDL model with a concept map strategy can improve students' metacognition skills. The metacognition skills achieved by students in general for each indicator have also increased, according to the data in Table 6.

Table 6. Achievement Data for Each Indicator of Metacognition Skills in Each Cycle

No.	Metacognition Skills Indicator	Score and Achievement Category					
		I	Category	II	Category	III	Category
1.	Formulate general and specific learning objectives	6460	Enough	73.30	High	81.30	Very high
2.	Formulate problems and hypotheses	6710	High	7292	High	7625	Tall
3.	Create a problem solving plan	6460	Enough	71.25	High	8083	Tall
4.	Carry out planning systematically	6330	Enough	71.25	High	75.00	Tall
5.	Observing the planning implementation process,	6080	Enough	6542	Enough	6958	Tall
6.	Examine the planning implementation process,	6330	Enough	6417	Enough	65.00	Enough
7.	Record or collect data	5920	Enough	61.25	Enough	6833	Tall
8.	Evaluate results	53.30	Low	5833	Enough	5958	Enough

The data in Table 6 shows that indicators 1, 3, 4, 5, 7 experienced an increase in scores from the moderate category to the high category, indicator 8 experienced an increase in scores from the low category to the sufficient category, and indicators 2 and 6 experienced an increase in scores but did not experience an increase category (high and sufficient).

Critical Thinking Ability Lessons Learned Using the GDL Model with a Concept Map Strategy

The critical thinking skills of students who are taught using the GDL model with a concept map strategy experience an increase in each learning cycle. The increase in critical thinking skills increased in the high and very high categories with percentages of 63.33% (cycle I), 76.66% (cycle II), and 86.67% (cycle III), according to the data in Table 7. Increasing the achievement of students' critical thinking skills in general occurs in all indicators as shown in the data listed in Table 8.

Table 7. Data on students' critical thinking skills in each cycle

Value Intervals	Category	Acquisition of Students' KBK Value (%)		
		Cycle I	Cycle II	Cycle III
80 – 100	Very high	0.00	3,33	6,67
66–79	Tall	63,33	73,33	80.00
56–65	Enough	20.00	10.00	10.00
40 – 55	Low	13,33	6,67	3,33
30 – 39	Very low	3,33	6,67	0.00

Table 8. Critical Thinking Ability Data in Each Cycle

No.	Critical Thinking Ability Indicator	Scores and Achievement Categories in Cycles:					
		I	Category	II	Category	III	Category
1.	Focus	71.00	Tall	72,67	Tall	78.00	Tall
2.	Reason	69.00	Tall	72,33	Tall	77.00	Tall
3.	Inferences	68,67	Tall	69,67	Tall	72,67	Tall
4.	Situation	59,67	Enough	61,67	Enough	65,33	Enough
5.	Clarity	64.00	Enough	65,33	Enough	66.00	Tall
6.	Overview	47,33	Low	53,67	Low	56.00	Enough

The low percentage of students who scored in the high and very high categories in cycle I was caused by several things, namely: (1) students only memorized the formula and were less able to use the concepts contained in the formula, this happened due to a lack of ability to manage process of thinking that causes students to be confused when faced with different situations, (2) the teacher always gives practice questions with patterns that are easy to understand without requiring analysis, so that when students are faced with questions requiring analysis , students find it difficult in developing their knowledge and thinking skills in understanding the questions, as a result students answer at random.

GDL model can cause students to be very enthusiastic in solving problems that exist in LKS. Activities at the problem statement stage can be seen between students arguing with each other to equalize internal perceptions, identify problems, collect information related to the problems identified so that they can critically make hypotheses correctly. The second stage of GDL learning is to train students in exploring the material to be studied, learn to generalize newly obtained information so that it helps in developing critical thinking skills.

At the data processing stage, students are serious in conducting discussions and working on questions in LKPD with their group mates. Learning in experimental class, the LKPD is designed based on the GDL model, where the steps of the learning model can help students in solving problems appropriately and directed. This is supported by the opinion of Sulistyowati et al. (2012) , The advantages of applying the GDL learning model include: (1) student involvement in maximum learning, students are guided to find concepts independently, (2) collaboration and team dynamics solve problems, create active learners in critical thinking and improve learning activities, (3) students have skills and dexterity in solving questions, (5) spurring students to be more thorough in working on questions.

Conclusion

The current study has achieved the objective and research questions formulated, that (1) implementation of the guided discovery model with a concept map strategy can improve students' metacognition skills, seen from the increase in students' metacognition skills scores in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III); and (2) implementation of the guided discovery model with a concept map strategy can improve students' critical thinking skills, seen from the increase in critical thinking skills has increased in the high and very high categories with a percentage of 63.33% (cycle I), 76.66% (cycle II) , and 86.67% (cycle III).

For the future research, it is better if the teacher emphasizes more so that students can carry out data collection activities, process and verify data according to learning needs and problems. which will be resolved. This can make students more optimal in carrying out indicators of metacognition skills (evaluation) and critical thinking (situation and overview).

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Submission Review Copyediting Production

Round 1

Round 1 Status

Submission accepted.

Reviewer's Attachments

No Files

Revisions

18360-1 Article Text, 3. Revised (fix).docx

JPPIPA 9(1) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Guided Discovery Learning Model Using Concept Map Strategy to Improve Students' Metacognition and Critical Thinking Skills

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Received:
Revised:
Accepted:
Published:

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Abstract: This study aims to improve students' metacognition and critical thinking skills in learning physics through the implementation of *the guided discovery learning model* with a concept map strategy. This research is a classroom action research, with stages: (1) planning, (2) implementation, (3) observation and evaluation, and (4) reflection. The subjects of this study were 30 students of class XI IPA MAN 3 Central Lombok. The research instrument consisted of metacognition skill assessment sheets and critical thinking tests, which were declared valid and reliable. Data analysis was carried out in a quantitative descriptive manner. The results of this study are: (1) students' metacognition skills experienced an increase in scores in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III) ; (2) students' critical thinking skills also experienced an increase in scores in the high and very high categories with a percentage of 63.33% (cycle I), 76.66% (cycle II), and 86.67% (cycle III). thus, the implementation of the guided discovery learning model with a concept map strategy can improve students' metacognition and critical thinking skills in learning physics.

Keywords: Guided Discovery Learning (GDL), Concept Maps, Metacognition Skills, Critical Thinking

Introduction

Critical thinking and metacognition are two important aspects that overlap (Asy'ari, Ikhsan, et al., 2019; Asy'ari & Rosa, 2022; Fitriani et al., 2019) , and are components of 21st century innovative skills (Muhali, 2019) , which must be taught continuously to students because it is a demand in the world of education today and in the future. Teaching both of them requires certain strategies for educators considering the many indicators of critical thinking according to experts, while metacognition in learning must take place naturally by students. Educators as a determinant of student learning success play an important and very large role in learning (Sukaisih & Muhali, 2014) , and the process of understanding students and their various ways of learning is one of the challenges (Arends, 2012) . Therefore, educators must continue to seek and find solutions in an effort to improve the quality of the learning process so that students' learning success becomes better and optimal.

Various attempts have been made by researchers to train students' critical thinking skills and metacognition by applying the *problem solving model* (Sukaisih & Muhali, 2014) , the problem solving model with cognitive conflict strategies (Sukaisih et al., 2020) , the inquiry model (Asy'ari , Ikhsan, et al., 2019) , and its development is in the form of an active inquiry-based model (Prayogi & Muhali, 2015) , as well as a

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Example: Susilawati, S., Doyan, A., Muliyadi, L., & Hakim, S. (2019). Growth of tin oxide thin film by aluminum and fluorine doping using spin coating Sol-Gel techniques. *Jurnal Penelitian Pendidikan IPA, 1*(1), 1-4. https://doi.org/10.29303/jjppipa.v1i1.264

metacognitive reflective learning model (Muhali et al., 2019) , which in general can improve students' critical thinking and metacognition . Along with the development of curriculum and learning at the high school/MA level, especially science learning, and the development of the characteristics of students at this time, learning is more emphasized on learning by discovery or guided discovery learning (GDL). Therefore, it is important in learning science, especially physics, to train students with GDL learning.

GDL model learning is a series of learning activities that optimally involve all students' abilities to seek and investigate systematically, critically, and logically so that they can find their own knowledge, attitudes and skills as a form of behavior change (Nasruddin et al. , 2020) . GDL in its implementation students carry out experiments or demonstrations by observing the pictures and writing down the data produced in worksheets and answering questions given by the teacher in an effort to find concepts based on the data obtained and compare with the theory contained in the module or book lesson. GDL is a model learning which in practice gives problems to students, provides guidance to students in the form of observations, and solves problems with teacher guidance, and learning is assisted by worksheets. GDL Learning in this study there were 5 stages according to Bruner (Muhali et al., 2021) , namely: (1) Stimulation , the teacher instructs students to pay attention to the pictures on the LKS and gives questions that stimulate students' critical thinking, this stage is the most important stage. appropriate to encourage students to read books and think in preparation for problem solving. (2) problem statement, the teacher gives students the opportunity to identify as many problems as possible that are relevant to the subject matter, this stage greatly influences students' understanding in formulating problems to make hypotheses (3) data collection, students conduct experiments or observations to prove whether the hypothesis is correct or not. (4) data processing and verification , the teacher gives evaluation questions to each group and performs verification together, with the provision of evaluation questions, it encourages students to better understand the concept of material (5) generalization / make conclusions , students make conclusions on the problems that have been formulated according to the data and information obtained during the discovery process.

The implementation of the GDL model in this study was integrated with the concept map strategy. Concept maps are a strategy that displays information in the form of concepts in a systematic and interconnected manner. According to Katagall (2015) , concept maps are visual representations of key ideas that are interconnected and used to show the position of the relationship between the concepts being taught so that the subject matter is easier for students to follow. Concept maps are characterized as a way of showing the concepts and propositions of a field (Baliga et al., 2021) , such as fields of study, both physics, chemistry, biology, and mathematics (Machado & Carvalho, 2020) . With a concept map students in learning can see the field of study more clearly and study it more meaningfully. Concept maps clearly show the main concepts of a material or topic and how the relationships or relationships between existing concepts. Concept map strategy in its implementation, students are asked to make concept maps and the teacher is in charge of helping students. Students are asked to freely make a concept map of a material before discussing it, students are asked to read the material at home, and in class are asked to make their own concept maps, and explain the concept maps that are made and the relationships that exist.

Based on the descriptions, the formulation of the problem in this study is how the implementation of the GDL model with a concept map strategy can improve students' critical thinking skills and metacognition in science learning? Several studies believe that the GDL model can teach conceptual understanding well and has a significant influence (Aprilia et al., 2020; Vivanti et al., 2020) , the GDL model can teach students' critical thinking skills (Batubara, 2019; Fadillah et al. al., 2018; Noer, 2018) , and the GDL model for teaching conceptual understanding and critical thinking (Muhali et al., 2021; Yuliani & Saragih, 2015) . Thus, the purpose of this study was to determine the increase in students' critical thinking skills and metacognition in physics learning which were taught through the GDL model with a concept map strategy.

