The Conceptual Framework of Designing a Discovery Learning Modification Model to Empower Students' Essential Thinking Skills

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Abstract. This article aims to describe the modification of the discovery learning model as a conceptual framework to be applied in science learning to empower students' essential thinking skills. The method used is qualitative with the main data source of the literature review. This conceptual framework focuses on three aspects consisting of the discovery learning model, the TASC learning model, and the cognitive system in the Presseisen’s taxonomy. From the results of the conceptual framework of the discovery learning model modification with the TASC learning model, it is obtained the syntax of the learning model starting from the start with multi-modal representation problems, generating hypotheses, investigation, interpretation and inference, discussion and conclusion, and application. Then the new model is given the term discovery-based multi-modal representation (DIMEnsi). The implications of this research can empower students' essential thinking skills, which include analytical, critical, creative thinking, decision making, and problem-solving skills.

1. Introduction
Natural science is an important subject taught in schools [1]. The science education aims to make the students master the science process skills individually [2–4] and teach the students about how to be involved in investigations [5]. Also, students need to study science for personal and social development, to gain knowledge about scientific facts and principles, as well as scientific methods and skills and their application [6]. So, the student must have integrated skills, knowledge, and attitudes to improve their understanding of scientific concepts.

In science, to understand the scientific concept is closely related to the thought process [7]. Thinking skills must be possessed by scientists in the process of scientific discovery because it can be used to build knowledge, solve problems, and formulate results [4]. Some of the thinking skills according to Presseisen's taxonomy, namely essential thinking skills [8], which includes qualifying, classifying, finding relationships, transforming, and drawing conclusions [9–14]. The components of essential thinking skills are included in 21st-century skills, such as analytical thinking, critical, creative, decision making, and problem-solving.

Several studies have shown that students have a poor understanding of scientific thinking skills [15, 16]. For example, the conceptual understanding of science process skills among secondary school students in Botswana found that students did not have an adequate conceptual understanding of
science process skills [16]. Likewise, many studies have examined students' understanding of inquiry and concluded that they lacked sufficient understanding of such a process [17]. Other findings stated that almost all students were unable to provide true definitions and explanations about basic and integrated science process skills, but most of them gave answers that were partially true and false [15].

Having realized the importance of essential thinking skills for students, an appropriate learning model is needed. The learning model is defined as a conceptual framework that can describe or illustrate systematic procedures in managing student learning experiences and serves as a guide for teachers in implementing learning [18, 19].

Discovery learning is one of the learning models recommended in Curriculum 2013. Discovery learning applied in developing students' factual, conceptual, procedural and thinking abilities [20]. Discovery learning occurs through structured activities that require students to manipulate, investigate, and explore problems that can lead students to find important principles or relationships [21]. Therefore, students are not confronted with the concept in its final form but form the concept itself.

Various discovery learning models have evolved, for example; pure discovery learning, and guided discovery. Learning pure discovery in the learning process itself, students find independently the problems and solutions of a case in an unplanned way [22]. Students begin to learn guided discovery with interesting questions and concrete material, by working as individuals or groups they explore material, make observations, and find answers to their questions when the teacher works as a facilitator and guide [23]. Discovery activities motivate students during search and discovery [24]. Discovery activities also help students to find their meaning and systematize their ideas [25].

Various studies using discovery learning only emphasize the ability of students to retain and understand concepts [26–29]. However, when viewed from the characteristics of this discovery learning model which emphasizes the activeness of students in developing concepts through the discovery process, it also has the potential to develop students' thinking skills, but they do not involve collaborative activities and are associated with real problems. To overcome these problems need to be supported by a model that can maximize the potential of discovery learning models, including the learning model of Teaching Active in a Social Context (TASC). This model is in line with Bloom's taxonomy and scientific process so that it can train students to carry out the whole process of thinking both low and high-level thinking skills [30, 31]. Also supported by a survey in 2015 showing more than 10,000 classes in the UK have used the TASC work framework to improve students' problem solving and thinking skills [32].

Findings from several studies show that essential thinking skills can help develop key components in the learning process that are beneficial to students [33, 34]. Presseisen emphasizes that educators need to develop and use learning designs to link essential skills with higher-level, more complex thinking operations [8]. This means that the foundation in students' higher-order thinking skills is essential thinking skills.

Based on the above study, a conceptual design of new learning models is carried out by modifying the phase of discovery learning models with the TASC learning model and combining them using the Presseisen’s taxonomic cognitive system, which is adjusted to the need to empower students' essential thinking skills.

