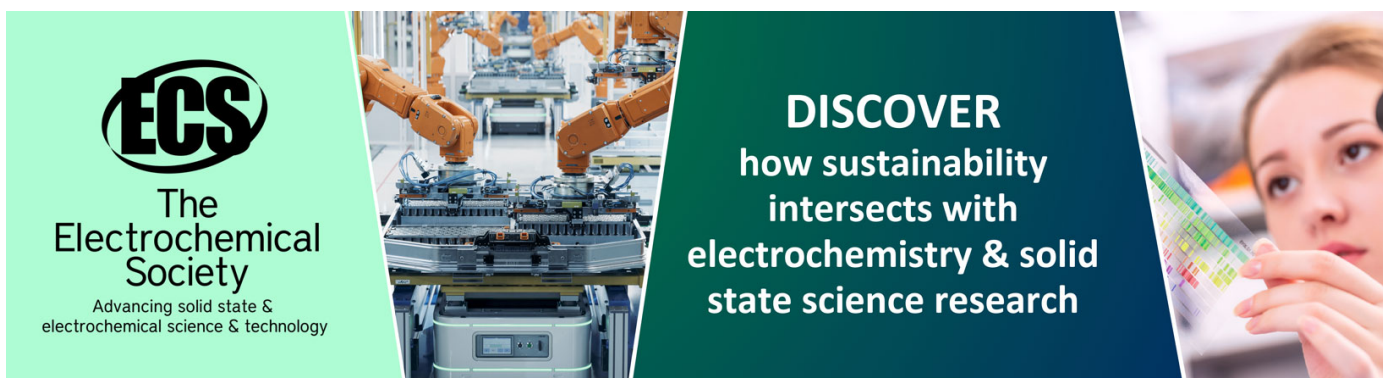**PAPER • OPEN ACCESS**

Modified Guided Discovery Model : A conceptual Framework for Designing Learning Model Using Guided Discovery to Promote Student's Analytical Thinking Skills

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Modified Guided Discovery Model : A conceptual Framework for Designing Learning Model Using Guided Discovery to Promote Student's Analytical Thinking Skills

I G. A. P. Arya Wulandari[1,2*], Cholis Sa'dijah[1], Abdur Rahman As'ari[1], Swasono Rahardjo[1]

[1]Department of Mathematics Education, Universitas Negeri Malang, Malang, 65145, Indonesia

[2]Department of Mathematics Education of Teachers' Training College, Universitas Mahasaraswati Denpasar, 80116, Indonesia

* *wulanmaroon@gmail.com*

Abstract :This paper introduces the Modified Guided Discovery learning model as a conceptual framework for learning that focuses on improving students' analytical skills at the secondary level through guided discovery to solve major problem in student analysis activities. The method used in this study is a qualitative method. This conceptual framework focuses on two main theories, which are Guided Discoverymodel and cognitive systems in New Taxonomy Marzano. The result of this study is a syntax of learning model which starts from retreival, comprehension, problem statement, analysis, verification, and conclusion.

1. Introduction

Analytical thinking is an important foundation for learning and living. The findings of several studies show that analytical thinking is able to help developingkey component in the learning process that benefits for all students [18, 16]. Thorndike states that all supreme intellectual performances of our mind is "analysis". This means that the foundation in the student's higher-order thinking skills (HOTS) is the analytical ability. However, based on the results of TIMSS 2011 study, it shows that only 2% of students in Indonesia can work on the reasoning problem with some missing informations. Only 43% of them can answer the low benchmark questions just by using knowing skills in which international median in knowing skills is 75% [22]. While the results of the 2012 PISA report [23] shows that Indonesia is ranked 64 out of 65 participating countries, and less than 1% of Indonesian students can answer questions in complex situations that require mathematical modeling, reflection, conceptualization, generalization and reasoning, which means that most of students in Indonesia can not work on a problem related to HOTS capability. Based on the results of PISA and TIMSS, it shows that it is essential to improve the quality of learning in Indonesia especially if it is focusing more onstudents' HOTS where the foundation of HOTS itself is analytical skills.