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Method

This type of research is Classroom Action Research (CAR), which is research conducted with the aim of improving students' critical thinking skills and metacognition by applying GDL learning with a concept map strategy in physics learning, especially material about Newton's Laws. The subjects of this study were 30 students of class XI IPA MAN 3 Central Lombok. This research was conducted in 3 (three) cycles with 3 (three) meetings in each research cycle. Each cycle consists of stages: (1) planning, (2) implementation, (3) observation and evaluation, and (4) reflection. The description of activities at each stage is described as follows.

Planning stage

The planning stage is an activity carried out in order to make all the preparations and completeness that support the implementation of the action. The activities carried out at this stage are: (1) compiling a GDL-based lesson plan (LP) with a concept map strategy, (2) compiling LKPD (student worksheets), (3) compiling AS (assessment sheet) of the implementation of learning, (4) preparing ASs for students' learning activities, (5) preparing instruments for assessing critical thinking skills, and (6) preparing AS instruments for metacognition skills.

Implementation stage

The implementation stage is the activity of carrying out learning in class by applying GDL-based learning with a concept map strategy with a series of activities as stated in the lesson plan. The activities carried out at this stage are: (1) the implementation of learning by educators according to the GDL-based RPP with a concept map strategy, and (2) the implementation of learning activities by students according to LKPD.

Observation and evaluation stage

This stage is the stage of monitoring and evaluating the process and results of the implementation of the action. The activities at this stage are: (1) observing and assessing the implementation of learning, (2) assessing metacognition skills according to the results of filling out the LKPD, and (3) assessing students' critical thinking skills.

Reflection stage

This stage is an activity to review the learning process that has been carried out by looking at the results of observations and evaluations that have been achieved. This activity was carried out with a team of observers (colleagues), to: (1) see the achievement of the learning process, student activities, critical thinking skills, and students' metacognition skills, (2) look for and find weaknesses in the process and results achieved, (3) seek and find solutions as alternative improvements, and (4) determine corrective solutions to be implemented in the next cycle of learning.

All of these stages are carried out in each research cycle by considering the reflection results at the end of each activity, until an indicator of learning achievement is obtained with a classical completeness percentage of 85%. The research design can be illustrated in Figure 1 as follows.

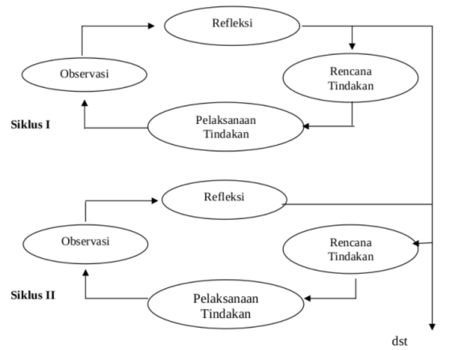

Figure 1. Flow of Classroom Action Research (CAR)

The instruments in this study included: (1) instruments for assessing the implementation of learning in the form of learning implementation AS, (2) instruments for assessing learning outcomes in the form of critical thinking skills tests, and AS for metacognition skills. Instruments for the implementation of learning include all learning activities carried out by educators listed in the lesson plans which consist of an introduction (apperception), this activity (stimulation, problem statements, data collecting, data processing and verification, and generalization), closing activities, enthusiasm in learning, and Time Allocation. The critical thinking ability instrument is a description of 6 (six) questions in each cycle containing indicators of critical thinking according to Ennis (2011), namely focus, reason, inference, situation, clarity, and overview. The metacognition skill instrument in the form of a performance appraisal sheet includes indicators according to Muhali et al. (2019) , namely formulating general and specific learning objectives, formulating problem formulations and hypotheses, planning problem solving, carrying out planning systematically, observing the process of carrying out planning in groups and individually, examining the process of carrying out planning in groups and individually, recording or collecting data, and evaluate results.

Instruments to obtain instruments that are valid and reliable so that they can be used to measure the achievement of learning processes and outcomes. Validation was carried out through the validator's assessment of 3 (three) experts in the field of science education at Mandalika University of Education. The assessment includes content and construct validity (r_a) and reliability (*Cronbach's Alpha, a*), validation results are analyzed with the equation according to Malhotra (Muhali et al., 2020) , and the results of the analysis are listed in Table 1.

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Table 1. Research Instrument Validation Results

No.	Instrument	Validity Value (r_α) and Reliability (α)				r_{table}
		Fill	α	Construct	α	
1	LP of Learning Implementation	0.751	0.858	0.739	0849	0.497
2	Metacognition Skills LP	0.793	0.884	0.840	0.913	0.532
3	Critical Thinking Ability Test	0.746	0.855	0.839	0.912	0.532

Data collection techniques were carried out using observation techniques, performance appraisals, and tests. Observation techniques to obtain data on the implementation of learning at each meeting conducted by observers using the LP on the implementation of learning, by giving a mark (√) in the score column for each activity according to what is observed. Performance appraisal techniques are used to obtain student performance data during carrying out learning activities at each meeting, carried out by the assessment team (teachers and observers involved) at each meeting from the results of filling in the LKPD. The assessment is carried out with reference to the LP's metacognitive skills, and the results of the assessment are data on students' metacognitive skills. The test technique for obtaining data on students' critical thinking skills is carried out at the end of each cycle, and is then evaluated by referring to the grid of questions, and the scores obtained are data on students' critical thinking abilities.

Analysis of learning implementation data was obtained in the form of scores with a range of 1–4, with categories 1 = not good, 2 = not good, 3 = good, and 4 = very good. The score for each aspect obtained from all the meetings that have been carried out in each cycle, the average is calculated, then interpreted in the form of a score as follows.

Table 2. Average Score Interval and Learning Implementation Criteria (Ratumanan & Laurens, 2011)

Average score interval	Average score criteria
1.00 – 1.8	Not good (K)
1.9– 2.7	Good enough (C)
2.8 – 3.6	Good (B)
>3,6	Very good (SB)

Learning success is achieved if a score is obtained for all activities in each cycle of 85% in the good and very good categories (Muhali, 2018). Data analysis of students' critical thinking skills (CBC) and metacognition skills (KM) of students is carried out using the following equation.

$$CBC\ or\ KM = \frac{Score\ obtained}{Maximum\ score} x100$$

The scores obtained are then grouped according to criteria and categories as shown in the following table.

Table 3. Criteria and Categories of Students' Critical Thinking Ability and Metacognition Skills (Muhali et al., 2019)

Mark	Category
80 – 100	Very high
66–79	High
56–65	Enough
40 – 55	Low
30 – 39	Very low

Students' critical thinking skills and metacognition skills are said to be successful in learning if ≥ 85% of students get scores in the high and very high categories (Muhali et al., 2019) .

Result and Discussion

The results of this study consist of the implementation of learning using the GDL model with concept map strategies, metacognition skills, and students' critical thinking skills which are presented in each cycle, described in full as follows.

Implementation of Learning Using the GDL Model with a Concept Map Strategy

Data on the implementation of learning was obtained from the results of peer observations on the implementation of a series of learning activities that had been listed in the GDL-based lesson plan using a concept map strategy. The complete observation results are listed in Table 4.

Table 4. Learning Implementation Data in Each Cycle

No.	Steps/Learning Activities	Average and Category of Learning Implementation in cycle to:					
		I	Category	II	Category	III	Category
1.	apperception	3.00	B	3.50	B	4.00	SB
2.	Stimulation	3.00	B	3.00	B	4.00	SB
3.	Formulation of the problem	2.75	CB	3.00	B	4.00	SB
4.	Collecting data	2.67	CB	2.75	CB	3.00	B
5.	Processing and Data Verification	2.50	CB	2.83	B	2.83	B

6.	Generalization	3.00	B	3.50	B	4.00	SB
7.	Closing activities	4.00	SB	4.00	SB	4.00	SB
8.	Enthusiasm	3.50	B	3.50	B	3.50	B
9.	Time Allocation	2.50	CB	3.00	B	3.00	B
	Average	**2.99**	**B**	**3.23**	**B**	**3.59**	**B**

Information: *SB = Very Good, B = Good, and CB = Fairly Good.*

The implementation of the GDL model with the concept map strategy in learning in each cycle experienced an increase in the average score of cycle I = 2.99, cycle II = 3.23, and cycle III = 3.59, but all three were in the good category. The percentage of learning implementation according to Table 4 above, in cycle I was 55.56%, cycles II and III were 88.89% and 100% in the good and very good categories. This means that in general the GDL model with a concept map strategy can be implemented properly in learning physics. This learning requires students to learn through a series of scientific processes by formulating problems, making hypotheses, conducting experiments in order to collect data, process and analyze data, and draw conclusions as a form of justification for the final decision. This is in accordance with the opinion of Arends (2012) and Fitriani et al. (2022) , through GDL students learn to find patterns in various concrete and abstract situations so that they can explain and predict the additional information presented. Yerimadesi et al. (2022) stated that GDL helps students develop readiness and mastery of skills in cognitive processes. Furthermore, Yuliani and Saragih (2015) state that the GDL model is a model by presenting questions or problems to direct students to think, observe, formulate conjectures, explain and analyze in discovering new knowledge. In line with this opinion, Fadillah et al. (2018) states that students' explanatory abilities can grow and develop after going through the stages of stimulation or giving stimulation, identifying problems, collecting and processing data as well as verification and generalization as stages in implementing the GDL learning model.

Implementation of the GDL model at each stage of learning on solubility material and solubility product, the first stage (Stimulation), by asking students to pay attention to the pictures on the LKS and asking questions that stimulate their thinking processes. This activity is intended to encourage students to read books, think, and set goals in preparation for understanding and solving problems. This allows changes in the behavior of students to build a mental strength within themselves, generates the desire/motivation to explore information through literacy, connects prior knowledge with ideas of knowledge acquired.

The second stage (problem statement), provides an opportunity for students to identify as many problem agendas as possible that are relevant to the subject matter. This stage greatly influences understanding in formulating problems to make hypotheses. The ability of students to formulate problems and hypotheses depends on: (1) accuracy in identifying each problem from each presentation of the material at the stimulation stage, (2) the ability to understand, analyze, and relate the concepts presented, (3) the participants' thinking processes educate. The third stage (data collection), students carry out experiments or observations to collect data that is used to prove whether the hypothesis made is true or not. Student activities at this stage actively carry out experimental procedures, record observational data, and perform calculations on observed data. Through this activity, students can bring about changes in behavior by carrying out experimental activities carefully and correctly until appropriate information and data are obtained. GDL learning requires students to learn by experiencing not memorizing, so they are able to construct knowledge. Students are accustomed to solving problems, so they know what to learn and how to use the knowledge and skills acquired. According to the behavioristic view, this learning is suitable to be applied to acquire skills that require practice and habituation that contain elements of speed, spotty, and endurance (Arends, 2012) .