2. Method
The method used is a qualitative analysis with the main source obtained from a literature review of learning models related to the development of students' essential thinking skills. The learning model used is the discovery model in the 2013 curriculum [20, 35], modified with the active thinking model in a social context (TASC) [36, 37] and the cognitive system of the Presseisen’s taxonomy [8, 34]. Based on this the conceptual framework is then designed accordingly to develop models so that they can be used effectively in learning science.
3. Results and Discussion
From the results of a literature study on discovery learning models applied to the 2013 curriculum, the syntax obtained is a sequence of learning accompanied by details of teacher and student activities at each stage, as can be seen in Table 1.

| Syntax        | Learning Activities |
|---------------|---------------------|
| Stimulation   | Students are confronted with something that confuses them. Learning begins with asking questions, encouraging reading books, and other learning activities that lead to the preparation of problem-solving. |
| Problem statement | The teacher allows students to identify as many problem agendas as possible that are relevant to the subject matter. Then the best is chosen and formulated in the form of a hypothesis. |
| Data collection | The teacher allows students to gather relevant information from various sources to test hypotheses. |
| Data Processing | Students try and explore their conceptual knowledge, practicing logical and applicative thinking skills. |
| Verification   | Students do a careful examination to prove whether or not the hypothesis set earlier with alternative findings, connected with the results of data processing. |
| Generalization | The process of drawing a conclusion that can be used as a general principle and applies to all events or problems that are the same, taking into account the results of verification. |

The scheme which is the flow of thought of TASC that presents the learning environment and its management system can be seen in Figure 1.

![Figure 1. TASC Working Model](image-url)

In Figure 1, the TASC learning syntax can be described in detail in learning activities, as shown in Table 2.
Table 2. Syntax of TASC Learning Model

| Syntax | Learning Activities |
|--------|---------------------|
| Gather and Organize: What do I know about this? | The teacher first explores the student's initial knowledge such as making an apperception from the material to be learned. |
| Identify: What is the task? | Often students forget the TASC small rules when they are already preoccupied with activities, the teacher needs to remind and monitor each student's activities. |
| Generate: How many ideas can I think of? | The problem that often arises when students are asked to respond to information is that they pick up too quickly the conclusion of what they saw. |
| Decide: Which is the best idea? | After giving an opinion, students are asked to give reasons for their actions. The role of the teacher here provides the opportunity for logical thinking and feedback to students whether the action they are taking is appropriate or not. |
| Implement: Let's do it! | Students apply the ideas that have been planned systematic before. This stage the teacher frees students to use all the abilities and skills he has in order imagination, creation and creativity are increasingly developing, however, they still need to monitor students so they do not get out of the goal to be achieved. |
| Evaluate: How well did I do? | The teacher can start by showing two examples of actions or in the form of objects that are considered good and judged not good. Then ask students to respond to them why the example of the action or object can be judged as good or not. The teacher slowly related it to the results of student work. The teacher gives opportunities to students to evaluate the results of their work and stimulate students to make decisions about what needs to be improved or what needs to be reduced. |
| Communicate: Let's tell someone! | So that students 'confidence and students' abilities make sense what they do increases, the results of student work need to be displayed publicly. |
| Learn from experience: What have I learned? | The last stage of all students is directed to reflect everything activities from the beginning to the end of a series of learning processes that they go through. Students are also guided to describe what benefits can be derived from the learning process of daily life and in different contexts. |

Explanation on the syntax of the TASC model in Table 2, can be simplified in the components of thinking, actively, socially, and contextually, each of which is defined in Table 3 [36].

| Thinking | Actively | Social | Context |
|----------|----------|--------|---------|
| An ongoing process experienced by students in the development ability to think. | Active thinking activities, issuing opinions, and exploring various learning resources. | Actively interacting, sharing knowledge and experiences, and work together to solve problems | Conditioning students by bringing them together to real-life problems that stimulate thought processes and strong concept formation. |

Meanwhile, Presseisen presents the taxonomy of essential thinking skills, complex thinking skills models and metacognitive thinking skills models Developing Minds [38]. According to Presseisen, there are at least five categories of thinking skills that must be included in the taxonomy of essential thinking skills [8]. That is as shown in table 4.
Table 4. Presseisen Taxonomies for Essential Thinking Skills

| Thinking skills                        | Indicator                                                                 |
|---------------------------------------|---------------------------------------------------------------------------|
| Qualifying (finding unique characteristics) | recognizing units of basic identity; defining; gathering facts; and recognizing tasks/problems |
| Classifying (determining common qualities) | recognizing similarities and differences; grouping and sorting; comparing, and making either/or distinctions |
| Finding relationships (detecting regular operations) | relating parts and wholes; seeing patterns; analyzing; synthesizing; recognizing sequences and order; and making deductions |
| Transforming (relating known to unknown) | making analogies; creating metaphors; making initial, and inductions |
| Drawing conclusions (assessing)        | identifying cause and effect; making distinctions; inferring; and evaluating predictions |

The hypothetical conceptual Discovery-based Multi-Modal Representation models by modifying the phase of discovery learning with the TASC learning model can be seen in Figure 2.