When it comesto developing analytical skills in the classroom, appropriate learning models are needed. The learning model could be said as the blueprint structure provides and the direction for teachers to teach [18]. Learning model is also defined as a conceptual framework that is able to describe and illustrate a systematic procedure in organizing learning and learning experiences in order to achieve a certain learning objective; and functionated as a guide on a kind of lesson plan for teachers in carrying out learning activities [31]. Discovery Learning (DL) is one of the best learning models to apply in developing students' factual and conceptual abilities [36]. DL occurs through

structured activities that require students to manipulate, investigate, and explore material that can lead students to find out important principles or relationships [4]. Therefore, students are not presented with concepts and ideas in the final form, but students are asked to formulate the concepts themselves.

There are various DL models that have evolved for instance; pure discovery learning, guided discovery, and modified free discovery. Pure discovery learning in the learning process iself, students find independentlythe problems and solutions of a case by an unplanned manner [33]. According to [33] on guided discovery learning teachers organize the subject matter, guide students by helping them to conclude a generalization through submitting questions. In guided discovery learning (GDL), the learning process has now started to be more directed by the guidance of teachers such as teachers to give a problem to the students, with the help of teachers, students make the hypothesis, then the teacher gives worksheets and briefing to the students as a reference in conducting the experiment.Furthermore, students are processing the dataof the experiment's results, draw conclusions and make a kind ofreport based on activity results, surely guided by teachers.

Various studies using GDL [32, 12, 17, 13, 38] only emphasize on retention capability and students' mathematical concepts comprehension. Nevertheless, when if it is observed from the characteristics of this GDL model whichemphasizes more on students' activeness in constructing the concept through the process of discovery, it isalso potential to develop students' analytical skills. However, a sort of research that emphasizes on improving students' analytical skills through the GDL model has not been conducted yet.

In the New Taxonomy of Marzano [20] consists of three systems and domains of knowledge, all of them are important to be considered and learned. The three systems are self-system, metacognitive system, and cognitive system. Marzano divides the cognitive system into four components. There are knowledge retrieval, comprehension, analysis, and knowledge utilization. Each process consists of all previous processes. Comprehension, for instance, requires knowledge retrieval, analysis requires comprehension, and so on. Based on those aspects, it can be seen that to improve the cognitive process of analysis,students must firstly pass the stages of knowledge retrieval and comprehension.

Applying the GDL model to classroom learning can help teachers improving students' retrieval and comprehension skills. This is supported by the results of [24], and [2] research that GDL is effective in improving student achievement and retention in science subjects. According to Bruner, there are several benefits that students can gain by learning using GDL, one of which is to assist students in doing retention and retrieval (retrieve information). On the other hand, some researches done by Cahyani [3, 6, 37]point out that the use of GDL model can improve students' understanding ability.

Based on Marzano's New Taxonomy study on students'analytical skills which assumes that to achieve the process of analysis, students must pass through the process of knowledge retreival and comprehension first, and some research results suggest that GDL is a good learning model used to improve students' knowledge retreival and comprehension , then we sees that GDL model can be applied as well to improve student analysis ability. Based on this, the problem currently is what kind of GDL model can contribute to the student's analytical skills.

Based on those above studies, we designed a new learning model by modifying the GDL syntax and combining it using the cognitive system of Marzano's new taxonomy, adjusted to the need in improving students' analytical skills, then named as Modified Guided Discovery Learning (MGDL) .

2.Method

Data collection was done initially through a preliminary study by examining the extent of students' mathematical analysis ability by involving 30 students of class X at SMKN (Public Vocational High School) 1 Denpasar and analyzing the textbooks that used by the students. Researchers also conducted a study on various learning theories related to the development of students' analytical skills. The two mainstream theories used are the Guided Discovery Learning Model in the Curriculum 2013 [15] and the cognitive system from new taxonomy Marzano [19]. Based on the results of this study, we then created a conceptual framework that is appropriate for developing the model so that it could be well

used in learning mathematics in the classroom.The syntax in Guided Discovery Learning Model at Curriculum 2013 [14] is presented in Table 1.