The fourth stage (data processing and verification), gives evaluation questions to each group as material for discussion, and asks each group to represent one of its members to read out the results and carry out joint verification. According to Skinner's view, a learning situation in which a response is made stronger due to direct reinforcement, and through continuous repetition and training can optimize the talents and intelligence of students who have been formed before (Biazus & Mahtari, 2022). With the provision of evaluation questions, it encourages students to better understand the concept and develop a mindset in analyzing questions. The GDL model provides opportunities for students to improve, expand, and apply their knowledge and skills in various activities. This helps students analyze their thinking processes and integrate newly acquired conceptual knowledge by asking them to rethink what is going on in their minds about the concept. This is in accordance with the opinion that the presentation of new problems or phenomena can direct students to carry out a more in-depth study of

Commented [MA3]: Support the claims with relevant research results a concept being studied or known as the internalization process (Muhali et al., 2019) .

The fifth stage (generalization), students make conclusions in response to the formulation of the problems that have been made. This stage directs students to be able to read data, process and interpret data, connect data with existing concepts/knowledge to construct new knowledge as decisions or answers to learning problems. This is according to Asy'ari et al. (2019) that generalization is a process of drawing conclusions to be used as general principles that apply to all the same events or problems, after going through the process or results of verification. The implementation of the GDL model in this study was carried out with group discussions, this was intended to provide a shared learning experience to produce a series of scientific process skills, construction of students' knowledge through the ideas or knowledge of other students in their group.

Students' Metacognition Skills Learned Using the GDL Model with a Concept Map Strategy

Metacognition skills are obtained from assessing the performance of students in filling out the LKPD at each meeting in each learning cycle. Data on metacognition skills in each cycle can be seen in Table 5.

Table 5. Students' Metacognition Skills in Each Cycle

Value Intervals	**Category**	**Acquisition of Students' KM Value (%)**		
		Cycle I	**Cycle II**	**Cycle III**
80 – 100	Very high	0.00	0.00	0.00
66–79	High	33,33	80.00	86,67
56–65	Enough	50.00	13,33	13,33
40 – 55	Low	16,67	6,67	0.00
30 – 39	Very low	0.00	0.00	0.00

Based on the data in Table 5, there was an increase in the scores of students' metacognition skills in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III). These results indicate that learning with the GDL model with a concept map strategy can improve students' metacognition skills. The metacognition skills achieved by students in general for each indicator have also increased, according to the data in Table 6.

Table 6. Achievement Data for Each Indicator of Metacognition Skills in Each Cycle

No.	**Metacognition Skills Indicator**	**Score and Achievement Category**					
		I	**Category**	**II**	**Category**	**III**	**Category**
1.	Formulate general and specific learning objectives	6460	Enough	73.30	High	81.30	Very high
2.	Formulate problems and hypotheses	6710	High	7292	High	7625	Tall
3.	Create a problem solving plan	6460	Enough	71.25	High	8083	Tall
4.	Carry out planning systematically	6330	Enough	71.25	High	75.00	Tall
5.	Observing the planning implementation process,	6080	Enough	6542	Enough	6958	Tall
6.	Examine the planning implementation process,	6330	Enough	6417	Enough	65.00	Enough
7.	Record or collect data	5920	Enough	61.25	Enough	6833	Tall
8.	Evaluate results	53.30	Low	5833	Enough	5958	Enough

The data in Table 6 shows that indicators 1, 3, 4, 5, 7 experienced an increase in scores from the moderate category to the high category, indicator 8 experienced an increase in scores from the low category to the sufficient category, and indicators 2 and 6 experienced an increase in scores but did not experience an increase category (high and sufficient).

Critical Thinking Ability Lessons Learned Using the GDL Model with a Concept Map Strategy

The critical thinking skills of students who are taught using the GDL model with a concept map strategy experience an increase in each learning cycle. The increase in critical thinking skills increased in the high and very high categories with percentages of 63.33% (cycle I), 76.66% (cycle II), and 86.67% (cycle III), according to the data in Table 7. Increasing the achievement of students' critical thinking skills in general occurs in all indicators as shown in the data listed in Table 8.

Table 7. Data on students' critical thinking skills in each cycle

Value Intervals	**Category**	**Acquisition of Students' KBK Value (%)**		
		Cycle I	**Cycle II**	**Cycle III**
80 – 100	Very high	0.00	3,33	6,67
66–79	Tall	63,33	73,33	80.00

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56–65	Enough	20.00	10.00	10.00
40 – 55	Low	13,33	6,67	3,33
30 – 39	Very low	3,33	6,67	0.00

Table 8. Critical Thinking Ability Data in Each Cycle

No.	Critical Thinking Ability Indicator	Scores and Achievement Categories in Cycles:					
		I	Category	II	Category	III	Category
1.	Focus	71.00	Tall	72,67	Tall	78.00	Tall
2.	Reason	69.00	Tall	72,33	Tall	77.00	Tall
3.	Inferences	68,67	Tall	69,67	Tall	72,67	Tall
4.	Situation	59,67	Enough	61,67	Enough	65,33	Enough
5.	Clarity	64.00	Enough	65,33	Enough	66.00	Tall
6.	Overview	47,33	Low	53,67	Low	56.00	Enough

The low percentage of students who scored in the high and very high categories in cycle I was caused by several things, namely: (1) students only memorized the formula and were less able to use the concepts contained in the formula, this happened due to a lack of ability to manage process of thinking that causes students to be confused when faced with different situations, (2) the teacher always gives practice questions with patterns that are easy to understand without requiring analysis, so that when students are faced with questions requiring analysis , students find it difficult in developing their knowledge and thinking skills in understanding the questions, as a result students answer at random.

GDL model can cause students to be very enthusiastic in solving problems that exist in LKPD. Activities at the problem statement stage can be seen between students arguing with each other to equalize internal perceptions, identify problems, collect information related to the problems identified so that they can critically make hypotheses correctly. The second stage of GDL learning is to train students in exploring the material to be studied, learn to generalize newly obtained information so that it helps in developing critical thinking skills.

At the data processing stage, students are serious in conducting discussions and working on questions in LKPD with their group mates. Learning in experimental class, the LKPD is designed based on the GDL model, where the steps of the learning model can help students in solving problems appropriately and directed. This is supported by the opinion of Sulistyowati et al. (2012) , The advantages of applying the GDL learning model include: (1) student involvement in maximum learning, students are guided to find concepts independently, (2) collaboration and team dynamics solve problems, create active learners in critical thinking and improve learning activities, (3) students have skills and dexterity in solving questions, (5) spurring students to be more thorough in working on questions.

Commented [MA7]: As above. Describe in more details and compare the research findings with relevant literatures

Conclusion

The current study has achieved the objective and research questions formulated, that (1) implementation of the guided discovery model with a concept map strategy can improve students' metacognition skills, seen from the increase in students' metacognition skills scores in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III); and (2) implementation of the guided discovery model with a concept map strategy can improve students' critical thinking skills, seen from the increase in critical thinking skills has increased in the high and very high categories with a percentage of 63.33% (cycle I), 76.66% (cycle II) , and 86.67% (cycle III).

For the future research, it is better if the teacher emphasizes more so that students can carry out data collection activities, process and verify data according to learning needs and problems. which will be resolved. This can make students more optimal in carrying out indicators of metacognition skills (evaluation) and critical thinking (situation and overview).

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JPPIPA 9(1) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Guided Discovery Learning Model Using Concept Map Strategy to Improve Students' Metacognition and Critical Thinking Skills

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Received:
Revised:
Accepted:
Published:

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Abstract: This study aims to improve students' metacognition and critical thinking skills in learning physics through the implementation of *the guided discovery learning model* with a concept map strategy. This research is a classroom action research, with stages: (1) planning, (2) implementation, (3) observation and evaluation, and (4) reflection. The subjects of this study were 30 students of class XI IPA MAN 3 Central Lombok. The research instrument consisted of metacognition skill assessment sheets and critical thinking tests, which were declared valid and reliable. Data analysis was carried out in a quantitative descriptive manner. The results of this study are: (1) students' metacognition skills experienced an increase in scores in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III) ; (2) students' critical thinking skills also experienced an increase in scores in the high and very high categories with a percentage of 63.33% (cycle I), 76.66% (cycle II), and 86.67% (cycle III). thus, the implementation of the guided discovery learning model with a concept map strategy can improve students' metacognition and critical thinking skills in learning physics.

Keywords: Guided Discovery Learning (GDL), Concept Maps, Metacognition Skills, Critical Thinking

Introduction

Critical thinking and metacognition are two important aspects that overlap (Asy'ari, Ikhsan, et al., 2019; Asy'ari & Rosa, 2022; Fitriani et al., 2019) , and are components of 21st century innovative skills (Muhali, 2019) , which must be taught continuously to students because it is a demand in the world of education today and in the future. Teaching both of them requires certain strategies for educators considering the many indicators of critical thinking according to experts, while metacognition in learning must take place naturally by students. Educators as a determinant of student learning success play an important and very large role in learning (Sukaisih & Muhali, 2014) , and the process of understanding students and their various ways of learning is one of the challenges (Arends, 2012) . Therefore, educators must continue to seek and find solutions in an effort to improve the quality of the learning process so that students' learning success becomes better and optimal.

Various attempts have been made by researchers to train students' critical thinking skills and metacognition by applying the *problem solving model* (Sukaisih & Muhali, 2014) , the problem solving model with cognitive conflict strategies (Sukaisih et al., 2020) , the inquiry model (Asy'ari , Ikhsan, et al., 2019) , and its development is in the form of an active inquiry-based model (Prayogi & Muhali, 2015) , as well as a

How to Cite:
Example: Susilawati, S., Doyan, A., Muliyadi, L., & Hakim, S. (2019). Growth of tin oxide thin film by aluminum and fluorine doping using spin coating Sol-Gel techniques. *Jurnal Penelitian Pendidikan IPA, 1*(1), 1-4. https://doi.org/10.29303/jjppipa.v1i1.264

metacognitive reflective learning model (Muhali et al., 2019) , which in general can improve students' critical thinking and metacognition . Along with the development of curriculum and learning at the high school/MA level, especially science learning, and the development of the characteristics of students at this time, learning is more emphasized on learning by discovery or guided discovery learning (GDL). Therefore, it is important in learning science, especially physics, to train students with GDL learning.