![Figure 2. Hypothetical Framework for Discovery-Based Multi-Modal Learning Model](image)

The results of a successful hypothetical conceptual framework are designed based on what is presented in Figure 2 with the following explanation.

3.1 Start with Multi-Modal Representation Problem
At this stage the teacher starts the teaching and learning process by asking questions, suggesting the student to read the books, and other learning activities that lead to prepare the student to have problem-solving skill. Stimulation based multi-modal representation to provide interactive conditions of the student in learning that can help students become active in exploring, recognizing basic identity units; define; collect facts, and identify tasks/ problems from the material being studied. This stage can provide the benefits of long-term learning [39] because it involves remembering knowledge from long-term memory [40]. Also, this is an effective activity to find out about students' initial concepts[39, 41, 42] because at this stage, students only call facts, sequences, or processes as they have been stored based on memory.

3.2 Generating Hypothesis
At this stage, the teacher allows students to identify problems associated with learning material. Then, problem identification is chosen and formulated in the form of a hypothesis. Potential thinking of students are expected to develop at this stage, namely in terms of recognizing similarities and differences; grouping and sorting; compare, and make a difference [8, 43].

3.3 Investigation
At this stage, the teacher allows students to gather relevant information to investigate whether the hypothesis is proven or not. Data can be obtained through reading literature, observing objects, conducting experiments and others. Potential students are expected to develop in this stage is the essential thinking skills can be trained with structured [2–4] and to teach students how to be involved in investigations [5].

3.4 Interpretation and Inference
At this stage in the form of activities to process data and information that have been obtained by students through experiments. Observation of data and results than analysis, to get related parts and whole, see patterns, analysis, synthesis, recognize sequence and order, make analogies, create metaphors; make initials, and induction. Potential students at this stage are used to explore their conceptual knowledge, practice logical thinking and applicative skills [6, 21].

This phase aims to provide students the opportunity to conduct an accurate examination of the results of an investigation. Activities carried out at this stage are looking for relationships and data linkages between one another, so that conclusions can be obtained based on the results of data processing. By sharing, they can examine their perceptions and perceptions of others and reinforce what they already know with what they have discussed [44, 45].

3.5 Discussion and Conclusion
Students are actively involved in the cognitive process in constructivist learning, through discussion in groups and presentations in front of the class to explain the results of their learning [46]. Therefore, after students explore concepts from the previous stage, students and teachers together make conclusions about the material being studied. It aims to train students in drawing conclusions that can be used as general principles by considering the results of interpretation and inference [47].

3.6 Application
Even though during the problem-solving process students are encouraged to reflect on their thought processes, so they end up trying to generalize what has been learned and to transfer what has been learned to other situations. The form of its activities by providing question exercises will train students to be able to assess the credibility and recognize the factors that make a person credible to understand events regarding a particular topic [47]. Both formative and summative evaluations related to success and collaborative project work processes can be feedback for students to realize and identify student performance levels [48].
Based on the syntax explanation of the DiMEnsi learning model in Figure 3, educators need to develop and use learning designs that connect essential thinking skills so that they can empower high-level thinking, as shown in Table 5.

| Aspect                   | Problem-solving | Analytical thinking | Critical thinking | Creative thinking |
|--------------------------|-----------------|---------------------|-------------------|-------------------|
| Activity                 | overcome known difficulties | connect each part understanding meanings | certain certain | make new ideas or products |
| The aspect of essential skills | transforming; conclusions | classifying; relationships | transforming; conclusions | qualifying; relationships; transforming |
| Results                  | solution; generalization | interpretation; pattern | the reasonable reason; proof; theory | new meaning; pleasant product |

Table 5 shows that aspects of essential skills are part of higher-order thinking skills such as problem-solving, analytical thinking, critical thinking, and creative thinking. For example, if students have good analytical thinking skills, they will be better equipped to face challenges in everyday life in the future [49, 50], so analytical thinking skills need to be trained on students from elementary to tertiary level [51].

4 Conclusion

The conceptual framework of the modification of the discovery learning model considers a coherent theoretical study in designing it. The conceptual framework of the model is done by modifying the syntax of discovery learning with the TASC learning model and integrating it with the cognitive system in Presseisen's taxonomy. The results of the conceptual framework of the discovery learning model modification with the TASC learning model obtained the syntax of the learning model starting from the start with multi-modal representation problems, generating hypotheses, investigation, interpretation and inference, discussion and conclusion, and application. Then the new model is given the term discovery-based multi-modal representation (DiMEnsi). The implications of this research can empower students' essential thinking skills, which include analytical, critical, creative thinking, decision making, and problem-solving skills.

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