Table 1. Syntax in Guided Discovery Learning at Curriculum 2013

Phases	Teacher's Activities
Stimulation	Teacher can start teaching and learning activities by asking some questions, suggesting reading books, and the other learning activities that lead to problem-solving preparation. Stimulation at this stage serves to provide interactive conditions in the learning which can help students to be more active in terms of exploring the material.
Problem Statement	Teacher providesa wide opportunity for students to identify all issues related to learning materials. Then, one of the problemidentifications is selected and formulated in the form of a hypothesis (temporary answerto the problem question).
Data Collection	Teacher provides an opportunity for students to collectrelevant informations as much as possible to prove whether or not the hypothesis is true. Data can be obtained through reading literature, observing objects, interviewing sources, conducting their own experiments, and so on.
Data Processing	It is a kind of activity to process data and informationswhichhave been obtained by students through interview, observation, and so on. The data and result observations are then interpreted.
Verification	Teacher provides a wide opportunity for students to conduct a thorough examination by means of proving whether the hypothesis has been proven, related to the results of data processing.
Generalization	It is such a process of drawing conclusion that can be used as a general principle and also applicable to the same event or problem by considering the verification results. Based on the verification results, an principle,underlying the generalization, is formulated.

Meanwhile, the cognitive system in the new taxonomy marzano [19] consists of five stages. There are knowledge retrieval, comprehension, anaylsis, and knowledge utilization. As for five processes of analytical skills contained in this cognitive system, are presented in Table 2.

Table 2 Analytical skills Components according to New Taxonomy Marzano

AnalyticalSkills Components		Steps Involved
Matching: Involving an identification of similarities and differences among concepts.	a	Selecting what to analyze.
	b	Identifying the attributes or characteristics which are going to be analyzed.
	c	Defining how attitudes and characteristics could be the same and different.
	d	Communicatingthrough appropriate similarities and differences.
Classification : It involves organizing concepts or ideas into meaningful categories	a	Selecting the concepts we are going to classify.
	b	Identifying important attributes of the concept
	c	Marking a superordinate category that becomes the concept and communicates

AnalyticalSkills Components	Steps Involved
	why it falls into that category
	d Identifying subordinate categories for its concept and explaining their correlation.
Error Analysis : It is sort of an important aspect of what is often called as critical thinking. By using this process, students evaluate the reasonableness of such knowledge.	Error analysis can be compared to logical thinking, argument assessment, and identification of errors in reasoning.
Generalization : It Can be done deductively and inductively, but it involves the conclusion to form a testable principle or rule against a particular event or concept.	a Directing attention towards observation or specific information. b Finding the pattern and connection in the information. c Makinga statement that explainstheir correlation and pattern d Collecting more examples and then test them to see if the generalizationindeed works in all situations or change them otherwise.
Spesifiying : The process of "producinga new application fromthe known generalizations or principles".	a Identifying the concept being analyzed. b Picking up an appropiate generalizationforthe concept itself. c Ensuring that the concept is in accordance with the generalization condition. d Drawing conclusions and making predictions based on generalization implementation.

3.Results

3.1. Initial Test Results of Student Analysis Ability

Before creating a conceptual framework of the MGDL model, we conducted a preliminary study. In this case, we tested the students' analytical skills in SMKN 1 Denpasarby involving 30 students of class XI TKJ (Computer and Network Engineering)1, academic year 2016/2017. As for some analytical questions,they are related to Trigonometric materials which we gave to the students refered to Marzano's new taxonomy indicators consisting of 5 questions, each question contains process of matching, classifiying, identifying errors (error analysis), generalizing, and spesifying. The results of the test are presented in Table 3.

Table 3. Results of Student Answers

Question Number	Cognitive Process and Analysis Ability	Percentage of Eligible Students
1.	*Matching*	46,7% (14 students)
2.	*Classifiying*	16,67% (5 students)
3.	*Errors Analysis*	50% (15 students)
4.	*Spesifiying*	6,67% (2 students)
5.	*Generalizing*	6,67% (2 students)

Based on table 3, shows that no more than half the number of students can perform cognitive analysis process well. Analytical skills is a capability that must be mastered by students to increase their HOTS, this means that students' analytical skills still need to be sharpened and developed.