GDL model learning is a series of learning activities that optimally involve all students' abilities to seek and investigate systematically, critically, and logically so that they can find their own knowledge, attitudes and skills as a form of behavior change (Nasruddin et al. , 2020) . GDL in its implementation students carry out experiments or demonstrations by observing the pictures and writing down the data produced in worksheets and answering questions given by the teacher in an effort to find concepts based on the data obtained and compare with the theory contained in the module or book lesson. GDL is a model learning which in practice gives problems to students, provides guidance to students in the form of observations, and solves problems with teacher guidance, and learning is assisted by worksheets. GDL Learning in this study there were 5 stages according to Bruner (Muhali et al., 2021) , namely: (1) Stimulation , the teacher instructs students to pay attention to the pictures on the LKS and gives questions that stimulate students' critical thinking, this stage is the most important stage. appropriate to encourage students to read books and think in preparation for problem solving. (2) problem statement, the teacher gives students the opportunity to identify as many problems as possible that are relevant to the subject matter, this stage greatly influences students' understanding in formulating problems to make hypotheses (3) data collection, students conduct experiments or observations to prove whether the hypothesis is correct or not. (4) data processing and verification , the teacher gives evaluation questions to each group and performs verification together, with the provision of evaluation questions, it encourages students to better understand the concept of material (5) generalization / make conclusions , students make conclusions on the problems that have been formulated according to the data and information obtained during the discovery process.

The implementation of the GDL model in this study was integrated with the concept map strategy. Concept maps are a strategy that displays information in the form of concepts in a systematic and interconnected manner. According to Katagall (2015) , concept maps are visual representations of key ideas that are interconnected and used to show the position of the relationship between the concepts being taught so that the subject matter is easier for students to follow. Concept maps are characterized as a way of showing the concepts and propositions of a field (Baliga et al., 2021) , such as fields of study, both physics, chemistry, biology, and mathematics (Machado & Carvalho, 2020) . With a concept map students in learning can see the field of study more clearly and study it more meaningfully. Concept maps clearly show the main concepts of a material or topic and how the relationships or relationships between existing concepts. Concept map strategy in its implementation, students are asked to make concept maps and the teacher is in charge of helping students. Students are asked to freely make a concept map of a material before discussing it, students are asked to read the material at home, and in class are asked to make their own concept maps, and explain the concept maps that are made and the relationships that exist.

Based on the descriptions, the formulation of the problem in this study is how the implementation of the GDL model with a concept map strategy can improve students' critical thinking skills and metacognition in science learning? Several studies believe that the GDL model can teach conceptual understanding well and has a significant influence (Aprilia et al., 2020; Vivanti et al., 2020) , the GDL model can teach students' critical thinking skills (Batubara, 2019; Fadillah et al. al., 2018; Noer, 2018) , and the GDL model for teaching conceptual understanding and critical thinking (Muhali et al., 2021; Yuliani & Saragih, 2015) . Unfortunately, these previous studies have not identified students' metacognition skills in implementing the GDL model. Furthermore, this research does not use a concept map strategy in implementing the GDL model. Thus, the purpose of this study was to determine the increase in students' critical thinking skills and metacognition in physics learning which were taught through the GDL model with a concept map strategy.

Method

This type of research is Classroom Action Research (CAR), which is research conducted with the aim of improving students' critical thinking skills and metacognition by applying GDL learning with a concept map strategy in physics learning, especially material about Newton's Laws. The subjects of this study were 30 students of class XI IPA MAN 3 Central Lombok. This research was conducted in 3 (three) cycles with 3 (three) meetings in each research cycle. Each cycle consists of stages: (1) planning, (2) implementation, (3) observation and evaluation, and (4) reflection. The description of activities at each stage is described as follows.

Planning stage

The planning stage is an activity carried out in order to make all the preparations and completeness that support the implementation of the action. The activities carried out at this stage are: (1) compiling a GDL-based lesson plan (LP) with a concept map strategy, (2) compiling LKPD (student worksheets), (3) compiling AS (assessment sheet) of the implementation of learning, (4) preparing ASs for students' learning activities, (5) preparing instruments for assessing critical thinking skills, and (6) preparing AS instruments for metacognition skills.

Implementation stage

The implementation stage is the activity of carrying out learning in class by applying GDL-based learning with a concept map strategy with a series of activities as stated in the lesson plan. The activities carried out at this stage are: (1) the implementation of learning by educators according to the GDL-based RPP with a concept map strategy, and (2) the implementation of learning activities by students according to LKPD.

Observation and evaluation stage

This stage is the stage of monitoring and evaluating the process and results of the implementation of the action. The activities at this stage are: (1) observing and assessing the implementation of learning, (2) assessing metacognition skills according to the results of filling out the LKPD, and (3) assessing students' critical thinking skills.

Reflection stage

This stage is an activity to review the learning process that has been carried out by looking at the results of observations and evaluations that have been achieved. This activity was carried out with a team of observers (colleagues), to: (1) see the achievement of the learning process, student activities, critical thinking skills, and students' metacognition skills, (2) look for and find weaknesses in the process and results achieved, (3) seek and find solutions as alternative improvements, and (4) determine corrective solutions to be implemented in the next cycle of learning.

All of these stages are carried out in each research cycle by considering the reflection results at the end of each activity, until an indicator of learning achievement is obtained with a classical completeness percentage of 85%. The research design can be illustrated in Figure 1 as follows.

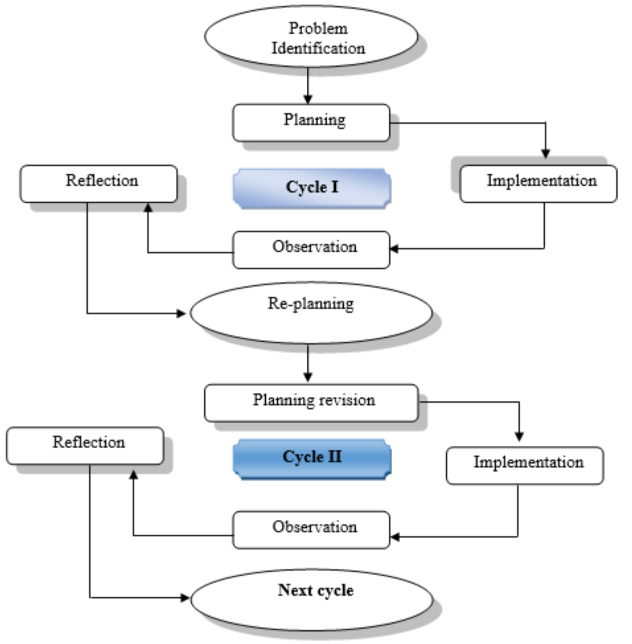

Figure 1. Flow of Classroom Action Research (CAR)

The instruments in this study included: (1) instruments for assessing the implementation of learning in the form of learning implementation AS, (2) instruments for assessing learning outcomes in the form of critical thinking skills tests, and AS for metacognition skills. Instruments for the implementation of learning include all learning activities carried out by educators listed in the lesson plans which consist of an introduction (apperception), this activity (stimulation, problem statements, data collecting, data processing and verification, and generalization), closing activities, enthusiasm in learning, and Time Allocation. The critical thinking ability instrument is a description of 6 (six) questions in each cycle containing indicators of critical thinking according to Ennis (2011), namely focus, reason, inference, situation, clarity, and overview. The metacognition skill instrument in the form of a performance appraisal sheet includes indicators according to Muhali et al. (2019) , namely formulating general and specific learning objectives, formulating problem formulations and hypotheses, planning problem solving, carrying out planning systematically, observing the process of carrying out planning in groups and individually, examining the process of carrying out planning in groups and individually, recording or collecting data, and evaluate results.

Instruments to obtain instruments that are valid and reliable so that they can be used to measure the achievement of learning processes and outcomes. Validation was carried out through the validator's assessment of 3 (three) experts in the field of science education at Mandalika University of Education. The assessment includes content and construct validity (r_a)

and reliability (*Cronbach's Alpha, a*), validation results are analyzed with the equation according to Malhotra (Muhali et al., 2020) , and the results of the analysis are listed in Table 1.

Table 1. Research Instrument Validation Results

No.	Instrument	Validity Value (r_{α}) and Reliability (α)				r_{table}
		Fill	α	Construct	α	
1	LP of Learning Implementation	0.751	0.858	0.739	0849	0.497
2	Metacognition Skills LP	0.793	0.884	0.840	0.913	0.532
3	Critical Thinking Ability Test	0.746	0.855	0.839	0.912	0.532

Data collection techniques were carried out using observation techniques, performance appraisals, and tests. Observation techniques to obtain data on the implementation of learning at each meeting conducted by observers using the LP on the implementation of learning, by giving a mark (√) in the score column for each activity according to what is observed. Performance appraisal techniques are used to obtain student performance data during carrying out learning activities at each meeting, carried out by the assessment team (teachers and observers involved) at each meeting from the results of filling in the LKPD. The assessment is carried out with reference to the LP's metacognitive skills, and the results of the assessment are data on students' metacognitive skills. The test technique for obtaining data on students' critical thinking skills is carried out at the end of each cycle, and is then evaluated by referring to the grid of questions, and the scores obtained are data on students' critical thinking abilities.

Analysis of learning implementation data was obtained in the form of scores with a range of 1–4, with categories 1 = not good, 2 = not good, 3 = good, and 4 = very good. The score for each aspect obtained from all the meetings that have been carried out in each cycle, the average is calculated, then interpreted in the form of a score as follows.

Table 2. Average Score Interval and Learning Implementation Criteria (Ratumanan & Laurens, 2011)

Average score interval	Average score criteria
1.00 – 1.8	Not good (K)
1.9– 2.7	Good enough (C)
2.8 – 3.6	Good (B)
>3,6	Very good (SB)

Learning success is achieved if a score is obtained for all activities in each cycle of 85% in the good and very good categories (Muhali, 2018). Data analysis of students' critical thinking skills (CBC) and metacognition skills (KM) of students is carried out using the following equation.

$$CBC\ or\ KM = \frac{Score\ obtained}{Maximum\ score} x100$$

The scores obtained are then grouped according to criteria and categories as shown in the following table.

Table 3. Criteria and Categories of Students' Critical Thinking Ability and Metacognition Skills (Muhali et al., 2019)

Mark	Category
80 – 100	Very high
66–79	High
56–65	Enough
40 – 55	Low
30 – 39	Very low

Students' critical thinking skills and metacognition skills are said to be successful in learning if ≥ 85% of students get scores in the high and very high categories (Muhali et al., 2019) .

Result and Discussion

The results of this study consist of the implementation of learning using the GDL model with concept map strategies, metacognition skills, and students' critical thinking skills which are presented in each cycle, described in full as follows.

Implementation of Learning Using the GDL Model with a Concept Map Strategy

Data on the implementation of learning was obtained from the results of peer observations on the implementation of a series of learning activities that had been listed in the GDL-based lesson plan using a concept map strategy. The complete observation results are listed in Table 4.

Table 4. Learning Implementation Data in Each Cycle

No.	Steps/Learning Activities	Average and Category of Learning Implementation in cycle to:					
		I	Category	II	Category	III	Category
1.	apperception	3.00	B	3.50	B	4.00	SB
2.	Stimulation	3.00	B	3.00	B	4.00	SB

No.	Steps/Learning Activities	Average and Category of Learning Implementation in cycle to:					
		I	Category	II	Category	III	Category
3.	Formulation of the problem	2.75	CB	3.00	B	4.00	SB
4.	Collecting data	2.67	CB	2.75	CB	3.00	B
5.	Processing and Data Verification	2.50	CB	2.83	B	2.83	B
6.	Generalization	3.00	B	3.50	B	4.00	SB
7.	Closing activities	4.00	SB	4.00	SB	4.00	SB
8.	Enthusiasm	3.50	B	3.50	B	3.50	B
9.	Time Allocation	2.50	CB	3.00	B	3.00	B
	Average	**2.99**	**B**	**3.23**	**B**	**3.59**	**B**

Information: *SB = Very Good, B = Good, and CB = Fairly Good.*

The implementation of the GDL model with the concept map strategy in learning in each cycle experienced an increase in the average score of cycle I = 2.99, cycle II = 3.23, and cycle III = 3.59, but all three were in the good category. The percentage of learning implementation according to Table 4 above, in cycle I was 55.56%, cycles II and III were 88.89% and 100% in the good and very good categories. This means that in general the GDL model with a concept map strategy can be implemented properly in learning physics. This learning requires students to learn through a series of scientific processes by formulating problems, making hypotheses, conducting experiments in order to collect data, process and analyze data, and draw conclusions as a form of justification for the final decision. This is in accordance with the opinion of Arends (2012) and Fitriani et al. (2022) , through GDL students learn to find patterns in various concrete and abstract situations so that they can explain and predict the additional information presented. Yerimadesi et al. (2022) stated that GDL helps students develop readiness and mastery of skills in cognitive processes. Furthermore, Yuliani and Saragih (2015) state that the GDL model is a model by presenting questions or problems to direct students to think, observe, formulate conjectures, explain and analyze in discovering new knowledge. In line with this opinion, Fadillah et al. (2018) states that students' explanatory abilities can grow and develop after going through the stages of stimulation or giving stimulation, identifying problems, collecting and processing data as well as verification and generalization as stages in implementing the GDL learning model.

Implementation of the GDL model at each stage of learning on solubility material and solubility product, the first stage (Stimulation), by asking students to pay attention to the pictures on the LKS and asking questions that stimulate their thinking processes. This activity is intended to encourage students to read books, think, and set goals in preparation for understanding and solving problems. This allows changes in the behavior of students to build a mental strength within themselves, generates the desire/motivation to explore information through literacy, connects prior knowledge with ideas of knowledge acquired. The GDL learning model has a close relationship with the process of understanding, which is a mental construction, an abstraction created by the human mind for a number of reasons to different knowledge (Vivanti et al., 2020). A person's learning is more complex because of his involvement in other types of learning that require connection of ideas, analysis and analysis (Schunk, 2012). Thorndike's view of behavioristic theory, learning is the process of forming connections between stimulus and response (output) so that it is important in learning (Woolfolk Hoy et al., 2013).

The second stage (problem statement), provides an opportunity for students to identify as many problem agendas as possible that are relevant to the subject matter. This stage greatly influences understanding in formulating problems to make hypotheses. The ability of students to formulate problems and hypotheses depends on: (1) accuracy in identifying each problem from each presentation of the material at the stimulation stage, (2) the ability to understand, analyze, and relate the concepts presented, (3) the participants' thinking processes educate. The third stage (data collection), students carry out experiments or observations to collect data that is used to prove whether the hypothesis made is true or not. Student activities at this stage actively carry out experimental procedures, record observational data, and perform calculations on observed data. Through this activity, students can bring about changes in behavior by carrying out experimental activities carefully and correctly until appropriate information and data are obtained. GDL learning requires students to learn by experiencing not memorizing, so they are able to construct knowledge. Students are accustomed to solving problems, so they know what to learn and how to use the knowledge and skills acquired. According to the behavioristic view, this learning is suitable to be applied to acquire skills that require practice and habituation that contain elements of speed, spotty, and endurance (Arends, 2012) .

The fourth stage (data processing and verification), gives evaluation questions to each group as material for discussion, and asks each group to represent one of its members to read out the results and carry out joint verification. According to Skinner's view, a learning situation in which a response is made stronger due to direct reinforcement, and through continuous repetition and training can optimize the talents and intelligence of students who have been formed before (Biazus & Mahtari, 2022). With the provision of evaluation questions, it encourages students to better understand the concept and develop a mindset in analyzing questions. The GDL model provides opportunities for students to improve, expand, and apply their knowledge and skills in various activities. This helps students analyze their thinking processes and integrate newly acquired conceptual knowledge by asking them to rethink what is going on in their minds about the concept. This is in accordance with the opinion that the presentation of new problems or phenomena can direct students to carry out a more in-depth study of a concept being studied or known as the internalization process (Muhali et al., 2019) .

The fifth stage (generalization), students make conclusions in response to the formulation of the problems that have been made. This stage directs students to be able to read data, process and interpret data, connect data with existing concepts/knowledge to construct new knowledge as decisions or answers to learning problems. This is according to Asy'ari et al. (2019) that generalization is a process of drawing conclusions to be used as general principles that apply to all the same events or problems, after going through the process or results of verification.

The implementation of the GDL model in this study was carried out with group discussions, this was intended to provide a shared learning experience to produce a series of scientific process skills, construction of students' knowledge through the ideas or knowledge of other students in their group. This is consistent with social learning theory that a person's continuous reciprocal interaction behavior occurs between cognitive, behavioral and environmental determinants, a person and his environment are reciprocal determinants of one another (Cilliers, 2021). Hogan and Sherman (2020) state that although a person has been able to learn from direct experience, much more can be learned through observing the behavior of other people. Behavior is learned by individuals through interaction with the environment, and their personality development depends on this interaction (Horsburgh & Ippolito, 2018). According to Bandura's view, a person's behavior can be predicted and modified through learning principles by paying attention to thinking skills and social interaction, cognitive factors become internal factors and the environment as external factors in the learning process to modify behavior, and these behaviors color social interactions in their environment (Deaton , 2015). Thus, a person is not merely an object that is influenced by the environment, but also influences the environment. The group learning method encourages students to find their own way of solving a problem, to express their ideas, and to be involved in creating their school environment (Lesilolo, 2018).

Students' Metacognition Skills Learned Using the GDL Model with a Concept Map Strategy

Metacognition skills are obtained from assessing the performance of students in filling out the LKPD at each meeting in each learning cycle. Data on metacognition skills in each cycle can be seen in Table 5.

Table 5. Students' Metacognition Skills in Each Cycle

Value Intervals	Category	Acquisition of Students' KM Value (%)		
		Cycle I	Cycle II	Cycle III
80 – 100	Very high	0.00	0.00	0.00
66–79	High	33,33	80.00	86,67
56–65	Enough	50.00	13,33	13,33
40 – 55	Low	16,67	6,67	0.00
30 – 39	Very low	0.00	0.00	0.00

Based on the data in Table 5, there was an increase in the scores of students' metacognition skills in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III). These results indicate that learning with the GDL model with a concept map strategy can improve students' metacognition skills. The metacognition skills achieved by students in general for each indicator have also increased, according to the data in Table 6.

Table 6. Achievement Data for Each Indicator of Metacognition Skills in Each Cycle

No.	Metacognition Skills Indicator	Score and Achievement Category					
		I	Category	II	Category	III	Category
1.	Formulate general and specific learning objectives	6460	Enough	73.30	High	81.30	Very high
2.	Formulate problems and hypotheses	6710	High	7292	High	7625	Tall
3.	Create a problem solving plan	6460	Enough	71.25	High	8083	Tall

4.	Carry out planning systematically	6330	Enough	71.25	High	75.00	Tall
5.	Observing the planning implementation process,	6080	Enough	6542	Enough	6958	Tall
6.	Examine the planning implementation process,	6330	Enough	6417	Enough	65.00	Enough
7.	Record or collect data	5920	Enough	61.25	Enough	6833	Tall
8.	Evaluate results	53.30	Low	5833	Enough	5958	Enough

The data in Table 6 shows that indicators 1, 3, 4, 5, 7 experienced an increase in scores from the moderate category to the high category, indicator 8 experienced an increase in scores from the low category to the sufficient category, and indicators 2 and 6 experienced an increase in scores but did not experience an increase category (high and sufficient). These results are consistent with previous studies which found that the metacognition skills of students who were taught by discovery learning were better than those not taught by the discovery learning model (Wirzal et al., 2022) on indicators of planning, monitoring, and evaluation (Jaya et al., 2018). Planning skills require students to describe knowledge that is relevant to the problem, identify learning objectives, plan and organize reference sources and the time needed to solve problems (Delvecchio, 2011). Students' skills in monitoring can be improved with training and practice (Schraw et al., 2012).

The discovery learning model is facilitated to develop evaluation skills for students through its syntax, in particular verification can encourage students to carry out activities to seek the truth of their findings from various learning sources so that students indirectly evaluate especially if the findings do not match expectations. The final part as a form of evaluation effort is that someone with good metacognitive skills always changes their study habits and strategies when necessary, possibly due to a mismatch with the demands of their environment (Branigan & Donaldson, 2020).

Critical Thinking Ability Lessons Learned Using the GDL Model with a Concept Map Strategy

The critical thinking skills of students who are taught using the GDL model with a concept map strategy experience an increase in each learning cycle. The increase in critical thinking skills increased in the high and very high categories with percentages of 63.33% (cycle I), 76.66% (cycle II), and 86.67% (cycle III), according to the data in Table 7. Increasing the achievement of students' critical thinking skills in general occurs in all indicators as shown in the data listed in Table 8.