3.2. Result of Textbook Analysis

Textbooks that used by students and teacher should be analyzed with the following considerations: (1) there are still many teachers who rely heavily on this textbook so that the only source of learning is textbook. (2) Teachers tend to decide what to teach, how to teach and organize questions and exercises for their students based on this textbook even though the source of learning in addition to textbooks is overwhelming. The study of textbook analysis is divided into three categories: (1) material exposure, (2) examples, and (3) exercises, each described in Table 4.

Table 4 Analysis of Grade X High School Books

Category	Results of the Study
Material Exposure	The explanation of concepts in students' books involves many texts thereby it is potentially increasing extra cognitive load (ECL). • According to [40] if a diagram is presented by text along with an integrated explanation, it is very difficult to ignore text even when students do not need text for understanding, so students are forced to simultaneously assimilate some information elements, which strongly impose ECL on work memory. Itshows that ECL verily interferes learning and should be reduced optimally by reducing irrelevant cognitive activity
Examples	The sample type of the question asked is actually the same and too much for only one particular type of material.
Exercise	All the exercises presented in general only include the task of finding the right answer. • Based on Bloom's taxonomy, the types of questions given to students in this book's exercise mostly dominated by C1, C2, and C3 which occupy no less than 70% and other abilities (HOTS) of no more than 30% • Exercises that can improve students' analytical skills are still lacking. It can be seen from the aspects of analytical skills which must be owned by students based on Marzano's new taxonomy that includes matching, classification, error identification (error analysis), generalizations, and specifications not yet fully shown on the type of problem provided in this student's book. .

3.3. Conceptual Framework Development Result of MGDL Model

Modified Guided Discovery Learning (MGDL) is a new design of learning model by modifying Marzano's new GDL syntax and taxonomy that is adapted to improve students' analytical skills. MGDL consists of 7 steps namely, knowledge retrieval, stimulation, comprehension, problem statement, analysis, verification, conclusion. The results of conceptual framework successfully designed based on what presented in Figure 1 and supporting notions are discussed in the next section.
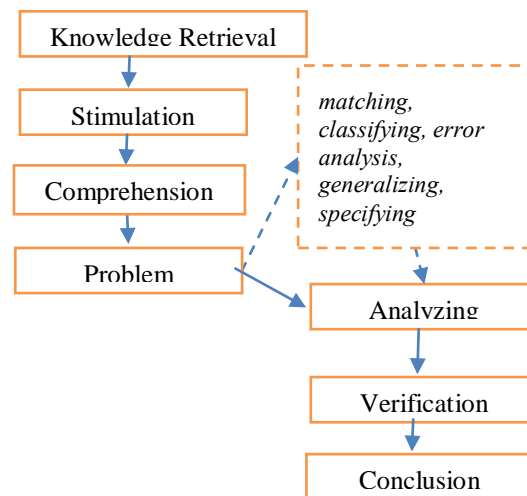
Figure 1. MGDL design Model

3.3.1. Knowledge Retreival

Retrieval practice, or trying to remember a piece of information from memory, usually produces more learning compared to not using it at all, and is more impressive [27]. Furthermore, [28] states that retreival practices provide long-term learning benefits. Studies have shown that retreaval is the most effective activity to get to know about learning concepts since itis easily applied to improve students' motivation in learning a concept in the classroom[29, 30, 21]. Several studies show that retrieval practice generally uses very easy tests such as free recall, cued recall, or multiple choice, and it is found that retrieval is highly beneficial in learning [10]. Meanwhile, according to [20], knowledge retrieval involves remembering information from permanent memory. At this level, students simply call facts, sequences, or processes exactly as they have been stored based on them, we used this principle in order to invite students to recall the prerequisite material needed to understand the concepts learned. The activities undertaken at this stage istopull up short questions to students, either in the form of multiple choice or essay.

3.3.2. Stimulation

Researchers use this principle with the aim to invite students to understand basic concepts first so that students can have a shadow about the material being studied. The activities undertaken at this stage is to provide a brief description of the basic concepts that must be studied.