Table 7. Data on students' critical thinking skills in each cycle

Value Intervals	Category	Acquisition of Students' KBK Value (%)		
		Cycle I	Cycle II	Cycle III
80 – 100	Very high	0.00	3,33	6,67
66–79	Tall	63,33	73,33	80.00
56–65	Enough	20.00	10.00	10.00
40 – 55	Low	13,33	6,67	3,33
30 – 39	Very low	3,33	6,67	0.00

Table 8. Critical Thinking Ability Data in Each Cycle

No.	Critical Thinking Ability Indicator	Scores and Achievement Categories in Cycles:					
		I	Category	II	Category	III	Category
1.	Focus	71.00	Tall	72,67	Tall	78.00	Tall
2.	Reason	69.00	Tall	72,33	Tall	77.00	Tall
3.	Inferences	68,67	Tall	69,67	Tall	72,67	Tall
4.	Situation	59,67	Enough	61,67	Enough	65,33	Enough
5.	Clarity	64.00	Enough	65,33	Enough	66.00	Tall
6.	Overview	47,33	Low	53,67	Low	56.00	Enough

The low percentage of students who scored in the high and very high categories in cycle I was caused by several things, namely: (1) students only memorized the formula and were less able to use the concepts contained in the formula, this happened due to a lack of ability to manage process of thinking that causes students to be confused when faced with different situations, (2) the teacher always gives practice questions with patterns that are easy to understand without requiring analysis, so that when students are faced with questions requiring analysis , students find it difficult in developing their knowledge and thinking skills in understanding the questions, as a result students answer at random. In line with this statement, several previous research opinions stated that experiences or learning that provide opportunities for students to acquire skills in problem solving can stimulate students' critical thinking skills (Verawati et al., 2022). Meanwhile, to be able to think critically, students must be able to identify, construct, and evaluate arguments (Bilad et al., 2022).

The application of the GDL model can cause students to be very enthusiastic in solving problems that exist in LKS. Activities at the problem statement stage can be seen between students arguing with each other to equalize perceptions, identify problems, collect information related to the problems identified so that they can critically make hypotheses correctly. The second stage of GDL learning is to train students in exploring the material to be studied, learn to generalize newly obtained information so that it helps in developing critical thinking skills. The use of GDL learning can facilitate initial knowledge, so that students can develop thinking skills and cultivate a scientific attitude in a better direction (Noer, 2018). The GDL learning model presents questions or problems so students can think, observe, make conjectures, explain and analyze in finding new knowledge (Yuliani & Saragih, 2015).

At the data processing stage, students are serious in conducting discussions and working on questions on LKS with their group mates. Learning in the experimental class, the LKS is designed based on the GDL model, where the steps of the learning model can assist students in solving problems appropriately and directed. This is supported by the opinion of Sulistyowati et al. (2012), the advantages of applying the GDL learning model include: (1) student involvement in maximum learning, students are guided to find concepts independently, (2) there is cooperation and team dynamics in solving problems, making students active in critical thinking and increasing learning activities, (3) students have skills and dexterity in solving problems, (5) spurring students to be more thorough in working on problems. Student problem statement stage

GDL learning provides opportunities for students to design, find out, find new concepts and reconstruct new knowledge in their minds through data collecting and verification activities, with an emphasis on student group activities, meaning that social systems are very important to foster uniformity in cognitive and skills as behavior change. Social intelligence helps students to interact more (Williams et al., 2022). Zeldin (2000) states that by observing other people's success, student participants can evaluate their own abilities, so that the process of self-confidence can develop. Social intelligence is a person's ability to understand and manage to act wisely in relation to other people (Zautra et al., 2015). This is in accordance with Vygotsky's constructivism learning expert who stated that social interaction can encourage the formation of new ideas and enrich intellectual development (Hidayat & Evendi, 2022).

The GDL model trains students in carrying out the generalization process or making conclusions on what has been observed and obtained during data collecting and verification. This can directly train students in the inference aspect which is an important part of critical thinking skills. In line with this opinion, Sambudi et al. (2023) stated that concluding activities are abilities that require students to be able to identify the elements needed in making logical conclusions, formulate conjectures and hypotheses and consider relevant information.

Conclusion

The current study has achieved the objective and research questions formulated, that (1) implementation of the guided discovery model with a concept map strategy can improve students' metacognition skills, seen from the increase in students' metacognition skills scores in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III); and (2) implementation of the guided discovery model with a concept map strategy can improve students' critical thinking skills, seen from the increase in critical thinking skills has increased in the high and very high categories with a percentage of 63.33% (cycle I), 76.66% (cycle II) , and 86.67% (cycle III).

For the future research, it is better if the teacher emphasizes more so that students can carry out data collection activities, process and verify data according to learning needs and problems. which will be resolved. This can make students more optimal in carrying out indicators of metacognition skills (evaluation) and critical thinking (situation and overview).

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JPPIPA 9(1) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Guided Discovery Learning Model Using Concept Map Strategy to Improve Students' Metacognition and Critical Thinking Skills

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Received: November 28, 2022
Revised: January 25, 2023
Accepted: January 29, 2023
Published: January 31, 2023

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DOI: 10.29303/jppipa.v9i1.3868

Abstract: This study aims to improve students' metacognition and critical thinking skills in learning physics through the implementation of *the guided discovery learning model* with a concept map strategy. This research is a classroom action research, with stages: (1) planning, (2) implementation, (3) observation and evaluation, and (4) reflection. The subjects of this study were 30 students of class XI IPA MAN 3 Central Lombok. The research instrument consisted of metacognition skill assessment sheets and critical thinking tests, which were declared valid and reliable. Data analysis was carried out in a quantitative descriptive manner. The results of this study are: (1) students' metacognition skills experienced an increase in scores in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III) ; (2) students' critical thinking skills also experienced an increase in scores in the high and very high categories with a percentage of 63.33% (cycle I), 76.66% (cycle II), and 86.67% (cycle III). thus, the implementation of the guided discovery learning model with a concept map strategy can improve students' metacognition and critical thinking skills in learning physics.

Keywords: Critical Thinking; Concept Maps; Guided Discovery Learning (GDL); Metacognition Skills

Introduction

Critical thinking and metacognition are two important aspects that overlap (Asy'ari, Ikhsan, et al., 2019; Asy'ari & Rosa, 2022; Fitriani et al., 2019) , and are components of 21st century innovative skills (Muhali, 2019) , which must be taught continuously to students because it is a demand in the world of education today and in the future. Teaching both of them requires certain strategies for educators considering the many indicators of critical thinking according to experts, while metacognition in learning must take place naturally by students. Educators as a determinant of student learning success play an important and very large role in learning (Sukaisih & Muhali, 2014) , and the process of understanding students and their various ways of learning is one of the challenges (Arends, 2012) . Therefore, educators must continue to seek and find solutions in an effort to improve the quality of the learning process so that students' learning success becomes better and optimal.

Various attempts have been made by researchers to train students' critical thinking skills and metacognition by applying the *problem solving model* (Sukaisih & Muhali, 2014) , the problem solving model with cognitive conflict strategies (Sukaisih et al., 2020) , the inquiry model (Asy'ari , Ikhsan, et al., 2019) , and its development is in the form of an active inquiry-based model (Prayogi & Muhali, 2015) , as well as a metacognitive reflective learning model (Muhali et al., 2019) , which in general can improve students' critical thinking and metacognition . Along with the development of curriculum and learning at the high school/MA level, especially science learning, and the development of the characteristics of students at this time, learning is more emphasized on learning by

How to Cite:
Muhali, M., & Sukaisih, R. (2023). Guided Discovery Learning Model Using Concept Map Strategy to Improve Students' Metacognition and Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 554–563. https://doi.org/10.29303/jppipa.v9i1.3868

discovery or guided discovery learning (GDL). Therefore, it is important in learning science, especially physics, to train students with GDL learning.

GDL model learning is a series of learning activities that optimally involve all students' abilities to seek and investigate systematically, critically, and logically so that they can find their own knowledge, attitudes and skills as a form of behavior change (Nasruddin et al. , 2020) . GDL in its implementation students carry out experiments or demonstrations by observing the pictures and writing down the data produced in worksheets and answering questions given by the teacher in an effort to find concepts based on the data obtained and compare with the theory contained in the module or book lesson. GDL is a model learning which in practice gives problems to students, provides guidance to students in the form of observations, and solves problems with teacher guidance, and learning is assisted by worksheets. GDL Learning in this study there were 5 stages according to Bruner (Muhali et al., 2021) , namely: (1) Stimulation , the teacher instructs students to pay attention to the pictures on the LKS and gives questions that stimulate students' critical thinking, this stage is the most important stage. appropriate to encourage students to read books and think in preparation for problem solving. (2) problem statement, the teacher gives students the opportunity to identify as many problems as possible that are relevant to the subject matter, this stage greatly influences students' understanding in formulating problems to make hypotheses (3) data collection, students conduct experiments or observations to prove whether the hypothesis is correct or not. (4) data processing and verification, the teacher gives evaluation questions to each group and performs verification together, with the provision of evaluation questions, it encourages students to better understand the concept of material (5) generalization/make conclusions, students make conclusions on the problems that have been formulated according to the data and information obtained during the discovery process.

The implementation of the GDL model in this study was integrated with the concept map strategy. Concept maps are a strategy that displays information in the form of concepts in a systematic and interconnected manner. According to Katagall (2015) , concept maps are visual representations of key ideas that are interconnected and used to show the position of the relationship between the concepts being taught so that the subject matter is easier for students to follow. Concept maps are characterized as a way of showing the concepts and propositions of a field (Baliga et al., 2021) , such as fields of study, both physics, chemistry, biology, and mathematics (Machado & Carvalho, 2020) . With a concept map students in learning can see the field of study more clearly and study it more meaningfully. Concept maps clearly show the main concepts of a material or topic and how the relationships or relationships between existing concepts. Concept map strategy in its implementation, students are asked to make concept maps and the teacher is in charge of helping students. Students are asked to freely make a concept map of a material before discussing it, students are asked to read the material at home, and in class are asked to make their own concept maps, and explain the concept maps that are made and the relationships that exist.

Based on the descriptions, the formulation of the problem in this study is how the implementation of the GDL model with a concept map strategy can improve students' critical thinking skills and metacognition in science learning? Several studies believe that the GDL model can teach conceptual understanding well and has a significant influence (Aprilia et al., 2020; Vivanti et al., 2020) , the GDL model can teach students' critical thinking skills (Batubara, 2019; Fadillah et al. al., 2018; Noer, 2018) , and the GDL model for teaching conceptual understanding and critical thinking (Muhali et al., 2021; Yuliani & Saragih, 2015) . Unfortunately, these previous studies have not identified students' metacognition skills in implementing the GDL model. Furthermore, this research does not use a concept map strategy in implementing the GDL model. Thus, the purpose of this study was to determine the increase in students' critical thinking skills and metacognition in physics learning which were taught through the GDL model with a concept map strategy.

Method

This type of research is Classroom Action Research (CAR), which is research conducted with the aim of improving students' critical thinking skills and metacognition by applying GDL learning with a concept map strategy in physics learning, especially material about Newton's Laws. The subjects of this study were 30 students of class XI IPA MAN 3 Central Lombok. This research was conducted in 3 (three) cycles with 3 (three) meetings in each research cycle. Each cycle consists of stages: (1) planning, (2) implementation, (3) observation and evaluation, and (4) reflection. The description of activities at each stage is described as follows.

Planning stage

The planning stage is an activity carried out in order to make all the preparations and completeness that support the implementation of the action. The activities carried out at this stage are: (1) compiling a GDL-based lesson plan (LP) with a concept map strategy, (2) compiling LKPD (student worksheets), (3) compiling AS (assessment sheet) of the implementation of learning, (4) preparing ASs for students' learning activities, (5) preparing instruments for assessing critical thinking skills, and (6) preparing AS instruments for metacognition skills.

Implementation stage

The implementation stage is the activity of carrying out learning in class by applying GDL-based learning with a concept map strategy with a series of activities as stated in the lesson plan. The activities carried out at this stage are: (1) the implementation of learning by educators according to the GDL-based RPP with a concept map strategy, and (2) the implementation of learning activities by students according to LKPD.

Observation and evaluation stage

This stage is the stage of monitoring and evaluating the process and results of the implementation of the action. The activities at this stage are: (1) observing and assessing the implementation of learning, (2) assessing metacognition skills according to the results of filling out the LKPD, and (3) assessing students' critical thinking skills.

Reflection stage

This stage is an activity to review the learning process that has been carried out by looking at the results of observations and evaluations that have been achieved. This activity was carried out with a team of observers (colleagues), to: (1) see the achievement of the learning process, student activities, critical thinking skills, and students' metacognition skills, (2) look for and find weaknesses in the process and results achieved, (3) seek and find solutions as alternative improvements, and (4) determine corrective solutions to be implemented in the next cycle of learning.

All of these stages are carried out in each research cycle by considering the reflection results at the end of each activity, until an indicator of learning achievement is obtained with a classical completeness percentage of 85%. The research design can be illustrated in Figure 1.

The instruments in this study included: (1) instruments for assessing the implementation of learning in the form of learning implementation AS, (2) instruments for assessing learning outcomes in the form of critical thinking skills tests, and AS for metacognition skills. Instruments for the implementation of learning include all learning activities carried out by educators listed in the lesson plans which consist of an introduction (apperception), this activity (stimulation, problem statements, data collecting, data processing and verification, and generalization), closing activities, enthusiasm in learning, and Time Allocation. The critical thinking ability instrument is a description of 6 (six) questions in each cycle containing indicators of critical thinking according to Ennis (2011), namely focus, reason, inference, situation, clarity, and overview. The metacognition skill instrument in the form of a performance appraisal sheet includes indicators according to Muhali et al. (2019) , namely formulating general and specific learning objectives, formulating problem formulations and hypotheses, planning problem solving, carrying out planning systematically, observing the process of carrying out planning in groups and individually, examining the process of carrying out planning in groups and individually, recording or collecting data, and evaluate results.

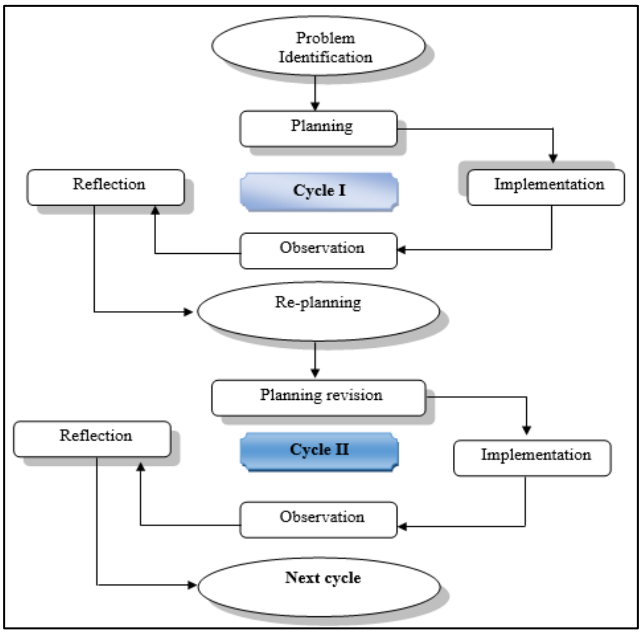

Figure 1. Flow of Classroom Action Research (CAR)

Instruments to obtain instruments that are valid and reliable so that they can be used to measure the achievement of learning processes and outcomes. Validation was carried out through the validator's assessment of 3 (three) experts in the field of science education at Mandalika University of Education. The assessment includes content and construct validity ($r_α$) and reliability (*Cronbach's Alpha, a*), validation results are analyzed with the equation according to Malhotra (Muhali et al., 2020) , and the results of the analysis are listed in Table 1.

Table 1. Research Instrument Validation Results

Instrument	Validity Value ($r_α$) and Reliability (α)				r_{table}
	Fill	α	Construct	α	
LP of Learning Implementation	0.751	0.858	0.739	0849	0.497
Metacognition Skills LP	0.793	0.884	0.840	0.913	0.532
Critical Thinking Ability Test	0.746	0.855	0.839	0.912	0.532

Data collection techniques were carried out using observation techniques, performance appraisals, and tests. Observation techniques to obtain data on the implementation of learning at each meeting conducted by observers using the LP on the implementation of learning, by giving a mark (√) in the score column for each activity according to what is observed. Performance appraisal techniques are used to obtain student performance data during carrying out learning activities at each meeting, carried out by the assessment team (teachers and observers involved) at each meeting from the results of filling in the LKPD. The assessment is carried out with reference to the LP's metacognitive skills, and the results of the assessment are data on students' metacognitive skills. The test technique for obtaining data on students' critical thinking skills is carried out at the end of each cycle, and is then evaluated by referring to the grid of questions, and the scores obtained are data on students' critical thinking abilities.

Analysis of learning implementation data was obtained in the form of scores with a range of 1–4, with categories 1 = not good, 2 = not good, 3 = good, and 4 = very good. The score for each aspect obtained from all the meetings that have been carried out in each cycle, the average is calculated, then interpreted in the form of a score as Table 2.

Table 2. Average Score Interval and Learning Implementation Criteria (Ratumanan & Laurens, 2011)

Average score interval	Average score criteria
1.00 – 1.8	Not good (K)
1.9– 2.7	Good enough (C)
2.8 – 3.6	Good (B)
>3,6	Very good (SB)

Learning success is achieved if a score is obtained for all activities in each cycle of 85% in the good and very good categories (Muhali, 2018). Data analysis of students' critical thinking skills (CBC) and metacognition skills (KM) of students is carried out using the Equation 1.

$$CBC\ or\ KM = \frac{Score\ obtained}{Maximum\ score} x100 \quad (1)$$

The scores obtained are then grouped according to criteria and categories as shown in the following table.

Table 3. Criteria and Categories of Students' Critical Thinking Ability and Metacognition Skills (Muhali et al., 2019)

Mark	Category
80 – 100	Very high
66–79	High
56–65	Enough
40 – 55	Low
30 – 39	Very low

Students' critical thinking skills and metacognition skills are said to be successful in learning if ≥ 85% of students get scores in the high and very high categories (Muhali et al., 2019) .

Result and Discussion

The results of this study consist of the implementation of learning using the GDL model with concept map strategies, metacognition skills, and students' critical thinking skills which are presented in each cycle, described in full as follows.

Implementation of Learning Using the GDL Model with a Concept Map Strategy

Data on the implementation of learning was obtained from the results of peer observations on the implementation of a series of learning activities that had been listed in the GDL-based lesson plan using a concept map strategy. The complete observation results are listed in Table 4.

Table 4. Learning Implementation Data in Each Cycle

Steps/Learning Activities	Average and Category of Learning Implementation in cycle to:					
	I	Category	II	Category	III	Category
apperception	3.00	B	3.50	B	4.00	SB
Stimulation	3.00	B	3.00	B	4.00	SB
Formulation of the problem	2.75	CB	3.00	B	4.00	SB
Collecting data	2.67	CB	2.75	CB	3.00	B
Processing and Data Verification	2.50	CB	2.83	B	2.83	B
Generalization	3.00	B	3.50	B	4.00	SB
Closing activities	4.00	SB	4.00	SB	4.00	SB
Enthusiasm	3.50	B	3.50	B	3.50	B
Time Allocation	2.50	CB	3.00	B	3.00	B
Average	2.99	B	3.23	B	3.59	B

Information: *SB = Very Good, B = Good, and CB = Fairly Good.*

The implementation of the GDL model with the concept map strategy in learning in each cycle experienced an increase in the average score of cycle I = 2.99, cycle II = 3.23, and cycle III = 3.59, but all three were in the good category. The percentage of learning implementation according to Table 4 above, in cycle I was 55.56%, cycles II and III were 88.89% and 100% in the good and very good categories. This means that in general the GDL model with a concept map strategy can be implemented properly in learning physics. This learning requires students to learn through a series of scientific processes by formulating problems, making hypotheses, conducting experiments in order to collect data, process and analyze data, and draw conclusions as a form of justification for the final decision. This is in accordance with the opinion of Arends (2012) and Fitriani et al. (2022) , through GDL students learn to find patterns in various concrete and abstract situations so that they can explain and predict the additional information presented. Yerimadesi et al. (2022) stated that GDL helps students develop readiness and mastery of skills in cognitive processes. Furthermore, Yuliani and Saragih (2015) state that the GDL model is a model by presenting questions or problems to direct students to think, observe, formulate conjectures, explain and analyze in discovering new knowledge. In line with this opinion, Fadillah et al. (2018) states that students' explanatory abilities can grow and develop after going through the stages of stimulation or giving stimulation, identifying problems, collecting and processing data as well as verification and generalization as stages in implementing the GDL learning model.

Implementation of the GDL model at each stage of learning on solubility material and solubility product, the first stage (Stimulation), by asking students to pay attention to the pictures on the LKS and asking questions that stimulate their thinking processes. This activity is intended to encourage students to read books, think, and set goals in preparation for understanding and solving problems. This allows changes in the behavior of students to build a mental strength within themselves, generates the desire/motivation to explore information through literacy, connects prior knowledge with ideas of knowledge acquired. The GDL learning model has a close relationship with the process of understanding, which is a mental construction, an abstraction created by the human mind for a number of reasons to different knowledge (Vivanti et al., 2020). A person's learning is more complex because of his involvement in other types of learning that require connection of ideas, analysis and analysis (Schunk, 2012). Thorndike's view of behavioristic theory, learning is the process of forming connections between stimulus and response (output) so that it is important in learning (Woolfolk Hoy et al., 2013).

The second stage (problem statement), provides an opportunity for students to identify as many problem agendas as possible that are relevant to the subject matter. This stage greatly influences understanding in formulating problems to make hypotheses. The ability of students to formulate problems and hypotheses depends on: (1) accuracy in identifying each problem from each presentation of the material at the stimulation stage, (2) the ability to understand, analyze, and relate the concepts presented, (3) the participants' thinking processes educate. The third stage (data collection), students carry out experiments or observations to collect data that is used to prove whether the hypothesis made is true or not. Student activities at this stage actively carry out experimental procedures, record observational data, and perform calculations on observed data. Through this activity, students can bring about changes in behavior by carrying out experimental activities carefully and correctly until appropriate information and data are obtained. GDL learning requires students to learn by experiencing not memorizing, so they are able to construct knowledge. Students are accustomed to solving problems, so they know what to learn and how to use the knowledge and skills acquired. According to the behavioristic view, this learning is suitable to be applied to acquire skills that require practice and habituation that contain elements of speed, spotty, and endurance (Arends, 2012) .