3.3.3. Comprehension

According to [26], the learning experience in GDL occurs when students are assigned specific tasks (eg, problems or projects) to be supported by inquiry. GDL is also called an inductive method that guides students to discuss and organize ideas and processes themselves [1]. During GDL activities, teachers invite students to start discussions and react to other students[11]. Based on this, after passing the stimulation stage, students are guided to understand more complex concepts. At this stage students are given the opportunity to explore their ideas, and this exploration can be guided by appropriate and good questions that lead to students' deeper understanding of more complex concepts. This phase is also adapted to new taxonomy marzano on the cognitive system, where the second level that students must passed the level of comprehension. We use this principle with the aim to know the extent to which students can understand the concepts that have been given at the stage of stimulation. The activities undertaken are to provide the right questions and good so as to cause students to understand more deeply into a more complex concept. The questions given can be essentially constructivist.

3.3.4. Problem *Statement*

We use this principle with aim to improve students' analytical skills. Students are faced with real-world case studies with some questions that are cognitively adapted to analytical activities according to the new taxonomy of Marzano [20] i.e. matching, classifying, error analysis, generalizing, and

specifying. [34] argues that contextual issues that require students to apply social and mathematical thinking have the potential to prepare students in facing the challenges of everyday life, while demonstrating that math is useful. [39] states that by connecting the real world in mathematics subject is often assumed as a way to increase student motivation therewith brings benefits such as facilitating understanding of mathematical concepts, motivating students, and improving students' attitudes towards mathematics.

3.3.5. Analyzing

We used this principle with the aim to improve students' analytical skills by answering the questions given to the problem statement. Activities undertaken in the cognitive matching process include: (1) students are asked to determine how attitudes and characteristics being analyzed are the same and different, (2) students are asked to communicate appropiate similarities and differences. The activities performed on the cognitive process "classfying" include: (1) choosing the concepts to be classified, (2) the students identify essential attributes of the concept itself. Activities performed on the cognitive process "error analysis"can be compared to logical thinking, argument assessment, and identification of errors in reasoning. The activities undertaken in generalizing cognitive processes include: (1) directing attention to observations or specific information, (2) finding patterns and connections in information, (3) making statements, explaining correlations and patterns. Activities undertaken in cognitive processes specifying include: (1) identifying the concept being analyzed, (2) selecting appropriategeneralizations to the concept, (3) ensuring that the concept fits the generalization conditions.

3.3.6. Verification

We used this principle with the aim of providing opportunities for students to conduct accurate examination to their outcomes. The activity undertaken at this stage is that students promote their ideas one to another in front of the class. This is because when students are hearing ideas and explanations from the other students, they may gain a better understanding of math, which could be a very powerful way to provide equity in the classroom, since all students gain access to other ways of thinking about mathematics [5]. By sharing, they are able to examine the perceptions and perceptions of others, and establish or strengthen whatis already known to what they have heard [7,25]. This activity can also be used as an indicator of how well students understand their concepts and ideas.

3.3.7. Conclusion

In constructivist learning, students engage in active cognitive processes, such as paying attention to relevant incoming information, organizing information into coherent representation, and integrating incoming information with existing knowledge. Therefore, after the students explore the concepts from the previous stages, students along with teachers make final conclusions and provide practice questions which is the application of the concept they havebeen studied. Researchers used this principle with the aim to invite students simultaneosly drawing conclusions that could be used as general principles and generally applicable by considering the results of verification.

4. Conclusion

The conceptual framework of the MGDL Model aims to encourage learning using guided discovery learning to improve students' analytical skills. This conceptual framework also considers a coherent theoretical study. In designing the conceptual framework of the MGDL model, we modified the syntax of guided discovery learning and integrated it with three cognitive systems in the new taxonomy marzano which contains five processes related to the development of students' analytical skills, including matching, classifying, error analysis, specifying, and generalizing . This research has not yet developed learning device that support MGDL concept. In consequence, it is suggested in subsequent research to develop appropriate learning tools,in order to comparea learning by using this model, which is better than other learning in terms of developing students' analytical skills.

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