The fourth stage (data processing and verification), gives evaluation questions to each group as material for discussion, and asks each group to represent one of its members to read out the results and carry out joint verification. According to Skinner's view, a learning situation in which a response is made stronger due to direct reinforcement, and through continuous repetition and training can optimize the talents and intelligence of students who have been formed before (Biazus & Mahtari, 2022). With the provision of evaluation questions, it encourages students to better understand the concept and develop a mindset in analyzing questions. The GDL model provides opportunities for students to improve, expand, and apply their knowledge and skills in various activities. This helps students analyze their thinking processes and integrate newly acquired conceptual knowledge by asking them to rethink what is going on in their minds about the concept. This is in accordance with the opinion that the presentation of new problems or phenomena can direct students to carry out a more in-depth study of a concept being studied or known as the internalization process (Muhali et al., 2019) .

The fifth stage (generalization), students make conclusions in response to the formulation of the problems that have been made. This stage directs students to be able to read data, process and interpret data, connect data with existing concepts/knowledge to construct new knowledge as decisions or answers to learning problems. This is according to Asy'ari et al. (2019) that generalization is a process of drawing conclusions to be used as general principles that apply to all the same events or problems, after going through the process or results of verification.

The implementation of the GDL model in this study was carried out with group discussions, this was intended to provide a shared learning experience to produce a series of scientific process skills, construction of students' knowledge through the ideas or knowledge of other students in their group. This is consistent with social learning theory that a person's continuous reciprocal interaction behavior occurs between cognitive, behavioral and environmental determinants, a person and his environment are reciprocal determinants of one another (Cilliers, 2021). Hogan and Sherman (2020) state that although a person has been able to learn from direct experience, much more can be learned through observing the behavior of other people. Behavior is learned by individuals through interaction with the environment, and their personality development depends on this interaction (Horsburgh & Ippolito, 2018). According to Bandura's view, a person's behavior can be predicted and modified through learning principles by paying attention to thinking skills and social interaction, cognitive factors become internal factors and the environment as external factors in the learning process to modify behavior, and these behaviors color social interactions in their environment (Deaton , 2015). Thus, a person is not merely an object that is influenced by the environment, but also influences the environment. The group learning method encourages students to find their own way of solving a problem, to express their ideas, and to be involved in creating their school environment (Lesilolo, 2018).

Students' Metacognition Skills Learned Using the GDL Model with a Concept Map Strategy

Metacognition skills are obtained from assessing the performance of students in filling out the LKPD at each meeting in each learning cycle. Data on metacognition skills in each cycle can be seen in Table 5.

Table 5. Students' Metacognition Skills in Each Cycle

Value Intervals	Category	Acquisition of Students' KM Value (%)		
		Cycle I	Cycle II	Cycle III
80 – 100	Very high	0.00	0.00	0.00
66–79	High	33.33	80.00	86.67
56–65	Enough	50.00	13.33	13.33
40 – 55	Low	16.67	6.67	0.00
30 – 39	Very low	0.00	0.00	0.00

Based on the data in Table 5, there was an increase in the scores of students' metacognition skills in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III). These results indicate that learning with the GDL model with a concept map strategy can improve students' metacognition skills. The metacognition skills achieved by students in general for each indicator have also increased, according to the data in Table 6.

Table 6. Achievement Data for Each Indicator of Metacognition Skills in Each Cycle

Metacognition Skills Indicator	Score and Achievement Category					
	I	Category	II	Category	III	Category
Formulate general and specific learning objectives	6460	Enough	73.30	High	81.30	Very high
Formulate problems and hypotheses	6710	High	7292	High	7625	Tall
Create a problem solving plan	6460	Enough	71.25	High	8083	Tall
Carry out planning systematically	6330	Enough	71.25	High	75.00	Tall
Observing the planning implementation process,	6080	Enough	6542	Enough	6958	Tall
Examine the planning implementation process,	6330	Enough	6417	Enough	65.00	Enough
Record or collect data	5920	Enough	61.25	Enough	6833	Tall
Evaluate results	53.30	Low	5833	Enough	5958	Enough

The data in Table 6 shows that indicators 1, 3, 4, 5, 7 experienced an increase in scores from the moderate category to the high category, indicator 8 experienced an increase in scores from the low category to the sufficient category, and indicators 2 and 6 experienced an increase in scores but did not experience an increase category (high and sufficient). These results are consistent with previous studies which found that the metacognition skills of students who were taught by discovery learning were better than those not taught by the discovery learning model (Wirzal et al., 2022) on indicators of planning, monitoring, and evaluation (Jaya et al., 2018). Planning skills require students to describe knowledge that is relevant to the problem, identify learning objectives, plan and organize reference sources and the time needed to solve problems (Delvecchio, 2011). Students' skills in monitoring can be improved with training and practice (Schraw et al., 2012).

The discovery learning model is facilitated to develop evaluation skills for students through its syntax, in particular verification can encourage students to carry out activities to seek the truth of their findings from various learning sources so that students indirectly evaluate especially if the findings do not match expectations. The final part as a form of evaluation effort is that someone with good metacognitive skills always changes their study habits and strategies when necessary, possibly due to a mismatch with the demands of their environment (Branigan & Donaldson, 2020).

Critical Thinking Ability Lessons Learned Using the GDL Model with a Concept Map Strategy

The critical thinking skills of students who are taught using the GDL model with a concept map strategy experience an increase in each learning cycle. The increase in critical thinking skills increased in the high and very high categories with percentages of 63.33% (cycle I), 76.66% (cycle II), and 86.67% (cycle III), according to the data in Table 7. Increasing the achievement of students' critical thinking skills in general occurs in all indicators as shown in the data listed in Table 8.

Table 7. Data on students' critical thinking skills in each cycle

Value Intervals	Category	Acquisition of Students' KBK Value (%)		
		Cycle I	Cycle II	Cycle III
80 – 100	Very high	0.00	3.33	6,67
66–79	Tall	63.33	73.33	80.00
56–65	Enough	20.00	10.00	10.00
40 – 55	Low	13.33	6.67	3.33
30 – 39	Very low	3.33	6.67	0.00

Table 8. Critical Thinking Ability Data in Each Cycle

Critical Thinking Ability Indicator	Scores and Achievement Categories in Cycles:					
	I	Category	II	Category	III	Category
Focus	71.00	Tall	72.67	Tall	78.00	Tall
Reason	69.00	Tall	72.33	Tall	77.00	Tall
Inferences	68,67	Tall	69.67	Tall	72.67	Tall
Situation	59,67	Enough	61.67	Enough	65.33	Enough
Clarity	64.00	Enough	65.33	Enough	66.00	Tall
Overview	47,33	Low	53.67	Low	56.00	Enough

The low percentage of students who scored in the high and very high categories in cycle I was caused by several things, namely: (1) students only memorized the formula and were less able to use the concepts contained in the formula, this happened due to a lack of ability to manage process of thinking that causes students to be confused when faced with different situations, (2) the teacher always gives practice questions with patterns that are easy to understand without requiring analysis, so that when students are faced with questions requiring analysis , students find it difficult in developing their knowledge and thinking skills in understanding the questions, as a result students answer at random. In line with this statement, several previous research opinions stated that experiences or learning that provide opportunities for students to acquire skills in problem solving can stimulate students' critical thinking skills (Verawati et al., 2022). Meanwhile, to be able to think critically, students must be able to identify, construct, and evaluate arguments (Bilad et al., 2022).

The application of the GDL model can cause students to be very enthusiastic in solving problems that exist in LKS. Activities at the problem statement stage can be seen between students arguing with each other to equalize perceptions, identify problems, collect information related to the problems identified so that they can critically make hypotheses correctly. The second stage of GDL learning is to train students in exploring the material to be studied, learn to generalize newly obtained information so that it helps in developing critical thinking skills. The use of GDL learning can facilitate initial knowledge, so that students can develop thinking skills and cultivate a scientific attitude in a better direction (Noer, 2018). The GDL learning model presents questions or problems so students can think, observe, make conjectures, explain and analyze in finding new knowledge (Yuliani & Saragih, 2015).

At the data processing stage, students are serious in conducting discussions and working on questions on LKS with their group mates. Learning in the experimental class, the LKS is designed based on the GDL model, where the steps of the learning model can assist students in solving problems appropriately and directed. This is supported by the opinion of Sulistyowati et al. (2012), the advantages of applying the GDL learning model include: (1) student involvement in maximum learning, students are guided to find concepts independently, (2) there is cooperation and team dynamics in solving problems, making students active in critical thinking and increasing learning activities, (3) students have skills and dexterity in solving problems, (5) spurring students to be more thorough in working on problems. Student problem statement stage

GDL learning provides opportunities for students to design, find out, find new concepts and reconstruct new knowledge in their minds through data collecting and verification activities, with an emphasis on student group activities, meaning that social systems are very important to foster uniformity in cognitive and skills as behavior change. Social intelligence helps students to interact more (Williams et al., 2022). Zeldin (2000) states that by observing other people's success, student participants can evaluate their own abilities, so that the process of self-confidence can develop. Social intelligence is a person's ability to understand and manage to act wisely in relation to other people (Zautra et al., 2015). This is in accordance with Vygotsky's constructivism learning expert who stated that social interaction can encourage the formation of new ideas and enrich intellectual development (Hidayat & Evendi, 2022).

The GDL model trains students in carrying out the generalization process or making conclusions on what has been observed and obtained during data collecting and verification. This can directly train students in the inference aspect which is an important part of critical thinking skills. In line with this opinion, Sambudi et al. (2023) stated that concluding activities are abilities that require students to be able to identify the elements needed in making logical conclusions, formulate conjectures and hypotheses and consider relevant information.

Conclusion

The current study has achieved the objective and research questions formulated, that (1) implementation of the guided discovery model with a concept map strategy can improve students' metacognition skills, seen from the increase in students' metacognition skills scores in the high category of 33.33% (cycle I), 80.00% (cycle II), and 86.67% (cycle III); and (2) implementation of the guided discovery model with a concept map strategy can improve students' critical thinking skills, seen from the increase in critical thinking skills has increased in the high and very high categories with a percentage of 63.33% (cycle I), 76.66% (cycle II) , and 86.67% (cycle III). For the future research, it is better if the teacher emphasizes more so that students can carry out data collection activities, process and verify data according to learning needs and problems. which will be resolved. This can make students more optimal in carrying out indicators of metacognition skills (evaluation) and critical thinking (situation and overview).

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